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Research Article

Trend And Performance Of Agriculture Production In Haryana: An Empirical Analysis

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1. Introduction

Agriculture held a significant position in Haryana's economic landscape, accounting for approximately 18-20 percent of the state's Gross State Domestic Product (GSDP) (PHDCCI, 2019). Moreover, it served as a crucial source of employment for a substantial segment of the population, primarily characterized by its emphasis on achieving high crop yields in staple crops such as wheat and rice. Therefore, the cultivation of labor-intensive high-value crops has the potential to offer stable employment and income to a significant proportion of rural households that experience the serious issues of seasonal unemployment and underemployment within a mono-crop economy (Vaidyanathan, 1986; Chand & Singh, 2023). Haryana also pursued agricultural diversification, with a growing focus on sectors like horticulture and dairy farming (Rakshit, et al., 2021). The main crops grown in Haryana are expanding as a result of increased output levels brought about by the deployment of technology (Ramphul, 2012). Haryana's main Rabi crops include wheat, tobacco, grams, linseed, rapeseed, and mustard. They are planted in late October or early November and harvested in March and April[1]. 86 percent of the land is arable, and 96 percent is under cultivation. Furthermore, nearly 75 percent of the region is irrigated by a large network of canals and tube Wells (Sharma et. al., 2018). Although one-fifth of the state is rain-fed, it is best suited for growing rapeseed and mustard, pearl millet, cluster beans, agro-forestry, and dry horticulture. Because irrigation is available throughout the bulk of the state, a rice-wheat production system is the most realistic alternative. Agroforestry, dairying, poultry, fishing, desert horticulture, mushroom farming, beekeeping, and other related industries have enormous potential, but they are also dependent on agriculture. A major factor in increasing farmers' income is agricultural marketing because farmers in Haryana are required to sell their produce on the spot market. Agricultural marketing practices in India are unethical due to unjust rates and a lack of on-the-spot purchases for farmers.
Given this backdrop, the paper tries to examine trends and performance of agriculture production in Haryana in the last half-decade. The paper investigates the cropping patterns in Haryana and measures the driving factors in the changes in agricultural production and yield. The paper also examines the determinants of crops in Haryana. For that, the paper is categorized into seven sections. Apart from the introductory paper, section two discusses the data source and section three highlights the agricultural situation in Haryana. Section four examines the cropping patterns in Haryana and section five deals with the decomposition analysis. Section six examines the determinants of crops in Haryana. Section seven concludes the paper.

2. Data Source and Methodology

The study is based on secondary sources of data. The data is taken from several government sources including the Department of Economic & Statistical Analysis and Haryana Economic Survey. The study also uses NSS 77th round "The Situation Assessment Survey of Agricultural Households" and "Land and Livestock Holding" to estimate the number of agricultural households and the percentage of rural agricultural households. The decomposition analysis has been used to measure the drivers of variable fluctuations across time and a regression model has been employed to estimate the determinants of agricultural crops in Haryana.

3. Agriculture Situation in Haryana

Haryana state officially came into existence on November 1, 1966, and became the 17th state of India. Haryana, with 4.4 million hectares of land, is one of India's smallest states, accounting for 1.34 percent of the

[1]https://slbcharyana.pnbindia.in/agriculture/

country's total land area[2]. The state is surrounded by Rajasthan, Himachal Pradesh on one side, Punjab on the west, and Uttar Pradesh on the east. Almost 80 percent of the total land area in the state is cultivated, with 84 percent of that area irrigated and an average cropping intensity of 184 percent (NABARD, 2020). Haryana is considered part of the economically vital National Capital Region for planning and development purposes because it borders Delhi, the nation's capital, on three sides (the north, west, and south). Haryana, known as the "Bread Basket of India", is one of the top agricultural-producing states in the country and has been at the forefront of adopting cutting-edge agricultural technologies[3]. Map-1 shows the Haryana Agriculture map.

Map-1: Haryana Agriculture Map

Source: https://www.mapsofindia.com/

The 77th round of the National Sample Survey (NSS) Situation Assessment Survey of Agricultural Households was used to estimate the number of agricultural households, while the 77thround of the NSS Land and Livestock Holding was used to estimate the number of rural households. Column 4 of Table 1 shows the percentage of rural agricultural households in India's major states. This clearly shows that rural areas

[2]https://fsi.nic.in/isfr19/vol2/isfr-2019-vol-ii-haryana.pdf
[3]https://www.hry.in/haryana-agriculture/haryana-agriculture-some-important-facts/

continue to house more than two-thirds of the Indian population. Haryana has around 30.2 and 15.7 lakh rural and agricultural families, respectively. The flip side of this is that approximately half of rural households work in the non-agricultural sector. Figure 1 shows that 1.73 percent of India's rural households belong to Haryana. This clearly shows that Haryana has a sizable proportion of rural agricultural families, accounting for approximately 51.95 percent of those in the state and contributing 1.7 percent of all agricultural homes nationwide (Figure-1). It shows that Haryana is not just one of the most populous states, but also one of the states with the highest share of rural and agricultural households. This demonstrates that, despite receiving one of the lowest wages among major states, the majority of farmers/cultivators continue to be involved in the agrarian economy, supporting the idea that the rural-agrarian socioeconomic pattern constitutes the center of Haryana's entire society.

