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Cropping System Analysis Using Geospatial Approach: A Case Study of Sirsa District in Haryana, India

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Abstract: ***Agriculture plays a crucial role in the economy of developing countries, and provides the main source of food, income and employment to their rural populations. With increasing population pressure throughout the nation and the concomitant need for increased agricultural production. A cropping system is defined as the cropping pattern and its management to derive benefits from a given resource base under a specific environmental condition. Crop rotation means the successive cultivation of different crops in a specified order on the same fields, in contrast to a one-crop system or to haphazard crop successions. The paper describes methodology and results of cropping system analysis for Sirsa district of Haryana, India climatologically characterized by hot summer, cold winter and dry air except during rainy season. Multi-date & multi-season IRS LISS-III digital satellite data of 2007-2008 was geo-referenced with the already geo-referenced master images by collecting GCP's using second polynomial order and Nearest Neighborhood resembling approach. District boundary was overplayed on the image and all the data elements (pixels) within this were extracted for further analysis. Multi-layer stacks were prepared for Monsoon, winter and summer seasons using multi-date images of each season. Multiphase unsupervised classification approach Iterative Self-organizing Data Analysis Technique (ISODATA) Clustering classifier was used and class of interest were identified using ground truth information collected using hand held GPS. Mask of mixed classes was prepared and image under the mask was reclassified. The reclassification process was continued till the classes of interest were segregated. To improve the accuracy Normalized Difference Vegetation Index (NDVI) of each date and mask of non-agricultural classes such as urban, forest, water bodies and wastelands was prepared and used at the time of classification. The Monsoon, Winter and Summer seasons cropping pattern maps and statistics were generated using classified images and applying logical combinations. During Monsoon season cotton* **(Gossypium)** *is the major crop which occupies 179.29 (000' ha.) areas and in the Winter season wheat is major crop occupying 276.9 (000' ha.) areas. In the summer season most of the area is lying vacant as fallow and major crops are mung, fodder, vegetables etc. Horticulture fruit crops are long duration crops and available in all three cropping seasons. Some minor crops are unable to separate out due to less area scattered distribution and hence here termed as Other Crops. Paddy-Wheat-Other Crops, Cotton* (Gossypium)*-Wheat-Mung/Fallow/Other Crops are the major crop rotations identified in the district. Multi-date and multi-season IRS LISS-III data is found to be useful for the cropping system analysis at the state level.***

Keywords: Cropping system, Remote Sensing, IRS-P6 satellite, LISS-III, Winter, Monsoon & Summer

1. Introduction

Agriculture resources are among the most important renewable, dynamic natural resources. Comprehensive, reliable and timely information on agricultural resources is very much necessary for a country like India whose mainstay of the economy is agriculture. Agricultural plays a crucial role in the economy of developing countries, and provides the main source of food, income and employment to their rural populations. India is an agricultural country. About seventy percent of our population depends on agriculture. One-third of our National income comes from agriculture. India economy is based on agriculture. The development of agriculture has much to do with the economic welfare of our country. Our agriculture remained under developed for a long time. We did not produce enough food for our people. Our country had to buy food-grains from other countries, but the things are changing now. India is producing more food-grains than its needs. Some food-grains are being sent to other countries. Great improvements have been made in, agriculture through our five year plans. Green Revolution has been brought about in the agricultural field. Now India ranks the world in the production of tea. It ranks second in the world in the production of rice, sugarcane, jute and oil seeds. India is among the world's leading producers of wheat, paddy and sugarcane.

Haryana is primarily an agricultural state. About 70% of residents are engaged in agriculture. Haryana is at second position in food grain production in the country. Wheat and Paddy are the major crops. Haryana is self-sufficient in food production and the second largest contributor to India's central pool of food grains. The main crops of Haryana are Wheat, Paddy, Sugarcane, Cotton (Gossypium), Oilseeds and Black Gram etc. There are two main types of crops in Haryana: Monsoon and Winter. The major Monsoon crops of Haryana are paddy, cotton (Gossypium), sugarcane, Gwar and Bajra (Pearl Millet). The major Winter crops are wheat, mustard, Black gram and barley. The state of Haryana has a geographical area of 44.20 lakh hectare About 86% of the geographical area is cultivable, of which 96% has already been brought under plough. About 80.5 of the total area is irrigated, through tubewells and an extensive system of canals. Haryana contributed significantly to the Green Revolution in India in the 1970s that made the country self-sufficient in food production.

