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A Geographical Analysis of Changing Cropping Pattern in Haryana

[1]Ravinder Gautam and [2]Prof. (Dr.) Binu Sangwan
[1]Research Scholar, Department of Geography, M. D. University, Rohtak, Haryana, India
E-mail: ravinder.gautam.mdu@gmail.com
[2]Professor, Department of Geography, M. D. University, Rohtak, Haryana, India
E-mail: binusangwan1@gmail.com

Abstract:
In a geographical study, it is essential to study the cropping pattern because it plays a vital role in finding an agricultural transformation of an area. The present paper attempts to study the trends and fluctuations in an area under important crops in Haryana, depicting the changes in the cropping pattern in the state from 1966-67 to 2014-15 and taking five points of time, i.e., 1980-81, 1990-91, 2000-01, 2010-11 and 2014-15. Statistics of cropping pattern reveals that cereals, particularly wheat and rice, have come to dominate the cropping pattern in the state in the wake of new farm technology, and the area mainly under pluses, sugarcane, bajra, maize, barley, and jowar have declined. The changing structure of irrigation and a shift in cropping pattern gives rise to two corresponding facts. First is the increase in demand for water with an increase in rice cultivation. Secondly, this increase in demand for water is increasingly met by groundwater irrigation as water availability in the canals has declined on account of low maintenance, and the tubewells have their own set of advantages regarding flexibility and reliability of irrigation. Result also clarifies that the extent of tubewell irrigation highly corresponds to the rice crop area, which shows the considerable pressure on groundwater resources, so, there is a need for crop diversification in the study area.
Keywords: – Cropping Pattern, Rice-Wheat, Groundwater Irrigation.

Introduction:

In a geographical study, it is essential to study the cropping pattern because it plays a vital role in finding an agricultural transformation of an area. There are many changes that take place in the cropping pattern of Haryana from the green revolution during the 1960s to the dates (Kumar, 2014). In Haryana state, it has been observed that, as the technological irrigation infrastructure has improved, the trend in the cropping pattern has been shifting towards the specialization of a few majors' crops (Singh, 1976). The nature of shifts in cropping patterns is one of the most important determinants of economic gains in an area's agriculture. Therefore, it is desirable to examine the growth in the acreage of important crops in a region. A Cropping pattern refers to the proportionate area under different crops during an agricultural year. It means the series of crops at a point in time (Gautam, 2012; Hussain, 1996; and Siddiqui and Afzal, 2018). In other words, the cropping pattern of an area means a farmer's cropping choices in favor of one or preference for one over other competing crops. These choices are directly governed by the family requirement of grain, the requirement of fodder for livestock, irrigation facility, soil type, marketing facility, and economic returns from growing the crops (Gautam, 2012). The cropping pattern expresses the share of

different crops in a farmer's total cultivated area in an agricultural year. It is a vital indicator of a farmer's decision- making ability, which witnesses' dynamism over space and time to transform physical and socio- economic factors. Cropping pattern must ensure the greatest efficiency of man, irrigation, fertilizers, and other inputs. It is a dynamic concept as no cropping pattern can be suitable for all times to come (Siddiqui and Afzal, 2018; Khan and Ahmad, 2019). A successful cropping pattern implies the most efficient use of arable land, consequent upon application of water resources, biochemical inputs, and the like. Besides, it must offer the cultivators the possibility to maximize agricultural productivity per unit area per unit of time. A cropping pattern is determined by the interaction of physical and socio- economic factors over a period of time. No cropping pattern can be useful for all times to come. Nevertheless, there is often a tendency for the cropping pattern to stabilize over a period of time in different agro-climatically homogeneous farming areas (Hussain, 1996).

Objectives:

The present study has been carried to obtain the following objectives: -

1. To show the changing cropping pattern in the state of Haryana.
2. To show the cropping pattern shifts towards rice-wheat crop combination and analysis of the decline in area under coarse cereals, pulses, oilseeds, cotton, and sugarcane.
3. To reveals how the extent of groundwater use and its productive capability shaped the agrarian change in Haryana, with particular emphasis on the change in irrigation structure and shifts in cropping patter, drawing the interrelationship between these two aspects of the Haryana agriculture sector (rice cultivation and groundwater irrigation).

Database and Research Methodology:

The present study has been conducted in Haryana at the districts level. The study covers the period from 1966-67 to 2014-15 for showing the trends of crops. To show the district-wise area under crops five points of time have been selected, i.e., 1980-81, 1990-91, 2000-01, 2010-11 and 2014-15, a period of 35 years. The related data and associated information used in the study have been obtained from various issues of statistical abstracts of Haryana. For the meaningful conclusions of data, some statistical tools have been used in this study. To show the growth rate of area under wheat and rice, the annual compound growth rate has been computed with the help of the following formula: -

$R = \text{Antilog} (\text{Log}X_2 – \text{Log}X_1) – 1/N$

Where,

R is an annual compound growth rate of a chosen variable; X_1 is the value of the variable during an earlier period; X_2 is the value of the variable during the later period; N is the interval between two periods.

To show the crop combination J. C. Weaver's method has been used. In this method, the actual percentage area under different crops in a region is compared with the different theoretical base curves (Weaver, 1954). The formula used is to calculate the index (σ) is given below. The minimum of σ gives the best fit.

$$\sigma^2 = \frac{\sum (X_i – X)^2}{N}$$

Where,

X is the theoretical percentage; X_i is an actual percentage; N is the number of crops.

The theoretical curve for the measurement is employed as follows: -

Monoculture	-	100 percent of the total harvested cropland in one crop
Two Crop Combination	-	50 percent in each of two crops
Three Crop Combination	-	33.3 percent in each of three crops
Four Crop Combination	-	25 percent in each of four crops
Five Crop Combination	-	20 percent in each of five crops
Six Crop Combination	-	16.67 percent in each of six crops
Seven Crop Combination	-	14.29 percent in each of seven crops
Eight Crop Combination	-	12.50 percent in each of eight crops
Nine Crop Combination	-	11.11 percent of each of nine crops
Ten Crop Combination	-	10 percent in each of ten crops

For the visual representation of data, the simple and multiple bar diagram, line graphs, and scatter diagram have been used. ArcGIS software has been used for preparing maps works.

Result and Discussion

Cropping Pattern Shifts in Haryana

In Haryana State, it has been observed that, as the technological irrigation infrastructure has improved, the trend in the cropping pattern has been shifting towards the specialization of a few majors' crops (Singh, 1976). The nature of shifts in cropping patterns is one of the most important determinants of economic gains in an area's agriculture (Singh and Grover, 1991). Therefore, it is desirable to examine the growth in the acreage of important crops in a region. The present section attempts to study the trends and fluctuations in an area under important crops in Haryana, depicting the changes in the cropping pattern in the state from 1966-67 to 2014-15 and taking five points of time, i.e., 1980-81, 1990-91, 2000-01, 2010-11 and 2014-15. There have been significant shifts in cropping patterns in the Haryana state after the Green Revolution (Kumar, 2014). The cropping pattern in the state is shown in table- 1 and 2.

Table: 1 Shifts in Cropping Pattern in Haryana (1966-67 to 2014-15)

(Area in 000' Hectares)

Year	Food Grains		Total Food Grains	Oil Seeds	Sugarcane	Potato	Cotton	Total Gross Cropped Area
	Cereals	Pulses						
1966-67	2370 (67.32)	1150 (32.67)	3520 (76.54)	212 (4.61)	150 (3.26)	4 (0.09)	183 (3.98)	4599
1970-71	2709 (70.03)	1159 (29.96)	3868 (78.03)	143 (2.88)	156 (3.15)	5 (0.10)	193 (3.91)	4957
1975-76	3017 (71.65)	1194 (28.35)	4211 (77.25)	154 (2.83)	158 (2.90)	11 (0.20)	255 (4.68)	5451
1980-81	3168 (79.94)	795 (20.06)	3963 (72.55)	311 (5.69)	113 (2.07)	11 (0.20)	316 (5.79)	5462
1985-86	3197 (79.07)	846 (20.93)	4043 (72.18)	380 (6.78)	104 (1.86)	10 (0.18)	344 (6.14)	5601
1990-91	3337 (81.81)	742 (18.19)	4079 (68.91)	489 (8.26)	148 (2.50)	11 (0.19)	491 (8.30)	5919
1995-96	3571 (88.81)	450 (11.19)	4021 (67.31)	611 (10.23)	144 (2.41)	12 (0.20)	652 (10.91)	5974
2000-01	4187 (96.39)	157 (3.61)	4344 (71.03)	414 (6.77)	143 (2.34)	9 (0.15)	555 (9.08)	6115
2005-06	4116 (95.48)	195 (4.52)	4311 (66.23)	736 (11.31)	129 (1.98)	13 (0.20)	583 (8.96)	6509
2010-11	4525 (96.28)	176 (3.74)	4700 (72.25)	521 (8.00)	85 (1.31)	12 (0.18)	493 (7.58)	6505

2014-15	4398 (98.13)	84 (1.87)	4482 (68.57)	495 (7.57)	96 (1.47)	12 (0.18)	647 (9.90)	6536

Source: Computed from Statistical Abstract of Haryana (Various Issues) 1966-67 to 2014-15
Note: Figures in parentheses show the percentage of Area under Crops

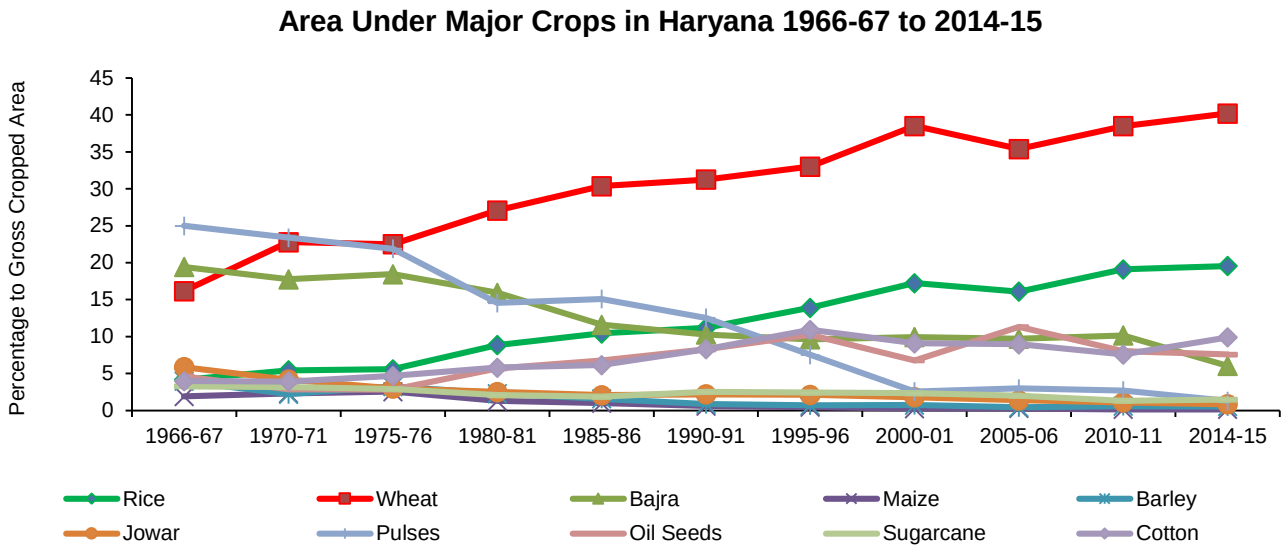
Table: 2 Area Under Major Cereals in Haryana (1966-67 to 2014-15)

(Area in 000 Hectares)

Year	Rice	Wheat	Bajra	Maize	Barley	Jowar
1966-67	192 (8.10) {4.17}	743 (31.35) {16.16}	893 (37.68) {19.42}	87 (3.67) {1.89}	182 (7.68) {3.96}	270 (11.39) {5.87}
1970-71	269 (9.93) {5.43}	1129 (41.68) {22.78}	880 (32.48) {17.75}	114 (4.21) {2.30}	109 (4.02) {2.20}	207 (7.64) {4.18}
1975-76	304 (10.08) {5.58}	1226 (40.64) {22.49}	1006 (33.34) {18.46}	139 (4.61) {2.55}	177 (5.87) {3.25}	163 (5.40) {2.99}
1980-81	484 (15.28) {8.86}	1479 (46.69) {27.07}	870 (27.46) {15.93}	71 (2.24) {1.30}	125 (3.95) {2.29}	137 (4.32) {2.51}
1985-86	584 (18.27) {10.43}	1701 (53.21) {30.37}	650 (20.33) {11.61}	55 (1.72) {0.98}	88 (2.75) {1.57}	116 (3.63) {2.07}
1990-91	661 (19.81) {11.17}	1850 (55.44) {31.26}	609 (18.25) {10.29}	35 (1.04) {0.59}	51 (1.53) {0.86}	129 (3.87) {2.18}
1995-96	830 (23.24) {13.89}	1972 (55.22) {33.01}	575 (16.10) {9.63}	26 (0.73) {0.44}	41 (1.15) {0.69}	126 (3.53) {2.11}
2000-01	1054 (25.17) {17.24}	2355 (56.25) {38.51}	608 (14.52) {9.94}	15 (0.36) {0.25}	44 (1.05) {0.72}	109 (2.60) {1.78}
2005-06	1047 (25.44) {16.09}	2303 (55.95) {35.38}	632 (15.35) {9.71}	18 (0.44) {0.28}	28 (0.68) {0.43}	89 (2.16) {1.37}
2010-11	1243 (27.47) {19.11}	2504 (55.34) {38.49}	660 (14.59) {10.15}	10 (0.22) {0.15}	37 (0.82) {0.57}	71 (1.60) {1.09}
2014-15	1278 (29.06) {19.55}	2628 (59.75) {40.21}	394 (8.96) {6.03}	9 (0.20) {0.14}	35 (0.80) {0.54}	54 (1.23) {0.83}

Source: Computed from Statistical Abstract of Haryana (Various Issues) 1966-67 to 2014-15
Note: Figures in parentheses ( ) shows the percentage to Total Cereals
and { } shows the percentage to Total Gross Cropped Area

Table 1 shows that during the year 1966-67, about 76.54 percent of the total cropped area was under food grains, about 11.85 percent under cash crop, i.e., cotton (3.98 percent), sugarcane (3.26 percent), oilseeds (4.61 percent), and 0.09 percent area was occupied by potato. Percent area under cereals to total food grains and total gross cropped area is increased from about 67.32 percent and 51.53 percent in 1966-67 to about 98.13 percent and 67.29 percent in 2014-15. It is noteworthy to mention that the percentage of area under wheat to total cereals and total gross cropped area has increased from 31.35 percent and 16.16 percent in 1966-67 to 59.75 percent and 40.21 percent in 2014-15. Similarly, the area under rice to total cereals and total gross cropped area has increased from 8.10 percent and 4.17 percent to 29.06 percent and 19.55 percent in the corresponding period. Haryana state has not been a traditional rice-growing state in the pre-green revolution period (Neeraj, 2014). Nevertheless, after the green revolution, now it contributes about 30 percent of rice towards the central pool of food grains. Among the cereals, rice and wheat are the two most important crops, which occupy 88.81 percent of cropped area in the state during 2014-15 and 59.76 percent area occupy under total gross cropped area. The other cereal crops like maize, bajra, barley, and jowar had only 11.19 percent and 7.54 percent of the total cereal and total gross cropped area. In cereal, the third dominated crops are bajra, which registered a declined trend from 37.68 percent and 19.42 percent in 1966-67 to 8.96 percent and 6.03 percent to total cereal and total gross cropped area in 2014-15.



