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Changing Current Scenario of Rice-Wheat System in Indo-Gangetic Plain Region of India

Avadhesh Kumar Koshal

Project Directorate for Farming Systems Research, Meerut

Abstract- The Indian Green revolution region "Indo Gangetic Plain" occupies nearly 15% of the total geographical area of the country. The study area covered five states (Punjab, Haryana, Utter Pradesh, Bihar & West Bengal) in the Indian part of IGP, extended from 73º E and 32º N to 89º E and 21º N. Rice- wheat system is a main food security system of the India. The analysis of rice yield with rainfall CV=0.10 was observed and coefficient of correlation between rainfall and yield was 0.44 and wheat was computed which less than linear function is provided value of R^2 of 0.55, which is reasonably less indicating that 55% variation in wheat yield is explained by the yearly rainfall. The major agricultural areas identified the rice-wheat crop calendar was identified using the SPOT VGT IMAGES. The images were classified in ERDAS Imagine using Density slicing classification (Un-supervised) algorithm. The analysis of kharif and rabi time series data; the overall analysis of total DN values are divide in three range classes viz. 128, 128-192 &192 assigned in pink, yellow and green, and re-classified in low, medium and high agriculture area. The overall DN values of kharif and rabi season average temporal data analysis are observed medium class (128-192) have 46.6% and 57.1% values coverage area and high coverage area having only 13% and 17.6 % respectively. The remote sensing and GIS technology play an important role to control and management of problematic areas. The long term study of satellite data are help to monitor with latest technology for save fertilized crop land.

Key words: IGP, DN value, Density slicing, SPOT, Cropping system

I. INTRODUCTION

The Indian Green revolution region " Indo Gangetic Plain " occupies nearly 15% of the total geographical area of the country. It is one of the most fertile large plain to developed agriculture based densely populated region. It produces about 50% of the total food grains to feed 40% of the population of the country [1]. The Indo-Gangetic Region is bound on the north by Himalayas. The IGPs, also known as the "Great plains", it is formed by the basin of three distinct rivers systems-the Indus, the Ganga and the Brahmaputra [2]. The major rivers of this systems are the Ganges and the Indus along with their tributaries; Beas, Yamuna, Ravi, Chambal, Sutluj and Chinab. These plains comprise one of the world's greatest stretches of flat and deep alluvium [3]. It is the source of the fertile alluvium soil which is favorable for double and triple cropping. The important crops grown in the Indian IGP are rice *(Oryza sativa* L.), maize *(Zea mays* L.), pearl millet (*Pennisetum glaucum* L.) and sorghum (*Sorghum bicolor* L.) in Kharif season and wheat (*Triticum aestivum* L.), barley *(Hordeum vulgare* L.), chickpea (*Cicer arietinum* L.),and mustard *(Brassica* sp), in rabi seasons and cotton (*Gossypium sp*), sugarcane (*Saccharum officinarum* L.), and potato (*Solarium tuberosum* L.) are cash crops in this region [4]. Rice (*Oriza sativa)*-Wheat (*Triticum aestivum*) cropping system is the most important predominant cropping system of the IGP in India. It is the "food bowl" or "food basket" of India having 53 per cent of total area under rice and wheat crops. RWS occupies around 42% of the total agricultural area in the India [5]. Rice is mostly grown in *Kharif* (June October) season, while wheat is mostly grown in *Rabi* (December-April) season [6&7]. The major cropping systems are rice-wheat, maize-wheat, sugarcane- wheat, cotton-wheat, rice-mustard-jute, rice-potato and rice-vegetables-jute. The three major cropping systems are rice-wheat rice-fallow and rice-mustard- summer rice belongs to four region of IGP but pre dominated system is rice-wheat and occupies 72% of the total cultivated area [8]. The rapid spread of rice-wheat system has mainly been attributed on account of its better adaptability, availability of high yielding varieties and mechanization of both crops. The productivity of these system are higher because the agro climatic conditions i.e. productive alluvial soil, maximum irrigated land , sub tropical climate is most favorable to rice and wheat crops in comparison to other cereals. Therefore the farmers of central plain zone are adopting rice-wheat system in large scale. The crop production pattern the IGP can also be divided into two major zones western (Haryana, Punjab, parts of central, western & northern) dominated by rice-wheat cropping systems and eastern part (Eastern UP, Bihar and West Bengal) dominated by rice based cropping systems. Climate change is one of the most important global environmental challenges facing humanity with implications for food production, natural ecosystems, freshwater supply, health, etc. After decades of continuous cropping, over irrigation, urbanization, pest pressure nutrient mining, burning of crop residue and water shortage. That problem is covering all IGP areas [9]. The effects of global warming combined with the region's rapidly growing population. Declining soil fertility (Punjab), development of salinity (Haryana, South –west Punjab) ground water depletion (Central & Western UP), floods (Bihar & West Bengal).

The advances satellite remote sensing (RS) data, Global Positioning System (GPS) and Geographical Information Systems (GIS) have vital role in system based study. Remote sensing provides tools for advanced cropping system management [10]. Many land use studies has been successfully using RS approach [11, 12&13].The remote sensing data for prospective view; multi spectral, multi-

resolution and frequent monitoring capability can provide various spatial information amenable to cropping systems analysis. The LANDSAT (US), SPOT (France), IRS (India) and IKONOS [14] spacecrafts have been launched for earth observation. The IRS series- IRS1A, 1B, 1C, &D satellites provide a wide range spatial, temporal and multi –spectral data used for inventorying, management and monitoring of the different resources(renewable & non-renewable) of the nation [15&16]. Multi temporal remote sensing data are widely acknowledge as having significant advantages over single date imagery [17] for studying dynamic phenomena. SPOT (French: *Satellite Pour l'Observation de la Terre*, "Satellite for observation of Earth") is a high-resolution, optical imaging Earth observation satellite system operating from space. SPOT4 launched March 24, 1998 and now stopped functioning July, 2013. S10 or 10-day synthesis: a result of the merging of data strips from 10 consecutive days[18]. The purpose of this study is to analysis of rice wheat system covering IGP areas during vegetative growing period in March & August. Then early predict to production/yield based on 1 km spatial SPOT VGT image. SPOT vegetation (VGT) has been found very useful to study the dynamics temporal agricultural system [19].

II RESEARCH ELLOBORATIONS

Why IGP- Rice- wheat system is a main food security system of the India. It also providing food, income and employment to millions of people engaged with this system based related work. The changing of climatic factors (temperature and rainfall) and natural problems (floods and drought) declining the rice and wheat crop productivity. The continuous excessive uses of chemical fertilizer, weed control and pest control chemical giving the problems to soil health as well as in environment. The rice-wheat rotation is one of the largest agricultural production systems of the world. The nursing of climate and soil of Indo Gangetic states (Punjab, Uttar Pradesh, Haryana, Bihar and WB.) area with the help of advance tools & technology.