The majority of people in Haryana's agrarian state work in agriculture and related sectors. With land sizes ranging from one to five acres, marginal, small, medium, and large farmers account for 48.11, 30.28, 11.11, and 10.49 percent of all farmers in the state, respectively (Figure-2). Figure 3.4 presents the pattern of landholding size of agricultural households in Haryana. The emphatic finding from the figure is that not only there is inequality in landholding size, but the majority (48.11 percent) of rural households own less than one hectare, and the 48.11 percent of rural households in Haryana. 30.28 percent of rural households own land from one to three hectares. If we combine these two, we find that more than three-fourths (78.39 percent) of rural households in Haryana have less than three hectares. 11.11 percent of rural households in Haryana own three to five hectares while 10.5 percent own more than 5 hectares. It implies that land reform has not been that effective in Haryana as even in present times majority of farmers own less amount of land which might impact economies of scale in Agriculture. It might also be responsible for low income for rural households. Marginal, small, medium, and large farmers own 9.88, 24.68, 19.11, and 46.3 percent of the state's total land, indicating a reversal in the area they own. As illustrated, marginal farmers, who account for 48 percent of the population, occupy 46 percent of the state's total area, whereas big farmers occupy only 10 percent. Haryana's average land holding is 2.25 hectares, which is higher than the national average of 1.16 hectares (Ministry of Agriculture & Farmers Welfare, 2021). In Punjab, 3.11 hectares are at stake. The states with the most land are Rajasthan (3.07 ha) and Arunachal Pradesh (3.51 ha). In Kerala, the average size of land ownership is 0.22 hectares. The net sown area for the area under cultivation increased little between 2005-06 to 2020-21, however, the area sown more than once has declined slightly during the same period (Table-2). Thus, there was also a slight rise in land utilization when the total crop area expanded from 6509 ha in 2005-06 to 6528 ha in 2020-21. The net irrigated area increased as well, rising from 2936 ha to 3360 ha in the same period. During the period 2005-06 to 2015-2016, the share of the net irrigated area to the Net Sown area (NSA) increased from 82.3 percent to 93 percent. On the other hand, the cropping intensity increased as well, increasing from 134 percent in 2005-06 to 181 percent in 2020-21. As a result, land usage in the state has improved during the last one and half decades.

Let us take a look at the coverage of the sown area and the extent of irrigation in Haryana over the years with the help of table 3.4. The area of Haryana is 44212 hectares. Net sown area in Haryana was 3566 hectares in 2005-06 which increased to 3611 hectares in 2020-21. It shows that the net sown area has increased by just 45 hectares in fifteen years. An area that is sown more than once has declined from 2943 hectares in 2005-06 to 2917 hectares in 2020-21. The cropped area also increased slightly from 6509 hectares in 2005-06 to 6528 hectares in 2020-21. Although the total cropped area increased only by 19 hectares, there has been a phenomenal increase in cropping intensity in Haryana. The index of cropping intensity in 2005-06 was 134.1 percent and the same increased to a whopping 180.7 in in 2020-21. However, 2020-21 witnessed a dip as compared to 2019-20 (193.7). The increase in cropping intensity could be attributed to the expansion of irrigational facilities which is quite evident from the table. Haryana has an excellent record in terms of coverage of irrigation. 93 percent of the net sown area is irrigated in Haryana as of 2020-21. There has been a consistent increase in the net irrigated area since 2005-06, though the year 2020-21 saw a slight dip as compared to 2019-20 during which the relevant figure was 94.9 percent.

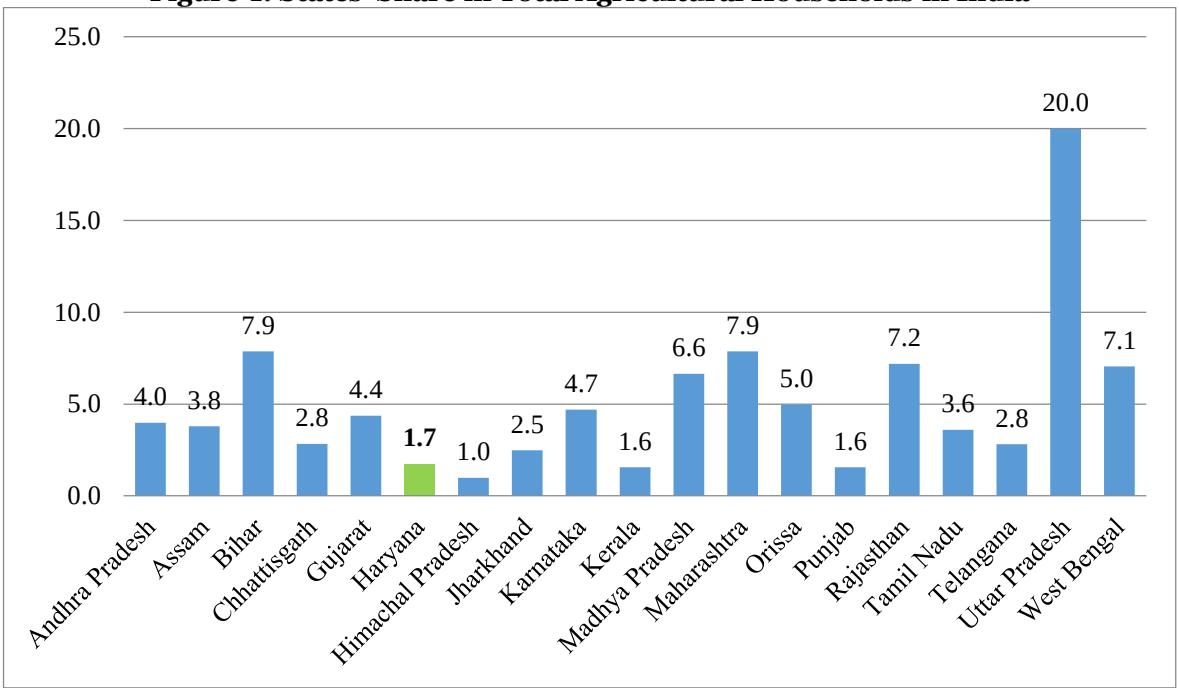
Table-1: Agricultural Households Across States

State Name	Agricultural Households	Rural Households	percent of Rural Agricultural Households
Andhra Pradesh	3596783	8946548	40.20
Assam	3423046	5460450	62.69
Bihar	7094347	16975344	41.79
Chhattisgarh	2560807	4356532	58.78
Gujarat	3930478	6695209	58.71
Haryana	1569260	3020870	51.95

Himachal Pradesh	881075	1372548	64.19
Jharkhand	2233573	4749789	47.02
Karnataka	4242059	8128896	52.18
Kerala	1404297	4346787	32.31
Madhya Pradesh	5994969	10427663	57.49
Maharashtra	7097018	12977666	54.69
Orissa	4493522	8097694	55.49
Punjab	1408347	3460363	40.70
Rajasthan	6483542	9553475	67.87
Tamil Nadu	3244292	9902374	32.76
Telangana	2538903	5061178	50.16
Uttar Pradesh	18048631	26570762	67.93
West Bengal	6362429	14221663	44.74
All India	**90201141**	**170002794**	**53.06**