1.1 Role of Remote Sensing in Agriculture

Remote sensing techniques play an important role in agriculture. Remote sensing for agriculture can be defined simply as "observing a field or crop without touching it." Remote sensing (RS) in agriculture refers to the art and science of observing and obtaining information on crop and

soil characteristics using sensors attached to aircraft, satellite, and less commonly on ground-based platforms. RS can provide information that is useful for many crop management decisions**.** Remote sensing techniques play an important role in crop identification, acreage and production estimation, disease and stress detection, soil and water resources and also by providing required inputs for the following: generation of land and water resources developmental plans. The wavelengths used in most agricultural remote sensing applications cover only a small region of the electromagnetic spectrum. The green colour associated with plant vigor has a wavelength that centers near 5 micrometers on the spectrum band. The visible and infrared regions are widely used in agricultural remote sensing.

When electromagnetic energy from the sun strikes plants, three things can happen. Depending upon the wavelength of the energy and characteristics of individual plants, the energy will be reflected, absorbed, or transmitted. Reflected energy bounces off leaves and is readily identified by human eyes as the green color of plants. A plant looks green because the chlorophyll in the leaves absorbs much of the energy in the visible wavelengths and the green color is reflected. The spectral signatures of stressed plants appear altered from those of healthy plants. Cropping system study is useful to understand the overall sustainability of agricultural system. Agriculture resources considered being one of the most important renewable and dynamic natural resources. Comprehensive, reliable and timely information on agricultural resources is very much necessary for a country like India as it is the mainstay of our economy.

2. Study Area

Sirsa district came into existence on September 1, 1975. Sirsa is said to be one of the oldest places of North India and its ancient name was Sairishaka, which finds mention in the Mahabharata. There are a number of legends about the origin of the name of the town. Its ancient name was Sairishaka and from that it seems to have been corrupted to Sirsa. According to local tradition, an unknown king named Saras founded the town in 7th century A.D. and built a fort. According to another tradition, the name has its origin from the sacred river Sarasvati. Sirsa is the Administrative Headquarters of the district. The location of the Sirsa district is 29°14′ to 29°59′ north latitude and 74°27′to 75°18′ east longitude. It is surrounded by the districts Faridkot and Bathinda of Punjab in the north and north east, Ganga Nagar district of Rajasthan in the west and south. Geographical area of the district is 4,277 sq. km. which is 10.3% of total geographical area of the state. It is a part of the Indo-Gangetic alluvial plain and its terrain can be broadly classified from north to south into three major types i.e. Haryana Plain, alluvial bed of Ghaggar or Nali and Sand dune tract. The district comes under Hisar division and comprises three sub-divisions namely Sirsa, Dabwali and Ellenabad, four tehsils namely Sirsa, Dabwali, Rania and Ellenabad and seven development blocks- blocks namely Sirsa, Dabwali, Baragudha, Rania, Odhan, Ellenabad, Nathusari Chopta.

2.1 Demography

Sirsa district is one of the densely populated districts of the state. As per 2001 census, the population of the district was1295114 out of which number of males and females were 683242 and 611872. The population density is 261 persons per sq. km. There is a big population of the Sikh community in Sirsa. Sirsa has an average literacy rate of 68%, higher than the national average of 59.5%: male literacy is 73%, and female literacy is 62%. In Sirsa, 13% of the population is under 6 years of age.

