

Changing Wheat- Paddy Cropping Pattern in Haryana: Growth, Productivity Trends and Instability Analysis

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Abstract

Haryana is one of the significant states in India contributing to the food-grain production and the traditional farming system has been rice–wheat cropping system. This study deals with the wheat and paddy/rice change in the area, production and productivity during the period of last 15 agricultural years 2010-11 to 2024-25 in Haryana in which secondary annual data has been collected from agricultural statistics of Haryana government, Economic Surveys and Statistical Abstracts. The following methods were employed: compound annual growth rates (CAGR), linear trend regression, coefficient of variation (CV), and the Cuddy–Della Valle instability index (CDVI) and Pearson correlation. The aggregates suggest very weak overall wheat growth in wheat area (0.18% per year) relative to wheat production (1.15%) and wheat yield (0.96%). Growth rate in area and production is significantly higher for paddy in case of paddy [2.83% and 5.30% respectively] while growth rate in yield is slightly higher [2.40%]. No significant correlation is found between wheat and paddy areas at the 5% level with the value of $r = -0.366$, $p = 0.180$ for wheat and paddy area correlation and $r = 0.101$, $p = 0.719$ for wheat and paddy production correlation. Thus, there is no statistically significant direct wheat–paddy substitution effect evident in the analysis. The analysis therefore, does not provide evidences of direct wheat–paddy area substitution. But the findings indicate that the cropping pattern in Haryana would remain focussed on two cereals and expansion of paddy would be accompanied by a shift in the other kharif crops. The paper also discusses implications for water-resource sustainability and crop-diversification policy. A data quality audit is included because there are no annual official series and the statistical findings are intended to be analyzed in the series that have been compiled, not as causal estimates.

Keywords: Haryana, wheat, paddy, rice, cropping pattern, CAGR, productivity

1. Introduction

Despite the rapid industrialization of Haryana since its establishment in 1966, Agriculture still plays a key role in the rural economy of the State (Kumar and Sing 2021). While Agriculture and Allied Sectors has decreased from around 21 per cent in mid-2000s to 14.9 per cent in 2025-26 in Gross State Value Added at constant (2011-12) prices (Government of Haryana, 2026), the sector is still playing a significant role in the livelihoods of rural population, food security and Haryana's contribution to the national food-grain pool. Though Haryana is a small State in terms of land size accounting only for 1.3 per cent of the total landmass of India, it has a larger share in supplying wheat and rice to the Central Pool, the buffer-stock system of the Government of India which supports the public distribution system (Government of

Haryana, 2026). Since the mid-1960s, the cropping pattern has been reorganized so that paddy is planted in the kharif (monsoon) season and wheat is sown right after in the rabi (winter) season on the same piece of land. This system was actively promoted through high yielding variety seeds and the minimum support prices, canal and tube well irrigation and input subsidies during Green Revolution helped transform Haryana into one of the most important food-surplus states in India (Dhanda, Yadav, Yadav & Chauhan, 2022). The total wheat and paddy area increased from about 935 thousand hectares in 1966-67 to almost 4405 thousand hectares in 2024-25 and combined share in gross cropped area of the state increased from 28.2 percent to 65.9 percent during the same period (Government of Haryana, 2026).

This intensification has been, however, at a cost. The rice–wheat system of the north-western Indo-Gangetic Plains (NW-IGP) region, comprising a significant part of Haryana, has been coming under increasing stress (Kumar, 2018), with signs of fatigue from stagnating factor productivity; deteriorating soil health; residue-burning linked to air pollution; and, most alarmingly, rapid depletion of groundwater reserves because paddy is an unusually water-intensive crop grown in a semi-arid tract in the NW-IGP region (Bhatt et al., 2016; Dhanda et al., 2022; Gupta et al., 2003). The Government of Haryana has, in turn, introduced the Mera Pani Meri Virasat (MPMV) scheme in 2020 to encourage farmers to shift their cultivation from rice or paddy to crops that require less water like maize, cotton, pulses and oil seed crops (Government of Haryana, 2026). Despite this and the successive years of the scheme official figures reflect that the paddy area is still expanding and not shrinking. In this background, it is timely and policy relevant to have a systematic, updated statistical evaluation of the movement of area, production and productivity of these two crops, namely wheat and paddy in Haryana in the past 15 years and the degree of stability or instability of this movement. This paper does make such an assessment for every year period 2010-11 to 2024-25.

