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Analysis of Cropping System Using Geospatial Technology in Nathusari Chopta Block of Sirsa District (Haryana)

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A B S T R A C T

Enhancing the agricultural productivity has become the top priority, worldwide because of the exponential demographic expansion. However, the present agricultural scenario of eco-system degradation warrants a sustainable approach to the agricultural production. The cropping system (cropping pattern and crop rotation) of an area has high bearing on both agricultural production as well as sustainability of the agro-ecosystem. Geospatial technology is gaining importance as useful tools in sustainable agricultural practices with time and cost-effective information. Therefore, monitoring the dynamic changes in the cropping system over a large area for the management and development of sustainable agro-ecosystem using geospatial technology is essential. The study has been conducted for Nathusari Chopta block of Sirsa district of Haryana state (India) based on multi-dated and multi-season Sentinal-2A/B; digital satellite data for the year 2018-2019. This paper is evaluating the role of cropping system analysis for agro-ecosystem sustainability. The unsupervised method of digital image classification is adopted with iterative self-organizing data analysis technique (ISODATA) approach. The NDVI approach is also used to improve the accuracy level of the digital classification for finding the non- agricultural classes like; forest, water bodies and built-up, etc. A total of 11 cropping patterns in the study area were identified and mapped. The net cropped area under kahrif, rabi and summer cropping pattern were occupied 71.81%, 86.50% and 30.50% respectively. These cropping patterns indicate that the area has the major crop rotations like: cotton-wheat/mustard, rice-wheat/mustard and gawar-mustard/gram were the dominant, occupied 26.31%, 23.55% and 8% of the total geographical area of the study area.

Key words: Geospatial Technology, Unsupervised classification, Cropping pattern, Crop-rotation, Sustainability

At global level the agriculture plays major role to reduce poverty, increase income, and improve food security for 80% of the world's poor, who live in rural areas (Anonymous 2018). Therefore, the sustainable development of agriculture is one of the most powerful tools to end extreme poverty, increase prosperity and feed an estimated 9.7 billion people of the world by 2050 (Anonymous 2011, Anonymous 2016). As per analysis of World Bank Group, 2016 found that 65% of poor working adults made a living through agriculture (Savitpal *et al*. 2015). Thus, the agriculture is the backbone of all the countries of the world; whether underdeveloped, developing or even developed. Due to heavy pressure of population growth in Southeast Asia countries like; India, the demand for food is increasing at a fast rate. As of Today, India supports 16.8% of world's population on 4.2% of world's water resources and 2.3% of global land (Satyawan *et al*. 2015). Therefore, our country is required to raise food grain production by more than 2% per year to keep pace with the growth in demand but in the present day, per capita availability of resources is about 4 to 6 times less as compared to world average (Satyawan *et al*. 2015). It plays also major role in Indian economy and as per census 2011, the 54.6% of population is engaged in agriculture and allied activities. Further, the agricultural contributed 17.4% of GDP in year 2016-17 (Rani *et al*. 2015). Haryana is major agricultural domain state with 70% of population is engaged in agricultural and allied activities. Haryana is self-sufficient in food production and the second largest contributor to India's central pool of food grains. About 86% of the area is arable, and of that 96% is

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cultivated (Anonymous 2017). About 75% of the area is irrigated, through tube-wells 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. The primary crops of Haryana are Paddy, Wheat, Cotton, Oilseeds, Sugarcane and Black Gram etc.

Sirsa is the larger district of Haryana which is 10.3% of total geographical area of the state and also known as cotton growing district in Haryana. There are two types of cropping pattern of Rabi and Kharif. In the study area the crops like; Cotton, Paddy, Wheat and mustard is grown. A huge amount of water is required for irrigation to grow these water intensive crops. The rate of cropping intensity is very high in the Nathusari Chopta block. Thus, the degradation of agricultural land form of waterlogging and soil salinity has occurred at large scale. In this block 2465 ha land is affected by waterlogging and soil salinity as per District Agricultural Development Office, Sirsa. In this field many studies carried out by researchers. Kumar *et al*. (2015) tried to assess the cropping pattern and change analysis using geo-informatics with IRS-P6- LISS III data of 2007-08 of both seasons of Sampla block of Rohtak district of Haryana State. Further, Sharma et al (2011) analysed the cropping system of Kurukshetra district of Haryana state using remote sensing and GIS with multi dated IRS- P6 satellite data of both seasons. Satyawan *et al.* (2014) carried out the study of using geospatial technology for cropping system monitoring of Sirsa district and recommended the cropping system analysis at optimum interval to monitor the cropping pattern and suggested alternative cropping pattern for sustainable agricultural practices.