Objectives

The study aimed to analysis of changing current scenario about rice and wheat crop with the time series SPOT VGT data during vegetative season viz. August and. March.

Study area

The study area covered five states (Punjab, Haryana, Utter Pradesh, Bihar & West Bengal) in the Indian part of IGP (Figure 1), extended from 73º E and 32º N to 89º E and 21º N [20]. These five states cover nearly 15.8% of the total geographical area of the country and 37.4% of the population of the country. The analysis of current districts distribution list of India in IGP covered states are observed 179 districts but 172 districts distributed this area and 4 districts are covered to other agro-climatic regions (Table 1). The IGP have dominated loam soil but Haryana and south west Punjab having sandy soil with low rainfall. The climate of the Indo-Gangetic Region is dominated by the Asian summer monsoon. The cool, dry winter is followed by a warming trend with daytime temperatures reaching as high as 45°C in June or July.

Table 1: Distribution of States and region of IGP

State/UT	Region	No. of District	
Punjab	Trans-Gangetic Plain Region (District: 51)	20	Indo-Gangetic Plain Region (District: 172)
Haryana		21	
Delhi		9	
Chandigarh		1	
Uttar Pradesh*	Upper -Gangetic Plain Region (District: 45)	45	
Bihar + Uttar Pradesh	Middle-Gangetic Plain Region (District:61)	38+23	
West Bengal*	Lower-Gangetic Plain Region (District:15)	15	
*Uttar Pradesh: 4 Districts & West Bengal: 3 Districts not included			

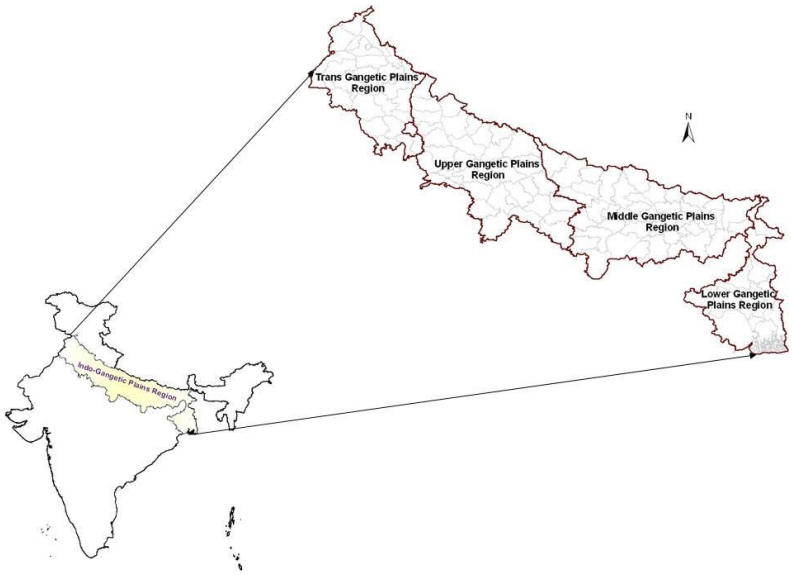

Figure 1: Study area

Planning Commission [21] divided the country into 15 broad agro-climatic zones based on physiogrphy and climate. The IGP (Figure 2) in India is divided in four agro climatic regions namely Trans Gangetic Plains Region (TGP), Upper Gangetic Plains Region (UGP), Middle Plains Region (MGP) & Lower Gangetic Plains Region (LGP). These zones are combinations of agro ecological, socio economic and political factors. It is not purely based on agro- ecological zones.

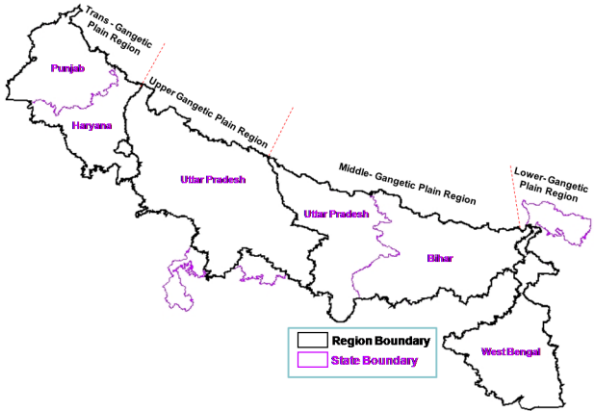

Figure 2: Map showing agro climatic regions of Indo-Gangetic Plains (IGP)

The data and method

The present study is based on secondary sources of time series analysis of rice and wheat data that are obtained from ICAR website [22&23]. The 10 years (2000-01 to 2010-11) data was used for achieve the stipulated objectives. The climatic data- rainfall, livestock census, population data and satellite images (2000-01 to 2010-11) are collected from the published records, cropping systems atlas [24], bulletin of the Directorate of Agricultural Statistics; SDDS-DES, Ministry of Agriculture, Govt. of India; ICAR report; DACNET; FSI-report and other national level institute reports and websites.

The climatic data (normal/annual rainfall,) of IGP for continuous 10 years 2000 to 2010 data were obtained from India water portal website, IMD, New Delhi; NASA POWER and [25]. The census data information of India and IGP states is taken from year 2001 & 2011 census report [26]. The 16^{th} and 18^{th} livestock data (1997 & 2007) were collected from different states animal husbandry websites [27] and reports [28].The state level land utilization and fertilizers consumption in rabi & kharif season data [29] were collected from FSI-2011 [30] report & related websites. The thematic layers of India, five states were joined in GIS to prepare a mosaic for the Indo- Gangetic Plain. The agro climatic region boundaries [31] were delineated from the master database of IGP. The remote sensing data used in this study included the Single composite data set (1to10days) S10 NDVI data derived from VEGETATION sensor of SPOT-4 satellite (Table. 2). The data was used to two different vegetative growth seasons (Figure 3) August and March of the every agricultural year (2000to2012). The time series remote sensing data freely download from SPOT VGT website www.free.vgt.vito.be. [32].