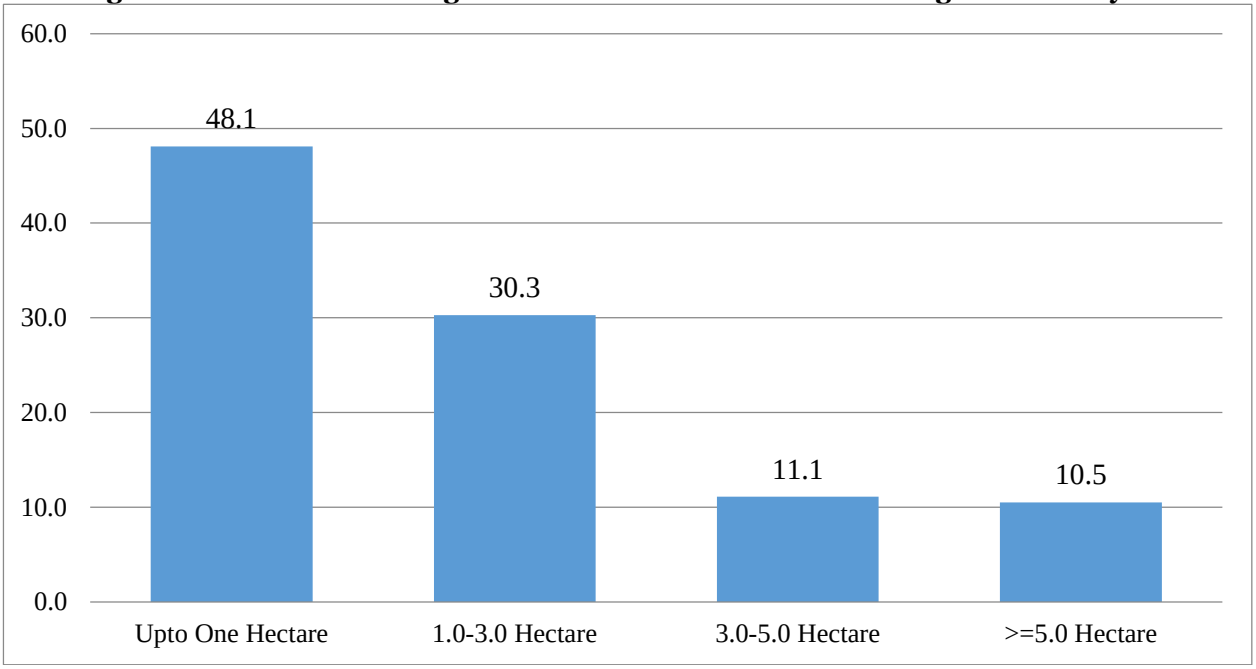
Source: Author's Computation from NSS 77th round "The Situation Assessment Survey of Agricultural Households" and "Land and Livestock Holding".

Figure-1: States' Share in Total Agricultural Households in India



Source: Author's Computation from NSS 77th round "The Situation Assessment Survey of Agricultural Households" and "Land and Livestock Holding".

Figure-2: Distribution of Agricultural Households' Landholding Size in Haryana



Source: Author's Computation from NSS 77th round "The Situation Assessment Survey of Agricultural Households" and "Land and Livestock Holding".

Table-2: Classification of the Area in Haryana

Year	Area	Net Area Sown	Area Sown more than once	Total Cropped Area	percent of Net Irrigated area to NAS	Index of Cropping Intensity
2005-06	44212	3566	2943	6509	82.3	134.1
2006-07	44212	3556	2851	6407	84.1	132.4
2007-08	44212	3594	2864	6458	84.2	179.7
2008-09	44212	3576	2924	6500	80.5	181.8
2009-10	44212	3550	2801	6351	86.5	178.9
2010-11	44212	3518	2987	6505	82.1	184.9
2011-12	44212	3513	2976	6489	87.4	184.7
2012-13	44212	3513	2976	6489	88.3	181.5
2013-14	44212	3497	2974	6471	83.8	185.0
2014-15	44212	3522	3014	6536	84.4	188.0
2015-16	44212	3519	3059	6578	85.6	185.8
2016-17	44212	3499	2953	6452	90.8	184.4
2017-18	44212	3508	3041	6549	93.0	189.8
2018-19	44212	3613	2992	6605	90.8	190.3
2019-20	44212	3570	3047	6617	94.9	193.7
2020-21	44212	3611	2917	6528	93.0	180.7