Thus, with increasing pressure of population on agricultural production throughout our country is needed to adopt the sustainable practices in the field of agriculture. The present study an analysis of cropping pattern and rotation of crop with geospatial technology can play a major role to improve the food grain production with sustainable use of our land resources. Because the geospatial technology is provided time and cost effective with temporal-spatial analysis services.

MATERIALS AND METHODS

The 'Nathusari Chopta block' of Sirsa district is situated on the border of Haryana and Rajasthan in the south east and the Sirsa block is situated in the north and Bhattu Kalan block (Fatehabad district) in the East of study area. It is located between 29°13'21" to 29°31'28" North latitude and 74°54'13" to 75°18'40 East longitude. The block is located from 20.3 kms distance from district headquarter Sirsa. As per Censes, 2011 the block has 56 villages without any urban area and total geographical area is 756.31 km^2. The primary source of data for this study was Remote sensing digital data comprising of Sentinal 2A/B satellite digital data of multi-seasons (Summer-2019, Rabi-2019 and Kharif-2018) were used.

Remote sensing geo-coded digital data of multi-dated and multi-season of Sentinal-2A/B satellite was digitally analysis using Erdas 9.3, Geomatica and ArcGIS 10.1 software packages. The geo-coded digital images were used for unsupervised digital classification method. In this classification, ISODATA clustering classifier method was adopted to assess the information regarding cropping pattern of both rabi, kharif and summer season. To improve the level of accuracy, NDVI approach was adopted to mask the non-agriculture classes such as urban area, forest and waste lands etc. clipped from land use /land cover maps. Mask of mixed crop classes was prepared and reclassified under the mask. This process was continued till the classes of interest were segregated. The summer, Rabi and Kharif season cropping pattern maps were generated using classified images and logical combination. The crop rotation maps were also generated using both season cropping patter maps.

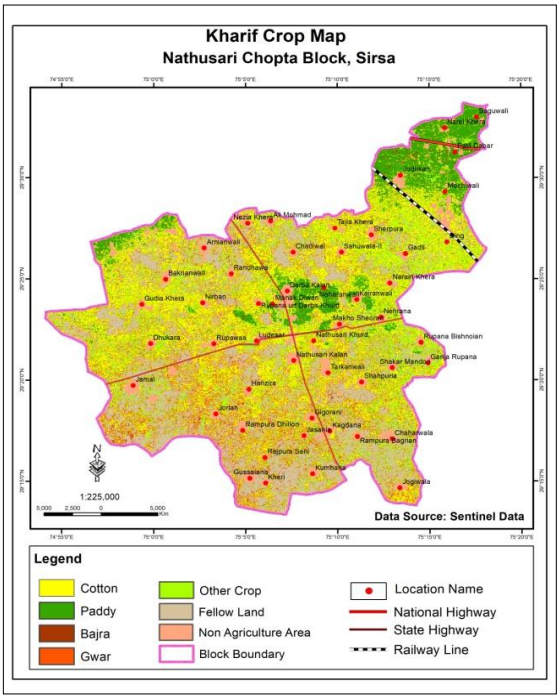
RESULTS AND DISCUSSION

Kahrif cropping pattern

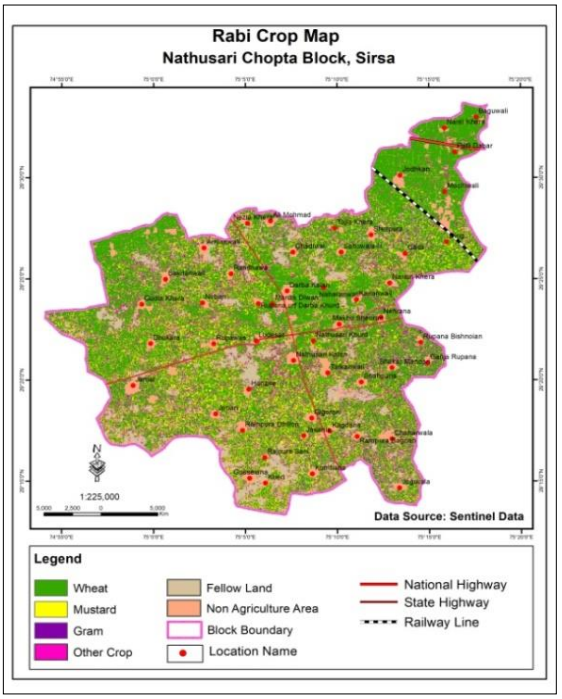
Kharif and Rabi are the two major cropping seasons in Haryana. Kharif cropping season begins from May-June and continue up to September-October. Assessment through remote sensing satellite data and ground truth shows that Paddy, Cotton and Bajra/ others crops are sown in Kharif season in study area. The class of other crops are integrated by minor and non-contiguous crops category. Paddy is evenly dominated in northern and central part of the study. The Cotton and Bajra/ other crops concentrated in southern and south western upland sandy part of the study area. In the South eastern and western part of study area occupies some fellow land also. Remote Sensing estimates showed that the Paddy, Cotton and Bajra/ Gwar other crops occupied 7.20, 19.92, 4.17, 6, and 14.13 (000'ha.) area; respectively as shown table-4.1, means thereby that major Kharif crop in the area is cotton. It is also observed that a substantial part of the study area occupied 20.18 (000'ha) by fallow during Kharif season. The fellow area is found mostly in southern part of the study area. The spatial distribution of kharif cropping pattern of the area is shown in (Map 1).