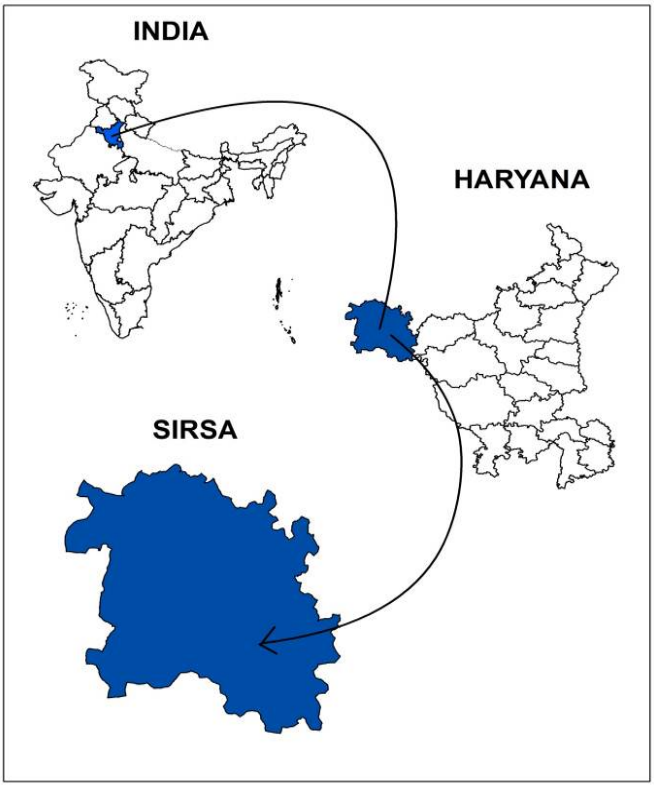

Figure 1: Location map of study area

3. Database Requirement

3.1 Remote sensing data

Remote sensing data is the basic data source for mapping the cropping system of the Sirsa district Indian Remote sensing Satellite (IRS-P6) LISS-III data is the ideal one optimum spatial and temporal resolution. These sensors provide 23.5m spatial resolution data in Green, Red, NIR and SWIR bands with 24 days revisit capability. Its repeat cycle can be used deriving Kharif, Rabi, & Summer Cropping pattern analysis. Remote sensing data from sensor LISS III on-board Indian Remote Sensing Satellite (IRS-P6) of 2007-08 were used to analyze the Monsoon, Winter, and Summer seasons cropping pattern and to generate crop rotation maps which are given in Table 1.

Table: 1 Satellite data used in digital analysis

Satellites	*Sensor*	*Season*	*Date of Acquisition*	*Path/Row*
IRS-P6	LISS-III	Monsoon	06-10-07 27-08-07	93/50 94/50
IRS-P6	LISS-III	Winter	25-12- 07 06-3- 08	93/50 94/50
IRS-P6	LISS-III	Summer	17-5-08	93/50 94/50

3.2 Collateral data

- ✓ Administrative boundary (district).
- ✓ Crop statistics at district & blocks level from "Dept. of Agriculture" (DOA).
- ✓ Land use statistics
- ✓ In season collected ground truth data in the form GPS location provided by HARSAC

3.3 Software Used

- ✓ ERDAS Imagine 9.3 software was used in importing, image rectification and Geo-referencing,
- ✓ Geomatica 10.3 was used for classification and crop rotation.
- ✓ Arc GIS 9.3 used to clip and map composition**.**
- ✓ For the current study we use Microsoft Office in Report generation and graphical presentation of data.

4. Methodology

Digital image analysis was carried out at HARSAC, Hisar using ERDAS 9.3, GEOMATICA 10.3 and ARCMAP 9.3 software packages. Multi-date and multi-season LISS-III digital satellite data was geo-referenced with the master images by collecting GCP's using second polynomial order and NN Resampling approach. The geo-referenced images were used for further analysis using complete enumeration approach. To improve the accuracy mask of non-agriculture classes clipped from land use/land cover maps and NDVI of each date were generated and used at the time of classification.

Unsupervised classification approach Iterative Self-organizing Data Analysis Technique (Iso-Data) Clustering classifier was used and class of interest were identified using ground truth information collected using hand held GPS. Mask of mixed classes was prepared and image under the mask was reclassified. The reclassification process was continued till the classes of interest were segregated. To improve the accuracy Normalized Difference Vegetation Index (NDVI) of each date and mask of non-agricultural classes such as urban, forest and wastelands was prepared and used at the time of classification. The Monsoon, Winter and Summer Season cropping pattern maps were generated using classified images and logical combination. The crop rotation maps were generated using Monsoon, Winter and Summer season cropping pattern maps.