Table 2: List of data used in the study

Data type	Data product	Satellite/ sensor	Spatial resolution/ scale	Time period	Source
Raster	Crop rotation	SPOT VGT S-10	1kmx1km	Year 2000-12 (March & August)	www.free.vgt.vito.be

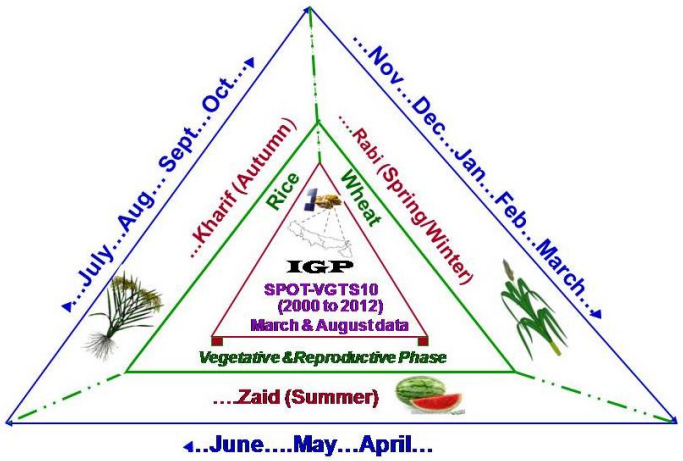

Figure 3: Crop calendar of IGP during Rabi, Kharif & Zaid season

Methodology

The major crops, different livestock, census, land uses and climatic data are integrated in the MS excel. The different type of statistical data analysis viz. Coefficient of Variation (CV), Correlation of Coefficient (R^2) and Trend Analysis to given important current scenario of current change pattern of time series data. The study area boundary feature file (.shp) was used for GIS layer in ARCGIS software to extracted information from remote sensing images. The data S10 was downloaded from the VGT [29] free data product Internet site. The ten-day composite NDVI products of SPOT- VEGETATION (VGT) sensor remote sensing 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 9.0 software was used for processing and analysis of remote sensing data. The software was used for processing and analysis of remote sensing data (Figure 4). The images are downloading in Hierarchical Data Format (HDF) format and directly open in ERDAS IMAGINE to save in .img format. The dataset 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. The SPOT VGT temporal series of image opened into the viewer of the ERDAS IMAGINE. The single band was stacked to create temporal series data (2000 to 2012) of March (for Wheat) and initial August (for Rice) 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.

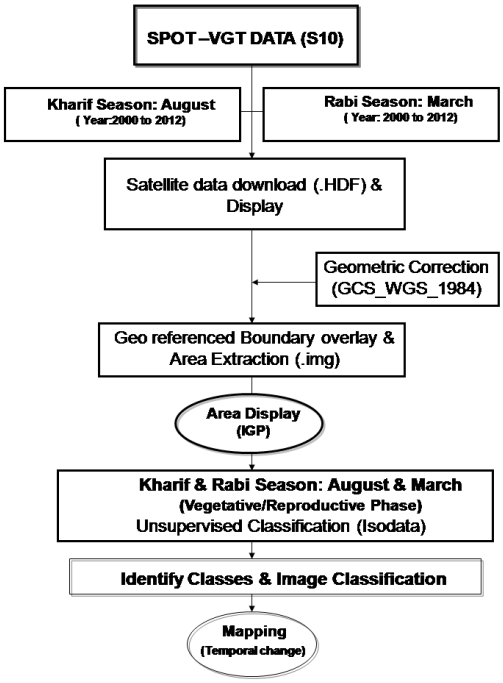

Figure 4: Flow chart of Methodology used in the study

III RESULTS OR FINDINGS

The statistical analysis (coefficient of variation (R^2) and trend analysis) are employed to study the trends in area, production and productivity of the rice-wheat crop. The rainfall, fertilizers, livestock & population census, land cover and remote sensing data analysis are given current scenario of IGP. After analysis of different data findings are discussed in sequence as under.

Current Scenario of rainfall pattern

The ten years monthly data were calculated in mean value, standard deviation and coefficient of variability is presented in Table.2. The average annual actual rainfall of ten years estimated 759.2 mm was observed in IGP. The standard deviation from mean annual rainfall was 340.7mm and coefficient of variation 0.45. The maximum coefficient of variation 67.6% observed year 2007 and minimum coefficient of variation 44.2% observed in year 2010.The lowest rainfall 607.7mm was observed in year 2000 while higher rainfall 939.1mm in year 2008. An increasing trend of monthly rainfall@8.76mm/year has been noticed (Figure 5). The ten years average moving trend of rainfall 721.86mm was observed

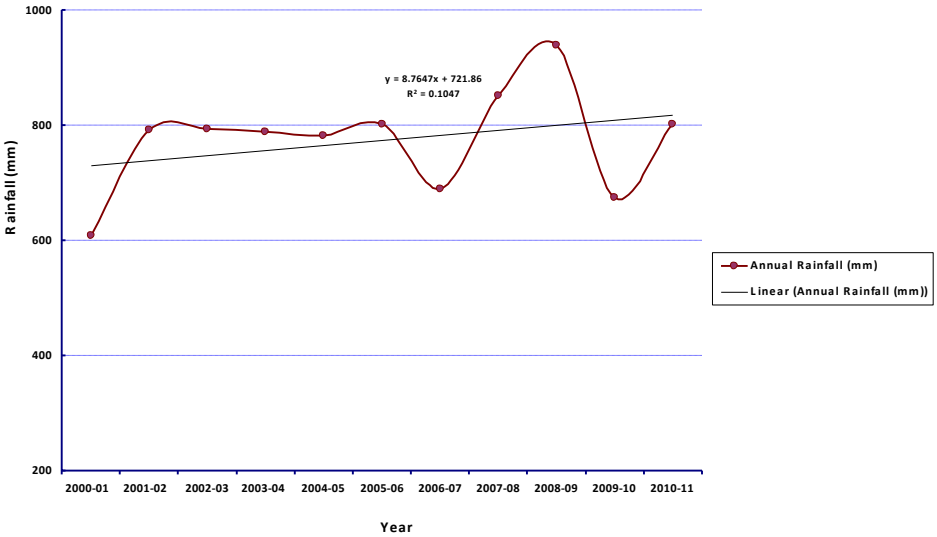

Figure 5: Time series actual rainfall data of IGP (2000-01 to 2010-11)

The geo statistical analysis of normal rainfall data for IGP was observed lowest rainfall in Trans Gangetic Plain region and higher rainfall in middle to lower Gangetic Plain Region (Figure 6). The overall current status of annual normal rainfall 993mm was observed in IGP. The Lower Gangetic plain region has maximum average rainfall 1530.5mm and Trans Gangetic plain region has lowest average rainfall 643.8mm (Table 3).