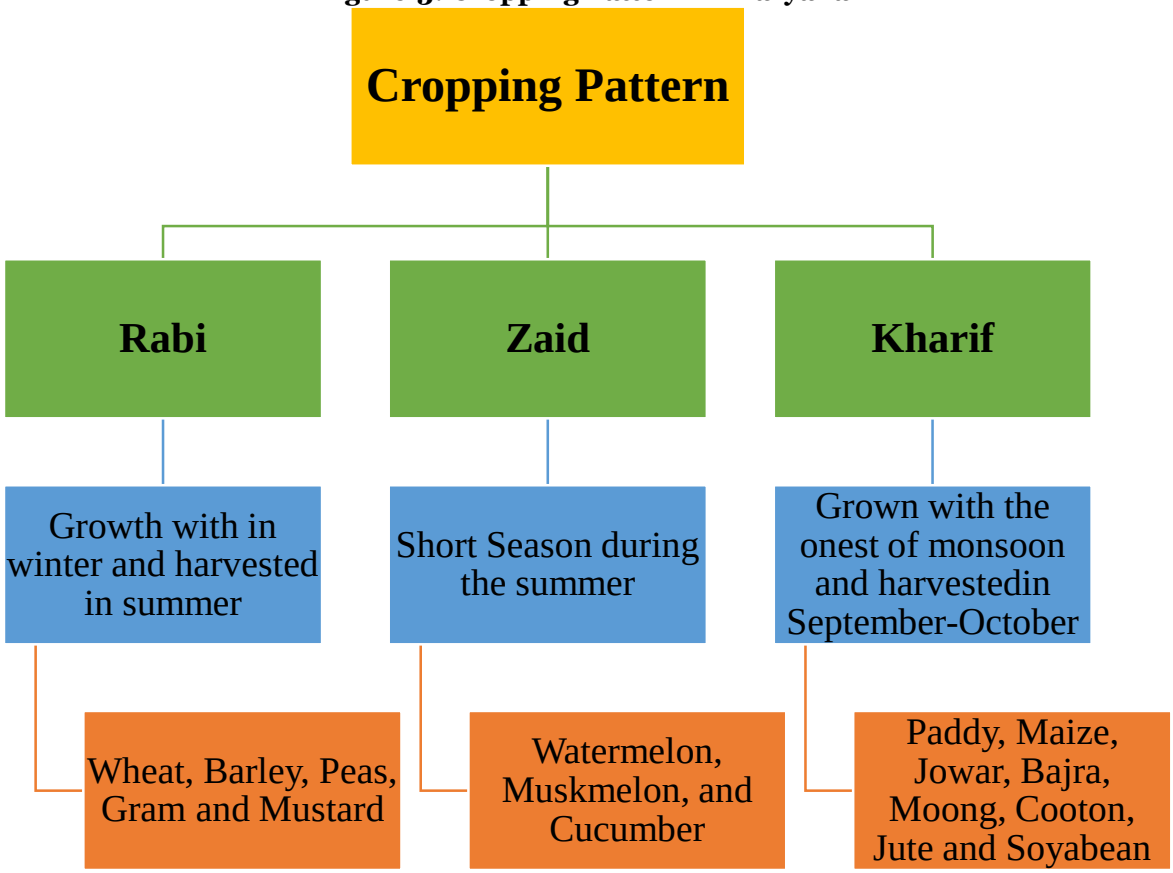
Source: Department of Economic & Statistical Analysis, Haryana
Note: Area in 000 Hectares

4. Cropping Patterns in Haryana

Haryana is known as the "Food Mine" of the country. Approximately 80 percent of the state's population is employed in agriculture in some way. Haryana produces enough food to cover its own needs while also considerably contributing to the nation's food supply. This region produces a large amount of the renowned Basmati rice. Wheat, rice, maize, and bajra are the main grains grown in the state. Rabi, Kharif, and Zaid are the three important growing seasons in Haryana (Figure-3). The main crops grown in the state during the kharif season include sugarcane, groundnuts, maize, paddy, and other crops. Minor kharif crops include

vegetables, pulses, chilies, bajra, jawar, and beans. Rice, wheat, vegetables, and temperate fruits thrive in the northwest of the state, whereas tropical fruits, exotic vegetables, and medicinal and herbal plants thrive in the southwest.

Figure-3: Cropping Pattern in Haryana



Haryana's cropping patterns are mostly determined by the state's geographic features, climate, and agricultural techniques. The state is one of the most agriculturally productive in India, and its planting pattern has evolved to fulfill market demands and boost agricultural productivity. It's important to remember that cropping patterns can change from year to year and season to season depending on factors such as market demand, weather, political laws, and the availability of irrigation infrastructure. Figure-3.5 shows the different cropping patterns in Haryana. The increased proportion of grains, which currently account for two-thirds of all planted land in Haryana, demonstrates crop pattern changes. According to Sangwanand Gautam (2020), significant growth in irrigation infrastructure resulted in a shift in the agricultural pattern of the state. Because of the diversity of soil, agro-climatic conditions, and accessibility of infrastructure services (such as highways and regulated markets) across the sub-regions, the state can cultivate a wide range of crops. The mainstay of Haryana's economy, agriculture makes a substantial contribution to its expansion and advancement. The state is one of the top producers of crops like wheat, rice, sugarcane, and cotton thanks to its fertile soil, well-developed irrigation infrastructure, and favourable agro-climatic conditions. Haryana is one of the largest producers of food grains in the country, producing 130 lakh tonnes in 2005-06 which reached 185 lakh tonnesin 2020-21 (Table-3). In addition, wheat and rice contributed 114 and 56 lakh tonnes, respectively, to the total amount of food grains produced in the state in 2020-21. Haryana is the country's fourth-largest wheat producer, accounting for more than 12 percent of total wheat production. The state also grows coarse grains such as jowar and bajra. Furthermore, it produces the ninth most rice in the country. As far as the production of pulses is concerned, it decreased from 112 thousand tonnes in 2005-06 to 67 thousand tonnes in 2020-21. It appears that either farmers in Haryana prefer the cultivation of cereals or land has become less favourable for the cultivation of pulses. Production of oilseeds increased from 822 thousand tonnes in 2005-06 to 1348.7 thousand tonnes in 2020-21. Haryana is one of the rare states in which the Agricultural Produce Marketing Committee Act has been implemented with reasonable success. Consequently, *mandi* is operational and with the provision of minimum support price for cereals, farmers prefer to cultivate cereals. The area used for coarse cereals and pulses has decreased and the area used for the specialised crops of wheat, rice, and cotton has increased in Haryana's agricultural boom since 1980. The state's level of crop diversification decreased as a result (Sihmar and Gautam, 2020). In the Hisar region of Haryana, the cost of fertiliser use per hectare on the net sown area was higher on small

farms than on large farms due to the greater percentage of the irrigated area (Kaushik and Paharia, 2014). According to Haryana's sustainable agricultural development, monoculture predominates in the state, and soil fertility and water table levels are decreasing. As a strategy for sustainable agricultural development to preserve natural resources while also earning an economic advantage, crop diversification towards horticulture and pulses was promoted (Priscilla. et. al., 2017).