Some empirical studies have been conducted to explore the growth and instability of wheat and rice cultivation in Haryana and Indo-Gangetic Plains region. Simhar (2014) studied the growth and instability in agricultural production at the district level and he observed that there is a wide range of variation across districts, which is much smaller at the state level. Structural change and unstable growth of agriculture in Haryana between 2007 and 2015 have been reported by Aggarwal and Moudgil (2015) with significant increase in wheat area, and even greater increase in wheat production, indicating an increase in productivity. Using growth-rate and instability analysis of wheat in the State of Haryana in comparison to the all-India trend, Nisha, Nain and Aneja (2019) have observed that the year-to-year fluctuations for wheat area and production in Haryana were higher than those in the aggregates. Ramadas Kumar and Singh (2019) analyzed the trends and prospects of wheat production in India and noted that although the sown area has increased slightly from 2008 to 2018, the gain in wheat production was relatively low in some years owing to terminal heat stress and untimely rains.

From the study of compound annual growth rates and the coefficient of variation of wheat area computed by Swati (2024) for the sub-periods 2005-10, 2010-15 and 2015-20, it was observed that the growth rate of wheat area for the last sub-period (2015-20) has gone negative while that of wheat production and yield have improved, and the instability of area, production and productivity was generally low but uneven across the districts. On the paddy side Dhanda, Yadav, Yadav and Chauhan (2022) comprehensively reviewed the rice–wheat cropping system in the north-western part of India, which revealed the rising production costs, the decline in the groundwater-table by about 1 metre per year in the worst affected districts, and the imperative need for diversification of the crops and adoption of water-saving technologies like direct-seeded rice and zero-till wheat. The results of the total factor productivity stagnation in the

system are similar as concluded by various agronomic reviews by Ladha, Pathak, Tirol-Padre, Dawe and Gupta (2003); and by Gupta, Naresh, Hobbs, Jiaguo and Ladha (2003).

The main official sources of crop area, production and yield at policy level are derived from two sources, namely, Economic Survey of Haryana and State Statistical Abstract. New official statistics have been released, confirming the continued significance of wheat and rice, and updating statistics for a number of recent years. This study is unique because it has combined the three measures of growth, productivity, and instability into a single, updated state-level framework that also incorporates association measures. The study, however, has deliberately not regarded correlation as evidence of substitution or the post-2020 trend as a causal estimate of the effectiveness of Mera Pani Meri Virasat. The research gap is thus methodological, as well as temporal: an updated descriptive-statistical evaluation is useful, but a causal evaluation requires information on prices, procurement, irrigation and other competing crops at the district level, as well as panel data. Objectives of the Study are (1) To study the trend of wheat and paddy area, production and yield of Haryana 2010-11 to 2024-25 (2) To calculate and compare compound Annual Growth Rate (CAGR) of the area, production and yield of the two crops during the entire period and three sub-periods of five years (3) Assess the level of instability in wheat and paddy area, production and yield in terms of coefficient of variation and Cuddy-Della Valle instability index (4) To analyse the statistical relationship between wheat area and wheat production with paddy area and paddy production to check whether there is a substitution or complementation between two types of crops (5) To discuss the implications of the observed cropping pattern with respect to sustainability of water resources and crop diversification policy in Haryana.

2. Materials and Methods

2.1 Areas of study and periods of time

The study period has been selected as the agricultural years between 2010-11 and 2024-25 and the area of the study is 22-23 districts of the state of Haryana (Fig.1) as the number changed when Charkhi Dadri district was established in 2016 and subsequent reorganisation. In India, agricultural year consists of kharif season (paddy) followed by rabi season (wheat) that runs from July of one calendar year to June of the next calendar year.

