Full Length Research Article

CARAS

Research Journal of Agricultural Sciences
Volume 15; Issue 02 (Mar–Apr 2024); pp 352–356

ISSN: 0976-1675 (P)
ISSN: 2249-4538 (E)

Changing Crop Pattern in Western Agroclimatic Zone (South Western Parts) of Haryana Using Geospatial Techniques

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Received: 22 Dec 2023; Revised accepted: 23 Feb 2024; Published online: 11 Mar 2024

Abstract

A cropping pattern refers to the proportionate area under different crops during an agricultural year. An area's agricultural transformation is mostly determined by the cropping pattern, so studying it is vital. The present research work attempts to study the trends and fluctuations in the area under important crops in the arid agroclimatic zone of south-west Haryana by using space-borne remote sensing data by unsupervised classification in ERDAS IMAGINE 2014 software along with secondary data. The study was conducted over three time frames, viz., 2000, 2010 and 2020. Analysis of cropping patterns in the study area revealed that rice, cotton and mustard crops have come to dominate, and the gram area has declined. Rice and cotton have increased due to fertilizer and irrigation by groundwater and canals. The area under gram has decreased and been replaced by mustard in some places. The study presented the spatial distribution of the present cropping pattern in the south-west parts of Haryana.

***Key words*:** ERDAS IMAGINE, Unsupervised classification, Cropping pattern, Western agroclimatic zone, Haryana

A cropping system is defined as the cropping pattern and its management to draw benefits from a given resource under a specific environmental condition. There have been many changes that have taken place in the cropping pattern of Haryana since the green revolution during the 1960s to the dates [1]. The nature of shifts in cropping patterns is one of the most important determinants of economic gains in an area's agriculture. In other words, the cropping pattern of an area means a farmer's cropping choices favor one crop over another competing crop. Remote sensing plays a major role in the agricultural field. GIS tools aid in understanding the health of crops, the extent of infestation or stress damage, or potential yield and soil conditions with NDVI. Crop classification, crop health and viability assessments, and agricultural practice monitoring are all accomplished through the use of satellite and aerial imagery as mapping tools. Overall, remote sensing and GIS tools play a crucial role in modern agriculture by providing valuable data and insights that help farmers make informed decisions, optimize resource use, and maximize yields while minimizing environmental impact.

Many studies have been conducted by several research scholars regarding changing crop patterns at the district, state, national and international levels. The earlier studies were mainly focused on crop diversification and the sustainability of cropping systems. Lata [2] studied "Agricultural change during the post-reform period in Haryana". This result shows changes in agricultural fields like land use, productivity, intensity, cropping pattern and human activities during the post-reform period in Haryana. Rawat and Bala [3] shared "Changing cropping pattern in Haryana: A spatio-temporal analysis of major food crops". As a result, the net sown area of wheat and rice production suffers from spatial variation over the reference period of 2001-2018. Gautam and Sangwan [4] shaded result, rice and wheat have increased while the area under pluses, sugarcane, bajra, maize, barley, and jowar has decreased.

MATERIALS AND METHODS

The study area of this research work is the part of the western Agroclimatic zone, comprising Bhiwani, Charkhi–Dadri, Mahendragarh, Rewari and some parts of Rohtak, Jhajjar, Gurugram, and Nuh districts in Haryana state, with 1,092,371.43 hectares area located from 27° 39' 8" N to 29° 04'55" N latitudes and 75° 30' 10" to 77° 03' 15" E longitudes. A major part of South-West Haryana is arid to semi-arid. This part of Haryana receives less than 400 mm annual rainfall. During winter (Oct. to March), an average minimum temperature of 5 – 6 °C is recorded. The high temperature around 35 °C in the months of mid-September to mid-October is responsible for delayed sowing of winter crops after the monsoon withdrawal in early September. In summer, the temperature reaches up to 45 °C, causing severe heat waves. The soils of the belt are grouped as Aridisols and Entisols. The soil is light-textured, sandy loam. Major crops are in this area: wheat, cotton, gram, bajra and rice [5].

In the present work, digital image analysis was carried out using the window platform of ERDAS IMAGINE 2014 software. In order to analyze the cropping pattern of the study area for the years 2000, 2010 and 2020, a complete enumeration approach was used. The unsupervised classification of

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Citation: Panwar K, Airon A, Kaswan R, Bishnoi KB. 2024. Changing crop pattern in western agroclimatic zone (South Western Parts) of Haryana using geospatial techniques. *Res. Jr. Agril. Sci.* 15(2): 352-356.

LANDSAT 4-5, 7 and 8 satellite images was done. Land use classes were identified as per reflection and corresponding Google Earth images as well [6].