Table-3: Production of Major Crops in Haryana 000 Tonnes

Year	Total Cereals	Total Pulses	Total Food Grains	Total Oil Seeds
2005-06	12894.0	112.0	13006.0	822.0
2006-07	14627.0	136.0	14763.0	821.0
2007-08	15193.0	101.0	15294.0	617.0
2008-09	16000.0	178.0	16178.0	912.0
2009-10	15248.0	97.0	15345.0	862.0
2010-11	16413.0	153.0	16566.0	965.0
2011-12	18263.0	107.0	18370.0	755.0
2012-13	18263.0	107.0	18370.0	755.0
2013-14	16879.0	90.9	16969.9	899.1
2014-15	15533.0	54.5	15587.5	739.5
2015-16	16292.0	34.5	16333.8	851.8
2016-17	17933.0	161.9	18094.9	984.7
2017-18	17976.0	113.8	18089.8	1134.7
2018-19	18063.0	92.8	18155.9	1311.4
2019-20	18256.0	65	18321.0	1176.0
2020-21	18524.0	67	18591.0	1348.7

Source: Department of Economic & Statistical Analysis, Haryana

Table-4: Major Crop Production in Haryana

	Rice			Wheat			Bajara			Barley		
	Area	Production	Yield	Area	Production	Yield	Area	Production	Yield	Area	Production	Yield
2005-06	1047.0	3194.0	3051	2303.0	8853.0	3844	632.0	706.0	1117	28.0	79.0	2821
2006-07	1042.0	3375.0	3239	2377.0	10059.0	4232	619.0	1021.0	1649	38.0	115.0	3026
2007-08	1073.0	3606.0	3361	2461.0	10232.0	4158	628.0	1156.0	1841	40.0	120.0	3000
2008-09	1211.0	3299.0	2724	2461.0	11360.0	4616	613.0	1087.0	1773	53.0	185.0	3491
2009-10	1206.0	3628.0	3008	2488.0	10488.0	4215	583.0	930.0	1595	42.0	137.0	3262
2010-11	1243.0	3465.0	2788	2504.0	11578.0	4624	660.0	1183.0	1792	37.0	130.0	3514
2011-12	1234.0	3757.0	3045	2531.0	13119.0	5183	576.0	1175.0	2040	41.0	149.0	3634
2012-13	1206.3	3941.0	3267	2496.9	11117.0	4452	410.7	791.0	1926	47.7	167.0	3501
2013-14	1244.6	4041.0	3247	2499.1	11800.0	4722	403.6	829.0	2054	38.6	151.0	3912
2014-15	1277.9	4041.0	3162	2628.1	10707.0	4074	393.8	670.0	1701	35.3	105.0	2975
2015-16	1353.1	4144.0	3063	2575.6	11351.0	4407	369.9	651.0	1760	28.9	99.0	3426
2016-17	1385.2	4453.0	3215	2564.0	12384.0	4830	467.1	964.0	2064	20.0	73.0	3650
2017-18	1422.0	4880.0	3432	2530.5	12263.0	4846	449.3	721.0	1605	20.2	69.0	3416
2018-19	1446.9	4517.0	3122	2553.2	12573.0	4924	424.7	878.0	2067	15.5	58.0	3742
2019-20	1559.0	5198.0	3334	2533.9	11877.0	4687	492.9	1101.0	2234	12.1	47.0	3884
2020-21	1525.8	5633.0	3692	2354.0	11406.0	4845	594.1	1411.0	2375	9.3	31.0	3333

Source: Department of Economic & Statistical Analysis, Haryana

Note: Area: 000 Hectares, Production: 000 Tonnes, Yield: Kgs. per Hectare

Table-5: Major Crop Production in Haryana

	Maize			Sugarcane			Mustard			Cotton		
	Area	Production	Yield	Area	Production	Yield	Area	Production	Yield	Area	Production	Yield
2005-06	18.0	36.0	2000	129.0	831.0	6442	708.0	793.0	1120	584.0	1502.0	2572
2006-07	13.0	30.0	2308	141.0	965.0	6844	598.0	804.0	1344	528.0	1805.0	3419
2007-08	14.0	37.0	2643	140.0	885.0	6321	497.0	597.0	1201	428.0	1882.0	4397
2008-09	12.0	25.0	2083	91.0	521.0	5725	514.0	895.0	1741	456.0	1862.0	4083
2009-10	12.0	26.0	2167	79.0	571.0	7228	511.0	847.0	1658	505.0	1918.0	3798
2010-11	10.0	19.0	1900	85.0	604.0	7106	510.0	953.0	1869	493.0	1747.0	3544
2011-12	11.0	30.0	2727	95.0	695.0	7316	536.0	747.0	1394	602.0	2621.0	4354
2012-13	9.9	26.0	2626	100.9	744.0	7374	558.3	959.3	1718	592.6	2378.0	4013
2013-14	8.5	24.0	2824	101.3	773.0	7631	536.9	870.0	1620	567.8	2025.0	3566
2014-15	8.8	18.0	2045	95.7	710.0	7419	481.9	706.0	1465	647.2	1943.0	3002
2015-16	6.1	18.0	2951	93.5	699.0	7476	510.4	823.0	1612	615.2	995.0	1617
2016-17	6.2	26.0	4194	101.8	822.0	8075	506.1	946.1	1869	571.2	2041.0	3573
2017-18	6.4	19.0	2969	114.9	963.0	8381	548.9	1107.5	2018	668.5	1626.0	2432
2018-19	6.2	16.0	2581	108.7	850.0	7820	609.8	1286.5	2110	708.9	2033.0	2868
2019-20	6.0	17.0	2833	96.3	773.0	8027	661.7	1176.0	1777	723.0	2484.0	3436
2020-21	9.3	28.0	3011	99.7	858.0	8606	643.2	1258.0	1956	719.9	1812.0	2517

Source: Department of Economic & Statistical Analysis, Haryana
Note: Area: 000 Hectares, Production: 000 Tonnes, Yield: Kgs. per Hectare

Table-6: Average Annual Growth of Major Crops in Haryana

		2005-06 to 2010-11	2011-12 to 2015-16	2016-17 to 2020-21
Rice	Area	3.60	1.75	2.48
	Production	1.90	3.68	6.61
	Yield	-1.18	2.03	4.04
Wheat	Area	1.70	0.60	-1.74
	Production	5.82	0.19	0.23
	Yield	4.07	-0.30	2.02
Bajara	Area	1.06	-10.33	10.72
	Production	12.93	-10.11	19.64
	Yield	11.58	0.23	7.64
Barley	Area	8.16	-3.72	-19.63
	Production	14.61	-3.81	-20.14
	Yield	4.78	0.54	-0.14
Maize	Area	-10.21	-8.26	10.70
	Production	-9.74	2.37	14.54
	Yield	0.09	12.81	3.18
Sugarcane	Area	-6.40	2.11	1.69
	Production	-3.58	3.26	4.99
	Yield	2.75	1.04	2.99
Mustard	Area	-5.96	0.22	4.88
	Production	6.54	-0.96	9.31

	Yield	12.45	-1.47	4.54
Cotton	Area	-2.72	5.08	3.50
	Production	3.49	-5.39	20.99
	Yield	8.14	-11.61	19.99

Source: Author's Estimation.