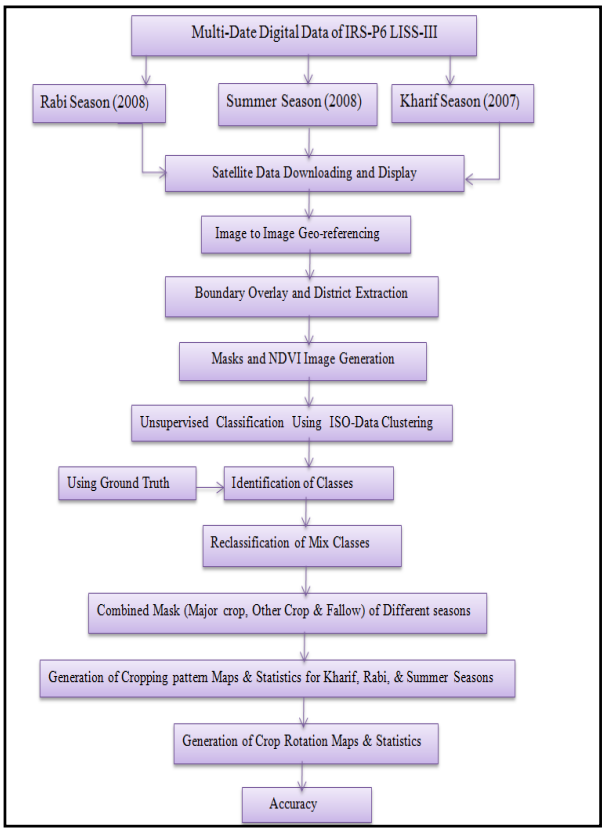

Figure 2: Methodology flow chart for cropping system analysis

4.1 Relative Deviation

Remote sensing based estimates were compared with Department of Agriculture (DOA) estimates published based on the basis of conventional field surveys, by computing per cent relative deviation as follows:

% RD = (RS-DOA)/DOA*100

Where,

RS is Area Computed by Remote Sensing Technique. Department of Agriculture (DOA) estimates.

5. Results

5.1 Monsoon Season Cropping Pattern

Analysis of remote sensing (RS) data reflected that Cotton (Gossypium), Paddy, Bajra (Pearl Millet), Gwar, and Horticulture fruit crops are major crops in Monsoon season, which could be identified using Multi-date LISS-III data.

Minor and non-contiguous crops are not separable and clubbed in to other crops category. Cotton (Gossypium) is evenly dominated in the district except Ghaggar flood plain situated in the central part where concentration of Paddy is more (Figure 4). Bajra (Pearl Millet), Gwar and other crops concentrated in southern and south western upland sandy part of the district. Horticulture crops are mainly located in northern and southern part of the district. R S estimation showed that the Cotton (Gossypium), Paddy, Bajra (Pearl Millet), Gwar and Horticulture occupied 180.58, 50.05, 7.04, 23.18 and 3.29 thousand hector are respectively (Table 2 , Figure 3) which are very close to with what obtained from department of Agriculture (DOA) estimates for the same year i.e. 2007-2008 .

Table 2: Monsoon Season cropping pattern of Sirsa District derived from RS Data

Crops	*Area (000' ha.)*
Cotton (Gossypium)	180.58
Paddy	50.05
Bajra (Pearl Millet)	7.04
Gwar	23.18
Horticulture Fruit Crops	3.29
Fallow	84.66
Other Crops	56.56

