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Changing Pattern of Cropping Intensity in Haryana with Special Reference to Sustainable Agricultural Development: A Spatio-Temporal Analysis

Rohit Kumar*

Abstract

Agriculture is the lifeblood of the Indian economy. Agriculture production in India has increased dramatically, albeit with certain adverse effects. Land for agriculture is limited but the population is increasing rapidly, necessitating more food. In order to feed the world's rising population, agricultural intensification must be increased as cropping intensity is an important indication of agricultural production and sustainability, and variations in cropping intensity can have large economic, social and environmental consequences. This study examines the Spatio-temporal patterns of cropping intensity over the last decade and identifies the mechanisms causing these changes using data from government records, Statistical Abstract and field observations. Cropping intensity has grown in some areas of Haryana while dropping in others, according to the findings. The research also demonstrates the impact of factors such as irrigation access and government regulations on cropping intensity. The study has significant significance for Haryana's agricultural development and policy, and also for other regions facing similar challenges.

Keywords: Agriculture Production, Changing Pattern, Cropping Intensity, Spatio-Temporal Analysis, Sustainability

Introduction

Agriculture is one of India's most important industries, accounting for more than 16% of the country's GDP and employing more than half of its people. Haryana, one of India's top agricultural states, is noted for its fertile terrain, diversified soil types and favourable climate, making it an important contributor to the country's food security. Agriculture dominates the state's economy, with crops like as wheat, rice, sugarcane and cotton dominating the terrain. However, cropping intensity in Haryana has changed significantly throughout the years, affecting the state's total agricultural yield. The number of crops cultivated in a particular amount of land during a single agricultural year is referred to as cropping intensity. Cropping intensity in Haryana has changed dramatically during the previous few decades. In Haryana, for example, cropping intensity was about 174% in 1980–81 and has since climbed to 200% in 2020–21. This suggests that farmers are growing two harvests on the same land in a single year, putting a significant pressure on the state's natural resources. High-intensity cropping depletes soil nutrients, causes water shortages and reduces total output. According to Bhattarai, Sakthivadivel and Hussain (2002), differences in cropping intensity between irrigated and unirrigated regions affect the breadth of employment prospects and poverty levels in rural areas. They also stated that migration from low cropping intensity regions to regions with adequate irrigation water is a prevalent scenario in the rural economy of Asian countries due to rained agriculture or poorly established irrigation systems. Siebert, Portmann and Doll (2010) discovered low cropping intensity in arid regions without irrigation facilities and high cropping intensity in locations where irrigation water is accessible in their investigation of global patterns of cropping intensity.

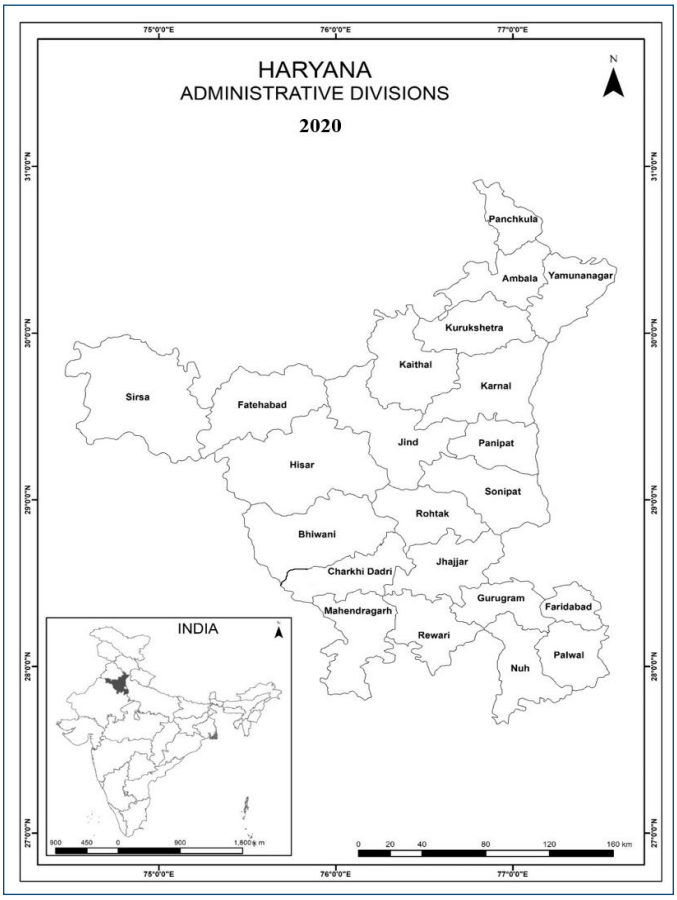
Valipour (2015) He investigated the Cultivate Plants Tendency for Designing Cropping Intensity in Irrigated Area. To accomplish sustainable agriculture in the future,