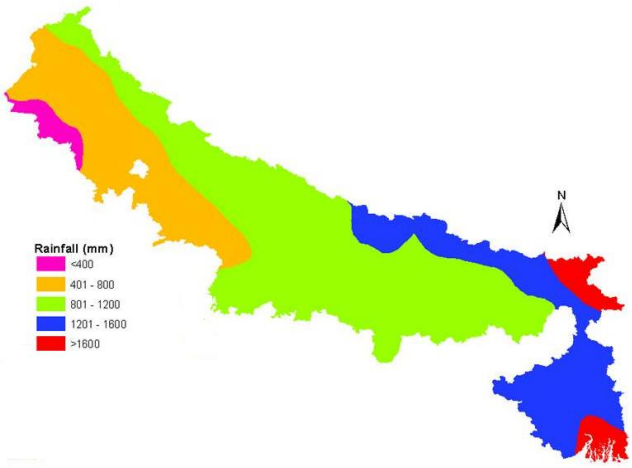

Figure: 6: Normal rainfall (mm) of IGP

Current Scenario of Rice-wheat system

The actual rainfall data were used for both rice and wheat crop yield for inter -relationship during ten years (2000to2010). Descriptive statistical analysis was made especially for the correlation, coefficient of variation and trend R^2. The statistical information on crop area, production and productivity form the backbone of agricultural statistical system. The Rice and wheat crop yield are dependent on climatic situation in India mainly on south west monsoon. The pattern of rainfall gives current scenario for production of both crops. It is easily to formulate and initiate appropriate policy measures if the data with regard to the trend of production in obtained and analyzed in advance.

Relationship between Rainfall and rice and wheat crop

The yearly rainfall data for the ten years were computed considering the crop growing season length based on planting and harvest dates. The developed model explained rainfall 10.4% and rice yield 70% of the variability in rainfall and rice yield (Figure 7). The analysis of rice yield with rainfall CV=0.10 was observed and coefficient of correlation between rainfall and yield was 0.44. The rice yield and rainfall was shown good correlation (Table 3). The current scenario of trend rice yield (70%) was observed with increasing trend of rainfall (10%). Although wheat is grown during non-monsoon months, its production shows a rather weak but significant correlation with monsoon rainfall is 0.16 for wheat.

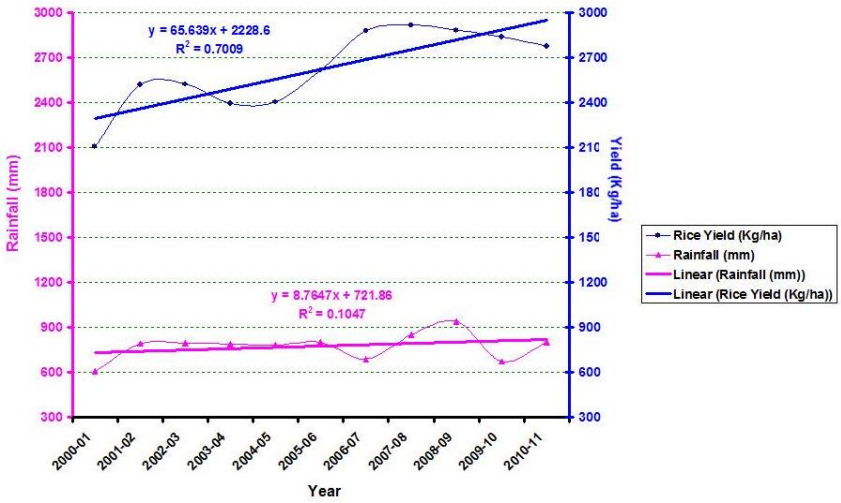

Figure 7: Relationship between average actual Rainfall (mm) and rice yield (kg/ha) (Year 2000-01 to-2010 -11)

The relationship between year wise rainfall and yield of wheat was computed which less than linear function is provided value of R^2 of 0.55, which is reasonably less indicating that 55% variation in wheat yield is explained by the yearly rainfall (Figure 8). The wheat crop yield CV=0.05 and coefficient of correlation between rainfall and yield was 0.16 observed. Rice crop is dependent on south-west monsoon rainfall but wheat crop is not dependent on rainfall in IGP.

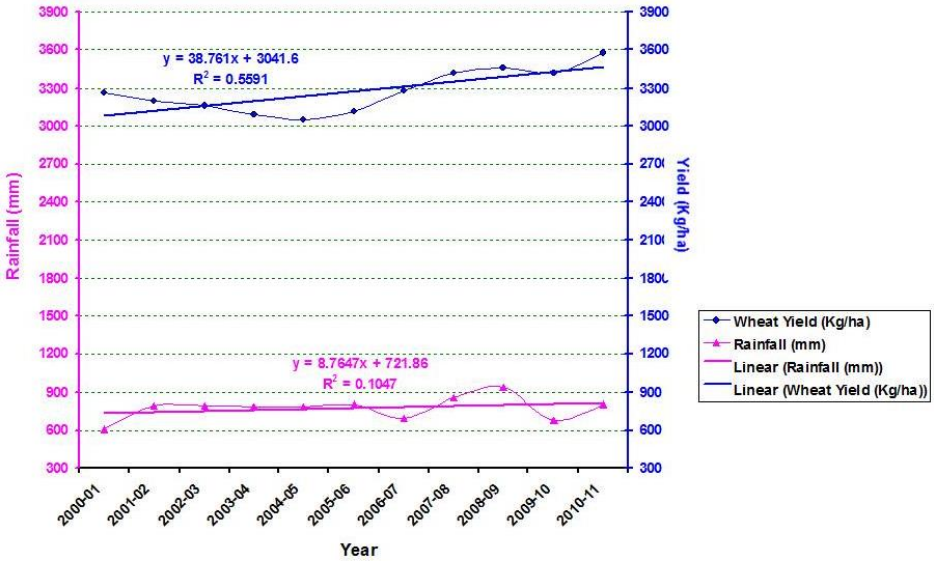

Figure 8: Relationship between average actual Rainfall (mm) and wheat yield (kg/ha) (Year 2000-01 to-2010 -11)

Table 3: Statistical relationship between 10 years rainfall: actual rainfall (mm), Rice & wheat yield (Kg/ha) of IGP

Year	Actual Rainfall (mm)	Rice Yield (Kg/ha)	Wheat Yield (Kg/ha)
2000	607.7	2106	3258
2001	791.6	2518	3197
2002	794.1	2523	3157
2003	788.9	2394	3091
2004	781.0	2404	3047
2005	800.9	2615	3119
2006	689.2	2878	3282
2007	851.9	2916	3416
2008	939.1	2882	3456
2009	673.6	2837	3414
2010	801.1	2775	3580
STANDARD DEV	89.84	259.93	171.90
MEAN	774.45	2622.55	3274.27
COFF. CORR.		0.44	0.16
CV	0.12	0.10	0.05

After analysis of ten years (2000-10) data for rice and wheat was observed current scenario of IGP (Table 4). The IGP percentage of area and production are contributes 42.7%, & 48.4% for rice and 65% &74.7% for wheat in India. The rice –wheat system is predominant cropping system. The crop area of wheat and rice is not very much increases because of farmers have not changing the cropping system pattern. The year-to-year variability of rice and wheat is increasing and lacks a strong association with monsoon rainfall in both season due to climate change and urbanization of agricultural land.