In Haryana State, it has been observed that as modern irrigation infrastructure has evolved, cropping patterns have shifted towards specialization of a few essential crops (Singh, 1976). Changes in cropping patterns are one of the primary elements influencing agricultural economic growth in a region (Singh et. al., 2013). As a result, the expansion of main agricultural acreage in a region should be closely watched. The current section tries to investigate trends and oscillations in a Haryana cropping region, demonstrating how the state's cropping pattern altered from 2005-2006 to 2020-21. Notably, the proportion of land planted for wheat and rice has increased from 35.38 percent and 16.1 percent, respectively, in 2005-06 to 36 percent and 23.4 percent in 2020-21 (Table-4). Similarly, the proportion of cotton-cropped area to total cropped land increased from 8.97 percent in 2005-06 to 11.03 percent in 2020-21 (Table-5). Table 4 and 5 represents the production of different crops in Haryana in terms of area under cultivation, production, and yield. Wheat is cultivated in the maximum cultivable area of Haryana followed by Bajra. Agricultural land in Haryana is most suitable for the cultivation of wheat. In addition to having the highest area under cultivation of wheat, production of wheat is highest (11406 thousand tonnes. However, in terms of yield, rice has the highest yield which stands at 3692 tonnes per hectare. Only 152 hectares of the area fall under cultivation of rice, but its production stands at 5633 thousand tonnes as of 2020-21. It is well known that rice and wheat are water-intensive crops, therefore it can safely be said that in addition to rainfall, Haryana has good coverage of irrigational facilities and hence higher production of wheat and rice. The guaranteed minimum support price for rice and wheat influences farmers' choice for the cultivation of crops in favour of wheat and rice with an orientation of enhancing income. Sugarcane, mustard, and cotton are major cash crops grown in Haryana. Among cash crops, cotton performs reasonably well, production stands at 1812 thousand tonnes, in fact even yield of cotton stood at 2517 tonnes per hectare which is more than reasonable. India is one of the major exporters of cotton and textile products, Haryana's cotton production augurs well for India. However, the proportion of total cropped land planted to bajara, barely, maize, sugarcane, and mustard has declined dramatically over the study period. Rice and wheat are the two most important cereal crops in the state, accounting for over 60 percent of total cultivated land in 2020-21. Other cereal crops, such as maize, bajra, barley, and jowar, received just 11.19 percent and 7.54 percent of total cereal and total gross cultivated area, respectively. Bajra is the third-most dominant crop in the grain sector, with a downward trend from 9.7 percent in 2005-2006 to 9.10 percent in 2020-21 to the total gross cultivated area. However, the proportion of area planted to pulses to total food grains and total gross cultivated land decreased throughout the same period. A second cash crop, sugarcane's share of total crops decreased from 1.98 percent in 2005–06 to 1.53 percent in 2020–21. The crop's poor pricing, particularly outside of places with sugar mills, was the cause of this. The area expected to be planted with sugarcane is expected to rise once more as a result of rising sugarcane support prices and more sugar mills functioning in the state. The cotton-planting area displayed an upward trend. This gained momentum thanks to the "Integrated Cotton Development Project." Since 1995–1996 it has decreased as a result of the American Bollworm problem. The invasion of the American Bollworm on the cotton crop has had a significant impact on the yield and productivity of cotton as a cash crop in the state of Haryana. Because of the consistent production and guaranteed price, numerous cotton-growing regions have also shifted to rice and wheat. According to the research, contemporary agricultural technology has resulted in a change in the state's cropping pattern toward cereals, specifically wheat, and rice, and a decrease in the area devoted mostly to pulses, sugarcane, bajra, maize, barley, and jowar. Table 6 shows the average yearly increase of the primary crops in Haryana across three different periods in terms of production, area, and yield. It demonstrates that there has been positive growth in the area, output, and yield of cotton, rice, sugarcane, mustard, and bajara over the last five years. Wheat and barley, on the other hand, grew negatively throughout the same timeframe. However, it should be noted that the bulk of crops (wheat, bajara, barley, maize, mustard, and cotton) experienced negative growth rates in terms of area, output, or yield between 2010-11 and 2015-16. Let us take a look at the growth rate of production of crops in Haryana for different crops;

Rice: The growth rate of the total area under cultivation of rice has gone down from 2005-06(3.6 hectares) to (2.48 hectares) in 2020-21, but both production and yield have been increasing, which is quite understandable given the excellent coverage of irrigation facility in Haryana.
Wheat: The area under cultivation of wheat has witnessed negative growth, and production and yield have been witnessing a declining growth rate.
Bajra: Increasingly, larger areas have come under cultivation of Bajra and production has increased well, however, yield has fallen from 11.58 tonnes per hectare to 7.64 tonnes per hectare.

Barley: There has been a constant decline in the area under cultivation of Barley it has registered a negative growth rate of 19.63 in the period 2016-17-2020-21 in terms of area under cultivation of Barley. It is quite understandable that as the area under cultivation goes down, so does production and yield which is presented in the table.

Maize: The area under cultivation witnessed a negative growth rate from 2005-06 to 2016-17, however the same registered increment of 10.70. Production growth registered a growth of 14.54 percent in the period 2005-06 but since then it has been witnessing a negative growth rate. As mentioned earlier, the minimum support price for rice and wheat compels farmers to cultivate rice and wheat, that's why they have cut down on the cultivation of maize.

Among the major cash crops, growth rates in terms of areas that have been highest in cotton have been remarkably well. Mustard and sugarcane have performed reasonably well.