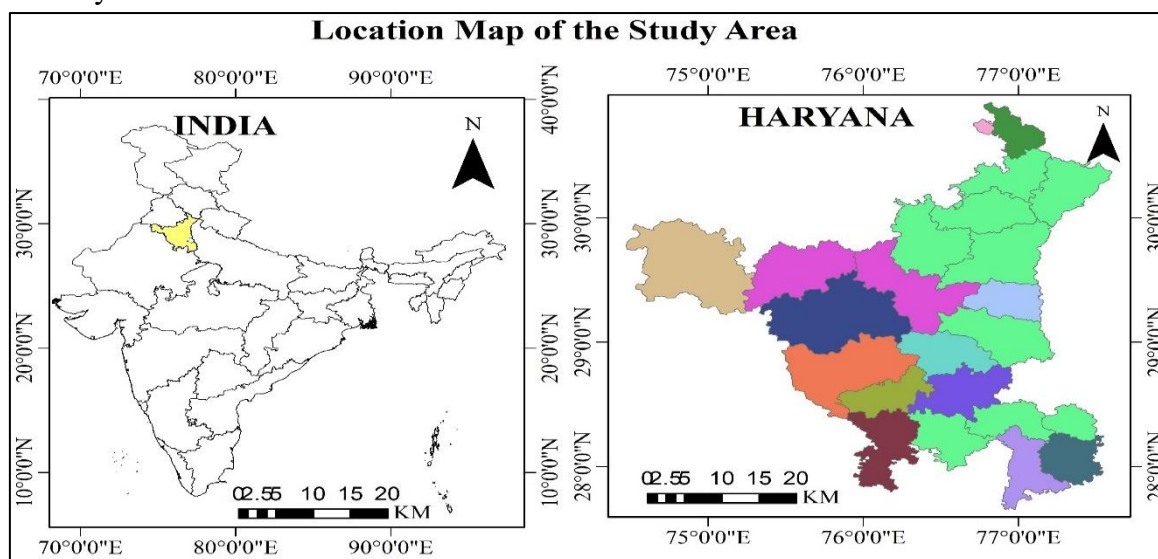


Fig.1: Location map

2.2 Data Sources

The study uses secondary annual time series data. The final dataset was compiled year-wise from the respective State Statistical Abstract of Haryana editions 2010-11 to 2023-24, and the latest Economic Survey of Haryana 2025-26 was used for the year 2024-25. The State Statistical Abstract and Economic Survey are the annual official statistical publications of the Haryana Department of Economic and Statistical Affairs. The area is reported in thousand ha, production in thousand tonnes and yield in kg/ha. The final analytical data does not contain any interpolation.

2.3 Statistical Tools

Using commonly used statistical tools given in the Indian literature on growth of agriculture (Swati, 2024; Nisha et al., 2019), the following techniques were used with the compiled time series.

Relative dispersion was measured with arithmetic mean, standard deviation and coefficient of variation. And expressed as arithmetic mean, standard deviation (s.d. and coefficient of variation (CV %) = (s.d. / mean) x 100, was calculated for the area, production and yield of each crop to estimate the degree of dispersion by the crop over time.

$$C.V. = \left(\frac{S.D.}{\bar{x}} \right) \times 100$$

(b) Compound Annual Growth Rate -CAGR was computed for the full 14-year span (2010-11 to 2024-25) as well as for three approximately five-year sub-periods (2010-11 to 2015-16, 2015-16 to 2020-21, and 2020-21 to 2024-25) to detect turning points in growth.

$$CAGR(\%) = \left[\left(\frac{V_f}{V_i} \right)^{\frac{1}{t}} - 1 \right] * 100$$

Each series was plotted against the number of years in the study and a linear trend regression was fitted using Ordinary Least Squares (OLS) regression. The regression line was of the form

$$Y_t = a + bt + \epsilon_t$$

where $t = 1, 2, \dots, 15$ represents the years in the study, b is the estimated average annual absolute change and R -squared is the proportion of variation explained by the linear trend. This is a linear trend model, NOT a semi-log model. Where applicable, the slope, R -squared and regression p -value are presented for the major trend coefficients.

(e) Cuddy–Della Valle Instability Index (CDVI (%)):

$$CDVI (\%) = CV \times \sqrt{1 - R^2}$$

(CV is the coefficient of variation of the series and R -squared is obtained from the linear trend regression in (c)). This index is the standard way of measuring year-to-year fluctuations in Indian agricultural growth studies (Cuddy & Della Valle, 1978; Simhar, 2014; Swati, 2024) after eliminating the secular trend from the simple coefficient of variation.

(e) Pearson's product-moment correlation coefficient between wheat area and paddy area, cotton area and paddy area and also between wheat production and paddy production were calculated. Two-tailed p -values were also computed to determine if the associations found are significantly different from zero. Due to the low number of annual observations ($n=15$) and the presence of strong time trends in both crop series, the correlation is understood as a descriptive association and not as evidence of causality or substitution.

$$r = \frac{\sum (X_i - \bar{X})(Y_i - \bar{Y})}{\sqrt{\sum (X_i - \bar{X})^2 \sum (Y_i - \bar{Y})^2}}$$

The tabulated data then was computed in python. The results provided to two decimal places. During revision, the statistical workflow was extended to add correlation p-values and OLS trend significance tests. Also, a source-audit note has been added to differentiate directly reported official observations from compiled/interpolated observations.