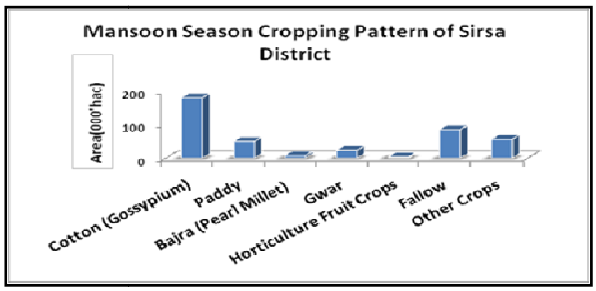

Figure 3: Monsoon season cropping pattern of Sirsa District derived from RS Data

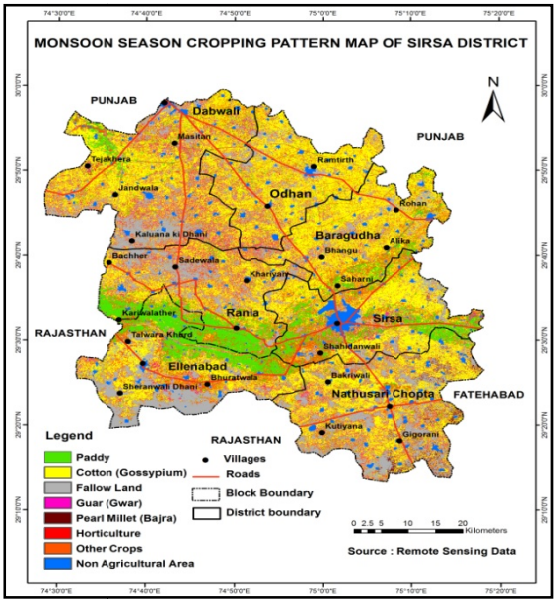

Figure 4: Monsoon season Cropping Pattern Map of Sirsa District derived from RS Data

5.2 Winter Season Cropping Pattern

Wheat, Mustard Black Gram and Horticulture fruit crops are the major crops during Winter season fallowed by other crops as can be seen from the Table 3 and Figure 5 which are derived from multi-date RS data, are close to with what obtained from DOA estimates for the same year i.e. 2007-08 (Table 6). Minor and non-contiguous crops are not separable and clubbed in to other crops category. Wheat cropping is evenly spread through the district but more in Ghaggar flood plain central and west-central part of the district and it occupies 276.9 thousand hectare area, Mustard, Black Gram and Horticulture crops are concentrated in south eastern and north western upland sandy part of the district occupies 41.68, 8.3 & 3.29 thousand hectare area. The other crops grown in the district include Vegetables and Fodder etc.

Table 3: Winter Season cropping pattern of Sirsa District derived from RS Data

Crops	*Area (000' ha.)*
Wheat	276.9
Mustard	41.68
Black Gram	8.3
Horticulture Fruit Crops	3.29
Fallow	91.37
Other Crops	44.4

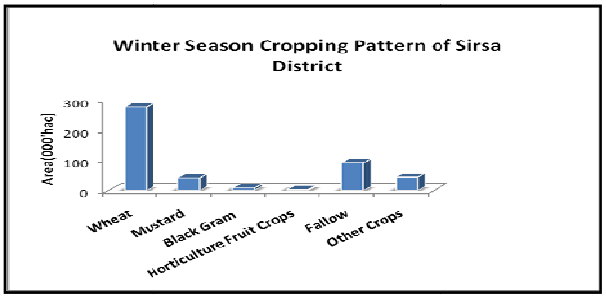

Figure 5: Winter season cropping pattern of Sirsa District derived from RS Data

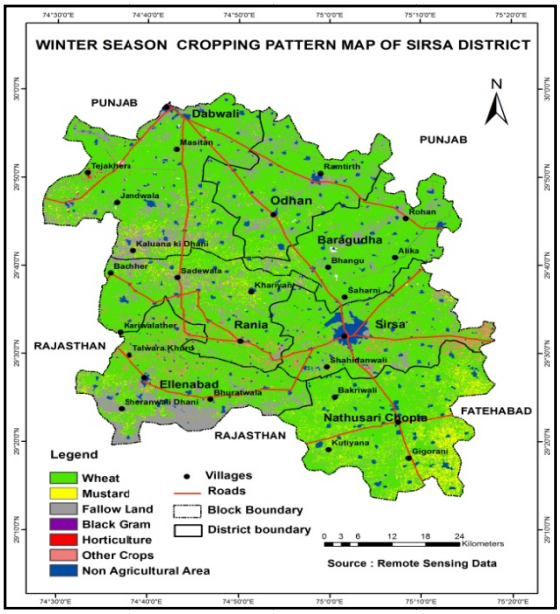

Figure 6: Winter Season Cropping Pattern Map of Sirsa District derived from RS Data

5.3 Summer Season Cropping Pattern

During summer season most of the area is lying vacant as fallow. Major crop during summer season is Mung followed by other crops derived using RS data given in Table 4, Figure 7 and spatial distribution depicted in Figure 8. Minor and non-contiguous crops are not separable and clubbed in to other crops category. Other Crops grown during Summer Season are Vegetables, Fodder etc.