Table 4: Rice and wheat Contribution of IGP percentage in India

Year	Percentage of contribution in IGP		
	Area (In %)	Production (In %)	Yield (In %)
Rice	42.7	48.5	126.7
Wheat	65.0	74.7	119.0

Current scenario of Land utilization, Fertilizer, census and livestock

The plain's population density is very high due to the fertile soil for farming. The fast development of urbanization the agriculture land converting in to urban area. The 38.4% Indian population living in IGP states (Census, 2011).The IGP states have annual population growth rate 2% annually. The decadal IGP population rise 19.5% observed in year 2001 to 2011. The analysis current data of land use pattern of IGP were observed forest coverage area 5.4%, current fallow land 9.6%, net sown area 24.9% and geographical areas covered 15.8%. The IGP land is famous for rice-wheat cropping system has maximum coverage of net sown area. The rivers: Indus, Ganga, Brahmaputra and its tributaries provide irrigation facility to big plains area.

Livestock has important role to supply in food chain through many types of products like milk, eggs, meat and others. It is a anthropogenic source of methane emission to changing the climatic condition of IGP areas due to increasing of livestock population. Ruminants (cattle, sheep and goats) account for a large share of total livestock emissions, because they are less efficient in converting forage into useful products than monogastrics (pig & poultry) [33]. Livestock production is an important source of income and employment in rural sector [34]. The decadal data analyses of 16th to 18th livestock census were conducted in year 1997 to 2007 for collected data of different category of livestock. The major livestock in IGP are buffalo, cow, goat, poultry, pig and sheep. The Bhadawari & Murrah breed of Buffaloes, Holstein Friension & Jersey breed of cattle, Barbari & Jamnapari breed of goat and Merino & Exotic breed of Sheep are observed in district level. The overall livestock census data (1997 & 2007) analysis, the change percentage observed in pig population declined (-16.2%) and poultry population rise 86%. The small change percentage was observed in cattle population only 0.10%. The other decadal livestock change percentages were observed in buffalo, sheep and goat are 17.2%, 24.5% and 14.5% respectively. The total livestock change was observed 9.1%.

The analysis of major livestock census data (1997) was observed maximum contributed percentage (42.8%) of pig population and lowest contribution was sheep population only 12%. But analysis of livestock data (2007) observed maximum contribution buffalo and lowest sheep viz.40.4% and 5.3 % respectively. The large scale industrial production of animals especially dairy and poultry are rising in IGP states [35]. The most of the IGP's farmers are having small to medium land holing size. The integration of ruminant livestock in to small holder farming system giving profitable conversion of crop by products, increased use of manure and possibilities of regular cash income from dairying. The feed transport cost low than other states and easily available dry and green fodder due to rice-wheat cropping system. The dairy and poultry business are increase the proximity of major urban markets in IGP areas.

After analysis of nitrogen, phosphorous and potassic fertilizer consumption in IGP region are observed in kharif season 40.9%, 25% & 22.4% and in rabi season 50.2%, 43.7% and 31.2% respectively. The overall fertilizers consumption in kharif and rabi season were observed 34.5% and 40.9. The rabi crop (wheat) has more consumption of fertilizers than kharif crop (rice).

Current Scenario of SPOT VGT image analysis

For the major agricultural areas identified the rice-wheat crop calendars were identified using the SPOT VGT IMAGES. The images were classified in ERDAS Imagine using Density slicing classification (Un-supervised) algorithm. It is a form of selective one-dimensional classification [36]. The continuous gray scale of an image is sliced into a series of classes based on ranges of brightness values. This slicing takes place in raster attribute editor in IMAGINE. The class signatures were visually compared and generalized. The availability of the time series VGT images (2000to2012) also enabled the area of the range values and cropping pattern of the study area showing the development of vegetation over the year. Two-date SPOT-VGT data was used to prepare various land cover classes.

Density slicing based classification of SPOT VGT Image

The SPOT VGT images were downloading in grayscale image /single band converted into colour image due to in colour image easily identify the different crop areas. The pseudocolour tables in gray scale values are mapped to particular colour. Single colour assign single crop and different range divided in different color in to different crop. Slicing based analysis give the very clear view to dividing the image with arrange of values in to unique classes. Those classes are divided in three classes to identify the crop growth pattern in whole areas. This method is good for identification of distribution pattern of particular crop in overall IGP area.

Table 5: Overall tonal classification of SPOT VGT images (Rabi &Kharif) of IGP

Land cover Class (Agricultural areas)	**Pixel Range**	**Tone**
Low	<128	Pink
Medium	128-192	Yellow
High	>192	Green

Kharif

The major IGP states are Punjab, Haryana, Uttar Pradesh, Bihar and West Bengal pattern showed high to low pattern of rice coverage area. The green and yellow tonal variation is too much indicating distribution of cropped area (Figure 9). The low range of pink tonal value observed in Eastern UP to West Bengal. The visual analysis of temporal images in year 2006, 2001&2002 are observed maximum coverage tonal patterns green, yellow & pink respectively. That are assigned in high, medium and low agricultural rice covered area.

Rabi

The analysis of Rabi season March is good for wheat crop growth and mainly grown in all over the parts of IGP region (Punjab, Haryana, U.P., Bihar & West Bengal). In the image analysis based on range of classification green, yellow and pink tonal values assigned high, medium and low agricultural areas (Figure 10). The visual analysis of overall temporal image are observed three data sets year 2008, 2003 & 2004 assigned maximum coverage of green, yellow and pink agricultural areas. It is also called Wheat belt of India. The time series image analyses are based on colour coding (DN values).