3. Results and Discussion

3.1 Trend analysis of Wheat and Paddy

Annual data on area, yield and production of wheat and paddy for Haryana for period 2010-11 to 2024-25 have been compiled as presented in Table 1.

Table 1: Area, Yield and Production of Wheat and Paddy in Haryana, 2010-11 to 2024-25

Year	Wheat Area ('000 ha)	Wheat Yield (kg/ha)	Wheat Prod. ('000 t)	Paddy Area ('000 ha)	Paddy Yield (kg/ha)	Paddy Prod. ('000 t)
2010-11	2504.0	4624	11578.0	1243.3	2788	3465.0
2011-12	2531.3	5183	13119.0	1234.1	3044	3757.0
2012-13	2496.9	4452	11117.0	1206.3	3268	3941.0
2013-14	2499.1	4722	11800.0	1244.6	3248	4041.0
2014-15	2601.0	3981	10354.0	1287.0	3113	4006.0
2015-16	2575.6	4407	11351.0	1353.1	3061	4144.0
2016-17	2564.0	4828	12384.0	1385.2	3213	4453.0
2017-18	2530.5	4847	12263.0	1422.0	3422	4880.0
2018-19	2553.2	4925	12573.0	1446.9	3121	4517.0
2019-20	2533.9	4687	11877.4	1559.0	3334	5198.0
2020-21	2354.0	4845	11406.0	1525.8	3692	5633.0
2021-22	2310.7	4533	10475.0	1534.5	3594	5514.0
2022-23	2377.0	4655	11063.0	1661.2	3564	5920.6
2023-24	2400.0	4674	11217.6	1777.7	3931	6987.8
2024-25	2568.0	5288	13580.0	1837.0	3885	7137.0

(Source: Compiled by the author from Government of Haryana (2024, 2025, 2026); CEIC Data (2024a, 2024b, 2024c); Ministry of Agriculture and Farmers Welfare (2026).

The area planted with wheat remained within a reasonably close range, ranging from 2,310.7 thousand hectares in 2021-22 to 2,601.0 thousand hectares in 2014-15, and back to 2,568.0 thousand hectares in 2024-25. Wheat yield increased from 4,624 kg/ha in 2010-11 to 5,288 kg/ha in 2024-25, while wheat production increased from 11,578.0 thousand tonnes to 13,580.0 thousand tonnes. Wheat production had reduced in 2021-22 due to both reduction in the area and yield of wheat.

A much bigger long-term expansion in Paddy is indicated. Paddy area increased from 1,243.3 thousand hectares in 2010-11 to 1,837.0 thousand hectares in 2024-25. During the same period, paddy yield rose from 2788 kg/ha to 3885 kg/ha with production growing from 3465.0 thousand tonnes to 7137.0 thousand tonnes. Paddy production was thus encouraged through both area expansion and productivity gains and used to be an essential part of the total gain.

3.2 Growth Rate (CAGR) Analysis

The divergent growth-rate results further support the divergent trajectories. The wheat area growth is insignificant throughout the period (0.18% per annum) Table 2, while the wheat production and yield are increased at a higher rate (1.15% and 0.96% per annum respectively). In all three indicators, Paddy shows a much faster growth rate, particularly in area (2.83%) and production (5.30%). The sub-period results indicate that the latest period has been marked with higher growth in paddy area and better wheat productivity growth. The patterns described are only descriptive and should not be interpreted as a causal relationship between a given policy and the changes observed.

Table 2. Compound Annual Growth Rate of Area, Production and Yield % per annum

Period	Wheat Area	Wheat Production	Wheat Yield	Paddy Area	Paddy Production	Paddy Yield
2010-11 to 2015-16	0.76	0.43	-0.32	1.36	3.00	1.61
2015-16 to 2020-21	-0.28	0.94	1.22	2.79	7.00	4.10
2020-21 to 2024-25	0.04	2.31	2.27	4.75	6.09	1.28
Overall, 2010-11 to 2024-25	0.18	1.15	0.96	2.83	5.30	2.40

Source: Author's computation from Table 1 using the CAGR formula given in Section 2.3(b).