* Research Scholar, Department of Geography, Panjab University Chandigarh, India. Email: rohitkumar80822@gmail.com

the study suggests that focus to exclusively commercial aims be decreased, trial and error procedures be avoided and exert remarks be used to irrigation systems for any crop. To discover significant and effective differences in cropping intensity on land for investment plans, net production in a region is heavily reliant on cropping intensity, which is viewed as a crucial indicator of food security (Jain et al., 2013). One of the tried-and-true methods for boosting agricultural productivity and rural employment is to take steps to intensify cropping. According to Sharma (2015) "the rate of increase in total cropped area was higher (3.53%) during the 2000s compared to the 1990s (2.1%), primarily due to an increase in irrigation area." He also noted that agricultural intensity in India grew from 128.9% to 138% during the early 1990s and 2011/12 due to a significant increase in irrigated area. The degree of cropping intensity is, however, largely determined by the Agro-ecological conditions that exist and the way that inputs are used in agriculture. When all farm inputs are taken into account, the amount of cropping intensity is mostly controlled by irrigation water availability and effective usage. In an irrigated area, the transition from subsistence to commercial farming increases cropping intensity. According to Kaini, Gardner and Sharma (2020), who based their statement on a study conducted in Nepal. Therefore, there is a need to research cropping intensity variations in Haryana and analyse their spatiotemporal trends. A Spatio-temporal study of cropping intensity can aid in identifying locations where high-intensity cropping is common, as well as the impact of such cropping practises on soil, water resources and crop yield. Furthermore, it can shed light on the causes for the shift in cropping patterns and recommend appropriate governmental actions.

Study Area

Haryana is an Indian state in the country's north western region. On November 1, 1966, it was created out of the previous state of East Punjab on linguistic grounds. Haryana has a total size of 44,212 km^2 and is located between 27°39' N and 30°35' N latitude and 74°28' E and 77°36' E longitude. Haryana's elevation ranges from 200 to 1200 metres above sea level. It is surrounded by Rajasthan to the west and south, Himachal Pradesh to the north, the Yamuna River along its eastern border with Uttar Pradesh and the Ghaggar-Hakra River flows along its northern border with Punjab.



Source: Official Website of Chief Minister Office, Government of Haryana.

Map 1

According to the 2011 Indian Census, the state has a total population of 25351462 people, making it the 18th most populated in the country. Haryana has an average population density of 573 persons per square km. Haryana has a population that is 65.12% rural and 34.8% urban. According to the 2011 census, 75.6% of the people of Haryana are literate. Faridabad, which is part of the National Capital Region, is the state's most populous city. Villages are home to more than two-thirds of the state's inhabitants, and agriculture is the principal industry. At the time of 2005–06 it has 20 districts but at present (20021–21) it has 22 districts. Palwal and Charkhi Dadri are the newly added districts. Haryana's official language is Hindi. In addition to Hindi, many other dialects are spoken in the state. The Ganges and its tributaries provided this state with fertile alluvial plains.

The Yamuna River, which also forms the state's eastern boundary, is one of the most important rivers in the state. Agriculture has spread throughout the state as a result of the abundant water and fertile land. The Green Revolution had a substantial influence on the state, increasing agricultural and food output.

Research Objectives

- To analyse the changing pattern of cropping intensity in Haryana from 2005-06 to 2020-21.
- To find out the factors responsible for changing cropping intensity in Haryana from 2005-06 to 2020-21.

Research Methodology

This study relies heavily on secondary data and secondary data were gathered in order to achieve the study's aims from the Office of the Deputy Director of Agriculture, Government of West Bengal, North Twenty-four Parganas district, West Bengal, India, and the Office of the Registrar General & Census Commissioner, Government of India.

Cropping intensity was estimated by dividing the gross cropped area by the net cropped area in a particular agricultural year (April 1 to March 31) and multiplying by 100 (BAES, DPSPM, GoWB 2015).

$$\text{Cropping Intensity} = \frac{\text{Total Cropped Area}}{\text{Net Sown Area}} * 100$$

After calculating the cropping intensity index value of each district for the years 2005-06 to 2020-21, tables have been prepared to process the data. Similarly, data has been analysed using excel sheet and GIS based maps has been prepared to interpret the data.