5. Decomposition Analysis

Decomposition analysis is a useful tool for determining what drives a variable's fluctuations across time. In the context of agriculture, decomposition analysis can help break down changes in agricultural production, yield, or any other relevant agricultural metric into distinct components, allowing policymakers, researchers, and practitioners to pinpoint the underlying factors influencing these changes. There are several key components in a typical decomposition analysis for agriculture:

- **Total Change:** The study begins with the total change in the agricultural variable over a certain period. It shows the overall increase or decrease in the relevant variable, such as total agricultural production.
- **Yield Change:** The impact of changes in crop or livestock yield on the overall change in agricultural production is referred to as the yield change component. It shows changes in productivity brought on by a variety of variables, such as the adoption of new technology, improved farming techniques, irrigation, or environmental circumstances.
- **Area Change:** The area change element takes into account how changes in the amount of cultivated land affect agricultural output. Agricultural land can be expanded or contracted in ways that have a big impact on overall production levels.
- **Input Change:** This component reflects the impact of changing agricultural inputs such as fertilisers, seeds, herbicides, and machinery on overall agricultural productivity. Changes in input consumption can have a direct impact on yields, which can subsequently affect overall production.
- **Price Change:** The price change component considers how variations in agricultural commodity prices affect the overall worth of the production. Prices may be affected by changes in market demand, supply dynamics, trade policies, or other economic variables.
- **Technology Change:** Technology change refers to the impact of new agricultural technologies and processes on output levels. This section covers technological advances in breeding, irrigation, mechanisation, and other fields.
- **Policy Change:** The impact of agricultural policies and regulations on production is taken into consideration by the policy change component. Government initiatives, subsidies, trade regulations, and assistance programmes can have a big impact on how agriculture performs.

Using decomposition analysis, agriculture stakeholders can gain a better understanding of the relative importance of each of these components in driving changes in agricultural productivity. By quantifying the value of each aspect, policymakers may establish specific policies to stimulate sustainable agricultural growth, manage challenges, and optimize resource allocation. It is critical to note that a strong decomposition analysis is dependent on data availability and quality. Furthermore, the type of decomposition used may vary depending on the specifics of the research issue and the qualities of the data. The Laspeyres decomposition method and the Logarithmic Mean Divisia Index (LMDI) are two famous decomposition approaches. The component analysis model, as used by other researchers (Minhas, 1965; Shende et al. 2011; Singh, et al. 2018), is used in this study to determine the relative contribution of area and productivity in total output changes for cotton, bajra, wheat, paddy, rapeseed & mustard, and gram crops. The model can be categorized into Area Effect, Yield Effect, and Interaction Effect.

$$\text{Area Effect} = \frac{A0\Delta Y}{\Delta P} * 100$$

$$\text{Yield Effect} = \frac{Y0\Delta A}{\Delta P} * 100$$

$$\text{Interaction Effect} = \frac{\Delta Y\Delta A}{\Delta P} * 100$$

Where,

A0 = Area in the base year

ΔA = Current Area minus the base year

Y0 = Yield in the base year

ΔY = Current yield minus the base yield

ΔP = Current production minus base production

Table-7: Decomposition Results (In percent)

	Area Effect	Yield Effect	Interaction Effect
Rice	2.75	5.99	1.26
Wheat	9.03	0.77	0.20
Bajara	11.28	-0.60	-0.68
Barley	-2.99	10.99	1.99
Maize	-22.74	21.75	10.99
Sugarcane	103.39	-69.91	-23.48
Mustard	12.73	-1.56	-1.16
Cotton	-1.03	11.27	-0.24

Source: Author's Estimation.

Table-7 shows how area and yield affect changes in agricultural production for the key crops. Sugarcane output has been impacted the most by area, followed by wheat, mustard, and bajara. shows the effect of area and yield on the productivity of different crops. It is commonly expected that larger areas under cultivation of any crops have a positive impact on total production and the table clearly shows this. In the case of rice, the impact is merely 2.75 times, however, in the case of wheat, the effect goes higher to 9 times. The effect of area for bajra and mustard goes higher to more than 11 and 12 times respectively. Production of sugarcane is hugely impacted by the scale of the area, an increase in the area under cultivation of sugarcane increases production by more than 100 times of the crop. The table also shows that there's a negative relationship between the size of land under which the crops are grown and their total production, the table clearly shows that this is true for crops like barley, maize, and cotton. The said relationship is more pronounced in the case of maize. It simply implies that the land of Haryana is not conducive to the cultivation of maize.
Yield is a major factor for the cultivation of any crop as it invariably impacts the income of farmers. In the case of rice, yield impacts productivity close to 6 times, but in the case of wheat, it is merely .77 times. The impact of yield is noticeable in the case of barley, maize, and cotton as the figures are in double digits for said crops. One worrying trend appears to be a negative impact of yield on the productivity of sugarcane and the concerned figure is 69.91. This might be because land in Haryana is not suitable for cultivation of sugarcane. The area effect reduced paddy crop productivity by 2.75 percent. Acreage and yield have a 9.03 percent and 0.77 percent impact on wheat production, respectively, while technology has a smaller impact. Wheat crop technologies increased throughout this period. As a result, output increased. Despite the negative consequences of technology, the area effect increases sugarcane productivity by 103.39 percent. Cotton gains from the impact of technology but not from the area effect. Technology has raised the cotton crop by 11.27 percent. At the time, there was little technological influence. The increase in millet crop output is attributed to technological advancements, as the impact of the area on millet crop yield has been negative. Production has increased as the acreage of the gram crop has increased, but it has also increased as the acreage and new technologies of the rapeseed mustard crop have increased.

6. Determinants of Agricultural Crops in Haryana

All significant crops have seen an increase in yield over the research period. Consequently, it will be beneficial to look at the yield of the main crops in Haryana. This section looks at the factors that affect the yield of the main crops grown in Haryana from 2005–06 to 2020–21. The yield of the crops is impacted by a variety of factors. These elements are as follows:

Climate and Weather: Haryana's climate and weather are semi-arid, with scorching summers and frigid winters. During the monsoon season, adequate and evenly distributed rainfall is critical for agricultural growth. Droughts, floods, and unusual rains can all have a negative impact on agricultural productivity. For measuring climate and weather conditions, this study considers average annual rainfall and maximum annual temperature variation as independent variables.

Irrigation Infrastructure: Access to dependable irrigation infrastructure is critical for crop yield maintenance, especially in locations with unpredictable rainfall. Canal irrigation, tube wells, and other water management methods play an important part in providing year-round water availability. Therefore, irrigation intensity is considered an independent variable.