Paddy area growth rises across the three sub-periods in the compiled series, from 1.36% annually in 2010-15 to 2.79% in 2015-20 and 4.75% in 2020-24. There is a time overlap with the introduction of Mera Pani Meri Virasat, but that does not mean that policy is ineffective. The observed pattern can be indicative of procurement incentives, relative profitability, irrigation infrastructure, crop risk, expectations of farmers and other factors that are not explicitly modelled here.

3.3 Instability Analysis

Simple CV shows that there is more variation for paddy as compared to wheat in overall variation, particularly for paddy production (CV 24.48%) (Table 3 & Table 4). Paddy does, however, have a very pronounced secular trend, though, and a significant portion of its CV is driven by the systematic nature of the trend, rather than by random instability. The CDVI thus offers a more trend-smoothing measure, however. In this regard, paddy area and yield have relatively low residual instability, whereas wheat production and yield are more vulnerable to shocks from one year to the next. Care should be taken in

interpreting these results, keeping in mind the difference between total variability and trend adjusted instability.

Table 3. Coefficient of Variation and Cuddy–Della Valle Instability Index, Wheat and Paddy, Haryana, 2010-11 to 2024-25

Crop / Variable	Mean	S.D.	CV (%)	R-squared (trend)	CDV Index (%)
Wheat - Area ('000 ha)	2506.53	73.44	2.93	0.045	2.86
Wheat - Production ('000 t)	12023.93	765.45	6.37	0.026	6.28
Wheat - Yield (kg/ha)	4794.80	224.44	4.68	0.112	4.41
Paddy - Area ('000 ha)	1452.00	184.55	12.71	0.897	4.07
Paddy - Production ('000 t)	4832.16	1182.86	24.48	0.907	7.46
Paddy - Yield (kg/ha)	3285.27	381.85	11.62	0.910	3.49

Source: Author's computation from Table 1 using the CV and Cuddy-Della Valle Instability Index formulae given in Section 2.3(a) and 2.3(e).

Table 4: Slope analysis of crops

Series	Slope	R ²	p-value	Inference
Wheat area	-9.03 thousand ha/yr	0.204	0.091	No significant linear trend
Wheat production	5.12 thousand t/yr	0.001	0.929	No significant linear trend
Wheat yield	18.22 kg/ha/yr	0.067	0.352	No significant linear trend
Paddy area	43.01 thousand ha/yr	0.928	<0.001	Strong significant upward trend
Paddy production	242.61 thousand t/yr	0.908	<0.001	Strong significant upward trend
Paddy yield	64.49 kg/ha/yr	0.782	<0.001	Strong significant upward trend

3.4 Correlation Between Wheat and Paddy Area and Production

The Pearson correlation between wheat and paddy area is $r = -0.366$ ($p = 0.180$, $n = 15$), while the correlation between wheat and paddy production is $r = 0.101$ ($p = 0.719$, $n = 15$) (Table 5.). For both of these relationships, the p-value is not less than 0.05. Thus, there is no statistically significant evidence of

direct wheat–paddy area substitution or production association in the analysis. The relationship between wheat area with paddy area is weak and negative in nature and hence have been interpreted only descriptively and not as causal or as crop displacement.

Table 5: Correlation analysis of wheat and paddy

Association	r	p-value	n	Interpretation
Wheat area × Paddy area	-0.366	0.180	15	Weak negative; not statistically significant
Wheat production × Paddy production	0.101	0.719	15	Very Weak positive; not statistically significant

3.5 Changing Share of Wheat and Paddy in the Cropping Pattern

The combined gross cropped area of wheat and paddy accounted for about 57.6% during 2010-11 and 65.9% during 2024-25 based on the gross cropped area reported in the manuscript. In the total wheat-paddy area, the proportion of paddy grew from approximately 33.2% to 41.7% (Fig. 1, Fig. 2, Fig.3 and Fig.4). This means that the concentration has been increasing in the two-crop system. Shares are derived values from the compiled gross-cropped-area dataset and should be viewed as indicators and the shares are calculated from the final analytical data in Table 1 and give the relative importance of wheat to paddy in the cropping pattern of Haryana in various years.