Results and Discussion

Cropping intensity is defined as the ratio of gross to net cropped area. Agricultural production may be raised by cultivating new land, increasing cropping intensity and productivity of land, or a combination of the two. Because land availability is fixed, intensive agriculture is more ideal for increasing output. There are only two options for meeting the country's escalating food and other demands: extend the net area under cultivation or intensify cropping over the present area. The Table 1 presents a comprehensive view on total cropped area, net shown area, cropping intensity and change in cropping intensity from 2005-06 to 2020-21:

Table 1: Haryana: District Wise Cropping Intensity From 2005-06 to 2020-21

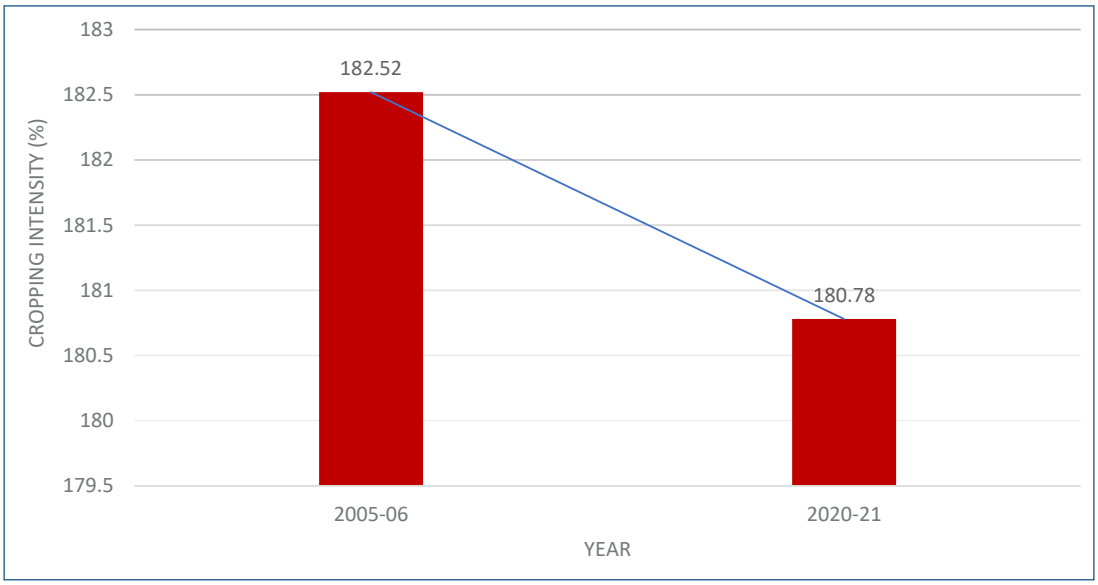
Name of the District	*Total Cropped Area (1000' Hectares)*		*Net Sown Area (1000' Hectares)*		*Cropping Intensity (%)*		*% Change in Cropping Intensity (2005-06 to 2020-21)*
	2005-06	*2020-21*	*2005-06*	*2020-21*	*2005-06*	*2020-21*	
Ambala	211	253	134	148	157.46	170.94	13.48
Bhiwani	792	532	394	294	201.01	180.95	-20.06
Charkhi Dadri	-	179	-	112	201.01*	159.82	-41.19
Faridabad	219	128	118	31	185.59	412.9	227.31
Fatehabad	422	439	225	219	187.55	200.45	12.9
Gurugram	123	119	98	118	125.51	100.84	-24.67
Hisar	637	656	313	335	203.51	195.82	-7.69
Jhajjar	240	267	161	134	149.06	199.23	50.17
Jind	470	401	233	254	201.71	157.87	-43.84
Kaithal	378	399	202	197	187.12	202.53	15.41
Karnal	394	399	200	200	197	199.5	2.5
Kurukshetra	271	291	150	143	180.66	203.49	22.83
Mahendragarh	276	286	152	152	181.57	188.15	6.58
Mewat	220	149	141	110	156.02	135.45	-20.57
Palwal	-	126	-	105	185.59*	120	-65.59

Name of the District	Total Cropped Area (1000' Hectares)		Net Sown Area (1000' Hectares)		Cropping Intensity (%)		% Change in Cropping Intensity (2005-06 to 2020-21)
	2005-06	2020-21	2005-06	2020-21	2005-06	2020-21	
Panchkula	47	50	24	23	195.83	217.39	21.56
Panipat	184	197	91	98	202.19	201.02	-1.17
Rewari	193	160	124	126	155.64	126.98	-28.66
Rohtak	223	183	142	153	157.04	119.6	-37.44
Sirsa	706	764	393	394	176.64	193.9	17.26
Sonipat	298	328	147	152	202.72	215.78	13.06
Yamunanagar	205	222	124	113	165.32	196.46	31.14
Total	6509	6528	3566	3611	182.52	180.78	-1.74

Source: Various Volumes of Statistical Abstracts of Haryana (2005-06 and 2020-21).

*For the better Comparative Analysis of the data Charkhi Dadri has given the same percentage of cropping intensity as of Bhiwani (201.01) for the Year 2005-2006, as this new formed district of Charkhi Dadri was earlier a part of Bhiwani district.