All Image data were processed using ERDAS IMAGINE version 8.5 [37], the colour ranges are directly based on DN value and grouped in together and dived in to ranges. The temporal image series classified based on processing the entire scene pixel by pixel. The analysis of kharif and rabi time series data; the overall analysis of total DN values are divide in three range classes viz. 128, 128-192 &192 assigned in pink, yellow and green, and re-classified in low, medium and high agriculture area. The overall DN values of kharif and rabi season average temporal data analysis are observed medium class (128-192) have 46.6% and 57.1% values coverage area and high coverage area having only 13% and 17.6 % respectively (Table 5). The observation of pixel data wheat area coverage more than rice area in low class but rice coverage area maximum (40.4%) than wheat area coverage (25.2%) in peak month of both season (Table 6). The Coefficient of variation observed in kharif season viz. 36%, 20.5% & 52.5 for low, medium and high agriculture area but rabi season observed 22.7%, 9.1 &31.7% respectively.

Table 6: Current scenario of average pixel distribution in classes of IGP in kharif & rabi season images

Class	**Pixel value**	**August**	**Distribution of Pixel**	**CV%**	**March**	**Distribution of Pixel**	**CV%**
Low	128	219736	40.4	36.0	127354	25.2	22.7
Medium	192	253413	46.6	20.5	288125	57.1	9.1
High	256	70983	13.0	52.5	89013	17.6	31.7
Total		**544132**			**504491**		

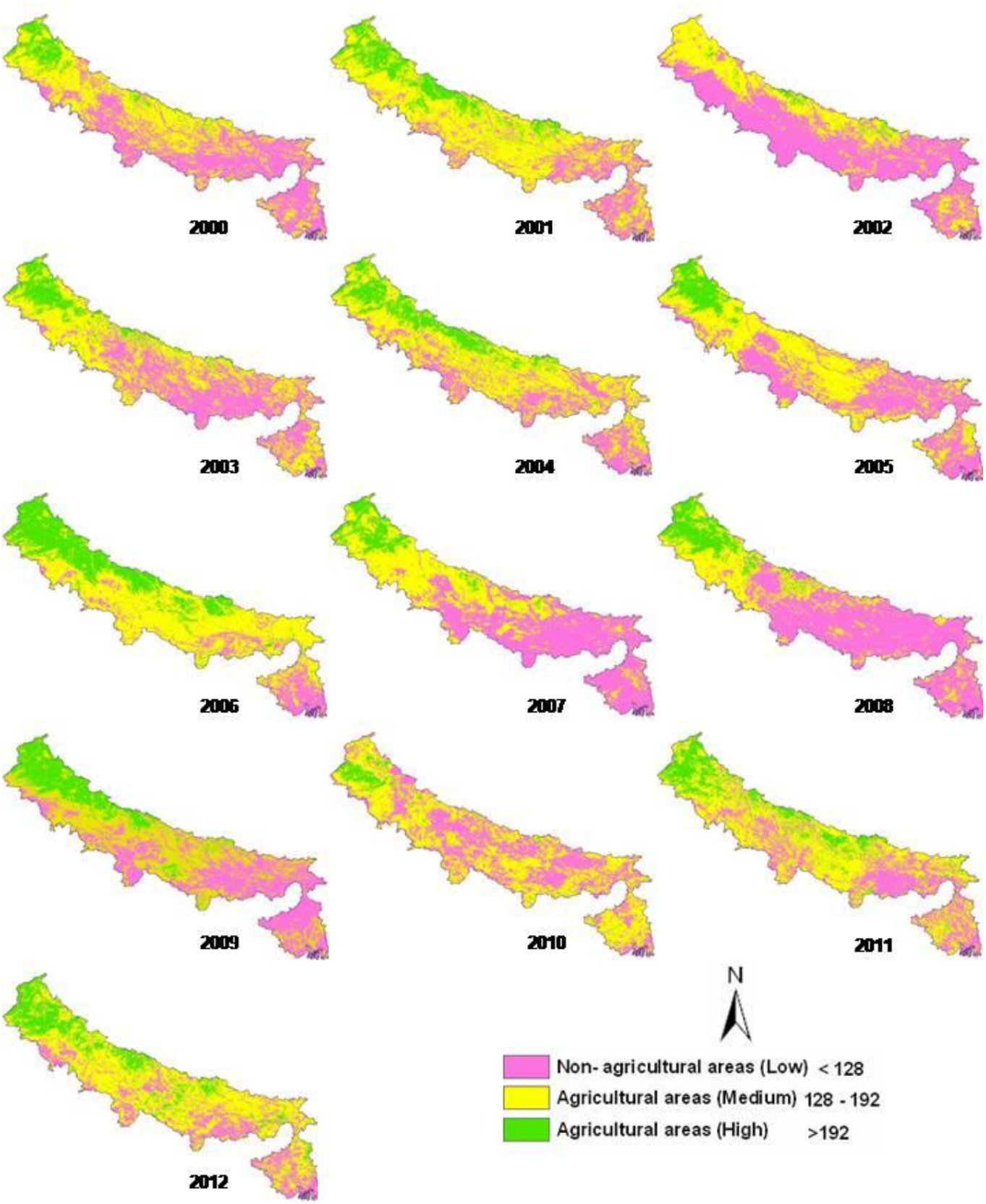

Figure 9: Kharif season map of IGP derived from multidate SPOT VGT data (August- 2000 to 2012)