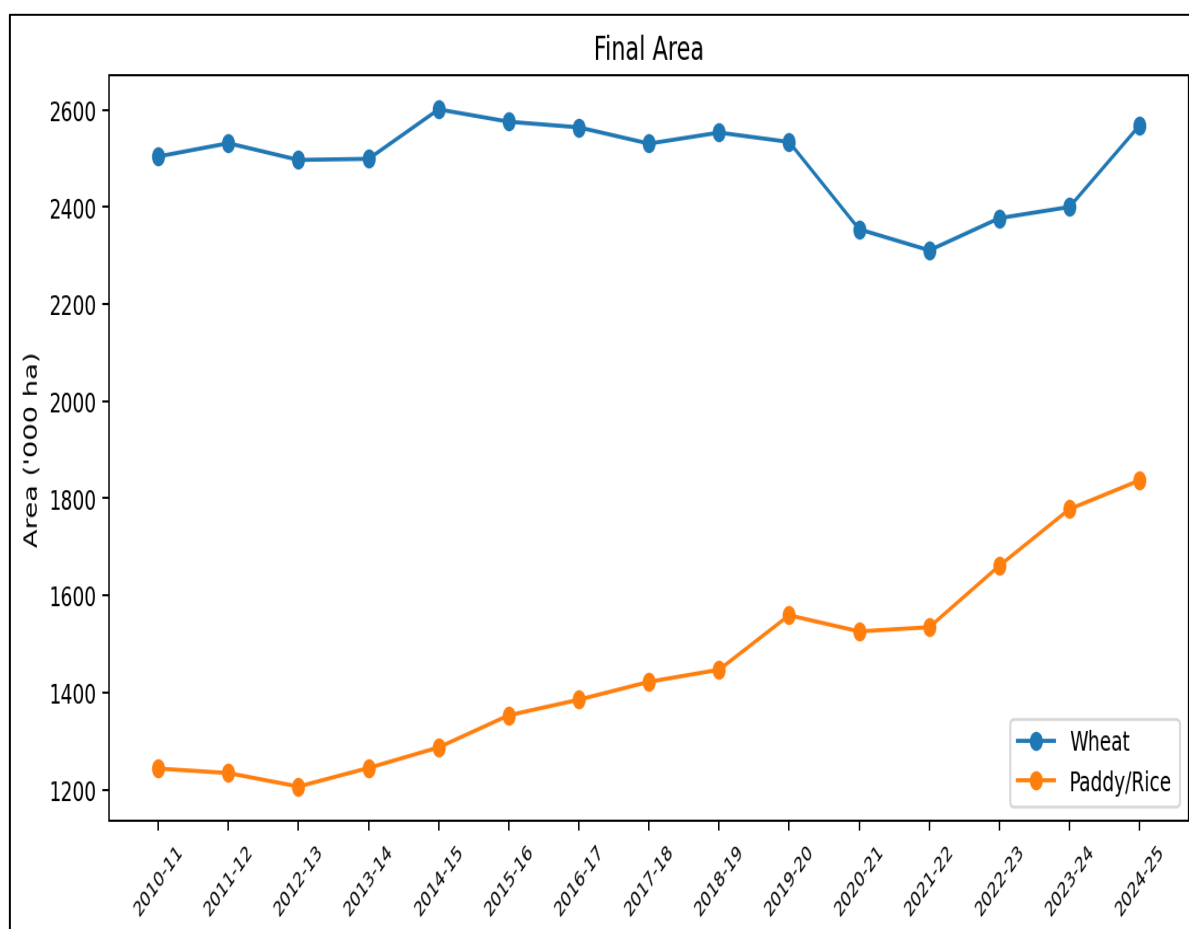


Figure 1. Trend in wheat and paddy/rice area, Haryana, 2010-11 to 2024-25

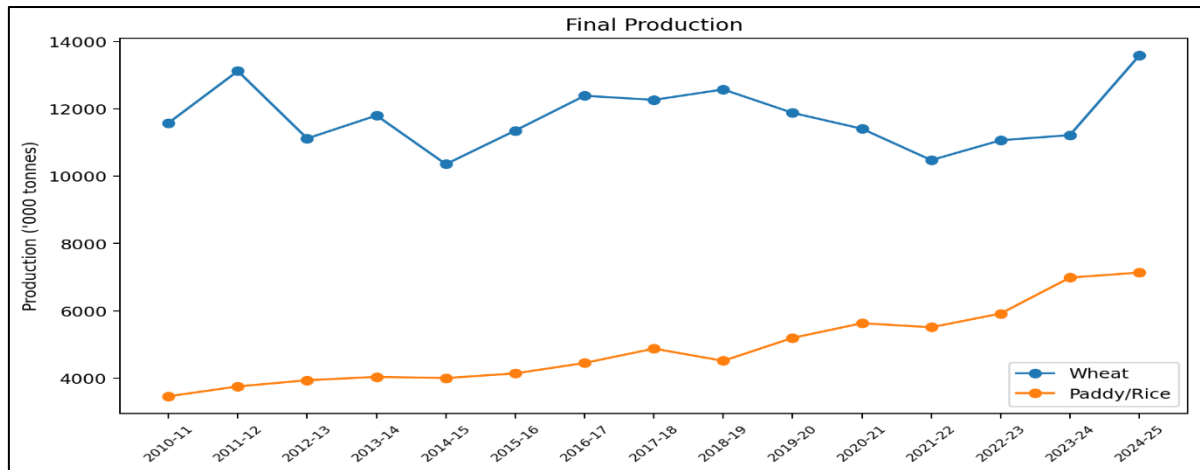