Table 1 Kharif, rabi and summer pattern of Nathusari Chopta block derived from RS Data

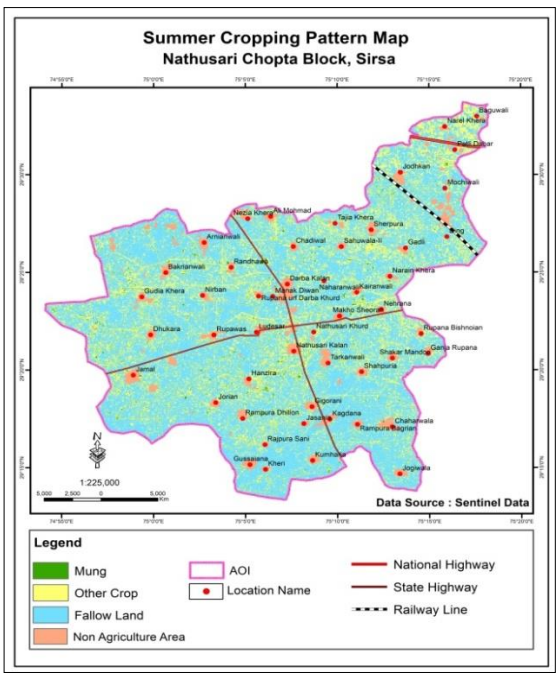
Kharif cropping pattern		Rabi cropping pattern		Summer cropping pattern	
Crops	Area (000'ha)	Crops	Area (000'ha)	Crops	Area (000'ha)
Cotton	19.92	Wheat	35.97	Mung	1.36
Paddy	7.2	Mustard	14.32	Other crops	20.48
Bajra	4.17	Gram	8.48	Fallow	49.76
Gwar	6	Other crops	3.17		
Other crops	14.13	Fallow	9.67		
Fallow	20.18				



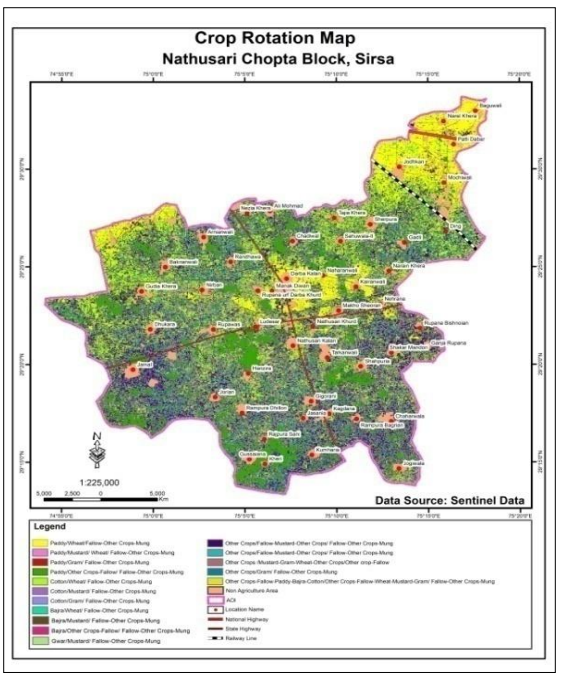
Map 1 Kharif pattern of Nathusari Chopta Block derived from RS Data



Map 2 Rabi pattern of Nathusari Chopta Block derived from RS Data



Map 3 summer pattern of Nathusari Chopta block derived from RS Data



Map 4 Crop rotation of Nathusari Chopta block derived from RS Data

Rabi cropping pattern

Rabi season is the main season in Haryana in which maximum area is cultivated. Wheat is the major crop of Rabi season followed by mustard in the study area. Mustard is sown in those areas having coarse texture soils and scarcity of water. Rabi cropping pattern map of the study area was generated using satellite data of the particular season. It is clear from the (Table 2, Map 2) that wheat crop is evenly spread throughout the study area and occupies 35.97(000'ha) area, followed by mustard. Mustard and Gram crops are concentrated in south eastern and south western upland sandy parts and occupy 14.32 and 8.48 (000'ha.) area, respectively. The fallow land & other crops occupy an area of 9.67 and 3.17 (000'ha.), respectively.