Source: Computed from Statistical Abstract of Haryana (Various Issues) 1966-67 to 2014-15

Fig. 1

Similarly, the area under jowar, maize, and barley to total cereal registered a decline from 11.39 percent, 3.67 percent, and 7.68 percent in 1966-67 to 1.23 percent, 0.20 percent, and 0.80 percent in 2014-15. On the other hand, the area under pulses to total food grains and total gross cropped area registered a declined trend from 32.67 percent and 25 percent in 1966-67 to only 1.87 percent and 1.29 percent in 2014-15 (figure 1). The area under cash crops, likes oilseeds, recorded a fluctuating trend from 1966-67 to 2014-15. The highest percentage area under oilseeds recorded in 2005-06 about 11.31 percent. Special incentives under the centrally sponsored "Intensive Oilseeds Development Schemes" helped the process, and the lowest percentage recorded in the year 1975-76 about 2.83 percent. Another second cash crop, sugarcane, also recorded a decline from 3.26 percent in 1966-67 to 1.86 percent in 1985-86. This was due to the unremunerative price for this crop, particularly in non-sugar mill areas. The area under sugarcane is likely to rise again (2.50 percent) in 1990-91, with its support price being enhanced and opening up of more sugar mills in the state. The area under cotton registered an increasing trend before the year 1995-96. This received a boost through the "Integrated Cotton Development Project." After the year 1995-96, it has decreased on account of the American Bollworm problem. The attack of American Bollworm on the cotton crop had adversely affected this cash crop's production and productivity in the Haryana state. Under these circumstances, some cotton areas have also shifted to rice and wheat on account of stable yield an assured price. Thus, the analysis reveals that cereals, particularly wheat and rice, have come to dominate the cropping pattern in the state in the wake of new farm technology, and the area mainly under pulses, sugarcane, bajra, maize, barley, and jowar have declined.

Table 3 shows the crop combination regions in Haryana by district-wise and agro climatic zone-wise at five points of time from 1980-81 to 2014-15. The crop combination regions have been derived by using Weaver's Method (Weaver, 1954). When we discuss the first rank crop in the state, it may be noticed here that the wheat is the main primary crop throughout the state. Wheat is the first rank crop in the northern and central zone throughout the entire period from 1980-81 to 2014-15. During 1980-81, in the southern and western zone, bajra and gram was the first rank crop; after that, it is replaced by wheat crop, and wheat becomes the first rank crop throughout the state. When we discuss the first two-crop combinations, bajra was the second rank crop in 1980-81 after that; due to the emergence of new irrigation facilities, rice becomes the second rank crop in the state.

Table: 3 District-Wise Crop Combinations in Haryana (1980-81 to 2014-15)

Districts	1980-81	1990-91	2000-01	2010-11	2014-15
Ambala	WRMGSu	WRMSuG	WR	WR	WR
Kurukshetra	WR	WR	RW	RW	RW
Karnal	WR	WR	WR	RW	WR
Yamunanagar	-	WSuR	WRSu	WRSu	WRSu
Panipat	-	WR	WR	WR	WR
Panchkula	-	-	WMR	WRM	WRM
Northern zone	**WRMGSu**	**WR**	**WR**	**WR**	**WR**
Sonipat	WJBaRSu	WRJSuR/M	WR	WR	WR
Rohtak	WBaGJSu	WR/MJBaG	WJRBaSu	WRBaJR/M	WRJCBa
Jind	WGBaRC	WBaRCG	WRBaC	WRCBa	WRC
Kaithal	-	WR	RW	WR	WR
Jhajjar	-	-	WJBaR/MR	WBaRR/MJ	WRBaR/MJ
Central zone	**WBaGJR**	**WRBaR/MJ**	**WRBaJC**	**WRBa**	**WR**
Faridabad	WBaJBeR/M	WBaJR/MSu	WRJBaSu	WRBaJR/M	WRBaJR/M
Gurugram	WBaBeJR/M	WR/MBaJG	WBaR/MJR	Wba	Wba
Mahendragarh	BaWGBeR/M	BaGR/MW	BaR/MW	BaR/MW	BaR/MW
Rewari	-	R/MBaWG	WR/Mba	BaR/MW	R/MbaW
Palwal	-	-	-	WRJBaR/M	WRBaJC
Nuh	-	-	-	WBaR/MJR	WBaR/MJR
Southern zone	**BaWBeGR/M**	**WBaR/MG**	**WBaR/M**	**WBaR/M**	**WBaR/M**
Bhiwani	BaGR/MW	GBaWR/M	BaWR/MGC	BaWR/MG	WR/MCBaG
Hissar	GCWBaR/M	WCGR/Mba	WCBaRR/M	WCR/MBaR	WCR/MRBa
Sirsa	GCWR/M	WCGR/M	WCRR/M	WCRR/M	WCRR/M
Fatehabad	-	-	WCR	WRC	WRC
Western zone	**GBaWCR/M**	**WGCBaR/M**	**WCBaR/MR**	**WCBaR/MR**	**WCR/MRBa**
Haryana	**WBaGRC**	**WRGBaC**	**WRBaCR/M**	**WRBaR/MC**	**WRCR/Mba**

Source: Computed from Statistical Abstract of Haryana (Various Issues) 1980-81 to 2014-15

Note: Wherever the Crop Combinations are more than five, the first five crops' names are mentioned.

W- Wheat, R- Rice, M- Maize, Su- Sugarcane, Ba- Bajra, C- Cotton, R/M- Rapeseed and Mustard, J- Jowar, G- Gram, Be– Barley; (-) Data not available

Rice is the second rank crop in the northern zone throughout the entire period, and the northern zone becomes the wheat-rice crop belt. During 1980-81, in the central zone, bajra was the second rank crop; after that, it is replaced by the rice crop, and rice became the second rank crop, and bajra becomes the third rank crop. In the southern zone, wheat was the second rank crop in 1980-81, and after that, it is replaced by bajra, and bajra becomes the second rank crop. In the western zone, bajra was the second rank crop in 1980-81; after that, it was replaced by gram in 1990-91, and after that cotton became the second rank crop, and the western zone becomes a wheat-cotton belt. When we discuss the first three crop combinations, gram was the third rank crop in 1980-81 to 1990-91, after that bajra becomes the third rank crop in the state, and cotton replaced it in 2014-15. In the northern zone, maize was the third rank crop in 1980-81; after that, only two crop combinations (wheat and

rice) were seen in the northern zone. In the central zone, gram was the third rank crop in 1980-81; after that, it is replaced by bajra, and bajra becomes the third rank crop, further in 2014-15, the central zone only two crop combinations (wheat and rice) seen. Barley was the third rank crop in the southern zone in 1980-81; after that, it is replaced by rapeseed and mustard, and rapeseed and mustard become the third rank crop. There is variation in the third rank crop in the western zone. In the western zone, wheat was thethird rank crop in 1980-81; after that, cotton replaced it in 1990-91, and further, it is replaced bybajra and rapeseed and mustard. In the case of the first four and five crop combination, rice and cotton were the fourth and fifth rank crop in 1980-81. Nevertheless, due to the emergence of better irrigation facilities, HYV seeds, and rural electrification, rice became second rank crop in 2014-15. Rapeseed and mustard, and bajra were the fourth and fifth rank crop in 2014-15. Gram and sugarcanewere the fourth and fifth rank crop in the northern zone in 1980-81. Jowar and rice were the fourth and fifth rank crop in the central zone in 1980-81, but after that, it is replaced by only two crop combinations, wheat, and rice. Gram and rapeseed, and mustard were the fourth and fifth rank cropin the southern zone in 1980-81. Nevertheless, after that in 1990-91, it is replaced by four crop combinations, and gram was constant in the fourth rank, the other southern zone is seen to be three crop combination (wheat-bajra-rapeseed and mustard) region till 2014-15. In the western zone, cotton and rapeseed and mustard were the fourth and fifth rank crop in 1980-81, but after that, it is replaced by rice and bajra; therefore, cotton and rapeseed and mustard become the second and third rank crop in 2014-15. It is quite clear from the above discussion that the northern and central zone was becoming the highly intensively two crop combination region (wheat and rice), which are the high water intensively crops. The southern zone emerged as a three-crop combination region (wheat- bajra-rapeseed and mustard) after 2000-01 because the southern zone lacks water resources, and these crops are the less water-intensive crop; thus, they are cultivated in the southern region by different farmers (Sangwan and Gautam, 2020). The western zone has been continuously observed asa five-crop combination region during the study period, where, Wheat and Cotton have been observed as a major cultivated crop. Table 3 and figures 2 and 3 shows the crop combination regions in Haryana by districts-wise at fivepoints of time from 1980-81 to 2014-15. It is quite clear from the table that the Haryana state's northern districts are undergoing specialization; whereby maximum districts have become a dominant wheat-rice crop region. Four districts of the state, i.e., Karnal, Kurukshetra, and Kaithal, Panipat, have shown a wheat-rice crop cycle from 1980-81 and 1990-91 onwards, and there have been no shifts till 2014-15. In 1980-81 and 1990-91, two districts, Ambala and Sonipat have observed five cropcombinations; in 2000-01 and onwards, it was replaced by two crop combinations of wheat and rice. In northern agro climatic zone, three crop combination regions have been observed in two districts named Yamunanagar and Panchkula. In Yamunanagar Sugarcane is the third dominate crop, because of increase in irrigation facilities, availability of large operational holdings, and existence of sugar mills at Yamunanagar (Malik and Singh, 2002). Maize is the third dominant crop in Panchkula district. Three districts of the state, i.e., Rohtak (wheat, bajra, gram, jowar, and sugarcane), Faridabad (wheat, bajra, jowar, barley and rape/mustard), and Hissar (gram, cotton, wheat, bajra and rape/mustard) have shown a five crop combinations from 1980-81 onwards, and there have been no shifts till 2014-15. Only one district Sirsa has observed four crop combinations from 1980-81 to 2014-15. In Sirsa district, the gram, cotton, wheat and rape/mustard combinations were seen in 1980-81, and in 2014-15 it was replaced by the combination of wheat, cotton, rice, and rape/mustard crops. Rewari and Fatehabad two district has observed three crop combinations from 2000-01 onwards, and there has been no change till 2014-15. In the district of Rewari (wheat, rape/mustard, and bajra) and in Fatehabad (wheat, cotton,

and rice) are the dominant crops in their entire period. Gurugram district with diversified cropping pattern (five or more than five crop combination regions) has shown large shifts from 1980-81 to 2010-11. Gurugram district has shifted to a bi-crop system of wheat and bajra after 2000-10.

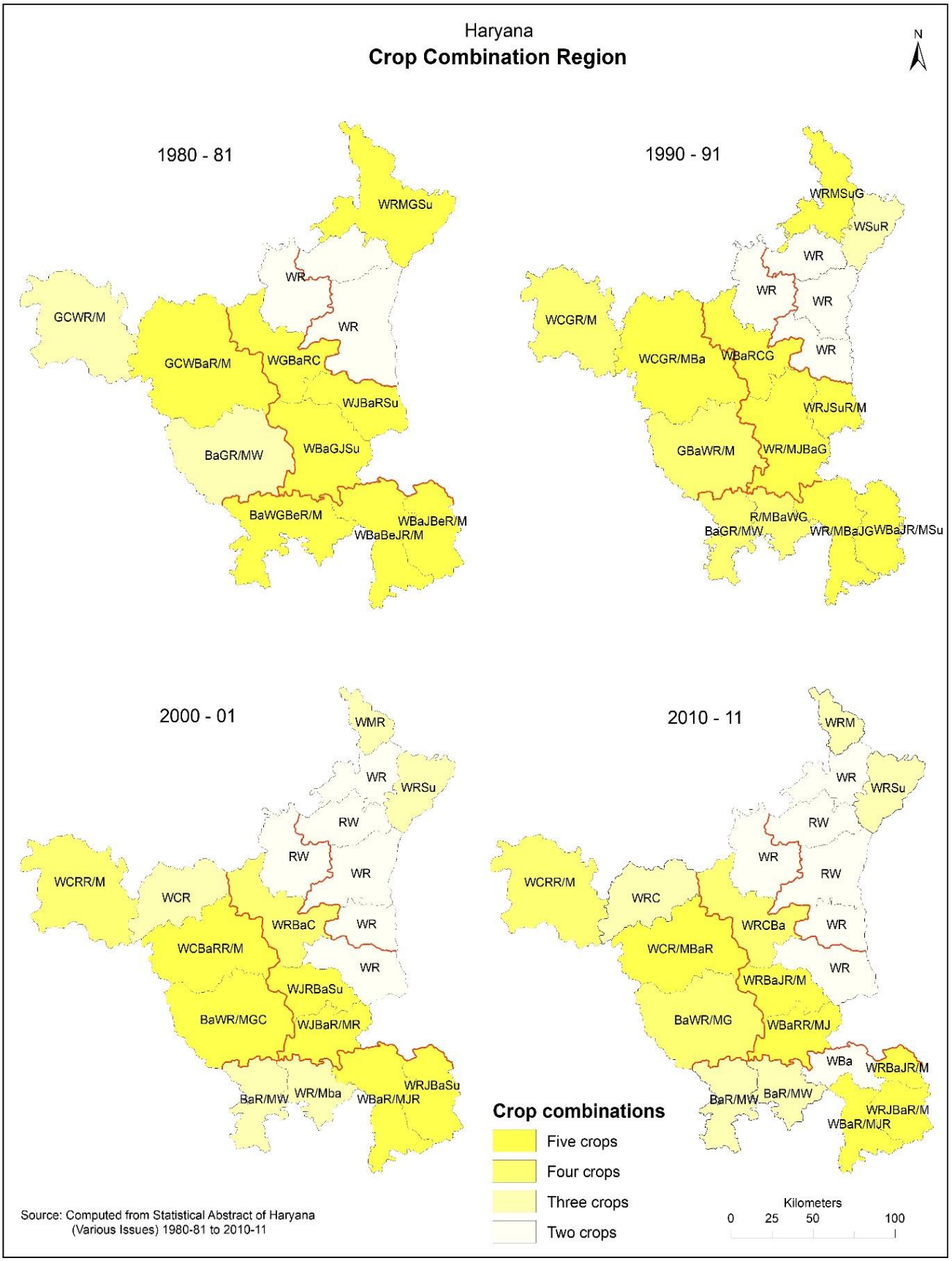


Fig. 2

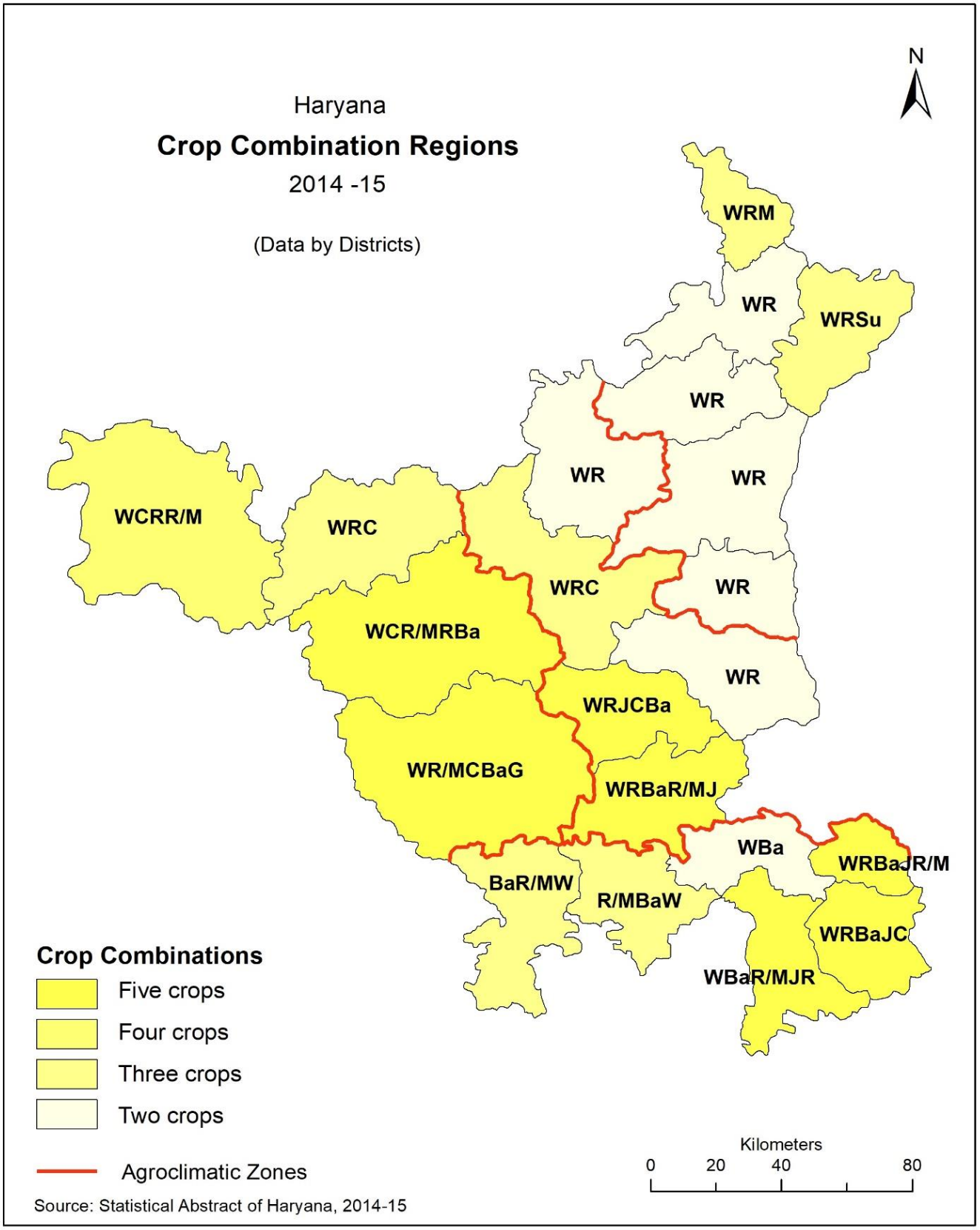


Fig. 3

Table: 4 Classifications of Districts by Crop Specialization (1980-81 to 2014-15)