Figure 2. Trend in wheat and paddy/rice production, Haryana, 2010-11 to 2024-25

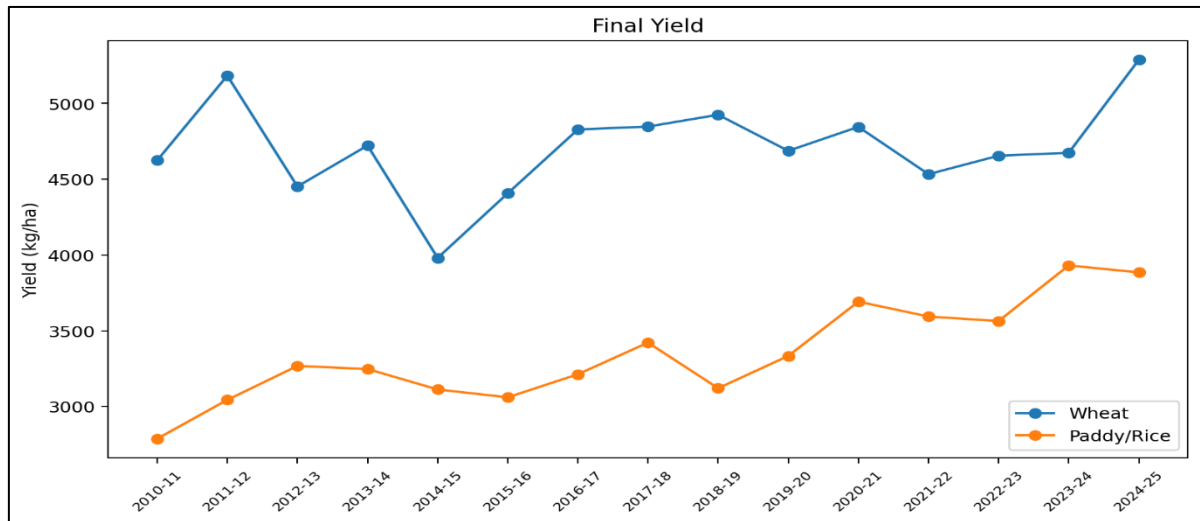


Figure 3. Trend in wheat and paddy/rice productivity, Haryana, 2010-11 to 2024-25