*Similarly, Palwal has given the same percentage of irrigation intensity as of Faridabad (185.59) for the Year 2005-2006, as this newly formed district was earlier a part of Faridabad district.



Source: Various Volumes of Statistical Abstracts of Haryana (2005-06 and 2020-21).

Fig. 1: Haryana: Cropping Intensity (%) for the Years 2005-06 to 2020-21

The Table 1 shows total cropped area, net sown area, cropping intensity and the percentage change in cropping intensity between 2005-06 and 2020-21 for various districts in Haryana, India. According to the data, total cropped area and net sown area have been nearly constant over the last 15 years. However, cropping intensity has decreased slightly, indicating that farmers are cultivating a smaller portion of their land. Cropping intensity has increased significantly in some districts, such as Faridabad and Yamunanagar, while decreasing significantly in others, such as Jind and Palwal. Climate change, the availability of irrigation facilities, soil fertility and government policy might all be contributors in these changes. To understand the spatial patterns of cropping intensity a detailed description is given below:

Spatial Patterns of Cropping Intensity in Haryana for 2005-2006

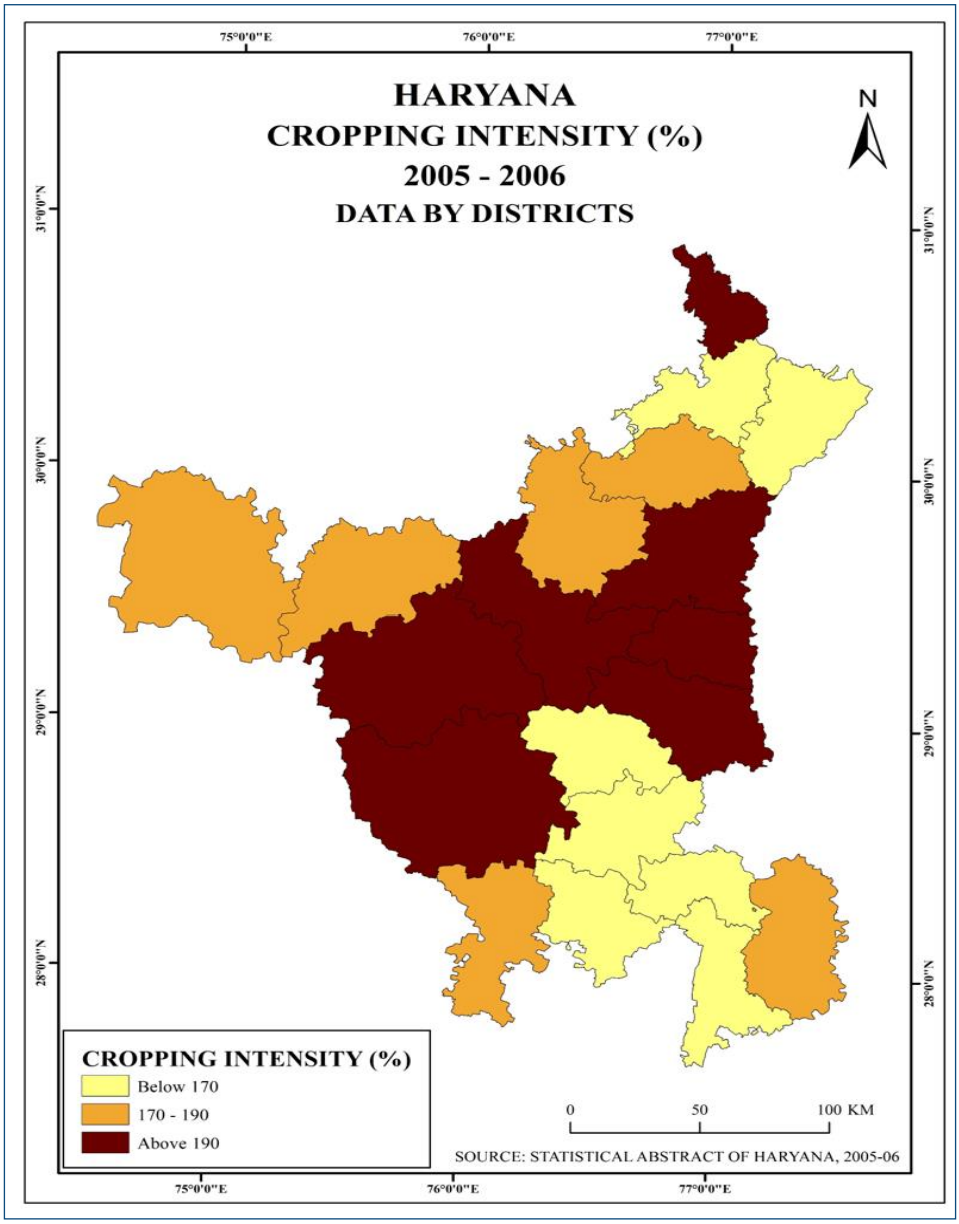
From the Table 2, we can categories the all the districts of Haryana into three categories of low, medium and high based upon their cropping intensity for the year 2005-06. A detailed description of the same is given below:

Districts with Low Cropping Intensity: Districts in the low group have cropping intensity ratings ranging from 0 to 170. Gurugram, Jhajjar, Rewari, Mewat, Rohtak, Ambala and Yamunanagar are the districts in this category. These districts have lower cropping intensity levels, suggesting that crop production takes up a lesser fraction of their net sown area.

Table 2: Haryana: Categories of District Wise Performance of Cropping Intensity, 2005-2006

Low (0-170)	Gurugram (125.51), Jhajjar (149.06), Rewari (155.64), Mewat (156.02), Rohtak (157.04), Ambala (157.46), Yamunanagar (165.32)
Medium (170-190)	Sirsa (176.64), Kurukshetra (180.66), Mahendragarh (181.57), Faridabad (185.59), Kaithal (187.12), Fatehabad (187.55)
High (>190)	Panchkula (195.83), Karnal (197), Bhiwani (201.01), Jind (201.71), Panipat (202.19), Sonipat (202.72), Hisar (203. 51)

Source: Statistical Abstract of Haryana 2005-2006.



Map 2

Districts with Medium Cropping Intensity: Districts in the medium group have cropping intensity scores ranging from 170 to 190. Sirsa, Kurukshetra, Mahendragarh, Faridabad, Kaithal and Fatehabad are among the districts in this group. Cropping intensity levels in these districts are modest.

Districts with High Cropping Intensity: Districts in the high category have cropping intensity scores more than 190. Panchkula, Karnal, Bhiwani, Jind, Panipat, Sonipat and Hisar are the districts included in this group. These districts have higher cropping intensity scores, suggesting that a greater proportion of their net sown land is utilised for crop production.

Spatial Patterns of Cropping Intensity in Haryana for 2020-2021

This Table 3 depicts cropping intensity performance in several districts of Haryana for the agricultural year 2020-21. The districts are divided into three groups of low, medium and high depending on cropping intensity. A detailed description of the patterns of cropping intensity for 2020-21 is given below:

Table 3: Haryana: Categories of District Wise Performance of Cropping Intensity, 2020-2021

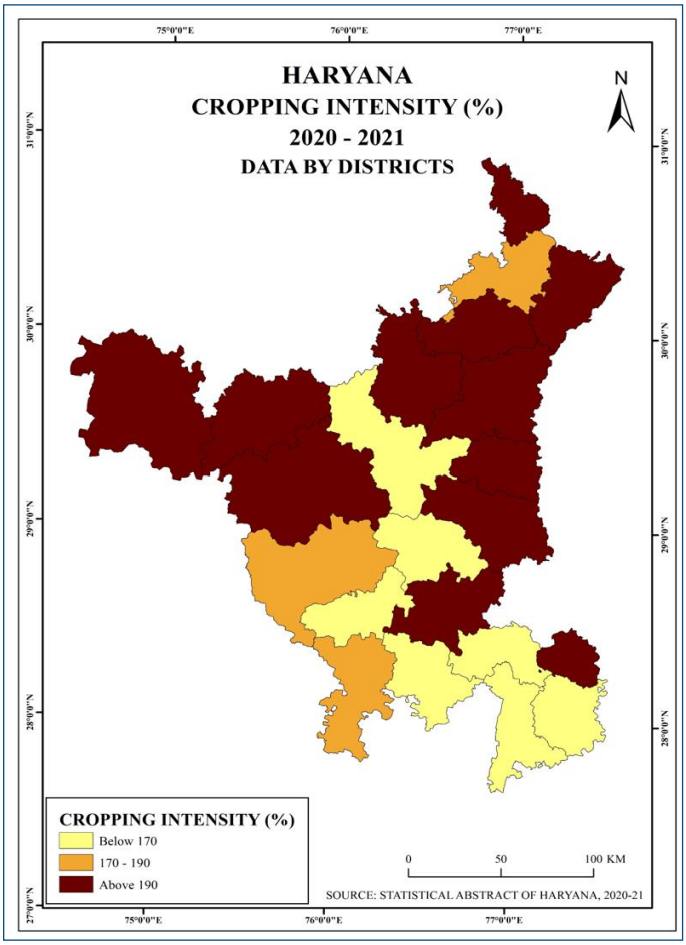
Low (0-170)	Gurugram (100.84), Rohtak (119.6), Palwal (120), Rewari (155.64), Mewat (135.45), Jind (157.87), Charkhi Dadri (159.82)
Medium (170-190)	Ambala (170.94), Bhiwani (180.95), Mahendragarh (188.15)
High (>190)	Sirsa (193.9), Hisar (195.82), Yamunanagar (196.46), Jhajjar (199.23), Karnal (199.5), Fatehabad (200.45), Panipat (201.02), Kaithal (202.53), Kurukshetra (203.49), Sonipat (215.78), Panchkula (217.39), Faridabad (412.9)

Source: Statistical Abstract of Haryana 2020-2021.