Years	Crop Combination	Districts
1980-81	2	Kurukshetra and Karnal

	3	Nil
	4	Bhiwani and Sirsa
	5	Ambala, Sonipat, Rohtak, Jind, Faridabad, Gurugram, Mahendragarh, and Hissar
1990-91	2	Kurukshetra, Karnal, Panipat, and Kaithal
	3	Yamunanagar
	4	Mahendragarh, Rewari, Bhiwani and Sirsa
	5	Ambala, Sonipat, Rohtak, Jind, Faridabad, Gurugram, and Hissar
2000-01	2	Ambala, Kurukshetra, Karnal, Panipat, Sonipat, and Kaithal
	3	Yamunanagar, Panchkula, Mahendragarh, Rewari and Fatehabad
	4	Jind and Sirsa
	5	Rohtak, Jhajjar, Faridabad, Gurugram, Bhiwani and Hissar
2010-11	2	Ambala, Kurukshetra, Karnal, Panipat, Sonipat, Kaithal and Gurugram
	3	Yamunanagar, Panchkula, Mahendragarh, Rewari and Fatehabad
	4	Jind, Bhiwani and Sirsa
	5	Rohtak, Jhajjar, Faridabad, Palwal, Nuh, and Hissar
2014-15	2	Ambala, Kurukshetra, Karnal, Panipat, Sonipat, Kaithal and Gurugram
	3	Yamunanagar, Panchkula, Jind, Mahendragarh, Rewari and Fatehabad
	4	Sirsa
	5	Rohtak, Jhajjar, Faridabad, Palwal, Nuh, Bhiwani, and Hissar

Source: Computed from Table: 3

Table: 5 Classifications of Districts by Status of Crop Specialization (1980-81 to 2014-15)

Increased Specialization	Remained Constant	Decreased Specialization
Ambala (3)	Kurukshetra	Bhiwani (1)
Sonipat (3)	Karnal	
Jind (2)	Yamunanagar	
Gurugram (3)	Panipat	
Mahendragarh (2)	Panchkula	
Rewari (1)	Kaithal	
Rohtak (1)	Jhajjar	
Faridabad (1)	Nuh	
Palwal (1)	Fatehabad	
Hissar (1)		
Sirsa (1)		

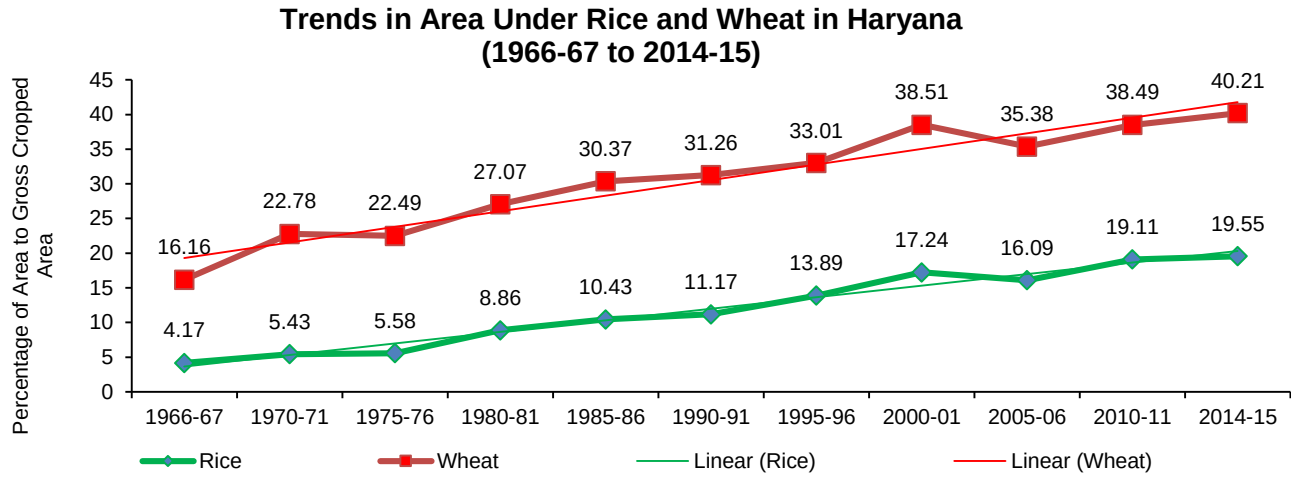
Note: The figures in parentheses indicate the increase/decrease in the number of crops in the critical combination in case of specialization according to Weaver's method. In the case of Rohtak, Faridabad, Palwal, Hissar, and Sirsa, the combination of crops has changed, but the number of crops has remained constant

The status of crop specialization is also studied at the district level (Table 5). It is seen that at the district level, there is an increase in crop specialization in eleven districts of the state. In nine districts, the number of important crops according to their acreage has remained constant in the entire study period. These districts (Kurukshetra, Karnal, Yamunanagar, Panipat, Panchkula, and

Kaithal) cover most northern and central zones, where the wheat and rice crop combination was registered and remained constant in the entire study period, these districts move towards from crop diversification to crop specialization, which shows the huge pressure on groundwater resources. The districts with a high degree of specialization are Ambala, Sonipat, and Jind, where five or more than five crop regions have specialized in a wheat-rice crop rotation. In the case of Rohtak, Faridabad, Palwal, Hissar, and Sirsa, the combination of crops has changed, but the number of crops has remained constant. Crops were also more diversified in Rohtak, Jhajjar, and Faridabad districts on account of diversion of large area from common field crops to high value crops like vegetables, flowers crops due to its proximity to the metropolitan city, Delhi (Malik and Singh, 2002). To capture the demand of milk of Delhi these districts also grow fodder crops to feed animals, so these districts show a high degree of diversification in the entire study period. Only in the Bhiwani district, the number of important crops according to its acreage has decreased. The diversification among crop in Bhiwani district was observed because of introduction of sprinkler irrigation system for growing irrigation oriented crops (Malik and Singh, 2002). The other districts indicated specialization in crops due to absence of proper markets, amount of risks involved, availability of irrigation, agro-climatic conditions etc. The districts, where crop diversification is, are not in the over-exploitation situation of groundwater, and the districts, where crop specialization is, are in the over-exploitation situation of groundwater. To conclude crop diversification can be a solution to water challenges in Haryana (Malik and Singh, 2002).

Shifts towards Rice-Wheat Crop Combination: Analysis of Area under Rice and Wheat in Haryana

The cropping pattern's most dramatic transformation is replacing the multiple cropping patterns with a cropping pattern dominated by just two crops (rice and wheat). At the start of the green revolution, high yielding varieties (HYV) seeds were available only for few crops, which changed the cropping pattern adversely from mixed farming to monoculture (rice and wheat). Since then, all over Haryana, the rice and wheat cycle pattern has dominated the cropping (Kumar, 2014). Agricultural policy in the 1960–1970s focused on food security. It aimed at production through increased coverage of HYV, expansion of Irrigation, and increased use of external inputs (Bhalla and Singh, 1997).



Source: Computed from Statistical Abstract of Haryana (Various Issues) 1966-67 to 2014-15

Fig. 4

Rice and wheat have become the most prominent crops in the present Haryana since the mid-1960s (Kumar, 2014). The total area under rice increased from 192 thousand hectares (8.10 percent) in

1966-67 to 1278 thousand hectares in 2014-15 and covered approximately 29 percent cereals crops. Similarly, the area under wheat has increased from 743 thousand hectares (31.35 percent) in 1966-67 to 2628 thousand hectares in 2014-15, covering about 60 percent of the total Cereals. The area under rice and wheat crops to total gross cropped area increased from 20 percent in 1966-67 to 60 percent in 2014-15 respectively. The trend of the area under rice and wheat crops from 1966-67 to 2014-15 is better fitted by a linear trend (figure 4). Several factors were responsible for the change in the scenario of such a rapid expansion of area under rice and wheat crops in Haryana. At the early stage of the green revolution, the government policies were responsible for the shift in such a cropping pattern (Singh, 2011). The availability of high yielding varieties (HYV) seeds only for a few crops, short-duration varieties, agronomic packages to much the varieties, support from the government in developing irrigation, and the availability of proper marketing including support price and procurement mechanism for selected crops played a positive role to make the cropping pattern unsustainable (Singh, 2011). The western vision of agricultural development and commercialization of agricultural activities also played a significant role in changing the Haryanvi's farmers' psychology to shift towards the unsustainable cropping pattern. Now, the Haryana state has lost its number of traditional crops, which helped balance the consumption pattern of farming households and maintain the soil fertility and micronutrients of the soil. The decline in the area under pulses and increase in area under hybrid rice and wheat cropping cycle has a severe impact on soil fertility (Singh, 2011). The following section attempts to analyze the trends and patterns of the acreage of these two important crops rice and wheat, in Haryana state from 1980-81 to 2014-15. The area under rice and wheat is continuously increasing in the state. The increase in area under wheat in the state is on the cost of a decrease in thearea of other rabi crops such as barley, gram, etc. while the increase in area under rice is on the cost of a decrease in the area of jowar, bajra, maize, etc. these clearly indicate that the cropping pattern in the state is skewed towards the rice and wheat rotation. Haryana is a non-traditional rice growing state. Its cultivation started after the advent of the green revolution. Nevertheless, in due course of time, rice has emerged as the second-ranking crop of the state after wheat. Rice is a vital kharif crop of Haryana state (Neeraj, 2014).

Table: 6 District-Wise Area Under Rice and Wheat in Haryana (1980-81 to 2014-15)

(Area in 000' hectares)

District	Rice					Wheat				
	1980 -81	1990 -91	2000- 01	2010-11	2014-15	1980 -81	1990-91	2000-01	2010-11	2014-15
Ambala	65.3	58.8	71.9	81.9	83.0	111.8	92.9	79.0	86.8	88.3
	(17.37)	(24.54)	(36.0)	(39.85)	(40.1)	(29.73)	(38.77)	(39.56)	(42.24)	(42.66)
Kurukshetra	172.0	101.6	111.8	119.8	130.8	226.2	105.2	108.9	114.2	112.8
	(32.15)	(39.73)	(42.64)	(44.21)	(45.42)	(42.28)	(41.14)	(41.53)	(42.14)	(39.17)
Karnal	148.1	115.2	158.0	172.7	172.5	209.2	129.0	166.5	170.8	173.9
	(29.98)	(39.17)	(41.64)	(44.25)	(44.12)	(42.35)	(43.86)	(43.89)	(43.76)	(44.48)
Yamunanagar	-	43.9	55.5	74.6	70.2	-	57.7	61.8	83.4	88.6
		(22.50)	(29.01)	(35.11)	(33.43)		(29.57)	(32.31)	(39.25)	(42.19)
Panipat	-	76.8	77.4	76.9	54.1	-	112.8	82.6	86.6	83.7
		(31.19)	(39.55)	(40.33)	(33.40)		(45.81)	(42.21)	(45.41)	(51.67)
Panchkula	-	-	6.2	9.1	9.9	-	-	16.5	16.3	17.6
			(15.78)	(23.82)	(22.5)			(41.98)	(42.67)	(40)
Northern zone	**385.4**	**396.3**	**480.8**	**535**	**520.5**	**547.2**	**497.6**	**515.3**	**558.1**	**564.9**
	(27.43)	**(32.2)**	**(37.92)**	**(40.89)**	**(39.98)**	**(38.9)**	**(40.43)**	**(40.65)**	**(42.66)**	**(43.39)**
Sonipat	18.3	19.9	77.3	93.7	88.1	121.6	80.5	139.5	143.7	147.3

	(6.96)	(12.40)	(27.26)	(30.34)	(31.24)	(46.24)	(50.15)	(49.19)	(46.53)	(52.23)
Rohtak	3.2	9.7	23.9	39.3	41.4	132.8	185.5	91.7	101.6	106.7
	(0.73)	(1.86)	(11.12)	(17.10)	(18.32)	(30.18)	(35.48)	(42.67)	(44.21)	(47.21)
Jind	35.3	43.2	111.6	113.9	123.0	121.3	150.5	206.5	215.8	218.9
	(7.93)	(10.37)	(24.07)	(24.06)	(25.84)	(27.26)	(36.14)	(44.55)	(45.59)	(45.99)
Kaithal	-	119.4	164.2	158.7	161.5	-	176.5	153.4	177.6	175.2
		(31.51)	(45.28)	(41.21)	(42.39)		(46.58)	(42.31)	(46.12)	(45.98)
Jhajjar	-	-	16.5	31.0	35.0	-	-	105.1	101.0	113.9
			(7.17)	(12.90)	(14.64)			(45.70)	(42.01)	(47.66)
Central zone	**56.8**	**192.2**	**393.5**	**436.6**	**449**	**375.7**	**593**	**696.2**	**739.7**	**762**
	(4.95)	**(12.99)**	**(25.31)**	**(26.66)**	**(27.99)**	**(32.73)**	**(40.10)**	**(44.78)**	**(45.17)**	**(47.50)**
Faridabad	2.5	7.7	28.9	9.5	11.1	102.7	111.9	133.8	31.7	27.6
	(1.02)	(3.03)	(10.91)	(14.29)	(18.81)	(42.09)	(44.18)	(50.53)	(47.67)	(46.78)
Gurugram	0.4	1.6	7.9	5.2	5.0	92.1	98.1	136.5	50.8	48.9
	(0.15)	(0.54)	(2.63)	(4.58)	(4.76)	(33.86)	(33.21)	(45.48)	(44.76)	(46.57)
Mahendragarh	@	00	00	@	@	65.0	28.8	49.2	46.0	49.6
	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(17.57)	(10.98)	(18.42)	(16.41)	(17.16)
Rewari	-	@	0.7	2.7	2.0	-	39.3	54.8	50.5	49.7
		(0.0)	(0.37)	(1.37)	(1.03)		(19.69)	(29.04)	(25.62)	(25.75)
Palwal	-	-	-	33.1	34.1	-	-	-	97.6	105.1
				(17.24)	(17.05)				(50.83)	(52.55)
Nuh	-	-	-	6.2	6.6	-	-	-	72.2	76.6
				(3.57)	(3.82)				(41.59)	(44.28)
Southern zone	**2.9**	**9.3**	**37.5**	**56.7**	**58.8**	**259.8**	**278.1**	**374.3**	**348.8**	**357.5**
	(0.33)	**(0.92)**	**(3.67)**	**(5.54)**	**(5.77)**	**(29.32)**	**(27.52)**	**(36.67)**	**(34.09)**	**(35.08)**
Bhiwani	0.2	@	8.1	21.3	21.1	42.8	59.3	144.0	159.0	219.6
	(0.03)	(0.0)	(1.18)	(2.84)	(2.66)	(6.84)	(9.02)	(21.00)	(21.21)	(27.66)
Hissar	18.7	37.1	33.3	44.7	47.8	155.2	256.2	207.1	221.8	229.9
	(2.14)	(3.90)	(6.02)	(6.96)	(7.31)	(17.76)	(26.95)	(37.49)	(34.53)	(35.15)
Sirsa	20.0	26.3	39.8	61.4	81.2	97.3	165.9	244.3	290.0	303.8
	(3.82)	(4.45)	(6.35)	(8.55)	(11.05)	(18.60)	(28.09)	(38.99)	(40.39)	(41.33)
Fatehabad	-	-	61.3	87.6	99.5	-	-	173.6	186.6	190.4
			(15.02)	(20.61)	(23.25)			(42.55)	(43.91)	(44.49)
Western zone	**38.9**	**63.4**	**142.5**	**215**	**249.6**	**295.3**	**481.4**	**769**	**857.4**	**943.7**
	(1.92)	**(2.88)**	**(6.27)**	**(8.48)**	**(9.55)**	**(14.59)**	**(21.89)**	**(33.83)**	**(33.81)**	**(36.14)**
Haryana	**484.0**	**661.2**	**1054.3**	**1243.3**	**1277.9**	**1479.0**	**1850.1**	**2354.8**	**2504.0**	**2628.1**
	(8.86)	**(11.17)**	**(17.24)**	**(19.11)**	**(19.55)**	**(27.07)**	**(31.26)**	**(38.51)**	**(38.49)**	**(40.21)**

Source: Statistical Abstract of Haryana (Various Issues) 1980-81 to 2014-15 and Season and Crop Report for the Agricultural (1990-91, 2000-01, 2010-11), Director of land records Haryana, Chandigarh.

