LONG TERM CHANGES IN CROPPING PATTERN OF BATHINDA DISTRICT, PUNJAB - A REMOTE SENSING APPROACH

Anil Sood [a*], S S Ray [b], B U Choudhury [a], P K Sharma [a] and Sushma Panigrahy [b]

[a] Punjab Remote Sensing Centre, Ludhiana – 141 004
[b] Agricultural Resource Group, Space Application Centre, Ahmedabad -380 015
asdoegar@rediffmail.com

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ABSTRACT

With the availability of required inputs for intensive agriculture, the cropping system in Punjab state has undergone a paradigm shift, from a much diversified cropping pattern to a very specialized monocropped one. A study was undertaken in Bathinda district of Punjab State for mapping crop area, cropping pattern and finally long term changes in cropping pattern. Multi-year, multi-date, IRS LISS I, WiFS & LISS III and RADARSAT ScanSAR data were used to map area under major crops and to generate the cropping pattern maps for the years 1988-89, 1998-99 and 2003-04, respectively. The study revealed that in Bathinda district which is lying in the south-western part of Punjab, popularly known as cotton belt, rice (*Oryza sativa* L.) -wheat (*Triticum aestivum* L.) system has come in place of cotton (*Gossypium hirsutum* L.)-wheat (*Triticum aestivum* L.) and other minor cropping systems in large area where assured irrigation water is available. The results revealed that over the years, the area under rice has been increasing at the expanse of cotton as well as other minor crops, mainly because of clearing of sand dunes which were brought under cultivation by farmers and with the expansion of irrigation facilities. The closer look to the spatial distribution of different cropping systems reveal that rice wheat system, which was dominant in the northern part of the district in the year 1998-99 has spread to the other parts of the district by the year 2003-04.

INTRODUCTION

In the post green revolution era, changing socio-economic conditions, food security compulsions, policy support and incentives and farmers preferences in response to market demands have given rise to new cropping patterns that predominates in different agro-ecological sub-regions (Velayuthum and Planniappan, 2003). In the process, there has been loss of crop diversification, a glaring example of which is being witnessed in north-western plains. With the availability of inputs for intensive agriculture, the cropping system in Punjab state has undergone a paradigm shift, from a much diversified cropping pattern to a monocropped one. Bathinda is one district in Punjab, which has undergone a major change in cropping pattern. Multi-temporal satellite data is the valuable source to acquire timely, cost effective and relatively accurate information in spatial domain (maps) about the existing cropping systems, crop rotation etc. (Panigrahy et al., 1995; Panigrahy and Sharma, 1997; Panigrahy et al., 2005; Ray et. al., 2005). In view of this, present study was undertaken in Bathinda district of Punjab state for studying long term changes in cropping pattern using multi-temporal, multi-sensor remote sensing data.

METHODOLOGY

Study Area:

The study area lies in the south-western Punjab forming a part of Indo Gangetic alluvial plain covering 3376 km^2 area (Fig. 1). The district comprising of 8 blocks is nearly level with imperceptible slopes, except for sand dunes. The general gradient of the terrain is from north-east to south west. There is no river flowing through the district. However, presence of network of canals all around the district except sand dune areas reflected an assured irrigation facility. Bhakra (main branch) and Sirhind (Kotla branch) are the major canals passing through the area. The climate of the area is semiarid. Nearly 70% of the total rainfall is received during the monsoon period (July to September). Nearly 87 per cent area of the district is under irrigation, of which canal irrigated area is 62.8 per cent while tube well irrigated area is 24.2 per cent. Total area under agricultural use is 88.2 per cent of the total geographical area (TGA) with a cropping intensity of 184 per cent (ESO, 2004).

Fig: 1   Study Area
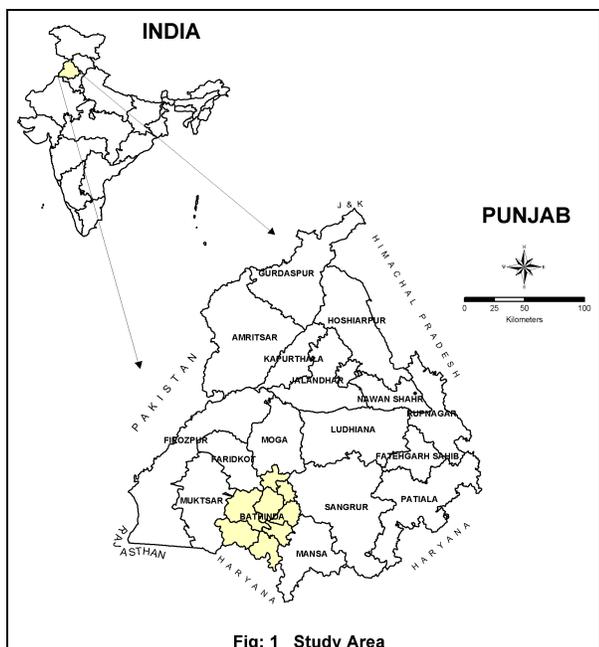
Data Used:

The Indian remote sensing satellite (IRS-1D) Linear Imaging Self Scanning III (LISS-III) data in four bands green (G), red (R), near infra red (NIR) and shortwave infrared (SWIR) for three dates in the months of September & October, 2003 and February 2004 were analyzed to estimate area under cotton, wheat and other crops in Bathinda district. In addition, three date synthetic aperture radar (SAR) data from RADARSAT ScanSAR narrow beam mode acquired during the months of June, July and August, 2004 were used to derive area under rice in kharif season, as cloud free data from optical sensors is rarely available during this period. Spatial data in respect of tehsils and village boundaries were obtained from Director, Land Records, Punjab and block information from Joint Development Commissioner, Rural Development, Punjab.

Analysis Approach:

Cropping Pattern Maps: After geo referencing the satellite data, using ground truth information and K-means unsupervised classification followed by maximum likelihood supervised classification, non agricultural mask covering both kharif and rabi seasons was generated by overlaying administrative boundaries of Bathinda district (district/block). Using logistic modeling approach and by overlaying the non agricultural mask on RADARSAT ScanSAR data, the rice mask was generated. Using the rice mask along with non agricultural mask, the cotton crop was segregated from the IRS-1D LISS-III, September and October data. Similarly, during rabi season, using the non agricultural mask, the wheat crop was classified from IRS- 1D LISS-III, February data of the year 2004. Subsequently, the corresponding area under rice, cotton and wheat were calculated from statistics generated through histograms. Since wheat is the single most dominant crop in the rabi season occupying 82 per cent of cropped area, all other crops were grouped into a single class namely other crops. Similarly, in kharif season, cotton and rice are the dominant crops covering together 76 per cent of cropped area, all other minor crops were classified as other crops.

Crop Rotation Map: Crop rotation indicates the dynamics of crop diversity i. e. the crops grown in a unit area as a sequence within a year. The two major cropping pattern maps (kharif and rabi) were used to generate crop rotation map. A logical class-code combination algorithm was used to derive the crop rotation map (Panigrahy and Sharma, 1997).

Long Term Change Analysis: The long term changes were studied using the crop coverage and the crop rotation maps generated from IRS-1D LISS-III for 2003-04 by comparing the maps already generated for the years 1988-89 and 1998-99 (Panigrahy et. al. 2002).

RESULTS

Kharif Cropping Pattern:

Kharif activities start as early as May and continue up to October and even November. A perusal of data in Table 1 revealed that cotton (*Gossypium hirsutum* L) is the dominant crop of Bathinda district followed by rice (*Oryza sativa* L.) covering 35.6 and 31.2 per cent of the total geographical area (TGA), respectively. The other crops comprising Guarseed (*Cyamopsis tetragonoloba* L.), Jowar (Sorghum bicolor L.), Bajra (*Pennisetum typhoides* L) etc. covers an area of 20.3 per cent of TGA during the year 2003-04

Table1 Area ('000 ha) under different kharif   crops during the year 1988-89, 1998-99 and 2003-04

Crops	1988-89	1998-99	2003-04
Cotton	169.5 (50.2)	178.9 (53.0)	120.3 (35.6)
Rice	0.0 (0.0)	69.7 (20.6)	101.8 (30.1)
Others	113.9 (33.7)	43.5 (12.9)	68.9 (20.4)
Non Agri.	54.2 (16.0)	45.5 (13.5)	46.7 (13.8)

Note: Figures in parenthesis are per cent of total geographical area of the district

Rabi Cropping Pattern:

Wheat (*Triticum aestivum* L.) is the single most dominant crop during the rabi season covering 71.14 per cent of TGA in Bathinda district (Table 2). The other minor crop in rabi season includes Pearl Millet (*Hordeum vulgare* L.), Gram (*Cicer arietinum* L), Toria (*Brassica compestris L)*, Rapeseed & Mustard *(Brassica spp.* L.) etc. covers an area of 15.02 per cent of TGA during the year 2003-04.