Table 4: Summer Season cropping pattern of Sirsa District derived from RS Data.

Crops	*Area (000' ha.)*
Mung	5.56
Horticulture Fruit Crops	3.29
Other Crops	32.78
Fallow	368.8

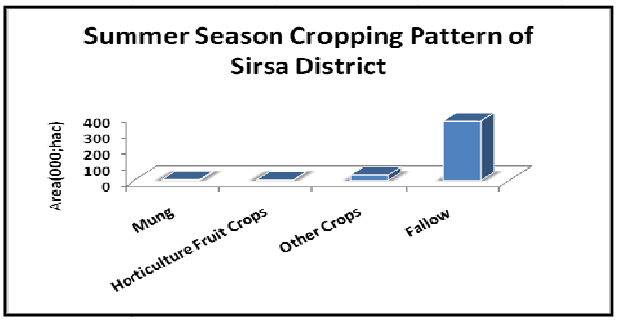

Figure 7: Summer season cropping pattern of Sirsa District derived from RS Data

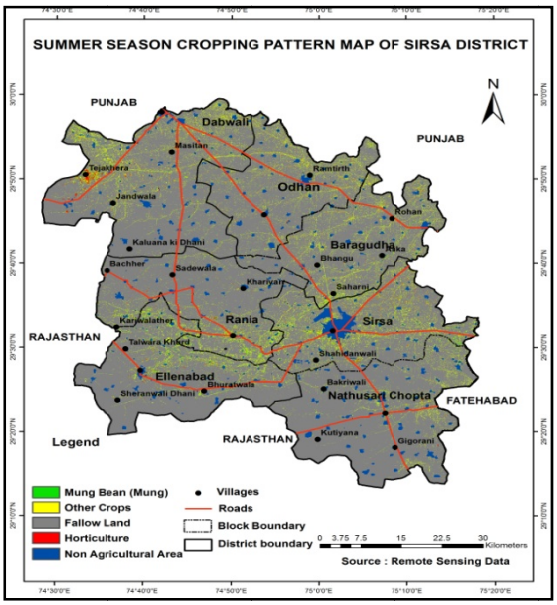

Figure 8: Summer season cropping pattern of Sirsa District derived from RS Data

5.4 Crop Rotation

The crop rotation shows sequential planting of crops in time. Analysis of cropping pattern maps of different seasons indicate that Sirsa district has the major crop rotations of Cotton (Gossypium)-Wheat-Mung/ Fallow/Other Crops (141.7' 000 ha.), Other Crops/Fallow-Wheat-Fallow/Other Crops (94.92' 000 ha.), Paddy-Wheat-Fallow/Other Crops (38.84'000 ha.), and Gwar-Wheat-Fallow/Other Crops(17.15' 000 ha.) based of three seasons Monsoon, Winter and Summer in 2007-08 (Table 5). Cotton (Gossypium)-Wheat-Mung/ Fallow/Other Crops rotation is evenly distributed in whole district except central and central western part where Paddy-Wheat-Fallow/Other Crops is more prominent. Gwar-Wheat- Fallow/Other Crops (15.04' 000 ha.) rotation is distributed in the south eastern part of the district. Other Crops/Fallow-Wheat-Fallow Other/ Crops rotation is scattered in whole district. Major crop rotations given in Table 5, Figure 9 and spatial distribution depicted in Figure 10.