Districts with Low Cropping Intensity: Cropping intensity in the Low category districts ranges from 0 to 170. This group includes the districts of Gurugram, Rohtak, Palwal, Rewari, Mewat, Jind and Charkhi Dadri. These districts have lower cropping intensities, implying that crop production accounts for a smaller proportion of their net planted area.

Districts with Medium Cropping Intensity: Cropping intensity in the medium category districts ranges from 170 to 190. Ambala, Bhiwani and Mahendragarh are the districts included in this group. Cropping intensity is low in these districts.

Districts with High Cropping Intensity: Cropping intensity in the High category districts exceeds 190. Sirsa, Hisar, Yamunanagar, Jhajjar, Karnal, Fatehabad, Panipat, Kaithal, Kurukshetra, Sonipat, Panchkula and Faridabad are among the districts included in this category. Cropping intensity is determined by the amount of land used in agricultural operations. A high cropping intensity means that several crops are cultivated on a particular plot of land in a given year. As a result, areas with higher cropping intensity are thought to have superior agricultural performance.



Map 3

Comparative Analysis of Total Percentage Change in Cropping Intensity From 2005-2006 to 2020-2021

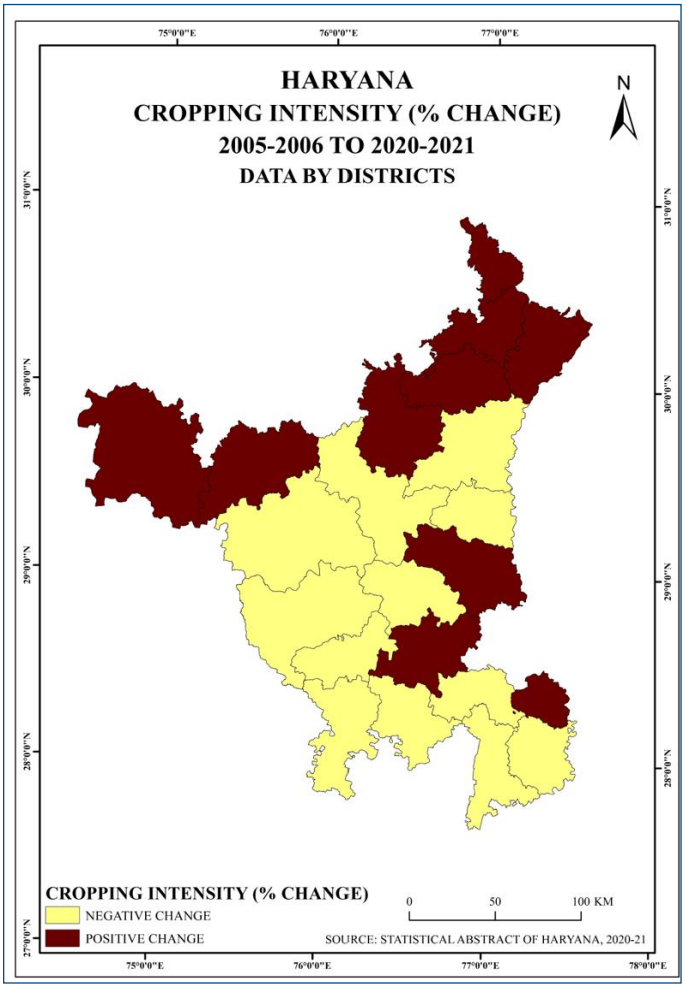
The Table 4 illustrates the percentage change in cropping intensity for several districts in the area from 2005-06 to 2020-21. From greatest to lowest, the districts are presented in decreasing order of negative percentage change. Palwal recorded the highest decrease in cropping intensity at -65.59%, which can be attributed to a shift towards non-agricultural activities and urbanisation. Jind district recorded the second-highest decrease at -43.84%, and this can be attributed to the depletion of groundwater and increasing costs of irrigation. The third-highest decrease was in Charkhi Dadri at -41.19%, which can be attributed to low soil fertility and increasing input costs. Rohtak, Rewari and Gurugram districts recorded moderate decreases in cropping intensity due to factors such as declining water availability, land degradation and a shift towards high-value crops. Hisar district recorded a small decrease in cropping intensity due to reduced rainfall, inadequate irrigation facilities and low soil fertility. Panipat district recorded a minimal decrease in cropping intensity due to the adoption of crop diversification and higher value crops.