Table2 Area ('000 ha) under different rabi crops during the year 1988-89, 1998-99 and 2003-04

Crops	1988-89	1998-99	2003-04
Wheat	196.2 (58.1)	252.8 (74.9)	240.2 (71.1)
Others	87.2 (25.8)	39.4 (11.7)	50.8 (15.0)
Non Agri	54.2 (16.0)	45.5 (13.5)	46.7 (13.8)

Note: Figures in parenthesis are per cent of total geographical area of the district

Crop Rotation:

The results revealed that in Bathinda district, cotton-wheat is the dominant cropping system and is closely followed by rice-wheat system occupying an area of 30.0 and 26.6 per cent of TGA, respectively, during the year 2003-04 (Table 3).The area covered by other cropping systems in the district varied from 3.5 to 14.5 per cent of TGA (Table 3).

Long Term Changes in Cropping Pattern:

In kharif season, cotton was the dominant crop during the years 1988-89 and 1998-99 in Bathinda district. Rice emerges as the second dominant crop in the district and it covers an area of 101.8 thousand hectares in the year 2003-04 (Table 1). The area under rice has increased at the expanse of cotton as well as other minor crops. In the rabi season, wheat remains the dominant crop over the years (Table 2). The presence of other minor crops is gradually reduced and the reduction was more prominent in rabi season particularly from the year 1988-89 to 1998-99. The reduction in area may be attributed that the minor crops like gram, toria, rapeseed & mustard which were grown largely on the sand dunes showed reduction in its acreage as most of the sand dunes in the district have been cleared by the farmers and brought under wheat cultivation. This is corroborated by the fact that the area under non agricultural use decreased from 16.06 per cent to 13.48 per cent within a span of ten years i. e. from 1988-89 to 1998-99 and it remains almost constant afterwards (Table 3).

Table 3: Long term changes in cropping pattern in Bathinda district

Cropping System	Area (% of TGA of the district)		
	1988-89	1998-99	2003-04
Cotton-Wheat	40.31	46.28	30.02
Rice-Wheat	0.00	20.65	26.62
Rice-Others	0.00	0.00	3.52
Cotton-Others	9.90	6.70	5.59
Wheat-Others	17.81	7.93	14.48
Others-Others	15.93	4.96	5.92
Non Agri.	16.06	13.48	13.84