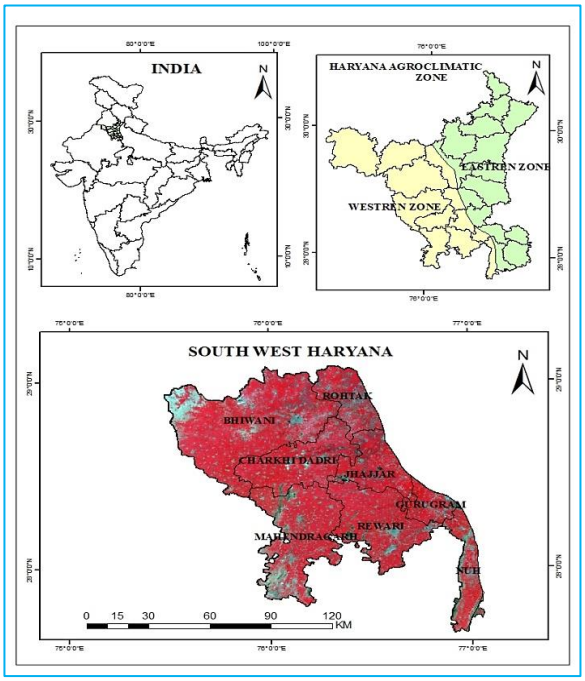

Fig 1 Location map of study area

Primary data

Primarily, satellite data available at the USGS website (LANDSAT series 4-5, 7 and 8) with optimum spatial and temporal resolution was downloaded [7]. The bands in the images used were 4, 3 and 2 in LANDSAT 4-5, 7 and LANDSAT 8; there were 5, 4 and 3 bands.

Table 1 Details of satellite data used in the present study

Satellite / Sensor	Path	Row	Date of scene
LANDSAT - 4 and 5	147	40, 41	21/02/2010,
Band 2 (0.52-0.60 µm)*			3/09/2010
3 (0.63-0.69 µm)			
4 (0.76-0.90 µm)			
LANDSAT - 7	147	40, 41	18/02/2000,
Band 2 (0.52-0.60 µm)			13/10/2000
3 (0.63-0.69 µm)			
4 (0.77-0.90 µm)			
LANDSAT - 8	147	40, 41	17/02/2020,
Band 3 (0.53-0.59 µm)			28/09/2020
4 (0.64-0.67 µm)			
5 (0.85-0.88 µm)			

*Wavelength (micrometers)

Secondary data

The secondary data from the statistical abstract of Haryana for the years 2000, 2010 and 2020 were accessed [8-10].

Unsupervised classification

Unsupervised classification is a method in which the computer searches for natural groupings of similar pixels called clusters [11]. The Iterative self-organizing data analysis technique (ISODATA) algorithm is used in ERDAS software to carry out unsupervised categorization. The analyst enters a confidence threshold and the desired number of clusters using this technique. Once the spectral enhancements were completed on the image, an unsupervised classification using (ISODATA) was performed with 36 classes with a 98% confidence threshold, and the maximum number of iterations was set at 36. The final result was an image with 36 groups of pixels, each represented by a different color. For identifying the classes, each class was highlighted at a time, and then it was determined which of the land uses it belonged to by interpreting the original multispectral image. In addition, NDVI of the image was also prepared and compared with each class to identify vegetation. Then each class was given a colour such as wheat and cotton in green colour, and rice and mustered in yellow and a separate label and code in the attribute table.