Note: Figures in parentheses show the percentage of area under Rice and Wheat to Gross Cropped Area.

@ = Less than 500 hectares; (-) Data not available

Rice is grown as a lowland crop in an irrigated area of the state (Neeraj, 2014). Figure- 5 and 6 reveals that the rice cultivation is mainly concentrated in the northern and central zone districts, along the Yamuna river of the state throughout the entire period. It includes the districts of Ambala, Yamunanagar, Kurukshetra, Kaithal, Karnal, Panipat, and Sonipat, which enjoyed relatively better irrigation facilities. Among these districts, Karnal, Kurukshetra, Kaithal, and Sonipat districts comprise the traditional rice belt where rice was gaining importance even before the onset of the green revolution. The area under rice in these districts increased from 29.98, 32.15, 31.51, and 6.96 percent of the cropped area in 1980-81 to 44.12, 45.42, 42.39, and 31.24 percent in 2014-15 respectively. Table 7 explains the annual compound growth rate of the area under rice crops in Haryana. The table shows that the maximum growth rate for

the area under the rice crop, i.e., 4.44 percent in Haryana, has been recorded from 1990-91 to 2000-01. The minimum growth rate for the area under rice crop, i.e., 0.23 percent in Haryana, has been recorded from 2010-11 to 2014-15.

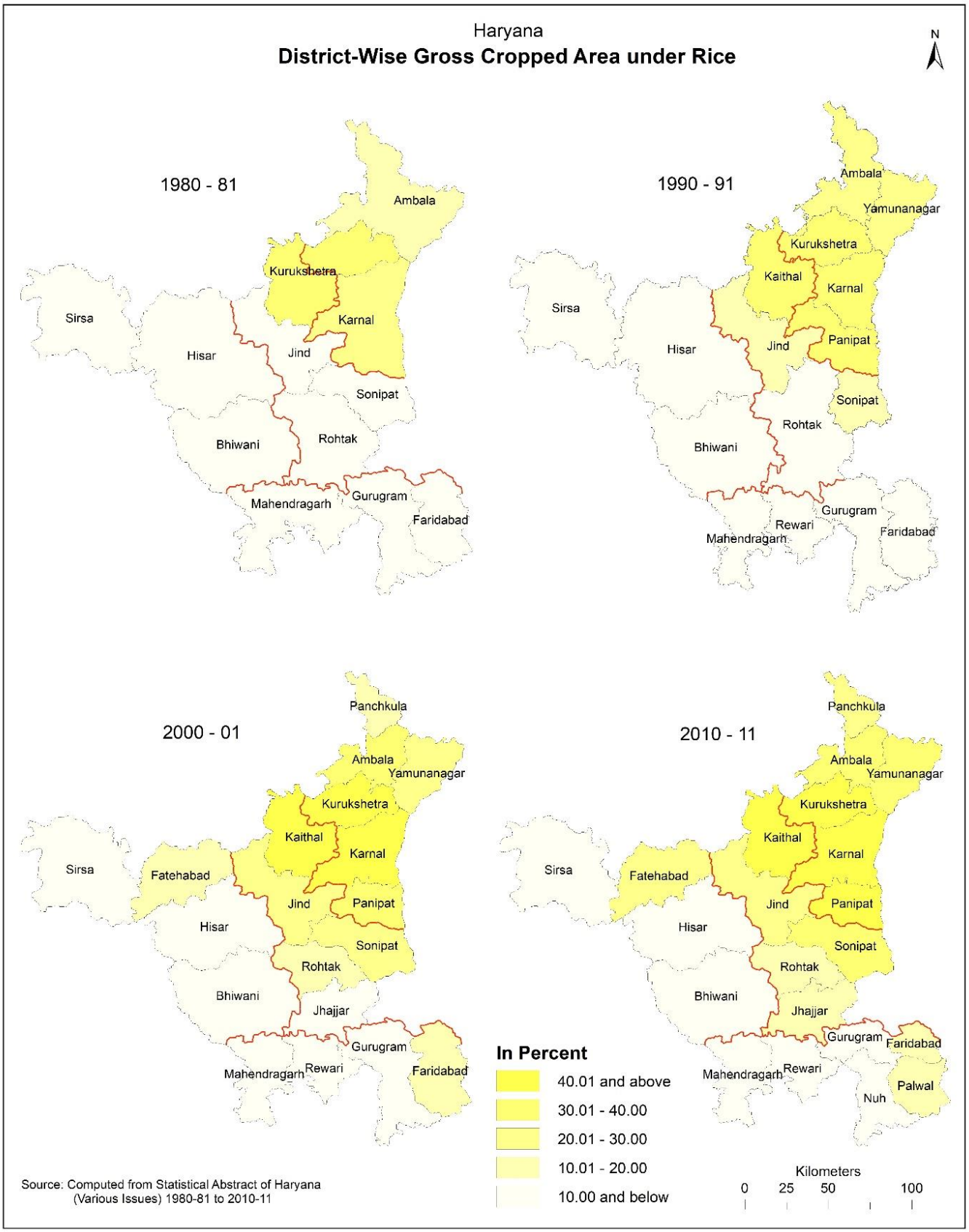


Fig. 5

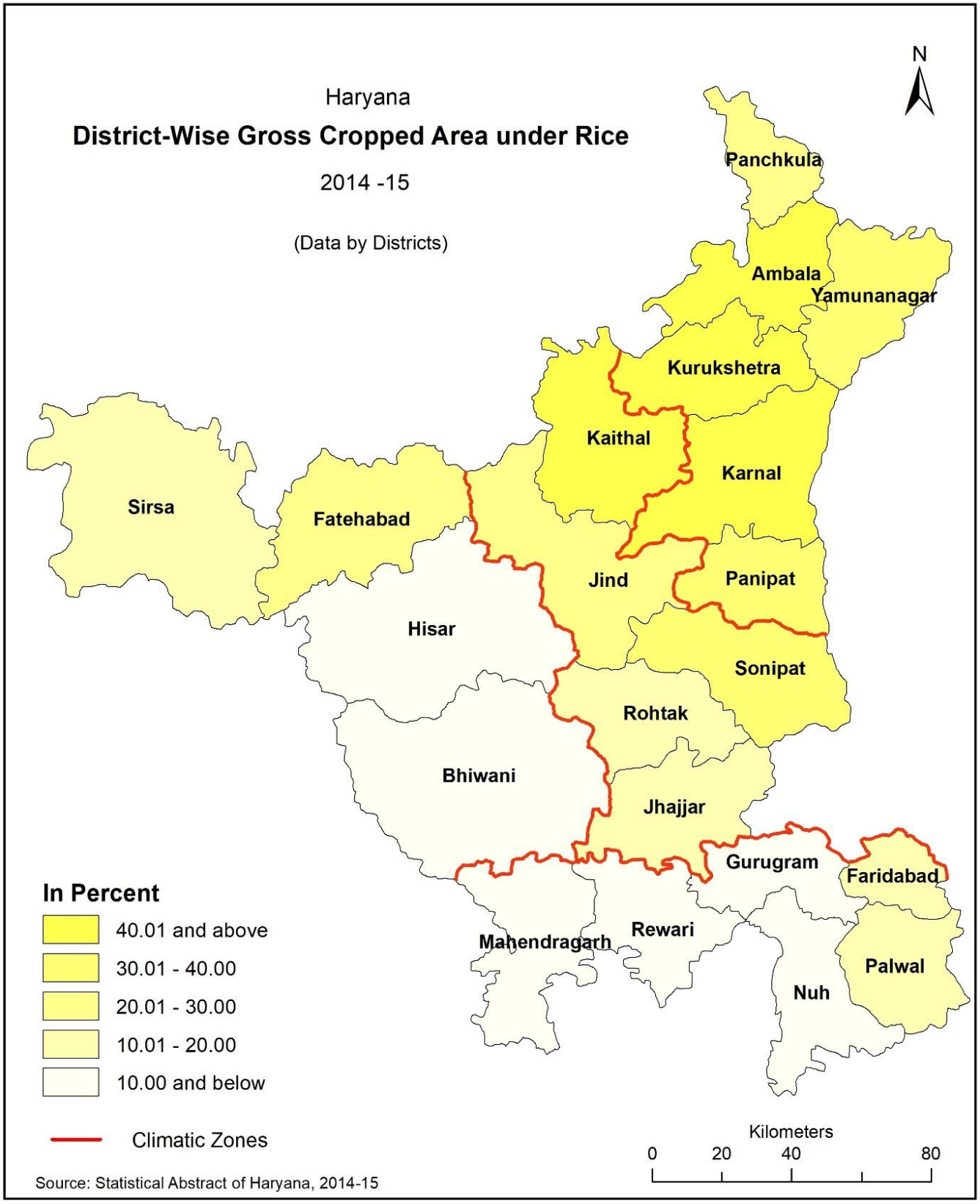


Fig. 6

All zones northern, central, southern, and western, have shown a consistent increase in area under rice, increase of 12.55 percent, 23.04 percent, 5.44 percent, and 7.63 percent points in the rice acreage from 1980-81 to 2014-15. In point of view of growth performance under rice cultivation, thenorthern zone shows the minimum growth rate of 1.08 percent per annum from 1980-81 to 2014-15. The central,

southern, and western zone show the highest growth of 5.07 percent per annum, 8.52 percent per annum, and 4.69 percent per annum in the corresponding period (table- 7). All districts of southern and western zone named Faridabad, Gurugram, Mahendragarh, Rewari, Palwal, Nuh, Bhiwani, Hissar, Sirsa, and Fatehabad show comparatively low areas under rice cultivation, but the growth rate is very high throughout the entire period from 1980-81 to 2014-15. Mahendragarh district shows the comparatively least cropped area under rice, throughout the entire study period about less than 500 hectares. The southern and western zones of the state have limited irrigation facilities. In 2014-15 all the districts except Palwal had shown an increase in area under rice cultivation. Palwal, since its inception, has shown a decline of 0.19 percentage points in the rice acreage. In the northern zone, the districts Ambala, Karnal, and Kurukshetra have shown a consistent increase in the rice area, an increase of 22.73 percent, 14.14 percent, and 13.27 percent points rice acreage from 1980-81 to 2014-15. The districts of Yamunanagar, Panipat, and Panchkula haveshown an unusual trend where the area under rice increased in 2010-11, but after that, it declined in 2014-15. The district Yamunanagar, Panipat, and Panchkula have shown an increase of 10.93 percent, 2.21 percent, and 6.72 percent points in the corresponding period's rice acreage. In the central zone, the districts Sonipat and Rohtak have shown a consistent increase in area under rice cultivation, an increase of 24.28 percent and 17.59 percent points in the rice acreage from 1980-81 to2014-15. The district Jhajjar since its inception has also shown a consistent increase of 7.47 percent points in an area under rice crop. The district Kaithal has shown an unusual trend where the area under rice increased in 2000-01, but after that, it had declined in 2010-11 and increased again in 2014-15. The district Jind has shown stagnation in the area under rice cultivation from 2000-01 to 2010-11, but after that, it increased in 2014-15. In the southern zone, the districts Faridabad and Gurugram have shown a consistent increase in area under rice cultivation increase of 17.99 percent and 4.61 percent points in the rice acreage from 1980-81 to 2014-15. Since its inception, the district Nuh has shown a slight increase of 0.25 percent in an area under rice crop. The district Rewari has shown an unusual trend where the area under rice increased in 2010-11, but after that, it slightly declined in 2014-15. The district Palwal since its inception, has shown a decline of 0.19 percentage points in the rice acreage. In the western zone, the districts Fatehabad, Sirsa, and Hissar have shown a consistent increase in area under rice, an increase of 8.23 percent, 7.23 percent, and 5.17 percent points in the rice acreage. The district Bhiwani has shown an unusual trend where the area under rice increased in 2010-11, but after that, it slightly declined in 2014-15. The Bhiwani district has shown aslight performance of 2.63 percent in rice acreage from 1980-81 to 2014-15. In 1980-81, the state reported only 484 thousand hectares under rice cultivation. This accounts for 8.86 percent of the totalgross cropped area. During this period, the important rice-growing district was Kurukshetra (32.15 percent), Karnal (29.98 percent), and Ambala (17.37 percent), occupying more than 17 percent of the total cropped area. The lowest area under rice cultivation was in Rohtak, Faridabad, Hissar, and Sirsa, i.e., below 4 percent. Gurugram, Mahendragarh, and Bhiwani district reported very negligible areas under rice crop. In 1990-91, the proportion of area under rice cultivation increased to 11.17 percent. The main concentration of rice cultivation was in the districts lying in northern and central regions. In 1990-91, Kurukshetra, Karnal, Kaithal, and Panipat ranked top in terms of the proportion of area under rice in the state. It occupied 39.73, 39.17, 31.51, and 31.19 percent of the total cropped area, occupying more than 30 percent of the total cropped area. In Sonipat and Jind districts, an area under rice cultivation accounted for 12.40 and 10.37 percent, respectively. In Rohtak, Faridabad, Gurugram, Hissar, and Sirsa, the rice occupied below 5 percent of the total cropped area. Mahendragarh, Rewari, and Bhiwani districts were non-rice growing districts till 1990-91. During 2000-01, 2010-11, and 2014-15, rice crops

came to occupy a second position among the cultivated crops in the state, occupying 17.24, 19.11, and 19.55 percent of total cropped area in the corresponding period. It was because of progress made in irrigation facilities of the state during the intervening period. During 2000-01 to 2014-15 Karnal, Kurukshetra, and Kaithal districts, rice occupied more than 40 percent of the total cropped area. It is pertinent to note that four districts named Karnal, Kurukshetra, Kaithal, and Panipat alone occupied about 50 percent of the total area devoted to rice cultivation in the state. Ambala is also a core rice-growing district, where rice crops occupied 36.00, 39.85, and 40.1 percent of total cropped area in the corresponding period. Other rice-growing districts are Yamunanagar, Sonipat, Rohtak, Jind, Fatehabad, Panchkula, and Faridabad. Throughout 2000-01 to 2014-15 areas under rice crop also increased in non-growing districts like Rohtak, Jhajjar, Sirsa, Hissar, Gurugram, Bhiwani, and Rewari districts. In the Bhiwani district, rice cultivation has been introduced at a limited scale in the canal irrigated areas in northern parts of the district (Neeraj, 2014). Mahendragarh district maintained its distinction of having no area under rice cultivation during the intervening period. Three major findings can be noted at this stage. Firstly, Karnal, Kurukshetra, and Kaithal have shown an enormous increase in the area under rice from 1980-81 to 2014-15. The remarkable rise in rice cultivation was made possible by increasing cropping intensity and also increases in the supply of assured water supply through an increase in tubewell irrigation, which is clearly reflected in the quantum jump in the tubewell irrigation in these districts in the same period from 63 percent, 82 percent and 44 percent to 83 percent, 100 percent and 96 percent. Secondly, central, southern and western zone show the highest growth rate of acreage under rice from 1980-81 to 2014-15 (5.07 percent, 8.52 percent, and 4.69 percent respectively), resulting in an increase in area under rice crop (table 7). Thirdly, in non-growing districts like Rohtak, Sonipat, Jind, Faridabad, and Sirsa, the area under rice not only increased, the crop combination region has also changed from wheat-jowar-bajra-gram-cotton (less water consuming) to wheat-rice (high water-consuming) combination (table 3). This rice area increase was mainly possible by replacing bajra, jowar, sugarcane, and gram crops.