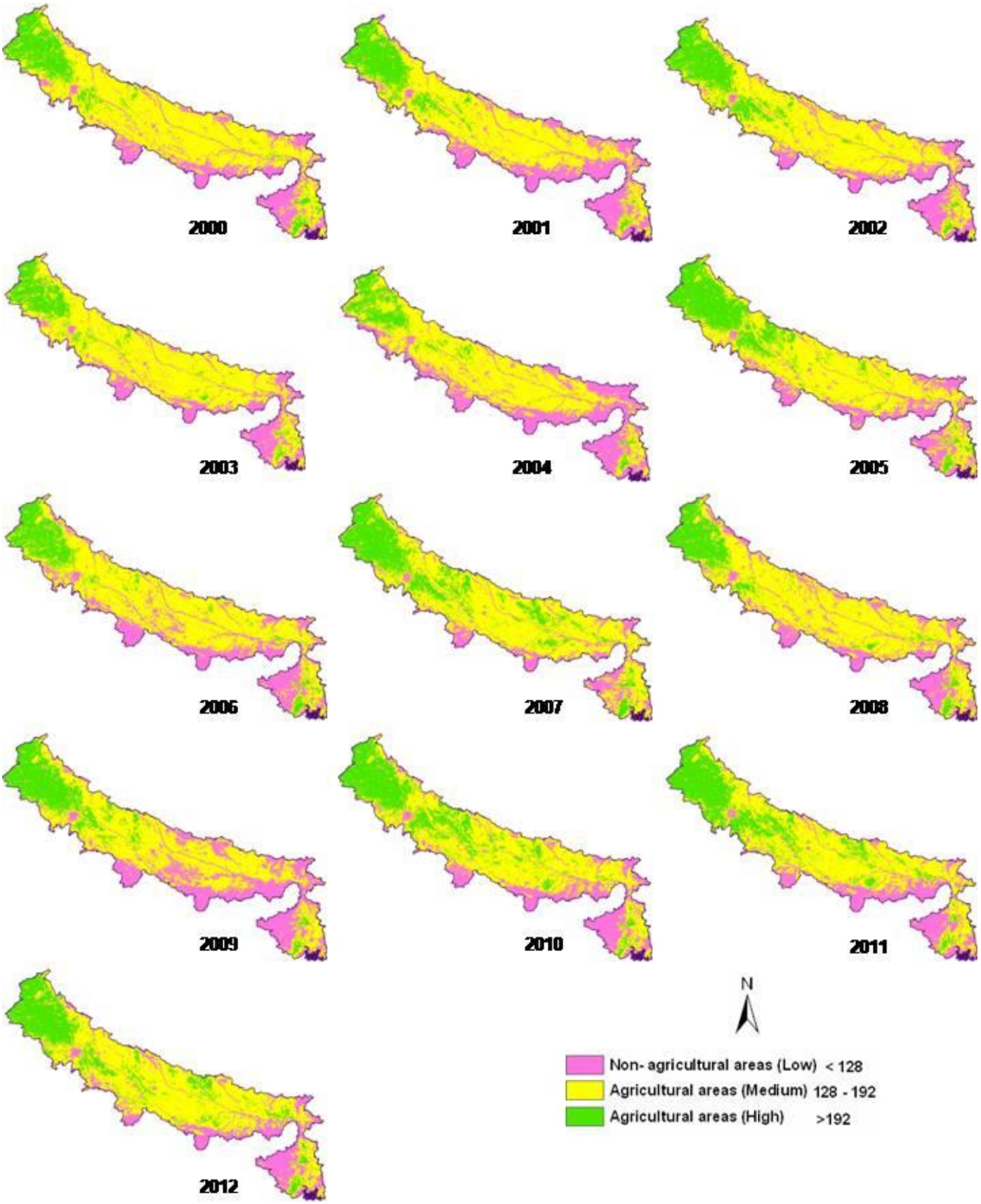

Figure 10: Rabi season map of IGP derived from multidate SPOT VGT data (March- 2000 to 2012)

IV. CONCLUSION

The rivers: Indus, Ganga, Brahmaputra and its tributaries provide irrigation facility to big plains area. The plain's population density is very high due to the fertile soil for farming. The decadal IGP population rise 19.5% observed in year 2001 to 2011. The IGP land is famous for rice-wheat cropping system has maximum coverage of net sown area. The average annual actual rainfall of ten years was estimated 759.2 mm was observed in IGP. The geo statistical analysis of normal rainfall data for IGP was observed lowest rainfall in Trans Gangetic Plain region and higher rainfall in middle to lower Gangetic Plain Region. The current scenario of trend rice yield (70%) was observed with increasing trend of rainfall (10%). After analysis of ten years (2000-10) data for rice and wheat was observed current scenario of IGP. The Contribution of IGP percentage area in India is 48.4% for rice and 74.7% for wheat. The rice-wheat system is pre dominant cropping system of IGP. The system covers all districts of IGP in Kharif and rabi season. The availability of the time series VGT images (2000to2012) also enabled the area of the range values and cropping pattern of the study area showing the development of vegetation over the year. The major IGP states are Punjab, Haryana, Uttar Pradesh, Bihar and West Bengal pattern showed high to low pattern of rice coverage area. The analysis of rabi season March is good for wheat crop growth and mainly grown in all over the parts of IGP region (Punjab, Haryana, U.P., Bihar & West Bengal). The overall fertilizers consumption in kharif and rabi season were observed 34.5% and 40.9. The rabi crop (wheat) has more consumption of fertilizers than kharif crop (rice).The cropping intensity in the dominant states of the IGP increased from 137% (1976-77) to 158% (1999-2000) due to the turnover of more biomass to the soils (both as above ground and below-ground biomass) as evidenced from the increased SOC in fertilized areas of IGP. The current scenario of IGP observed the trend of rice and wheat yield have not much change. The coverage areas are shrinking due to urbanization pressure on agricultural land. The rainfall distribution is irregular pattern due to climate change. Indian agriculture is particularly vulnerable to impacts of climate change due to its large livestock population. Currently, India has first rank in the world for livestock population. In the IGP states U.P. has maximum methane (18.2%) emission in the India. The dry and green fodders are easily available due to rice-wheat cropping system.

The series of SPOT VGT images areas identified the distribution of crop pattern in whole areas based on tonal variation which are assign pink, yellow and green color are mentioned low, medium and high classes based on grouping of slicing of images. The temporal SPOT-VGT remote sensing data is good for identification of distribution pattern of particular crop in overall IGP area. The statistical analysis and remote sensing data analysis show the good correlation to develop yield as well as areas of rice and wheat crop. The rainfall has good correlation with rice but not with wheat yield. After the analysis of data observed current scenario of climate changes (global warming), rising of temperature, irregular pattern of rainfall, excess use of fertilizers and irregular pattern of irrigation decline fertilize lands. Rice- wheat crops are the backbone of IGP for food security. The remote sensing and GIS technology play an important role to control and management of problematic areas. The long term study of satellite data are help to monitor with latest technology for save fertilized crop land.