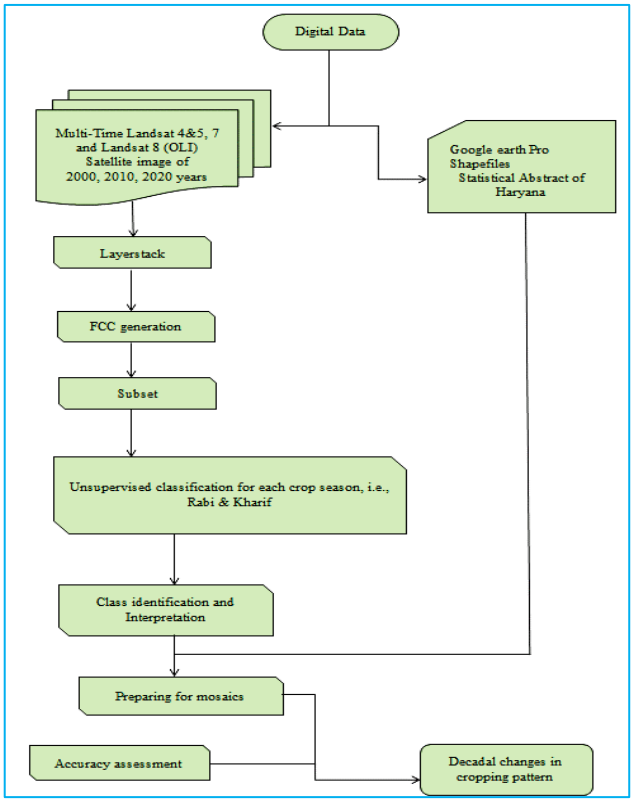

Fig 2 Methodology flow chart

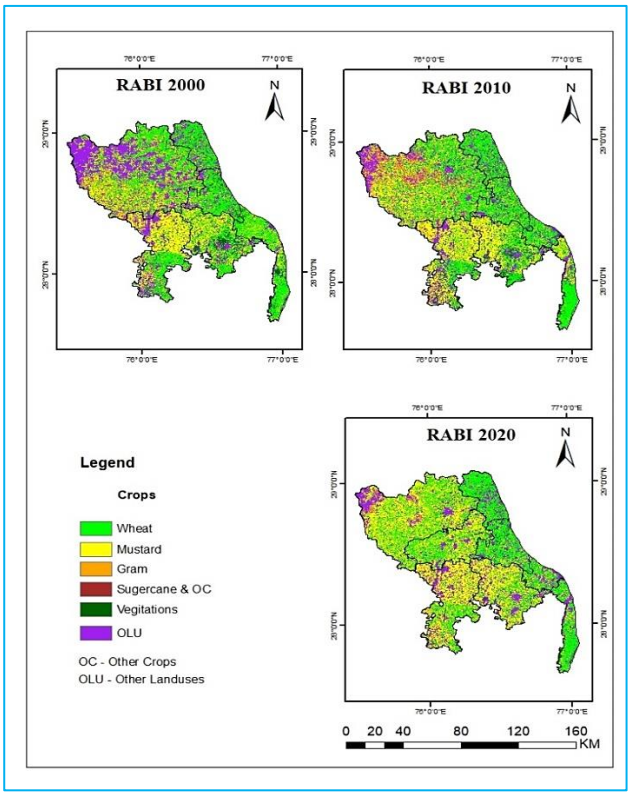

Fig 3 Comparison of crop area maps of rabi season

RESULTS AND DISCUSSION

Rabi season

This study area is represented in the rabi crops (Oct. to March) of 2000 (2000–2001), 2010 (2010–2011), and 2020 (2020–2021) with wheat, mustard, gram, and sugarcane. According to the 2000-2001 map, wheat was the largest area crop with 408,530.4 hectares, mustard and gram with 286,087.84 and 60315.48 hectares respectively. The purple pixel represents other land uses, i.e., fallow lands, settlements, water bodies, roads, etc. This classified area was compared with the statistical abstract (2000-2001), and small variations were observed in the area of different crops, i.e., wheat (0.7%), mustard (2.55%), and the gram (3.36%) [8-10]. Overall, these data provide insights into the changing cropping patterns over time in the study area, with notable shifts observed in the areas dedicated to wheat, mustard, and gram crops. These changes may reflect various factors such as market demands, technological advancements, and agricultural policies impacting farmers' cropping choices.

The classified image of rabi 2010-11 revealed an area under wheat of 414,345.1 hectares, under mustard of 337,061.53 hectares, and under gram of 65,789.84 hectares. The mustard area increased by 17.8% from 2000 to 2011, i.e., a decade. The deviation of crop area between statistical records (2010-11), was very low, i.e., wheat was 0.8%, mustard was 1.4%, and gram was 3.4%. Fallow land area was also found to have decreased in 2010 [8-10]. The data suggests a consistent increase in mustard area over the decade, along with relatively low deviations in crop areas between the classified image and statistical records for the Rabi season of 2010-11. These findings contribute to understanding the evolving agricultural landscape in the study area, including shifts in cropping patterns and changes in land use over time.

According to rabi 2020-21 map, the crop area of wheat was –401,653.5, mustard – 431,191.78 and gram – 26,198.69 hectares. In comparison with the 2010-11 rabi season, this rabi season (2020-21) has seen an increase in wheat area of 3.15%. The gram area had decreased, but it could not be classified accurately as pixels mixed with fallow or open land. The major reason for the reduction in grams was that it had been replaced by the mustard crop in some parts, where it had increased by 21.83% from rabi in 2010-11 [8-10]. It's noted that there was an increase of 3.15% in wheat area.

Table 2 District-wise crop areas at different times (Area in '000 ha.)