Table: 7 Compound Growth Rates of Area Under Rice and Wheat in Haryana (1980-81 to 2014-15)

(In Percent)

Districts/Agro Climatic Zone			**Rice**		
	1980-81 to 1990-91	1990-91 to 2000-01	2000-01 to 2010-11	2010-11 to 2014-15	1980-81 to 2014-15
Northern Zone	1.62	1.65	0.76	-0.22	1.08
Central Zone	10.13	6.90	0.52	0.49	5.07
Southern Zone	10.80	14.84	4.20	0.41	8.52
Western zone	4.14	8.09	3.07	1.20	4.69
Haryana	**2.34**	**4.44**	**1.04**	**0.23**	**2.29**
			Wheat		
Northern Zone	0.39	0.05	0.48	0.17	0.31
Central Zone	2.05	1.11	0.09	0.50	1.07
Southern Zone	-0.63	2.91	-0.73	0.29	0.51
Western zone	4.14	4.45	-0.01	0.67	2.63
Haryana	**1.45**	**2.11**	**-0.01**	**0.44**	**1.14**

Source: Computed from Table: 6

Wheat is the major rabi crop in Haryana. It occupied as much as 27.07 percent of the total cropped

area in 1980-81, which increased to 40.21 percent in 2014-15. The additional area under wheat was made possible by the substitution of other competing rabi crops. The maximum growth rate for the area under wheat crop, i.e., 2.11 percent in Haryana, has been recorded from 1990-91 to 2000-01. A slightly negative growth rate for the area under wheat crop, i.e., 0.01 percent in Haryana, has been recorded from 2000-01 to 2010-11.

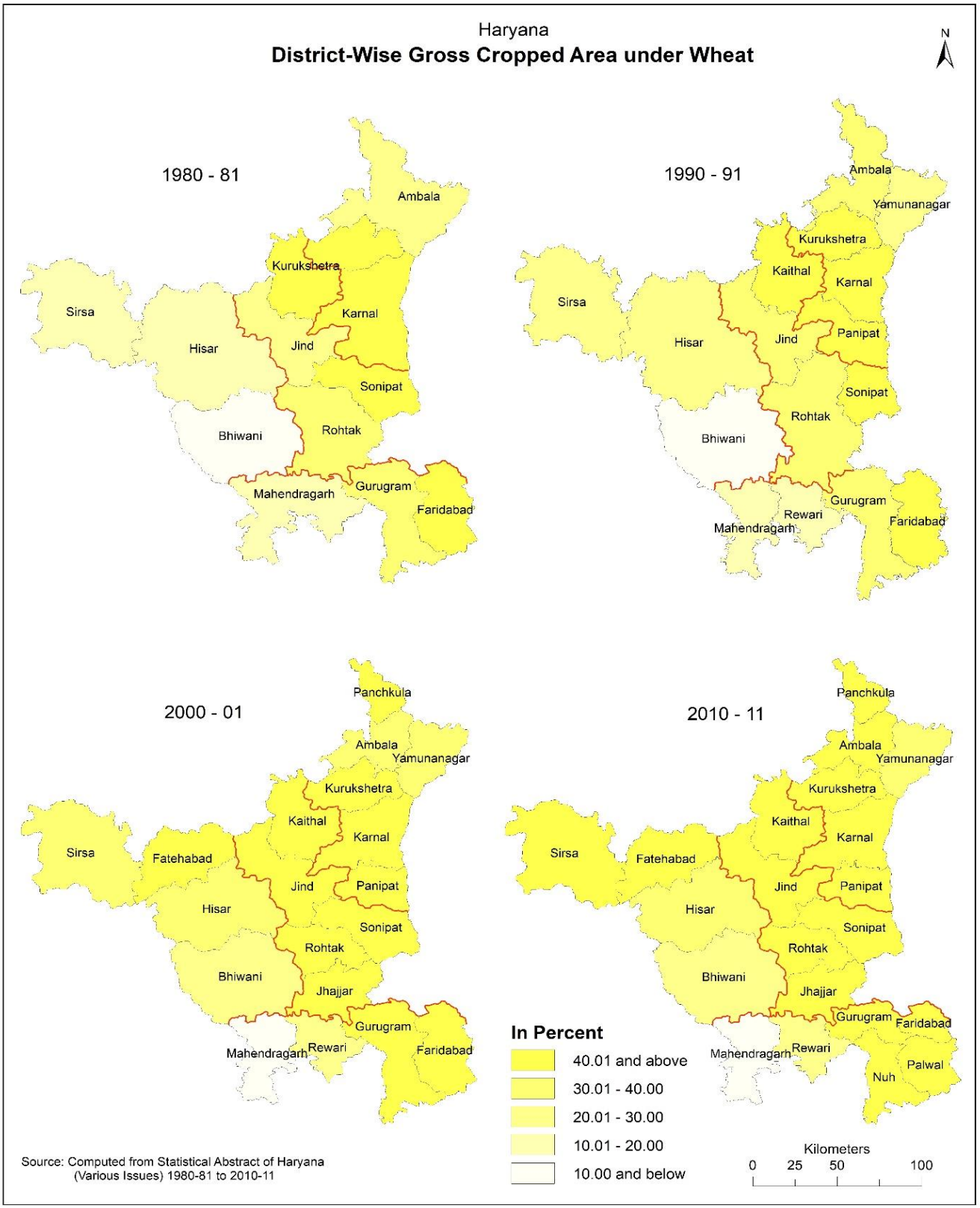


Fig. 7

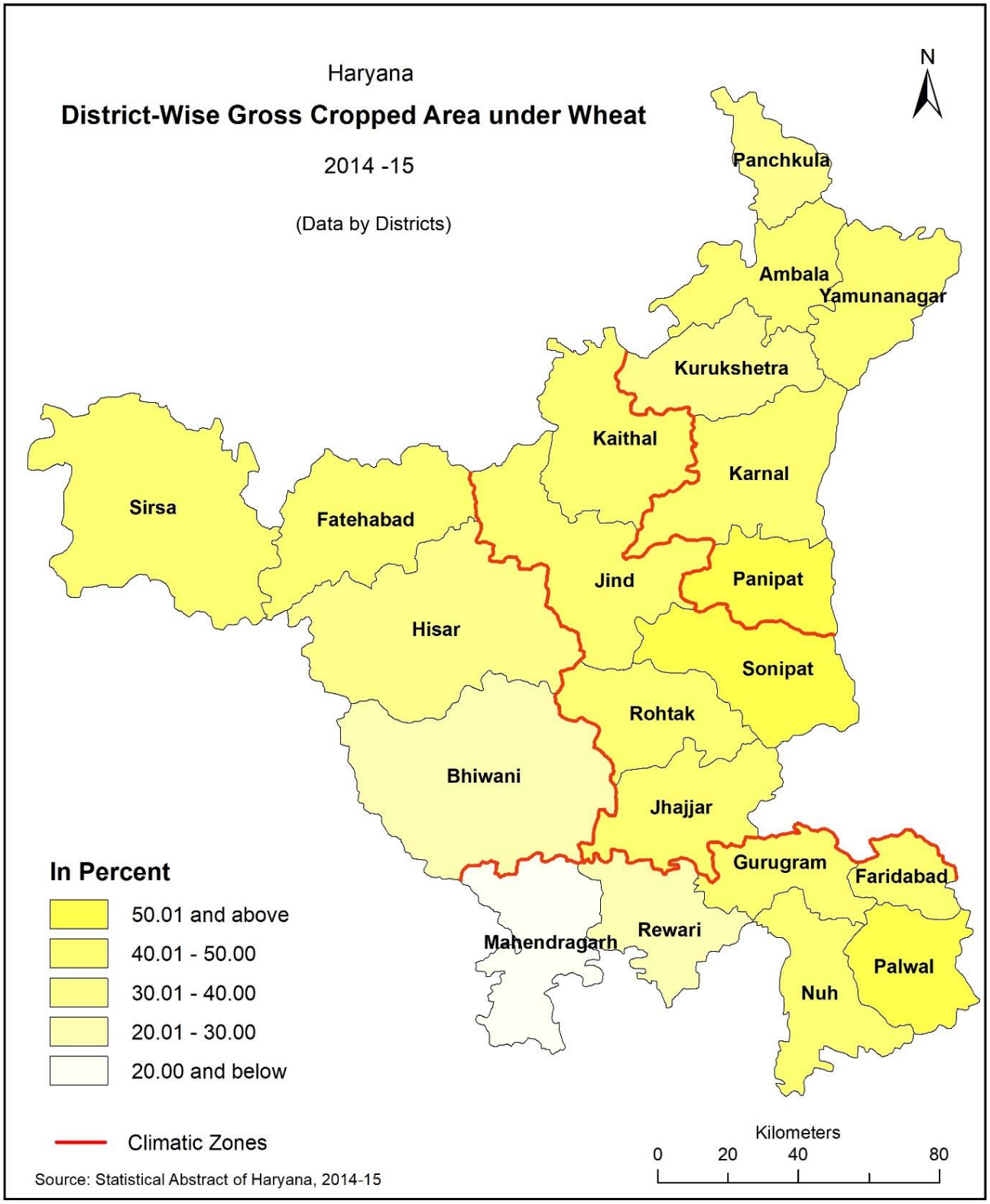


Fig. 8

The growth rate of area under wheat crop is stagnated from 2000-01 onwards, and it is interesting to note that the proportion of area under wheat crop has also stagnated after 2000-01 (table- 7). Figure-7 and 8 reveals that the wheat cultivation is mainly concentrated in the northern and central zone districts, throughout the entire period from 1980-81 to 2014-15. It includes the districts of Ambala, Kurukshetra, Karnal, Yamunanagar, Panipat, Sonipat, Rohtak, Jind, Kaithal, and Jhajjar. Two districts of the southern zone, named Faridabad and Gurugram, are also principal wheat cultivated

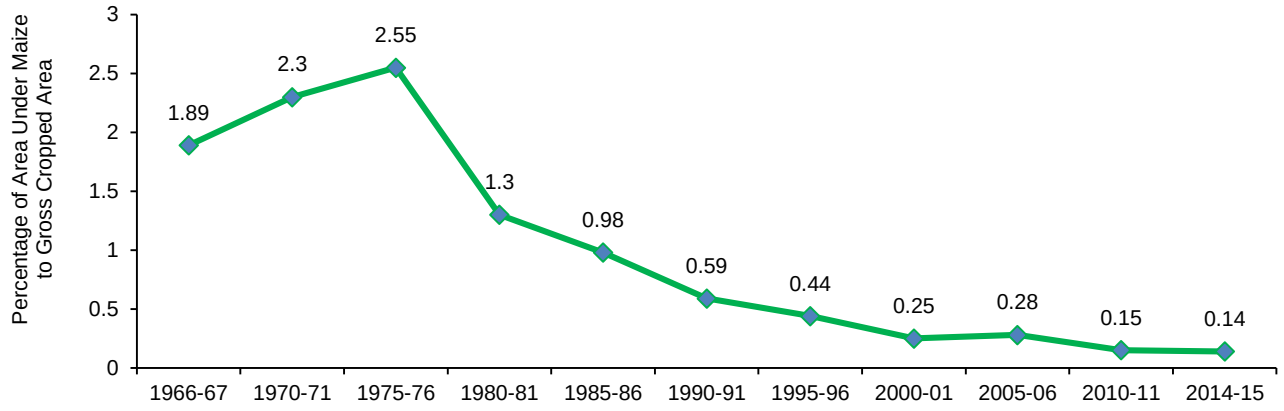
areas throughout the entire period. Mostly southern and western zone districts named Mahendragarh, Rewari, Palwal, Nuh, Bhiwani, Hissar, and Sirsa show comparatively least areas under wheat cultivation than northern and central zone districts. The northern zone and central zone have shown a consistent increase in area under wheat, an increase of 4.49 percent and 14.77 percent points in the wheat acreage from 1980-81 to 2014-15. The southern zone showed an unusual trend where the area under wheat increased in 2000-01, but after that, it declined in 2010-11. The western zone is shown stagnation from 2000-01 to 2010-11, but the western zone showed an increase of 21.55 percent point in the wheat acreage from 1980-81 to 2014-15, which is the highest in all zones. In point of view of growth performance under wheat cultivation, the northern and southern zone shows the minimum growth rate of 0.31 percent per annum and 0.51 percent per annum from 1980- 81 to 2014-15. The central and western zone shows the better performance of 1.07 percent per annum and 2.63 percent per annum compared to the northern and southern zone in the corresponding period (table- 7). Although acreage under wheat has almost stagnated at the state level after 2000-01, it shows many variations at the district level. In the northern zone, Ambala and Yamunanagar's districts have shown a consistent increase in wheat while Karnal district shows stagnation with the least fluctuation in the whole study period. The districts of Kurukshetra, Panipat, and Panchkula haveshown an unusual trend. Ambala, Yamunanagar, and Panipat's districts have increased 12.93 percent, 12.62 percent, and 5.86 percent in the wheat acreage from 1980-81 to 2014-15. Kurukshetra and Panchkula's districts have recorded a decline of 3.11 percent and 1.98 percent points in the wheat cultivation in the corresponding period. In the central zone, Rohtak and Jind's districts have shown a consistent increase in area under wheat, while Sonipat, Kaithal, and Jhajjar have shown an unusual trend. In Jhajjar, the area under wheat declined in 2010-11, but after that, it increased in 2014-15. Rohtak and Jind's districts have shown an increase of 17.03 percent and 18.73 percent points in the wheat cultivation from 1980-81 to 2014-15. In the southern zone, the districts of Palwal and Nuh since its inception have shown a consistent increase in area under wheat while Faridabad, Gurugram, Mahendragarh, and Rewari have shown an unusual trend, where the area under wheat has an increase in 2000-01, but after that, they have declined in 2010-11 and again increase in 2014-15. In the southern zone, only Gurugram district shows better performance of 12.71 percent points in the Wheat cultivation from 1980-81 to 2014-15. The only Mahendragarh district has shown a slight decline of 0.41 percent points in the wheat cultivation in the corresponding period. In the western zone, the districts of Bhiwani, Sirsa, and Fatehabad have shown a consistent increase in area under wheat while Hissar district has shown an unusual trend where the area under wheat has an increase in 2000-01, but after that, it has declined in 2010-11 and again increase in 2014-15. Bhiwani, Sirsa, and Hissar's districts have shown an increase of 20.82 percent, 22.73 percent, and 17.39 percent points in the wheat acreage from 1980-81 to 2014 15, which is the highest growth performance in the state. The district of Fatehabad has shown a slight increase of 1.94 percent point in wheat cultivation. In 2014-15 mostly districts except Kurukshetra, Panchkula, Kaithal, and Mahendragarh had shown an increase in area under wheat cultivation. Kurukshetra, Panchkula, Kaithal, and Mahendragarh have shown a decline of 3.11 percent, 1.98 percent, 0.6 percent, and 0.41 percent, respectively. The overall analysis of the trend in the area under the two most important crops in Haryana, i.e., rice and wheat, reveals that the green revolution gave a boost to the growth of area under these two crops by replacing other coarse cereals and pulses. The rice crop area continued to gain rapidly while the wheat crop stabilized after the period of rapid growth. It is evident that at the state level area under wheat has stabilized, whereas the area under rice is still increasing but at a comparatively slower rate. Four districts

named Kurukshetra, Panchkula, Kaithal, and Mahendragarh have shown a decline in wheat coverage; none shows a decline in rice cultivation area.