Table 4: Haryana: Total Percentage Change in Cropping Intensity From 2005-2006 to 2020-2021

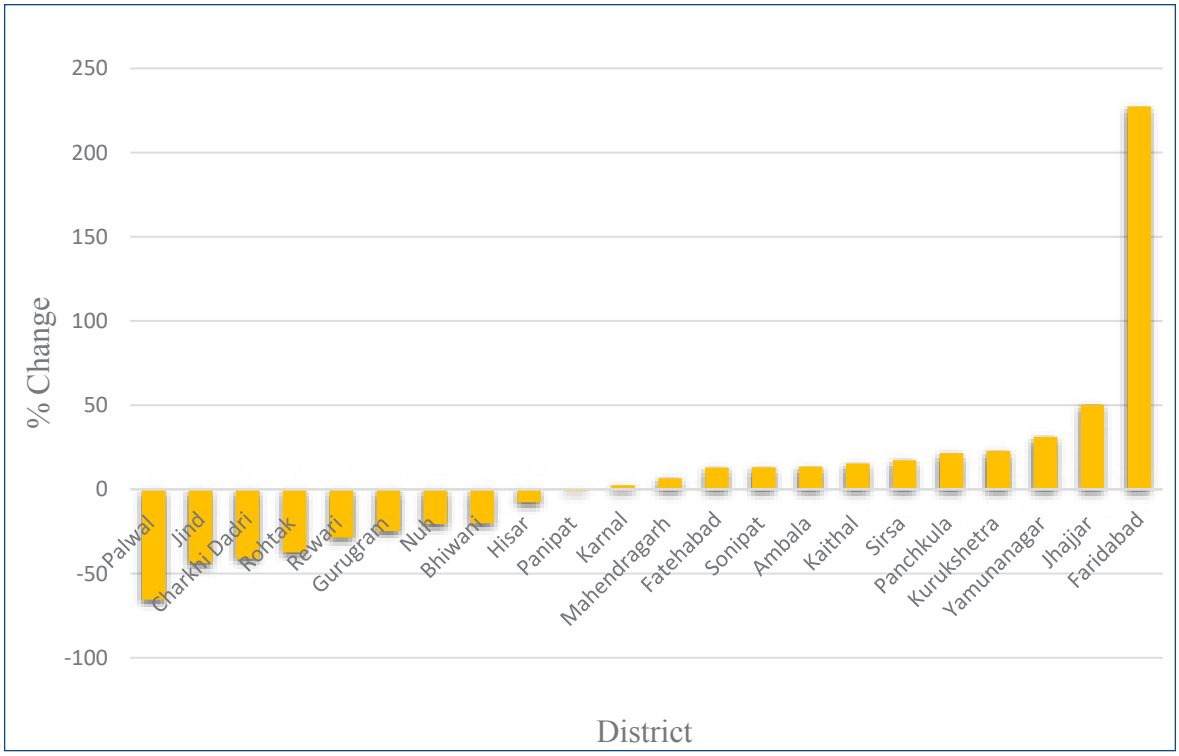
Negative Change (District)	*Index Value (%)*	*Positive Change (District)*	*Index Value* **(%)**
Palwal	-65.59	Karnal	2.5
Jind	-43.84	Mahendragarh	6.58
Charkhi Dadri	-41.19	Fatehabad	12.9
Rohtak	-37.44	Sonipat	13.06
Rewari	-28.66	Ambala	13.48
Gurugram	-24.67	Kaithal	15.41
Nuh	-20.57	Sirsa	17.26
Bhiwani	-20.06	Panchkula	21.56
Hisar	-7.69	Kurukshetra	22.83
Panipat	-1.17	Yamunanagar	31.14
-	-	Jhajjar	50.17
-	-	Faridabad	227.31

Source: Summarized from Table 1.

The cropping intensity decreased in 11 districts, and the index value of each district shows the extent of the negative change. On the positive side, nine districts recorded an increase in cropping intensity. Karnal recorded the highest increase at 2.5%, and this can be attributed to increased water availability and improved irrigation facilities. Mahendragarh and Fatehabad districts recorded moderate increases at 6.58% and 12.9%, respectively, due to the adoption of advanced agricultural technologies and practices. Sirsa and Panchkula districts recorded a small increase in cropping intensity due to improved water management and better soil fertility. Overall, the negative change in cropping intensity indicates the need for sustainable agricultural practices and policy interventions to enhance the agricultural productivity of the state.



Map 4



Source: Summarized from Table 1.