Remote sensing data					Statistical Abstract data		
Districts	Crops	Years			Years		
		2000	2010	2020	2000	2010	2020
Bhiwani	Wheat	140.7	155.9	104	140.0	156.6	107.4
	Mustard	107.4	135.8	149	108.8	138.6	143.5
	Gram	44.3	60.7	18.7	47.2	58.1	16.1
	Rice	8.1	18.6	26.6	7.3	19.0	26.4
	Cotton	53.1	30.9	105.8	50.5	32.8	101
	Bajra	194.6	180.9	87.7	196.4	172.1	80.8
Charkhi Dadri	Wheat	-	-	53.4	-	-	50.1
	Mustard	-	-	61.2	-	-	61.7
	Gram	-	-	1	-	-	0.9
	Rice	-	-	11.6	-	-	12
	Cotton	-	-	33.5	-	-	32.4
	Bajra	-	-	55.9	-	-	55.2
Mahendragrah	Wheat	50.7	41.2	37.7	48.5	40.7	36.6
	Mustard	84.2	92.7	101.6	87.5	93.7	100.4
	Gram	7.3	3.4	5.7	7.3	3.3	6.7
	Rice	0	0	0	0	0	0
	Cotton	4.4	1	22.8	4.2	0.9	23.4
	Bajra	95.2	97.8	112	94.6	103.0	113.5
Rewari	Wheat	56.6	50.5	38.5	53.9	48.6	37.7
	Mustard	55.9	65.3	78.5	60.1	65.2	78
	Gram	2.1	0.2	0	2.1	0.1	0
	Rice	1.2	2.2	3.1	1.1	2.1	2.9
	Cotton	2.3	0.9	17.9	2.4	0.6	18.9
	Bajra	54.1	62.9	66.4	54.3	58.6	67.2

Rabi crops Kharif crops

According to this rabi cropping pattern analysis, wheat and sugarcane crop areas had not noticed any major changes, but mustard area had increased (approximately 33.65%), Gram area very highly decreased (130.22%) from 2000 to 2020. Major area of gram was decreased in Bhiwani, Charkhi - Dadri and Mahendragrah districts due to uses of fertilizers and tube - well irrigation due to which. Mustard crop area had become a major crop in western part of Haryana in current decades.

Kharif season

The kharif crops for the year 2000 are represented by cotton, rice, bajra and pulses. Rice area in unsupervised classification was 36,446.28, cotton was 66,392.09, and bajra was 395,719.47 hectares. The variation of classified data with statistical abstract 2000–01 was very low, i.e., rice was 4.12%, cotton was 4.40%, and bajra was 0.16%.

The map 2010 shows having crops area are rice in 56,677.53, cotton in 37,256.68 and bajra in 394,785.47 hectares. Data comparison with kharif 2000 revealed an increase in rice area by 35.6% and cotton decreased by 43.8%. The rice area surprised increased in Bhiwani, Rohtak and Jhajjar districts due to irrigation facilities. The cotton area decreased in Rewari and Gurugram districts. Statistical abstract records in the 2010 comparison show little variation from remote sensing image classified data, i.e., rice (0.3%), cotton (3.6%), and bajra (1.4%).