The area under these crops further declined with the augmentation of irrigation facilities particularly by installing new tube wells. A perusal of the data in the Table 3 on the cropping pattern and its changes among important crops over time indicated that the district having major area under cotton- wheat rotation in the year 1988-89 has shifted to two crop rotations viz. cotton-wheat and rice-wheat in the year 2003-04. Though the area under cotton-wheat has been increased initially by 6 per cent during the period from 1988-89 to 1998-99, mainly due to clearing of sand dunes which were brought under cultivation by farmers and shifting of area from minor crops to cotton. However the area under cotton-wheat cropping system has decreased by 16 per cent in the year 2003-04 as compared to the year 1998-99 (Fig. 2). This can be attributed to the incidence of cotton boll worm infestation in the epidemic form, coupled with augmentation of irrigation facilities. The presence of poor quality under ground water for irrigation in larger areas also forced the farmers to shift from cotton to rice crop, as the germination of cotton seeds was affected by the quality of irrigation water available. On the other hand, the area under rice-wheat cropping system which was negligible in the year 1988-89 in Bathinda district, drastically increased to 20.65 and further to 26.62 per cent of TGA of the district (Table 3) in the years 1998-99 and 2003-04, respectively, due to better economic returns coupled with assured marketing policies of Government for rice and wheat. The area under other rotations has declined over the years, as the area under minor crops declined and so the minor crop rotations.
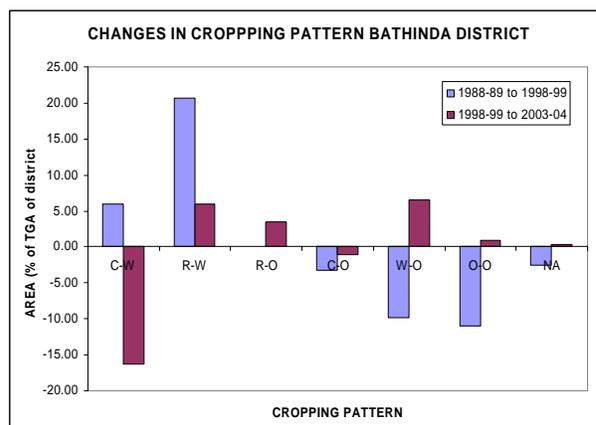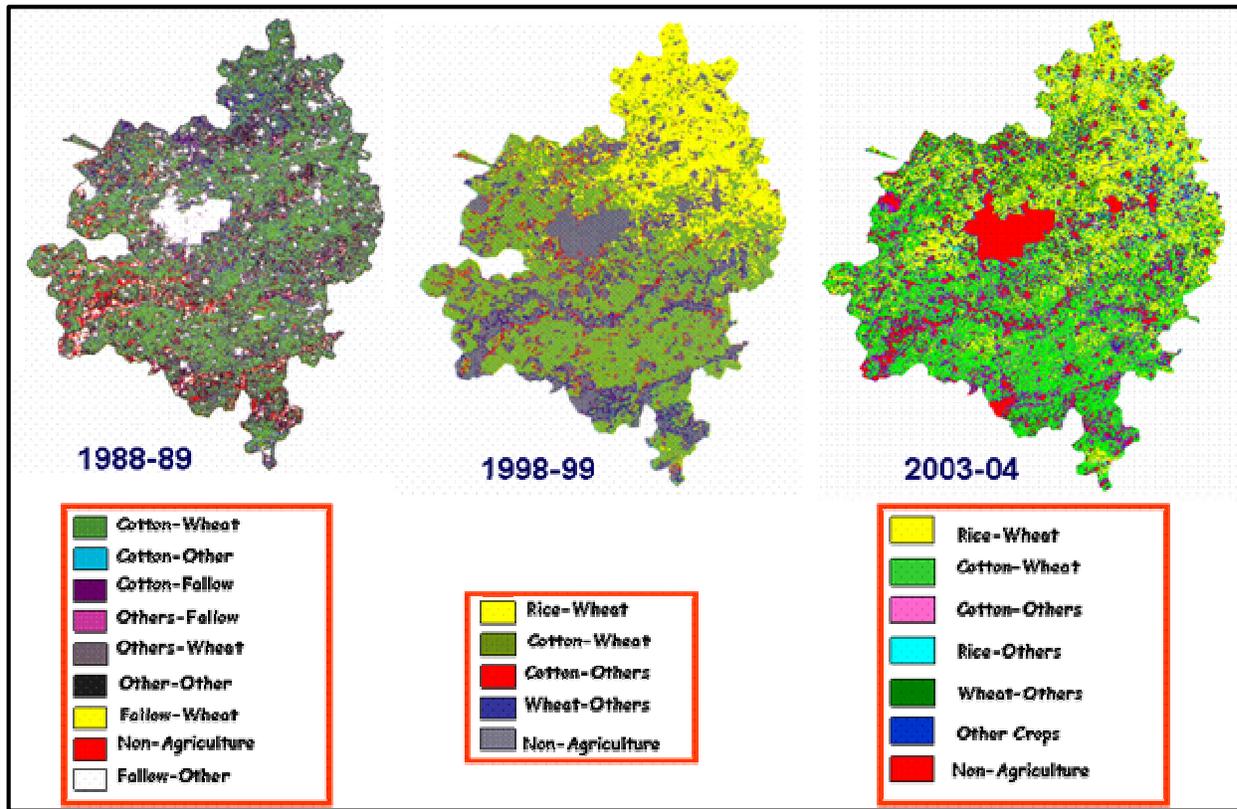

Fig. 2. Changes in cropping pattern in Bathinda district

Spatial Distribution:

The rice-wheat rotation dominates the northern while cotton-wheat rotation dominates in the central and southern parts of the district in the year 1998-99 (Map 1). However during the year 2003-04 rice-wheat rotation still remained dominant in the northern parts but also spread to the other parts of the district particularly in the central parts of the district. The area under other minor crops like bajra, pearl-millet, guar in kharif season and gram, toria and rapeseed & mustard in rabi season, which was a part of the other crop rotations, has decreased over the years.

Cotton-Wheat	Rice-Wheat	Rice-Wheat
Cotton-Other	Cotton-Wheat	Cotton-Wheat
Cotton-Fallow	Cotton-Others	Cotton-Others
Others-Fallow	Wheat-Others	Rice-Others
Others-Wheat	Non-Agriculture	Wheat-Others
Other-Other		Other Crops
Fallow-Wheat		Non-Agriculture
Non-Agriculture		
Fallow-Other		

Map.1: Changes in Cropping Pattern of Bathinda District

CONCLUSIONS

The study revealed that the Bathinda district which is lying in the south-western part of Punjab, popularly known as cotton belt, is progressively moving towards rice-wheat system along with cotton-wheat system. Incidence of cotton boll worm in the epidemic form, coupled with augmentation of irrigation facilities, clearing of sand dunes, better economic returns and assured marketing policies of Government for rice and wheat, forced the farmers in Bathinda district to adopt rice-wheat system in large area. Though rice-wheat cropping system is highly profitable in terms of economic returns, yet it has got negative agro-ecological impacts. Thus, there is an immediate need to study the long term effects of present cropping system on the natural resources (soil and water) and prescribing the alternate cropping system using the system simulation models.

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* Corresponding Author: Anil Sood, Ph: +91-161-2303484 Fax: +91-161-2303483
Email: asdoegar@rediffmail.com