Table 5: Crops Rotation of Sirsa District derived from RS Data

Crop Rotation	*Area (000' ha.)*
Paddy- Wheat- Fallow/Other Crops	38.84
Paddy- Mustard - Mung/Fallow/Other Crops	1.3
Paddy- Black Gram - Fallow/Other Crops	0.009
Paddy- Fallow/Other Crops - Fallow/Other Crops	8.01
Cotton (Gossypium)-Wheat- Mung/Fallow/Other Crops	141.7
Cotton (Gossypium)-Mustard - Mung/Fallow/Other Crops	7.88
Cotton (Gossypium)- Black Gram - Fallow/Other Crops	0.58
Cotton (Gossypium)- Fallow/Other Crops - Mung/Fallow/Other Crops	15.04
Bajra (Pearl Millet) -Wheat- Fallow/Other Crops	1.8
Bajra (Pearl Millet) -Mustard- Fallow/Other Crops	0.8
Bajra (Pearl Millet) -Black Gram - Mung/Fallow/Other Crops	0.01
Bajra (Pearl Millet) -Fallow/Other Crops- Fallow/Other Crops	0.47
Gwar-Wheat- Fallow/Other Crops	17.15
Gwar-Mustard- Fallow/Other Crops	1.75
Gwar-Black Gram-Mung/Fallow/Other Crops	0.02
Gwar- Fallow/Other Crops - Fallow/Other Crops	4.05
Other Crops/Fallow-Wheat-Fallow /Other Crops	94.92
Other Crops/Fallow-Mustard-Fallow /Other Crops	10.45
Other Crops/Fallow-Other Crops/Fallow-Fallow /Other Crops	61.43
Horticulture - Horticulture - Horticulture	3.3
Non Agricultural Area	17.63

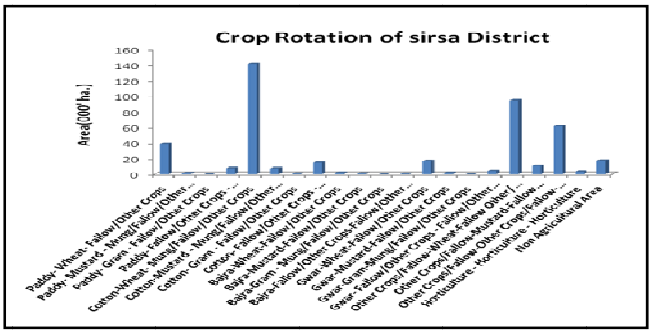

Figure 9: Crop Rotation of Sirsa District derived from RS Data

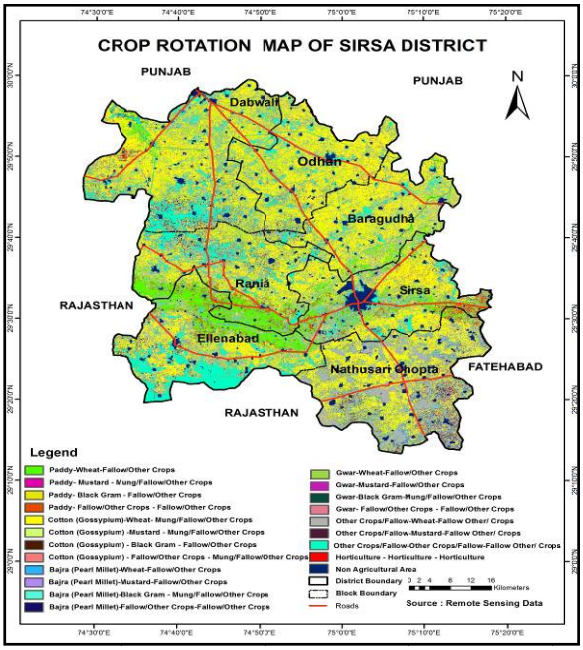

Figure 10: Crop Rotation Map of Sirsa District derived from RS data

5.5 Relation Deviation (%)

RS based estimates of Monsoon and Winter season are compared with Dept. of Agriculture (DOA) estimates by computing percent relative deviation. RS based estimates are found to be quiet close with DOA estimates of same year (Table 6). Relative deviation was not computed for summer crops and some Monsoon crops such as Gwar etc. as Dept. of Agriculture data was not available for the same.