Fig. 2: Haryana: Percentage Change in Cropping Intensity From 2005-2006 to 2020-2021

Some of the Significant factors that are Responsible for Changing Cropping Intensity in Haryana:

- *Agricultural Policies:* Government policies related to agriculture, such as subsidies, credit and minimum support prices can influence cropping intensity. Changes in policies related to crop diversification, incentives for non-farm activities and promotion of agro-industrial clusters can also impact cropping patterns.
- *Urbanisation and Industrialisation:* The rapid expansion of urban and industrial areas in Haryana has resulted in the conversion of agricultural land for non-agricultural purposes. This conversion reduces the area available for cultivation and leads to a decline in cropping intensity.
- *Climate Change:* Changes in weather patterns, such as erratic rainfall, extreme temperatures and prolonged droughts, can impact cropping intensity. Climate change also affects soil health, water availability and pest and disease prevalence, which can further impact crop productivity.
- *Technology Adoption:* The adoption of new technologies, such as high-yielding varieties, irrigation and mechanisation, can increase cropping intensity by allowing farmers to cultivate crops on the same land more frequently.
- *Landholding Size:* Changes in landholding patterns, such as fragmentation or consolidation of land, can impact cropping intensity. Smaller landholdings may lead to a shift towards intensive cropping systems, while larger landholdings may allow for crop diversification or the adoption of cash crops.
- *Market Demand:* Changes in market demand, both domestic and international, can influence cropping intensity. The demand for cash crops or export-oriented crops can lead to a shift towards more intensive cropping systems, while declining demand for traditional crops may result in a decline in cropping intensity.
- *Labour Availability:* Availability of labour for agricultural operations can impact cropping intensity. A shortage of labour can lead to a shift towards less labour-intensive crops or mechanisation, while

a surplus of labour may lead to more intensive cropping systems.

- Overall, these factors are interrelated and can have both positive and negative impacts on cropping intensity in Haryana. A comprehensive approach that addresses these factors while ensuring sustainability and resilience in agriculture is essential to maintain and increase cropping intensity in the state.

Here are Some Recommendations to Improve the Cropping Intensity in Haryana

- *Promote Crop Diversification:* Encourage farmers to grow a variety of crops on their land, especially those that are suitable for the local soil and climate conditions. This will help to reduce the risk of crop failure due to weather-related factors and also improve soil health.
- *Expand Irrigation Facilities:* Provide adequate irrigation facilities to farmers, especially in areas that are prone to drought. This will help to increase the number of crops that can be grown on the land and also reduce dependence on rain-fed agriculture.
- *Increase the Use of High-Yielding Varieties:* Promote the use of high-yielding crop varieties that are better suited to the local soil and climatic conditions. This will help to increase crop yields and also improve the overall productivity of the land.
- *Encourage Mechanisation:* Introduce and promote the use of modern farm machinery, such as tractors and harvesters, to increase the efficiency of farming operations. This will help to reduce the time and labour required for farming, making it more attractive to farmers.
- *Provide Financial Incentives:* Provide financial incentives to farmers who adopt sustainable agricultural practices, such as crop rotation and the use of organic fertilisers. This will encourage farmers to adopt more sustainable farming practices and help to improve the overall productivity of the land.
- *Support Research and Development:* Support research and development efforts aimed at improving crop yields and developing new crop varieties that are better suited to the local soil and climate conditions. This will help to improve the overall productivity of the land and reduce the risk of crop failure due to climate change.

Conclusion

Based upon the above discussion, it can be concluded that the overall cropping intensity in Haryana has decreased slightly by 1.74% from 2005-06 to 2020-21, despite a marginal increase in the net sown area. The district-wise analysis reveals that 9 out of 22 districts have experienced a decline in cropping intensity, while the remaining districts have shown an increase or no change in cropping intensity over the same period. The district of Faridabad has witnessed a significant increase in cropping intensity (227.31%), while Palwal district has experienced a substantial decrease (65.59%). The decline in cropping intensity in some districts could be attributed to the conversion of agricultural land for non-agricultural purposes, such as urbanisation and industrialisation, or the shift towards mono-cropping or non-agricultural activities. This shift has led to negative impacts on soil health, crop productivity and the sustainability of agriculture in the region. To address these challenges, suggestions include promoting crop diversification, encouraging sustainable agriculture practices, improving access to credit and market information for farmers and enhancing irrigation infrastructure. By implementing these suggestions, Haryana can achieve a more balanced cropping pattern and ensure the long-term viability of agriculture in the region. Moreover, the findings suggest that the agricultural sector in Haryana is facing various challenges such as water scarcity, soil degradation and declining groundwater levels, which could affect the cropping intensity in the future. Therefore, appropriate policies and interventions are required to sustain and increase cropping intensity to ensure food security and rural livelihoods in the state.

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