Shifts towards Rice-Wheat Crop Combination: Analysis of Decline in Area under Coarse Cereals, Pulses and Oilseeds

The coarse cereals mainly comprise kharif crops like jowar, bajra, and maize and rabi crop like barley. The coarse cereals' comparative economics in the context of shifts in technology and improvements of irrigation and other input facilities lagged much behind the wheat-rice rotation. As has already been discussed in the previous section, rice and wheat crops have replaced the kharif and rabi season's coarse cereals in the wake of the green revolution. The present section deals with the trends in the area under the coarse cereals. Maize has been the most important coarse cereal crop in the state. Being a kharif crop, it faces competition from rice, and after the wake of the green revolution, it is maize which has got mostly replaced by rice in mainly in northern zone districts. Despite the major shifts, it is the third crop in the district of Ambala and Panchkula (table- 3).

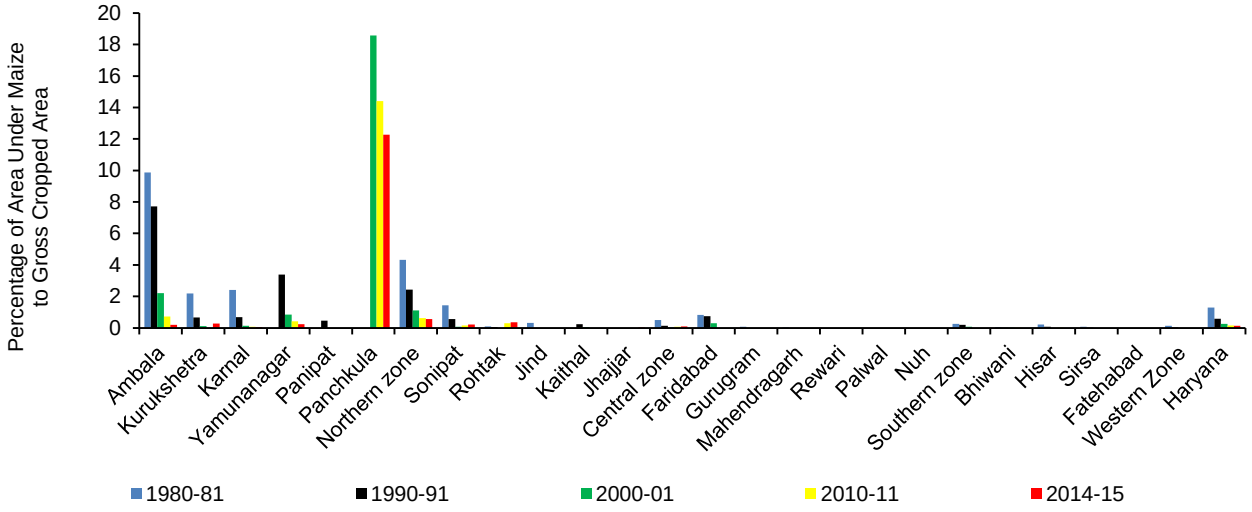
Trends in Area Under Maize in Haryana (1966-67 to 2014-15)



Source: Computed from Statistical Abstract of Haryana (Various Issues) 1966-67 to 2014-15

Fig. 9

District-Wise Area Under Maize in Haryana (1980-81 to 2014-15)

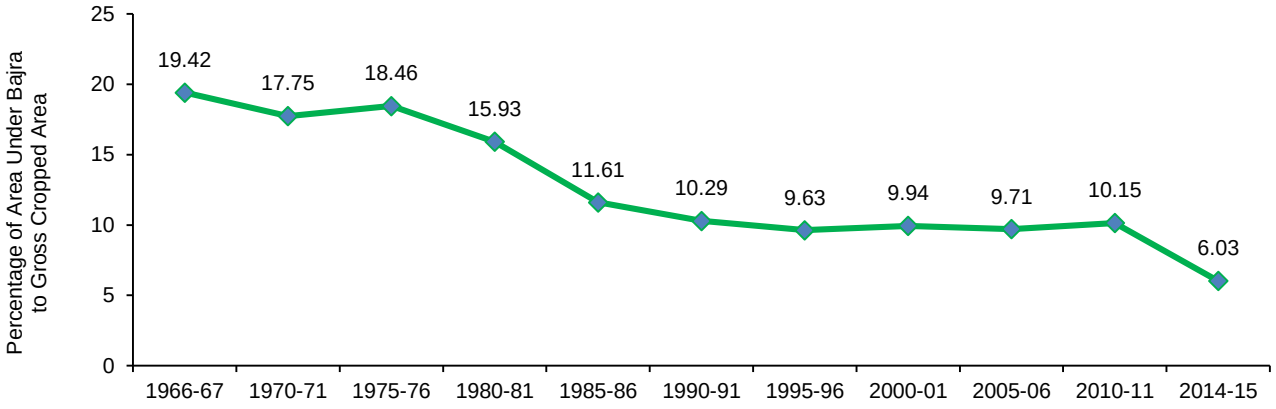


Source: Computed from Statistical Abstract of Haryana (Various Issues) 1980-81 to 2014-15

Fig. 10

Figure 9 shows the trends in an area under the maize crop in Haryana. In 1966-67, about 1.89 percent of the gross cropped area was under maize cultivation, which further declined to about 0.14 percent in 2014-15. The major decline in the acreage under the maize crop started in 1980-81, and instead, the acreage became constant after 1990-91 with minor fluctuation in the last twenty-five years. The district-wise and zone-wise area under maize shows the same trend, which is depicted in figure 10. Figure 10 shows that the maize cultivation was mainly concentrated in the northern zone. The highest decline has been noted in the northern zone, about 3.76 percent points in the maize cultivation from 1980-81 to 2014-15. The major shift in maize acreage has been noticed in the northern zone districts named Ambala, Kurukshetra, and Karnal, where the acreage has declined from 9.87 percent, 2.19 percent, 2.41 percent in 1980-81 to 0.19 percent, 0.28 percent, and 0.05 percent in 2014-15. From its inception, the Panchkula district is the high maize cultivated area in the state, but it also shows a consistent decline of 6.31 percent points in the maize cultivation from 2000-01 to 2014-15. Panipat district has virtually no area under maize cultivation after 2000-01. In the central zone, Sonipat and Rohtak have shown a slight increase after 2000-01. Jind district has virtually no area under maize cultivation after 1990-91. The negligible area under maize cultivation is recorded in the mostsouthern and western zone districts from 1980-81 to 1990-91; after that, these districts have virtually no area under maize cultivation.

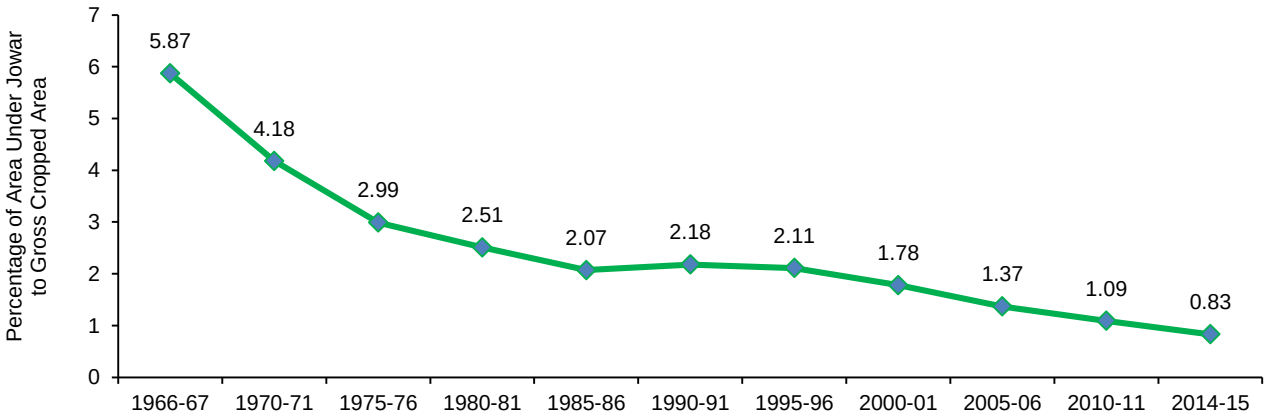
Trends in Area Under Bajra in Haryana (1966-67 to 2014-15)



Source: Computed from Statistical Abstract of Haryana (Various Issues) 1966-67 to 2014-15

Fig. 11

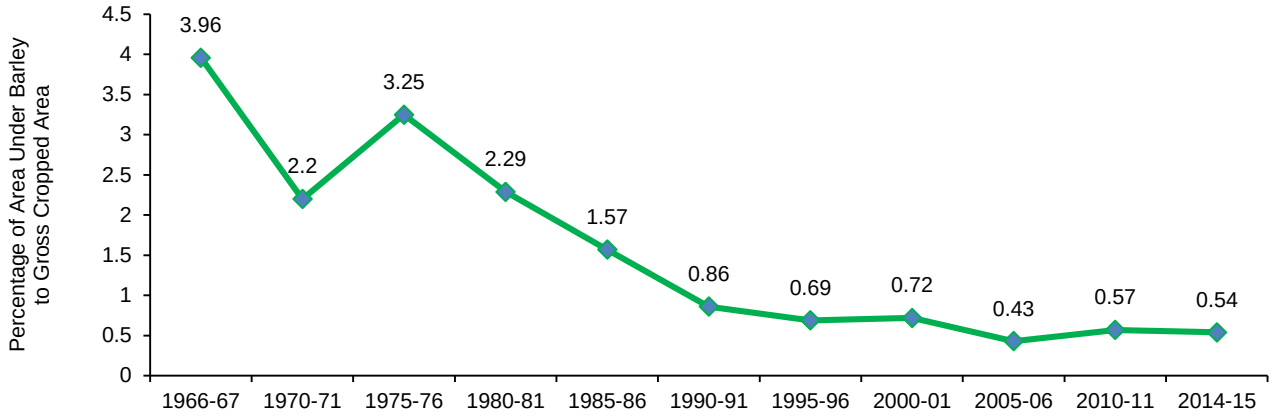
Trends in Area Under Jowar in Haryana (1966-67 to 2014-15)



Source: Computed from Statistical Abstract of Haryana (Various Issues) 1966-67 to 2014-15

Fig. 12

Trends in Area Under Barley in Haryana (1966-67 to 2014-15)

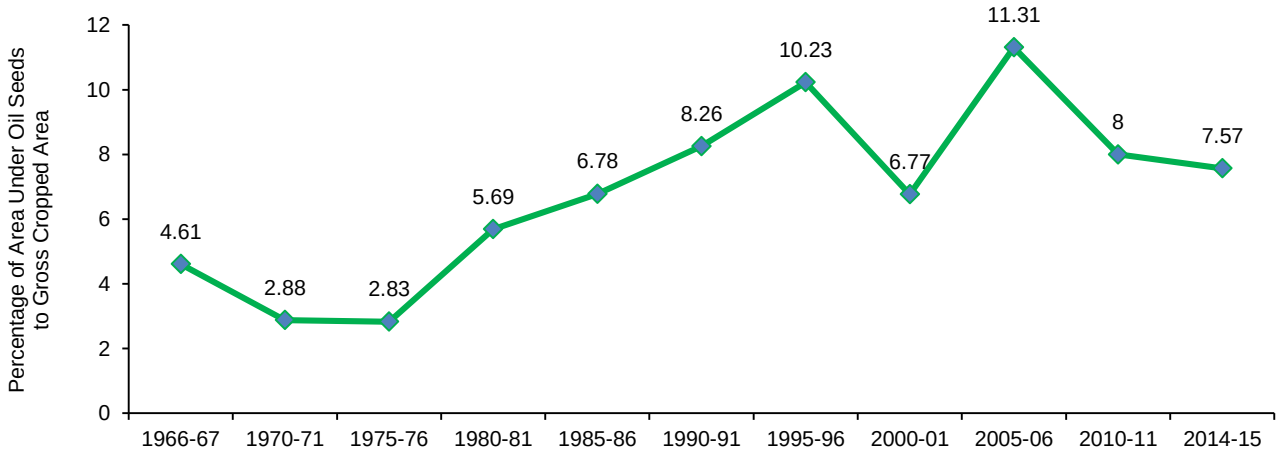


Source: Computed from Statistical Abstract of Haryana (Various Issues) 1966-67 to 2014-15

Fig. 13

The area under other coarse cereals, i.e., bajra, jowar, and barley, has been shown in figures 11, 12, and 13. Among these three crops, barley is the least cultivated crop in Haryana, covering less than 3.96 percent of the gross cropped area. Bajra and jowar used to cover about 19.42 percent and 5.87 percent of the gross cropped area in 1966-67, but gradually the acreage of both the crops consistently declined over time. Bajra and jowar were replaced by rice crop while barley by wheat crop. The decline was sharper in the case of jowar than that of barley, wherein 2014-15, the acreage under Jowar is about 0.83 percent, and that of barley is 0.54 percent. The oilseeds mainly comprise mustard, rapeseed, groundnut, sesamum, sunflower, and linseed. In the wake of the emerging agricultural crisis in Haryana's state due to its future sustainability problems of the wheat-rice cropping cycle, the Johl Committee had suggested a policy of agricultural diversification to shift away from such specialized cropping pattern as it has its own disadvantages. This committee had recommended oilseeds as one of the crops to which the farmers could diversify (Sharma and Singh, 2013).