Table 6: Relative deviation of Kharif and Rabi Crops of Sirsa district

Season	*Class*	*RS Area (000'ha.)*	*DOA Area (000' ha.)*	*% RD*
MONSOON	PADDY	50.05	48.3	3.62
	COTTON (GOSSYPIUM)	180.58	181.5	-0.51
	BAJRA (PEARLMILLET)	7.04	5.8	21.4
WINTER	WHEAT	276.9	280.06	-1.1
	MUSTARD	41.68	41.6	0.19
	GRAM	8.3	9.1	-8.79

6. Conclusion

Crops production is the result and effect of interaction between natural resources such as soil, water, weather and external inputs like seeds fertilizers management practices etc. Multi-date, multi-season optical remote sensing data of Indian Remote Sensing satellite having spatial resolution of 23.5 M. used to generate Monsoon, Winter and Summer Season cropping pattern maps for Sirsa district. RS data analysis showed that Cotton (Gossypium) is major crop followed by Paddy, Gwar, Bajra (Pearl Millet) and Horticulture fruit crops during Monsoon Season. Wheat is the major crop in Winter season evenly distributed in the district followed by Mustard, Black Gram and Horticulture fruit crops. Major area of the district is lying vacant as fallow in Summer Season and the only crops are Mung and Horticulture fruit crops derived using RS data. Horticulture fruit crops are long duration crops available in all three cropping seasons. Minor non- contiguous crops which are not separable using LISS-III data clubbed in other crops category. It includes vegetables, fodder, green manure etc. It was observed that Paddy-Wheat-Fallow/Other Crops, Cotton (Gossypium) -Wheat-Mung/ Fallow/Other Crops, and Other Crops/Fallow-Wheat-Fallow/Other Crops based are the major crop rotation in the district. Other rotations are scattered in the district. Multi-date and multi-season optical data with spatial resolution of 23.5m from Indian Remote Sensing Satellites is found to be useful for the cropping system analysis of major and contiguous crops at District-level.

Cropping system analysis at optimum intervals may be conducted to monitor the change in cropping pattern and to suggest alternative cropping pattern for utilization of land for sustainable utilization. To improve the productivity optimum cropping pattern for a piece of land is required. For the purpose micro-level study of cropping system is required which includes the minor and non-contiguous crops. For cropping system analysis of minor and non-contiguous crops high resolution multi-date, multispectral data such as LISS – IV from Indian satellites or World View – 1 & 2 from other satellites would be required to be analyzed.

References

[1] A. Rai, N.K.Gupta and R Singh, (2007), "Small area estimation of crop production using spatial models" Model Assisted Statistics and Applications, 89-98 IOS Press
[2] B. Sunil, (2009), "Cropping Pattern in India".
[3] B.N Chatterji, S.Mati, B.K Mandal, (1979), "Cropping System Theory & Practice".
[4] D.P. Malik and I.J. Singh (2002), Crop Diversification - An Economic Analysis, Indian J. Agric. Res. • 36 (1): 61 - 64.
[5] Dr. Michael, D. Peel, (1998), "Crop Rotations for Increased Productivity," EB 48 (Revised), January.
[6] J Nowatzki, R Andres, K Kyllo, (2004), Agricultural Remote Sensing Basics, AE-1262.
[7] M. P. Sharma, M Yadav, R. Prawasi, P Kumar and R. S. Hooda, (2011), Cropping System Analysis using Remote Sensing and GIS: A Block Level Study of

Kurukshetra District, ARPN Journal of Agricultural and Biological Science, VOL. 6, NO. 10.
[8] P Sushma, Hooda R S, Ray S S, Yadav Manoj, Manjunath K R, Sharma M P, Upadhyay Gargi, Kumar M, Panigrahy R K & Miglani Anshu(2008). Cropping system analysis using remote sensing & GIS: Haryanastate. TechnicalReport:EOAM/SAC/CS/SN/02/2008.
[9] Statistical Abstract Haryana. (2008-09). "Department of Economic and Statistical Analysis Haryana 2010," pp 228.
[10] Yadav Manoj, Sharma M P, Prawasi R, Rajeev, Kumar Pawan, Mandal Vinay, Saleem A and Hooda R S (2011). Area Estimation of Burning of Wheat/Rice Residue in Kaithal, Kurukshetra &Karnal Districts, Haryana. Technical Report: HARSAC/TR/01/2011, 21 pp.
[11] http://en.wikipedia.org/wiki/Sirsa, Haryana (From Wikipedia, the free cyclopedia)
[12] http://en.wikipedia.org/wiki/Haryana

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