Farm Practices and Technology: Adoption of modern agricultural practises and technologies has the potential to greatly increase agricultural productivity. Improved seeds, mechanisation, precision agriculture techniques, and effective crop management practises are all part of this. Thus, dairy cooperatives per hectare and the number of tubewells and pumping sets per hectare are considered independent variables.

Pest and Disease Management: Effective pest and disease management strategies are essential to safeguard crops from damage and ensure higher yields. Therefore, per-hectare pesticide consumption is considered an independent variable.

The regression model for determinants of yield of major crops can be represented as;
$LogY = \beta_0 + \beta_1 LogDS + \beta_2 LogPC + \beta_3 LogAAR + \beta_4 LogMATV + \beta_5 LogTPS + \beta_6 LogII + €$
Where,
LogY = yield pet kg in per hectare (natural logarithm)
LogDS= number of dairy cooperatives per hectare (natural logarithm)
LogPC= pesticide consumption per hectare (natural logarithm)
LogAAR= Average Annual Rainfall (natural logarithm)
LogMATV= Maximum Annual Temperature Variation (natural logarithm)
LogTPS= number of Tubewells and Pumping sets (natural logarithm)
LogII= Irrigation Intensity (natural logarithm)
€ = Error Term
β_1 to β_6 are coefficients.
The productivity of the major crops is positively impacted by dairy societies per hectare, pesticide use per hectare, tube wells and pumping sets per hectare, and irrigation intensity (table-8). On the other hand, some crops are negatively impacted by the maximum annual temperature variance and the average annual rainfall. Multiple regression analysis was used to examine the effects of all components from 2005–06 to 2020–21. The ordinary least square (OLS) approach has been used to estimate the Cobb Douglas type production function. In light of the cross-sectional data used in this study, the R-square value ranges from 0.899 to 0.435 can be regarded as quite a good fit, as it suggests that 89 to 44 percent of the yield variation is explained by the independent variables examined. For the paddy crop, the irrigation intensity coefficient has a value of 0.89. It shows that a 1 percent increase in irrigation intensity will boost paddy output by 89 percent. Only paddy, wheat, and maize are statistically affected by the average annual rainfall; the other crops are statistically unaffected. Only maize and sugarcane exhibit statistically significant maximum yearly temperature fluctuation; all other crops exhibit statistical insignificance. Except cotton, the coefficient of pesticide usage per hectare has also been relatively large for all crops. This demonstrates that increasing the amount of pesticides used per hectare increased agricultural yield by 1 percent. Except for barely and maize, the association between the number of tubewells and pumping sets is positive and statistically significant for all crops. It represents an increase of 1 percent in the usage of tubewells and pumps in the cultivation of comparable crop production. Therefore, it is important to note that the agricultural yield in Haryana can vary significantly from season to season and from region to region within the state. Localized factors and specific crop choices will also influence agricultural productivity in different areas. Therefore, a holistic and region-specific approach is needed to address the determinants of agricultural yield in Haryana effectively. By addressing these determinants and implementing appropriate agricultural practices, farmers in Haryana can increase major crop yield and contribute to the overall agricultural productivity of the state.

Table-8: Regression Results for Determinants of Yield of Major Crops

	Paddy	Wheat	Bajara	Barley	Maize	Sugarcane	Mustard	Cotton
Dairy Societies	0.017**	0.183*	1.037***	0.206**	0.140*	0.205*	0.612**	0.298**
Pesticide Consumption	1.298**	1.097*	0.084***	1.024**	0.740*	0.287*	2.082**	3.315
Average Annual Rainfall	-0.002*	-0.053*	0.344	0.119	-0.180*	0.005	0.001	0.090
Maximum Annual Temperature Variation	-0.129	-0.064	0.297	0.056	-0.122*	-0.019**	0.325	0.070
Tubewells and Pumping sets	0.597***	0.193***	-0.002**	0.039	1.312	0.843***	0.317***	2.145**
Irrigation Intensity	0.890***	0.188***	-0.178**	0.019	1.831	1.387***	0.337***	0.988**
Constant	17.676**	17.108**	-3.218**	14.879***	28.424***	14.214***	19.807***	69.497***
R Square	0.733	0.573	0.776	0.585	0.543	0.8993	0.742	0.435
Adj. R Square	0.555	0.483	0.627	0.409	0.338	0.8321	0.632	0.373
No of Observation	16	16	16	16	16	16	16	16

Source: Author's Estimation
Note: *, **, and *** significance levels at 10 percent, 5 percent, and 1 percent respectively

7. Conclusion

The yield of all major crops has been increased except the cotton in the respective year of the study. The government initiated the Pradhan Mantra Fasal BimaYojana scheme to boost agricultural expansion and development. According to the proposal, it will cover "kharif crops", which include cotton, maize, bajra, and paddy. Crop insurance, on the other hand, is paid for throughout the rabi season using wheat, barley, gram, and mustard. Pesticides and fertilisers are also to blame for soil erosion. Organic farming will be performed on 50 acres of land as part of this plan to slow soil deterioration. To mandate the use of organic fertiliser and

avoid agricultural waste from being buried under crops when mechanisation is used, the government also launched the new Paramparagat KrishiVikasYojana project. Haryana's farmers mainly plant basic crops due to these crops' detrimental effects on soil fertility and water pollution. The government has embraced a variety of crops given the situation of horticulture output in Haryana at the moment. The government wanted to triple the production of crops by 2030 to completely cover the land with them. The use of crop diversification will increase farmers' revenue and increase their output. In addition to the horticultural university at Karnal, the Haryana government established three regional research stations with the help of foreign organisations. To develop agriculture sustainably, the actuarial seed treatment and more extensive coverage in the sector must start. Additionally, India has a serious issue with agriculture marketing. Typically, farmers are not appropriately compensated for their marketable goods. The status of the market is influenced by a wide range of variables, including the amount of supply or demand for a certain good or commodity as well as the money that corporations and nonprofit organisations make. The government's top priority must include increasing farmer incomes, enforcing the watershed development plan, contract farming, and implementing broad-based policies that will benefit the agriculture industry in the long run.

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