Trends in Area Under Oil Seeds in Haryana (1966-67 to 2014-15)

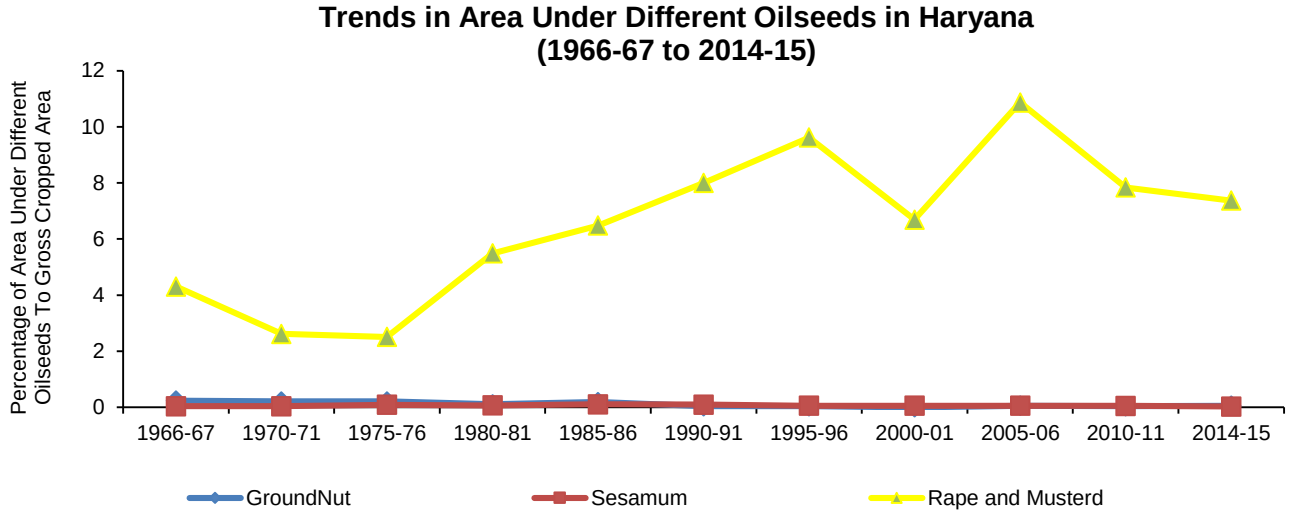


Source: Computed from Statistical Abstract of Haryana (Various Issues) 1966-67 to 2014-15

Fig. 14

The trend in an area under total oilseeds in Haryana has been shown in figure- 14. At the state level,

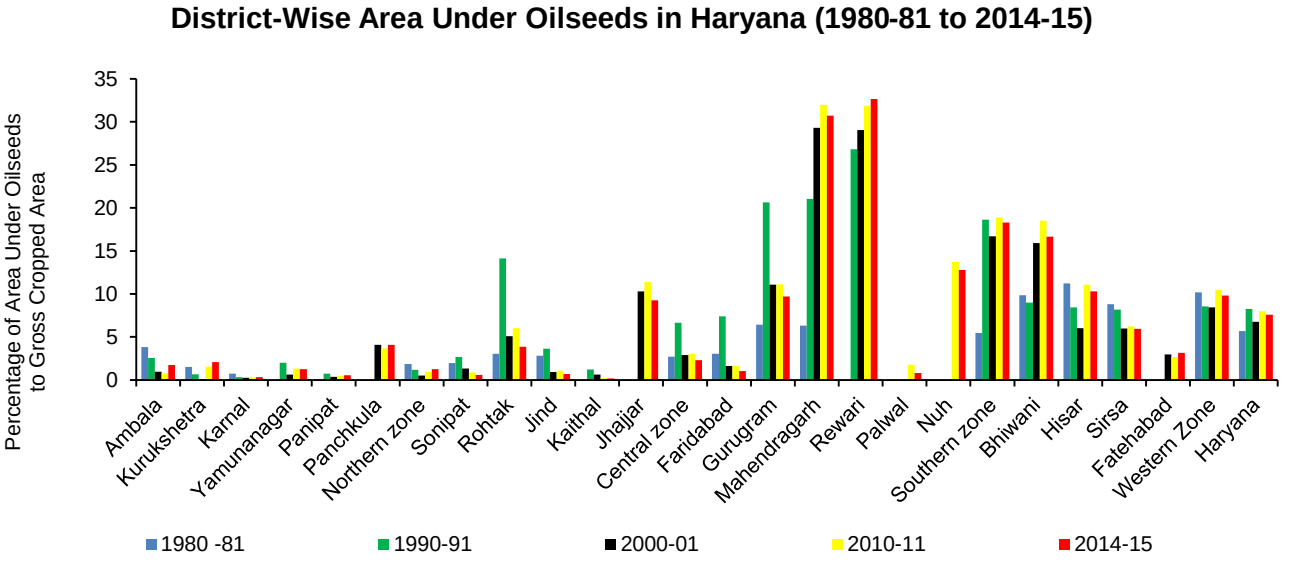
it is seen that the area under total oilseeds has been fluctuating trend. In 1966-67, the area under oilseeds to the gross cropped area was about 4.61 percent and reduced to 2.83 percent in 1975-76, and after that, it has shown an increasing trend to 1995-96, increased about 10.23 percent. Again in 2000-01 is reduced to 6.77 percent and again increased in 2005-06 about 11.31 percent, and after that, it has shown decreasing trend to till 2014-15. The trend in the acreage of different oilseeds shows that the most widely grown oilseeds in the state are rape and mustered, followed by groundnut and sesamum (figure-15).



Source: Computed from Statistical Abstract of Haryana (Various Issues) 1966-67 to 2014-15

Fig. 15

The area under rape seeds and mustered shows a very fluctuating trend throughout the entire period from 1966-67 to 2014-15. In 1966-67, the area under rape seeds and mustered to the gross cropped area was about 4.31 percent and reduced to 2.51 percent in 1975-76, and after that, it has shown an increasing trend to 1995-96, increased about 9.62 percent. Again in 2000-01 is reduced to 6.69 percent and again increased in 2005-06 about 10.87 percent, and afterthat, it has shown decreasing trend to till 2014-15. Groundnut and sesamum have shown an interesting trend where the acreage has almost negligible and remained constant throughout theentire period from 1966-67 to 2014-15.

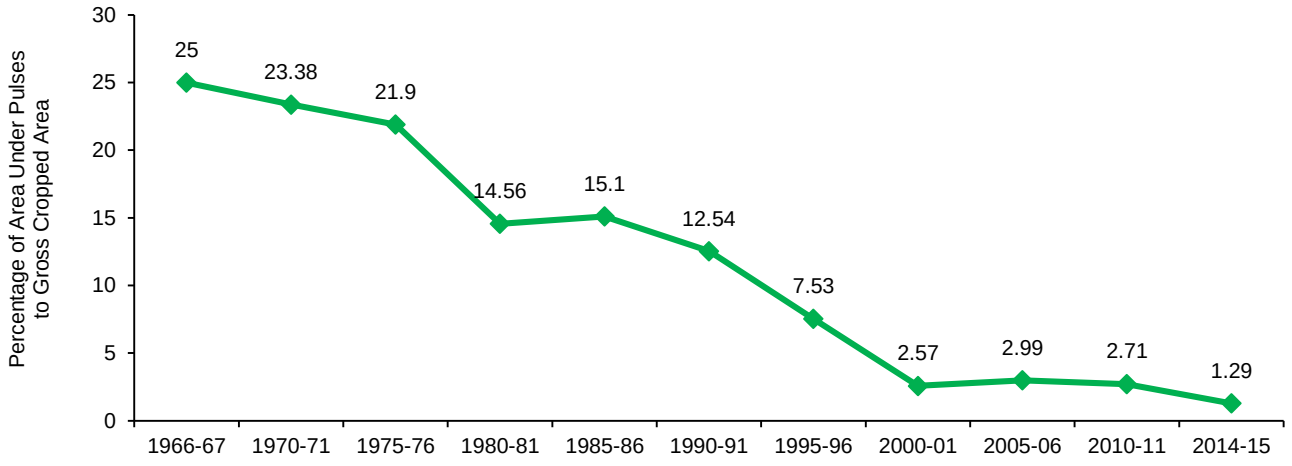


Source: Computed from Statistical Abstract of Haryana (Various Issues) 1980-81 to 2014-15

Fig. 16

Figure- 16 reveals that the oilseeds cultivation is mainly concentrated in the southern and western zone districts, throughout the entire period from 1980-81 to 2014-15. It includes the districts of Gurugram, Mahendragarh, Rewari, Nuh, Bhiwani, Hissar, and Sirsa. Mostly districts of northern and central zone named Ambala, Kurukshetra, Karnal, Yamunanagar, Panipat, Panchkula, Sonipat, Jind, and Kaithal shows comparatively least areas under oilseeds as compare to southern and western zone districts. It is noted that in most districts, the area under oilseeds has been fluctuating except Karnal, Kaithal, Mahendragarh, and Rewari, where Karnal and Kaithal districts have recorded a slightly decreasing trend, and Mahendragarh and Rewari districts have recorded increasing trend.

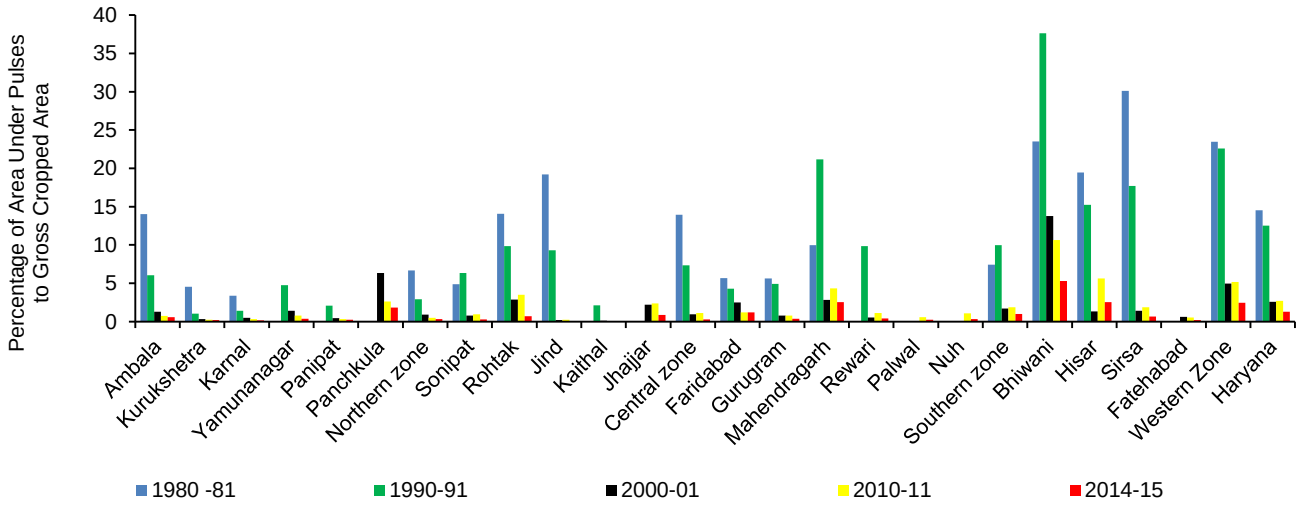
Trends in Area Under Pulses in Haryana (1966-67 to 2014-15)



Source: Computed from Statistical Abstract of Haryana (Various Issues) 1966-67 to 2014-15

Fig. 17

District-Wise Area Under Pulses in Haryana (1980-81 to 2014-15)



Source: Computed from Statistical Abstract of Haryana (Various Issues) 1980-81 to 2014-15

Fig. 18

Mahendragarh and Rewari districts have recorded a comparatively higher area under oilseeds throughout the entire period, where the acreage under oilseeds has increased from 6.32 percent and 26.80 percent to 30.73 percent and 32.64 percent in 1980-81 and 2014-15 respectively. Like the coarse cereals and oilseeds, the pulses also got replaced in the wake of the green revolution by wheat and rice. Pulses are leguminous crops that fix nitrogen for their requirement and do not respond to

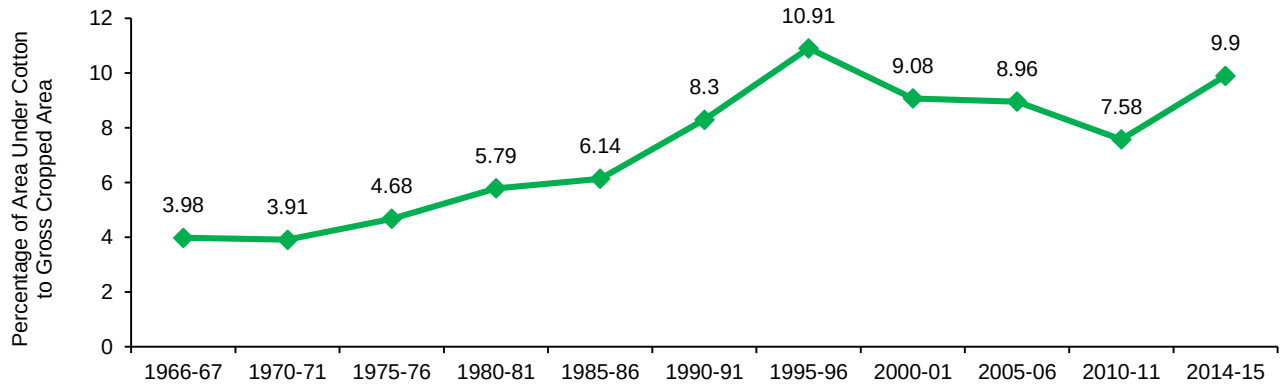
high doses of fertilizers giving high yields like the other cereals crops. This was thereason why pulses got neglected in the period of the green revolution, and farmers shifted towards cereals from pulses to obtain higher yields. It has been a fact that pulses have suffered a major setback at the country level, and their acreage has decreased tremendously. The acreage under pulses has declined from about 25 percent in 1966-67 to about 1.29 percent in 2014-15 (figure- 17).

The district-wise and zone-wise area under pulses shows the same trend, which is depicted in figure 18. Figure shows that the pulses cultivation was mainly concentrated in western zone districts. It has been seen that the area under pulses has been declining consistently in all the districts, and in the year 2014-15 most districts show less than 1 percent of their gross cropped area under pulses cultivation, except five districts named Panchkula, Faridabad, Mahendragarh, Bhiwani, and Hissar. The districts of Panchkula, Rohtak, Faridabad, Mahendragarh, Bhiwani, Hissar, and Sirsa have recorded a comparatively higher area under pulses, but all have recorded a decline in an area over time. Jind and Kaithal districts have virtually no area under pulses cultivation after 2010-11. The maximum area under pulses in 1980-81 was recorded in Sirsa with an area of 30.11 percent, but within thirty-five years, the acreage came down to 0.65 percent in 2014-15, and the shift has been mainly towards wheat-cotton-rice and, to some extent rapeseed and mustard (table 3). In all the districts, the area under pulses has been declining over time.

Area under Cotton and Sugarcane

After wheat and rice, the third most widely grown crops in Haryana are cotton. In the last twenty years' acreage under cotton has been decreasing. Cotton being a kharif crop, faces competition from rice. The cotton growing belt in Haryana comprises the districts of Bhiwani, Hissar, Fatehabad, Sirsa, and Jind. The trend in an area under cotton cultivation has been showing (figure- 19) an increasing trend from 1966-67 to 1995-96, but after that, it has shown a decreasing trend over the last twenty years. The reason has been the attack of the American Bollworm on the cotton crop. The farmers, on account of unstable yields, shift to rice cultivation. Nevertheless, since underground water is brackish in this belt, it becomes a limiting factor for rice cultivation.

Trends in Area Under Cotton in Haryana (1966-67 to 2014-15)



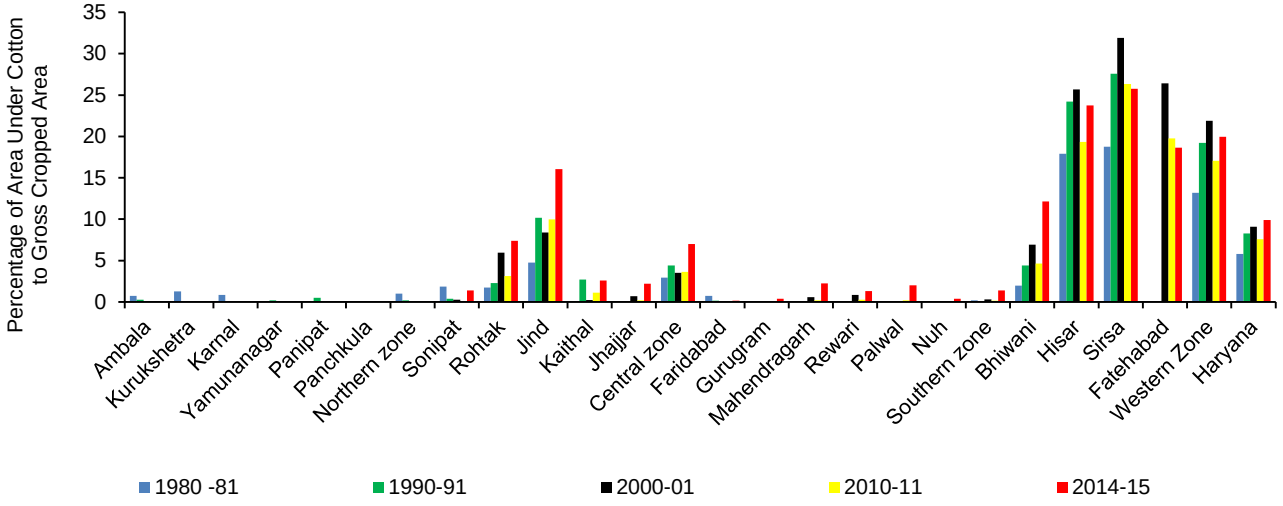
Source: Computed from Statistical Abstract of Haryana (Various Issues) 1966-67 to 2014-15

Fig. 19

Figure 20 shows that the cotton cultivation is mainly concentrated in the western zone (Sirsa, Hissar, Fatehabad, and Bhiwani) followed by the central zone (Rohtak and Jind). In the central zone, the main cotton cultivation is recorded in Rohtak and Jind districts. Other central zone districts named Sonipat, Kaithal, and Jhajjar recorded the least cotton cultivation over time. The negligible area

under cotton cultivation is recorded in the most northern and southern zone districts. In the northern zone, the negligible area under cotton cultivation is recorded from 1980-81 to 1990-91; after that, these districts have virtually no area under cotton cultivation. The area under cotton at the district level (figure- 20) shows that in the cotton-growing belt, the districts with the maximum area under cotton cultivation is Sirsa, followed by Hissar, Fatehabad, Jind, and Bhiwani. Cotton is the most important crop in Sirsa, having a maximum area under cotton, while it is the second most important crop in Hissar and the third most important crop in Bhiwani and Fatehabad district. In Fatehabad, the cotton used to be the third most important crop according to the crops' acreage, but in the last fifteen years, it has become the third most important crop as rice has occupied the second place (table 3). Cotton cultivation has been declining in the northern zone districts as they have shifted to the specialization in wheat-rice crop rotation. Cotton cultivation has been sharply increasing in the district of Rohtak, Jind, and Bhiwani from about 1.73 percent, 4.74 percent, and 1.96 percent of gross cropped area in 1980-81 to 7.39 percent, 16.05 percent and 12.14 percent of gross cropped area in 2014-15.