Summer cropping pattern

During summer season most of area is remains vacant as fallow land. Major crop during summer season is mung

that occupied 1.36 (000'ha.) fallowed by other crops derived using remote sensing satellite data given in table-4.3 and map-4.3. The minor and non-contiguous crops are not separable and clubbed into the other crop's category. Other crops grown during summer season are fodder and vegetables that occupied 20.48 (000'ha).

Table 2 Crop rotation of Nathusari Chopta block derived from RS Data

Crop rotation	Area (000'ha)
Paddy/Wheat/Fallow-Other Crops-Mung	6.63
Paddy/mustard/ wheat/ fallow-other crops-mung	0.25
Paddy/Gram/ Fallow-Other Crops-Mung	0.09
Paddy/Other Crops-Fallow/ Fallow-Other Crops-Mung	9.87
Cotton/Wheat/ Fallow-Other Crops-Mung	14.3
Cotton/Mustard/ Fallow-Other Crops-Mung	3.22
Cotton/Gram/ Fallow-Other Crops-Mung	1.29
Bajra/Wheat/ Fallow-Other Crops-Mung	2.31
Bajra/Mustard/ Fallow-Other Crops-Mung	0.94
Bajra/Other Crops-Fallow/ Fallow-Other Crops-Mung	0.17
Gwar/Mustard/ Fallow-Other Crops-Mung	1.8
Other Crops/Fallow-Mustard-Other Crops/ Fallow-Other Crops-Mung	15.52
Other Crops/Fallow-Mustard-Other Crops/ Fallow-Other Crops-Mung	8.11
Other Crops /Mustard-Gram-Wheat-Other Crops/Other crop-Fallow	6.89
Other Crops/Gram/ Fallow-Other Crops-mung	0.06
Other Crops-Fallow-Paddy-Bajra-Cotton/Other Crops-Fallow-Wheat-Mustard-Gram/ Fallow-Other Crops-Mung	0.11
Non-agriculture Area	4.18
Total	75.64

Crop rotation

The analysis of cropping pattern maps of different seasons indicate that study area has the major crop rotations of Cotton/Wheat/ Fallow-Other Crops-Mung Paddy-wheat, Fallow-Wheat, Other Crops/Wheat, Paddy-Fallow and Fallow mustard. The Cotton-wheat crop rotation occupies maximum area that is 14.30 (000'ha) followed by Other Crops/Fallow-Mustard-Other Crops/ Fallow-Other Crops-Mung occupies 15.52 (000'ha) area. Other rotations like Paddy/Other Crops-Fallow/ Fallow-Other Crops-Mung are occupied 9.87 (000'ha) and 6.63 (000'ha) area, respectively. The crop rotation of the study area with their areal extent is given in (Table 2). Cotton-wheat rotation is evenly distributed in whole study area except south east and south western part where Fallow-Fallow/other Crops-gram rotation is more prominent. The spatial distribution of crop rotation is shown in (Map 4).

The study presents the fallowing conclusion on the bases of spatial analysis of cropping system which is given below:

- Cropping system analysis should be carried out at optimum time interval to monitor the changes in the cropping pattern.
- Geospatial technologies are facilitator for changing cropping pattern & crop rotation mapping time to time with time and cost effectiveness.
- The central and eastern part of study areas are under critical situation because the more water consuming crops like i.e. Paddy, Cotton and Wheat are shown and in this area the availability of groundwater is not sufficient to meet the requirement of these crops. Further, the soil condition also not suitable.
- The cropping pattern of study area is not sustainable.
- Use of huge amount of fertilizers and bio-chemicals in the area has led to land degradation.
- The Western and northern part of study areas are having sandy soil which does not support the large water consuming crops like Paddy/Cotton and Wheat.
- The Central and western part of area is suffering from the problems of severe waterlogging and soil salinity due to flood irrigation and over use of fertilizers.

The area needs optimum land and water use techniques for sustainable development of agricultural.

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