REFERENCES

[1] Pal, D. K. et al. "Soils of the Indo-Gangetic Plains: their historical perspective and management" *Current Science* 2009. 96(9) 1193–1202p.
[2] http://cpwfbfp.pbworks.com/f/IGB_situation_analysis.PDF
[3] www.slideshare.net/ulhas0503/genearal-profile-and-land-pattern-india
[4] Duxburv, C. et al. "Legumes in rice and wheat cropping systems of the Indo-Gangetic Plain - Constraints and opportunities" Patancheru, Andhra Pradesh, India: ICRISAT and Ithaca, New York, USA. 2000.
[5] Panigrahy, S., et al. "Mapping of cropping system for the Indo-Gangetic Plain using multidate SPOT- NDVI-VGT data" *Journal of Indian Society of Remote Sensing* 2010. 38(4) 627-632p.
[6] www.odi.org.uk/resources/docs/5118.pdf
[7] http://www.arthapedia.in/index.php?title=Cropping_seasons_of_India_Kharif_%26_Rabi
[8] Yadav, R.L. et al. "Atlas of cropping systems in India" *PDCSR Bulletin No.* 2001. 96 p.
[9] http://blogs.worldwatch.org/nourishingtheplanet/safeguarding-rice-and-wheat-production-in-the-indo-gangetic-plains/
[10] Panigrahy, S. et al. "Cropping system analysis using remote sensing and GIS-Bathinda District, Punjab". *Scientific Note RSAM/SAC/HORT/SR/01/02. Space Applications Centre Ahmedabad* 2002.
[11] Anderson, J.R. et al. "A Land Use and land cover classification system for use with remote sensor data" U.S.G.S. Professional paper, 1976.964p.
[12]. Panigrahy, S. et al. "Cropping system analysis using remote sensing and GIS for the state of West Bengal", *Scientific Note RSAM/SAC/CS/SN/03*.2003. 130.
[13] Ganguly, D. et al. "Geomorphological study of Sunderban Deltaic Estuary" *Journal of Indian Society of Remote Sensing* 2006. 34(4) 431-445p.
[14] http://www.isro.org/satellites/allsatellites.aspx
[15] Parihar, J.S. et al. "Remote sensing in India: Achievements and future plan" *Proceedings of the Globe SAR regional seminar, Beijing*, 9-12 October. 1995.
[16] Navalgund RR and Ray SS "Geomatics in natural resources management" *In Proceedings of Geomatics-2000*,Pune, India, NR1-NR14. 2000
[17] Townshend , J. R.G. et al. " Multispectral dimensionality of images of normalized difference vegetation index at continental scales". *IEEE Transactions on Geoscience and Remote Sensing*, 1985. 23. 888-895p.
[18] http://www.spotimage.fr/data/images/vege/VEGETAT/book_1/e_frame.htm
[19] Marsh, S., et al. "Comparison of multi-temporal NOAA-AVHRR and SPOT-XS satellite data for mapping land-cover dynamics in the west African Sahel". *International Journal of Remote Sensing*, 1992. 13.2997-3016p.
[20] Panigrahy, S., et al. "A spatial database of cropping system and its characteristics to aid climate change impact assessment studies". *ISPRS Archives XXXVIII-8/W3 Workshop Proceedings: Impact of Climate Change on Agriculture*. Ahmadabad. December, 17-18, 2009,
[21] Khanna, S.S. "The agro-climatic approach. In: Survey of Indian agriculture". *The Hindu*, Madras, India1989. 28-35p.
[22] http://eands.dacnet.nic.in/StateData_96-12Year.htm& http://eands.dacnet.nic.in/APY_96_To_06.htm
[23] http://drdpat.bih.nic.in/Downloads/Statewise-APY-of-Rice-2006-07-to-2010-11.pdf;
http://www.rkmp.co.in/sites/default/files/ris/rice-state-wise/Status%20Paper%20on%20Rice%20in%20Punjab.pdf;
http://www.rkmp.co.in/sites/default/files/ris/rice-state-wise/Status%20Paper%20on%20Rice%20in%20Uttar%20Pradesh.pdf
http://www.rkmp.co.in/sites/default/files/ris/rice-state-wise/Status%20Paper%20on%20Rice%20in%20West%20Bengal.pdf
[24] Sharma, S.K. et al. "Atlas of rice-wheat cropping system in Indo –Gangetic Plains of India". *PDCSR, Bulletin No.* 2004-1. 110p.

[25] http://indiawaterportal.org/met_data; NASA POWR: http://power.larc.nasa.gov & IMD: http://www.imd.gov.in
[26] http://censusindia.gov.in/2011-prov-results/indiaatglance.html; http://mospi.nic.in/mospi_new/upload/sel_socio_eco_stats_ind_2001_28oct11.pdf & http://www.indiainvites.com/population.html
[27] http://upgov.nic.in/upinfo/allsites_1sep.htm; http://animalhusb.up.nic.in/18th_livestock_census_2007.htm; http://www.husbandrypunjab.org/pages/livestock.htm & http://www.ahduk.org/pdfs/stats/Comparision%20of%20State%202007%20Livestock%20Census%20With%20Indias%20Census.pdf
[28] 16th, 17th & 18th Livestock Census: Punjab, Haryana, Uttar Pradesh, Bihar, West Bengal, Department of Animal Husbandry, Dairying & Fisheries, *Ministry of Agriculture*; Krishi bhawan, New Delhi. 1997, 2003& 2007; Basic animal husbandry statistics *AHS SERIES 12*, 2010 (page145) & AHS SERIES 10, Government of India Ministry of agriculture, department of animal husbandry dairying & fisheries, Krishi Bhawan New Delhi.2006.198p; http://dahd.nic.in; Bihar Basic Animal Husbandry Statistics . Government of Bihar department of animal & fisheries resources. Bihar, Patna.2012 & Varma A, et al. "Crop–livestock interactions and livelihoods in the Gangetic Plains of West Bengal, India. Crop–livestock interactions scoping study". *Report 4. Research Report 13*. 2007. ILRI (International Livestock Research Institute), Nairobi, Kenya. 94p.
[29] http://www.mcxindia.com/knowledgehub/overview/PDF/2011/Part_3.pdf
[30] India Forest Report, "Forest Survey of India, Ministry of Environment & Forests, Govt. of India". 2011.286p. http://www.fsi.org.in/sfr_2011.htm
[31] Narang, R. S. and Virmani, S. M. "Rice-Wheat Cropping Systems of the Indo_Gangetic Plain of India*". Rice-Wheat Consortium* . Paper Series No. 11, RWC New Delhi and ICRISATs, Patancheru, Andhra Pradesh, India. 2001.
[32] http://free.vgt.vito.be
[33] Chhabra, A. et al. "Assessing the role of Indian livestock in climate change". *ISPRS Achieves XXXVIII-8/W3 Workshop procesidings: Impact of climate change on Agriculture*.2009.
[34] Dastagiri, M.B. "Demand and supply projections for livestock products in India". Policy paper 21, *National centre for Agricultural Economics and policy research.* 2004.58p.
[35] Major farming systems in South Asia -MAP
[36.] http://www.kevinroper.org/esci-442/density-slicing/
[37] http://geospatial.intergraph.com/Libraries/Tech_Docs/ERDAS_Field_Guide.sflb.ashx

AUTHOR

First Author – AVADHESH KUMAR KOSHAL, Ph.D., Project Directorate for Farming Systems Research, Meerut, akkoshal@hotmail.com.

Correspondence Author – AVADHESH KUMAR KOSHAL, akkoshal@hotmail.com, 09412551480