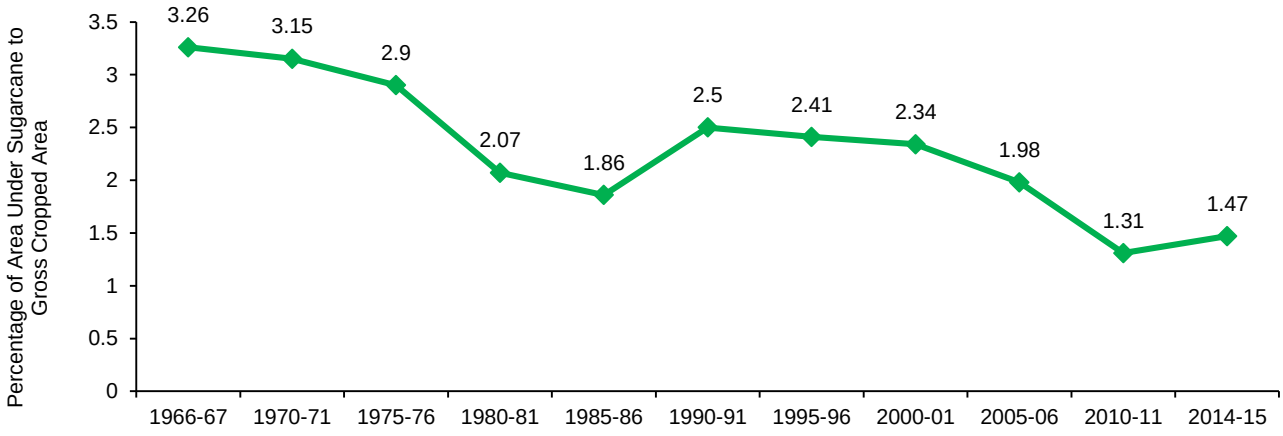
District-Wise Area Under Cotton in Haryana (1980-81 to 2014-15)



Source: Computed from Statistical Abstract of Haryana (Various Issues) 1980-81 to 2014-15

Fig. 20

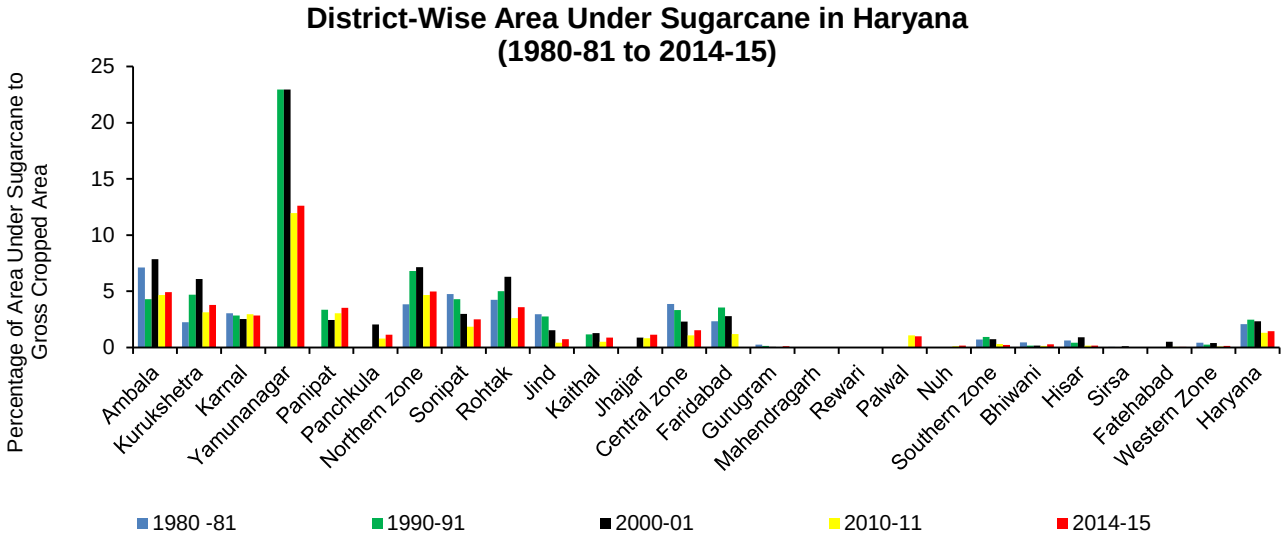
Trends In Area Under Sugarcane In Haryana (1966-67 to 2014-15)



Source: Computed from Statistical Abstract of Haryana (Various Issues) 1966-67 to 2014-15

Fig. 21

Sugarcane is an annual crop (Shukla, et al. 2017) that has been gaining acreage in the state of Haryana. Nevertheless, the area under sugarcane has fluctuated in the state from 1966-67 to 2014-15 (figure 21). In 1966-67, the area under sugarcane to gross cropped area was about 3.26 percent and reduced to 1.86 percent in 1985-86. This was due to the unremunerative price for this crop, particularly in non-sugar mill areas. After that area under sugarcane is likely to rise again in 1990-91 increased about 2.5 percent, with its support price being enhanced and opening up of more sugar mills in the state. Again in 1995-96 it slightly reduced to 2.41 percent and after that, it has shown decreasing trend to till 2010-11. In 2014-15 it slightly increased to 1.47 percent. Nevertheless, overall it has declined from about 3.26 percent of gross cropped area in 1966-67 to 1.47 percent of gross cropped area in 2014-15.



Source: Computed from Statistical Abstract of Haryana (Various Issues) 1980-81 to 2014-15

Fig. 22

Figure 22 shows that the sugarcane cultivation is mainly concentrated in the northern zone (Yamunanagar, Ambala, Kurukshetra, Karnal, and Panipat) followed by the central zone (Rohtak, Sonipat, and Jind). Kurukshetra district is the highest sugarcane cultivated area over time. In the central zone, the main sugarcane cultivation is recorded in Rohtak, Sonipat, and Jind districts. Other central zone districts named Kaithal and Jhajjar recorded the least sugarcane cultivation over time. The districts where a meager percentage of area is under sugarcane cultivation are the cotton belt districts (western zone), i.e., Bhiwani, Hissar, Sirsa, and Fatehabad. Another negligible acreage under sugarcane is the southern zone, where two districts named Mahendragarh and Rewari have virtually no area under sugarcane cultivation over time. Sugarcane cultivation has been sharply declining in the district of Ambala as it has shifted to the specialization in wheat-rice crop rotation. Sugarcane was the second most widely cultivated crop in Yamunanagar district in 1980-81, but from 1990-91 it became a wheat-rice cropping district; after 1990-91, it has become the third most important crop. Sugarcane was the main crop in Rohtak and Sonipat district from 1980-81 to 1990-91, but after that, these districts have shifted to the specialization in wheat-rice crop rotation. After the green revolution, the area under rice and wheat increased, and inevitability, the area under the other competing crops, declined. Under such circumstances, the cultivation of sugarcane is gaining importance in the recent period primarily because of the installation of sugar mills in the state. Moreover, net returns per hectare of sugarcane cultivation are comparatively higher than rice and wheat. Nevertheless, since the government does not give MSP for sugarcane, the farmers sell it to the

mill owners. The mill owners do not readily pay for the sugarcane, and the delay is sometimes up to one year. In such a situation, the farmers find it unviable as they have to wait for payments. On the other hand, rice has assured the market and hence assured profitability due to government support. So despite higher profitability, sugarcane is not preferred by the farmers over rice. In the areas where water availability is a limiting factor, farmers resort to sugarcane cultivation as it is comparatively less water-intensive than rice. With appropriate government policies of an assured market for sugarcane, the crop can gain further significance in the state with time.

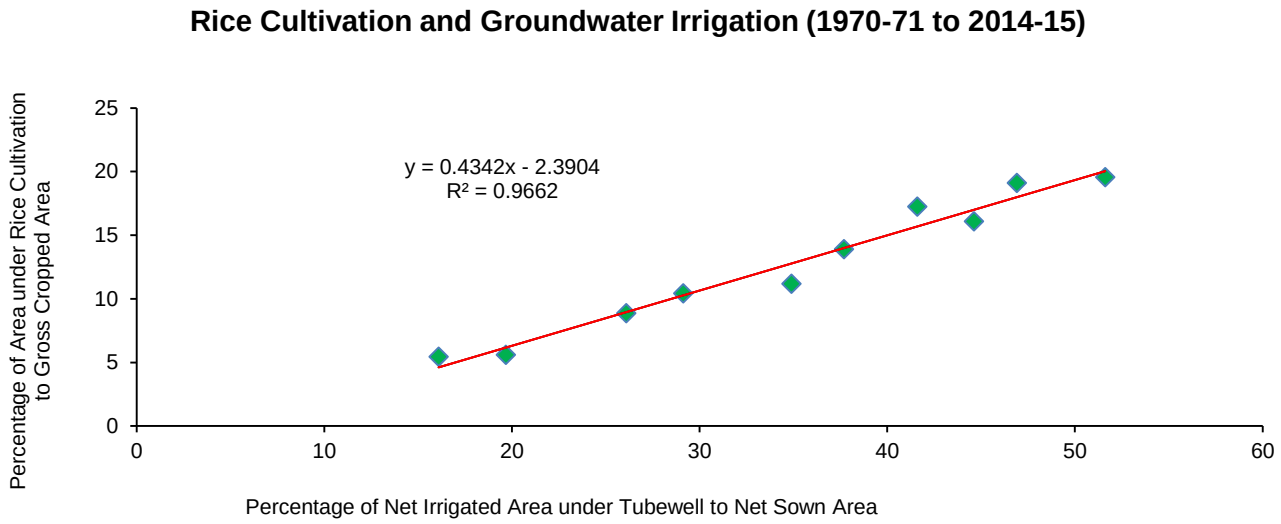
Interrelationship between Increasing Demands of Irrigation Water and Increase in Groundwater irrigation

The analysis of the changing structure of irrigation and shift in cropping pattern gives rise to two corresponding facts. First is the increase in demand for water with an increase in rice cultivation. Secondly, this increase in demand for water is increasingly met by groundwater irrigation as water availability in the canals has declined on account of low maintenance. The tubewells have their own set of advantages regarding the flexibility and reliability of irrigation. In this section, an attempt has been made to see how an increase in rice cultivation has also led to an increase in groundwater irrigation. Table 8 shows the gross irrigated area's percentage to gross cropped area in Haryana by some major crops named, rice, wheat, sugarcane, cotton, barley, jowar, maize, bajra and gram. The extent of irrigation varies from crop to crop, which is determined by the relative importance of the crop and the availability and feasibility of irrigation infrastructure. The extent of irrigated area under each crop indicates the quantity of water used as the water requirement of different crops varies significantly. Crops that are grown under maximum irrigation are rice, wheat, sugarcane, and cotton, where more than 80 percent of the gross cropped area was always under irrigation. Rice was always grown under irrigated conditions as it is more water-intensive and can only grow under irrigated conditions in semi-arid agro-climatic zones like Haryana. All area under rice cultivation is under irrigation in 2014-15. Other crops like wheat, sugarcane, cotton, barley, and bajra show increasing trends. Jowar, maize, and gram crops show fluctuating trends. Bajra is the least irrigated crop, but there has been a steady expansion of irrigation facilities after 1990-91 whereas gram shows decline after 2000-01. Thus it is adequately clear that whatever rice is grown in Haryana, it is grown with irrigation.

Table: 8 Percentage of Gross Irrigated Area to Gross Cropped Area in Haryana by Some Selected Crops

Years	Rice	Wheat	Sugarcane	Cotton	Barley	Jowar	Maize	Bajra	Gram
1970-71	87.36	80.96	85.26	97.93	49.54	26.57	30.70	10.00	22.39
1975-76	90.13	88.42	89.24	94.51	57.63	30.67	27.39	11.13	27.75
1980-81	96.90	93.17	91.15	98.42	60.8	27.01	23.94	11.84	43.08
1985-86	98.80	95.41	95.19	99.13	64.77	37.07	27.27	12.92	25.10
1990-91	99.09	97.57	95.95	99.39	80.39	47.29	22.86	15.44	21.72
1995-96	99.28	98.33	97.22	99.39	87.80	53.97	15.38	17.74	18.58
2000-01	99.81	99.11	97.90	99.82	90.91	64.22	13.33	24.18	32.93
2005-06	99.90	99.00	99.22	99.66	92.86	75.28	16.67	29.91	18.49
2010-11	99.76	99.36	98.22	100.00	94.59	70.42	20.00	30.30	12.56
2014-15	100.00	99.51	102.08	99.85	91.43	79.63	55.56	42.39	10.75

Source: Computed from Statistical Abstract of Haryana (Various Issues) 1970-71 to 2014-15



Source: Computed from Statistical Abstract of Haryana (Various Issues) 1970-71 to 2014-15

Fig. 23

To throw light on the correspondence of the extent of rice cultivation with the extent of groundwater irrigation, a scatter diagram has been prepared (figure 23). Figure amply clarifies that the extent of tubewell irrigation highly corresponds to the extent of area under rice. Thus, it can be emphasized that the rice cultivation area has tremendous significance in so far as are groundwater balance of the state is concerned. It can be further reiterated that the ushering of the "Green Revolution" initiated the rice cultivation and the support policies of the government encouraged the farmers to continue the water-intensive crop in the semi-arid agro-climatic region. To cater to the increasing demand for water on account of rice cultivation, the farmers resorted to an incredible draft of groundwater through shifting to tubewell and tubewell irrigation.

Conclusion

It has been observed that, as the irrigation infrastructure is improving, the trend in the cropping pattern has been shifting towards the specialization of these two crops (rice and wheat). Statistics of cropping pattern reveals that cereals, particularly wheat and rice, have come to dominate the cropping pattern in the state in the wake of new farm technology, and the area mainly under pluses, sugarcane, bajra, maize, barley, and jowar have declined. Statistics of crop specialization reveals that in nine districts, the number of essential crops according to their acreage has remained constant in the entire study period. These districts (Karnal, Kurukshetra, Yamunanagar, Panipat, Panchkula, and Kaithal) cover most of the northern and central zones, where wheat and rice crop combination was registered and remained constant in the entire study period, which shows the considerable pressure on groundwater resources. The changing structure of irrigation and a shift in cropping pattern gives rise to two corresponding facts. First is the increase in demand for water with an increase in rice cultivation. Secondly, this increase in demand for water is increasingly met by groundwater irrigation as water availability in the canals has declined on account of low maintenance, and the tubewells have their own set of advantages regarding flexibility and reliability of irrigation. Result also clarifies that the extent of tubewell irrigation highly corresponds to the rice crop area, which shows the considerable pressure on groundwater resources, so, there is a need for crop diversification in the study area.

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