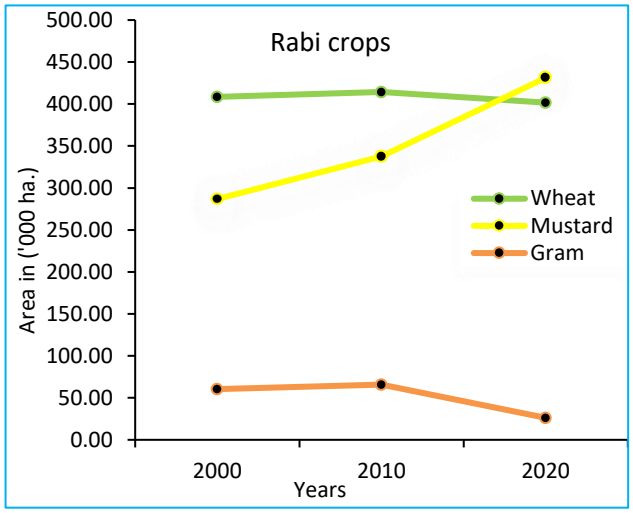

Fig 4 Comparison of crop area over three decades

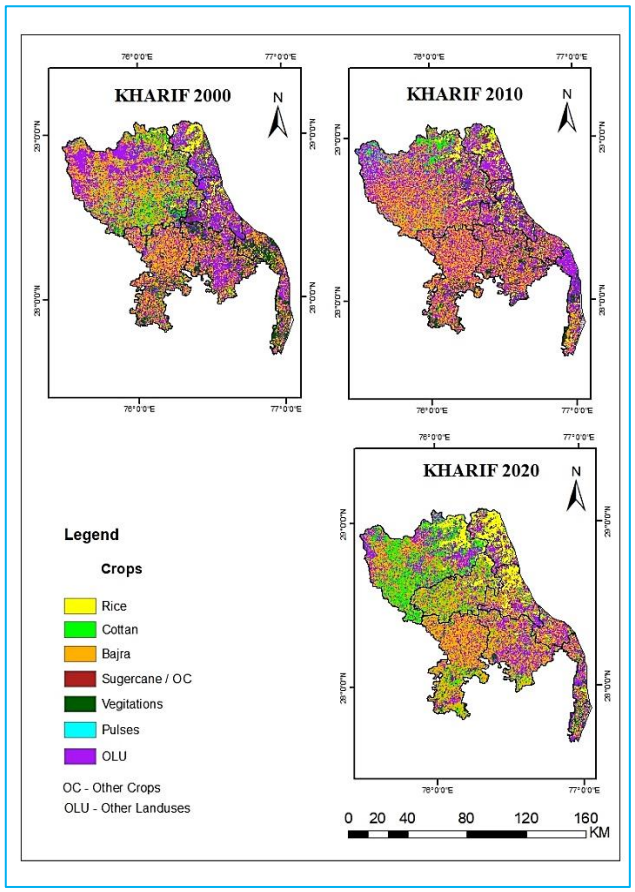

Fig 5 Comparison of crop area maps of kharif season

In the map 2020, the classification showed a rice area of 107,858.89 hectares, cotton at 201,511.27 hectares, and bajra at 381,206.28 hectares. The area very highly increased in rice (47.49%), cotton (81.53%) and Bajra decreased by 3.54%. Cotton areas are increasing on a large scale in Bhiwani, Charkhi - Dadri and Mahendragrah districts due to high-quality seeds, canal and tube well irrigation. Errors in classification with gazette data were rice (0.3%), cotton (2.5%), and bajra (2.4%).

According to this chart of kharif crops, the area under rice has greatly increased from 2000 to 2020. In 2000, the area under rice was 36,446.28 hectares, and in 2020 it was 107,858.89 hectares, or 66.2%. Cotton area increased by 67.9%, and bajra decreased by 3.80%. The main reason for the increased area under crops was new technology in irrigation and hybrid seeds. Rice and cotton areas increased in Rohtak, Bhiwani and Jhajjar districts.

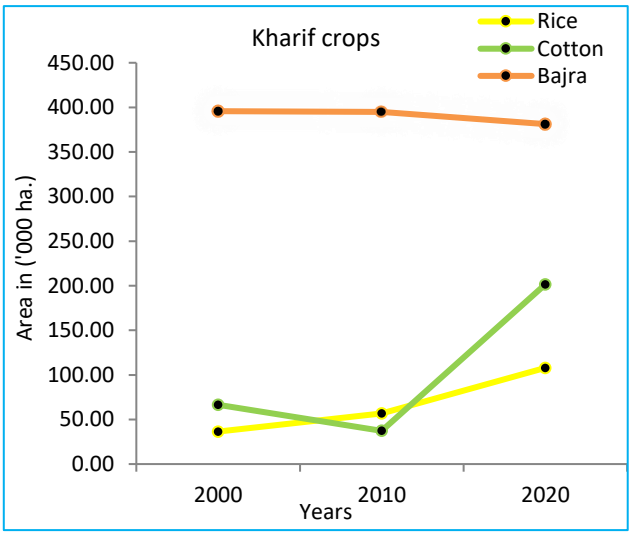

Fig 6 Comparison of crop area over three decades

CONCLUSION

The present study revealed a major increase in the mustard crop (rabi season) from 2000 to 2020 in Bhiwani, Charkhi-Dadri, Rewari and Jhajjar districts. The area under grams has decreased considerably (103%), mainly in Bhiwani, Charkhi-Dadri, and Mahendragrah districts. Due to the increased availability of irrigation, gram was replaced by wheat and mustard in this area. The other possible reason was the hybrid quality of seeds and pesticides. In the kharif season from 2000 to 2020, rice and cotton crops in Bhiwani, Charkhi-Dadri, Rohtak and Jhajjar districts emerged prominently as crops. The area under rice and cotton had increased by 70%. The increase in rice and cotton areas could be made possible by better and increased facilities for irrigation like sprinklers and lift-canal irrigation, along with improved seed quality. The changing cropping patterns in this arid to semi-arid region also raise environmental concerns about sustainable development.

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