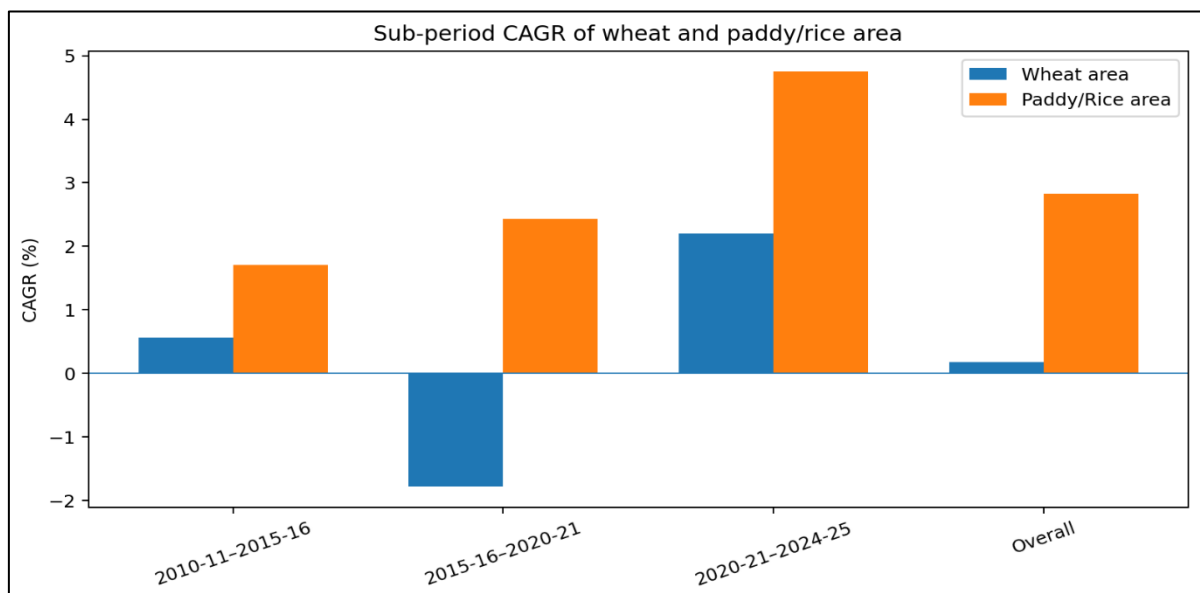


Figure 4. Sub-period CAGR of wheat and paddy/rice area

4. Discussion and Policy Implications

The wheat–paddy system has not lost its concentration in Haryana as seen from the increase in the significance of both cereals in the cropping pattern. The evidence corroborates the general literature on resource stress in the north-western Indo-Gangetic Plains particularly in the paddy intensive irrigated areas. This paper does not directly estimate groundwater depletion, however, as groundwater depth, rainfall, and irrigation intensity and water use data are not part of the statistical model. Therefore, the sustainability interpretation is not a casual estimation based on this data set, but literature-based.

Mera Pani Meri Virasat programme is an important policy programme encouraging crop diversification. The analysis done on the compiled annual series indicated that paddy area has been on the rise since 2020. This descriptive trend is however not sufficient to assess the effectiveness of this programme as there is no counterfactual or control group included in the current study. A rigorous evaluation would need district- or farm-level data that would compare programme participants with non-participants, taking into account the procurement prices, rainfall, groundwater availability, irrigation costs and crop profitability.

The productivity-oriented rise in wheat with a CAGR of 0.96 per cent per annum to a record 5,288 kg/ha in 2024-25 is actually welcome news from a food-security perspective as it means more area under the crop is not necessarily required to make it to the Central Pool. This gives some policy space: A part of the wheat area in Haryana could, in principle, be freed-up for diversifying and still contribute to food-grain production if there is scope for continued improvement in wheat yields through varietal and precision-input management and market and price incentives for other crops are made similar to wheat.

5. Conclusion

This paper dealt with wheat and paddy area, production, productivity, growth and instability of Haryana during 2010-11 to 2024-25. Paddy area grew faster, whereas area growth of wheat was almost stalling with positive productivity related output growth. Wheat area, production and yield had CAGRs of 0.18%, 1.15% and 0.96%, respectively, in the overall period as compared to CAGRs of 2.83%, 5.30% and 2.40% in the case of paddy, respectively. A weak correlation ($r = -0.366$, $p = 0.180$) was observed between the wheat and the paddy area, and the wheat and paddy production correlation was also statistically insignificant ($r = 0.101$, $p = 0.719$). Therefore, the analysis does not give enough statistically significant evidence of the direct substitution of wheat for paddy. The major feature is the persistence of the concentration on the rice–wheat system. Policy implications refer to the market and procurement support for other crops and causal evaluation of diversification programmes is over to future district level work.

6. The limitation of the study

There are five main limitations of the study. First, it is based on state-level aggregate data, thus it is not possible to account for the heterogeneity at the district or farm level. Second, thanks to the historical publications, some of the observations made by officials have been provisional, or may be subject to changes in later editions, the present analysis deals with the series of annual editions and makes the source status explicit. Third, the two-crop approach does not directly reflect all kharif/rai crop competition. Fourth, the study excludes the annual rainfall, groundwater depth, intensity of irrigation, relative prices, and procurement quantities and farmer-level adoption of diversification schemes, and thus causal claims are not justified. Fifth, correlation among time series that are trending should not be inferred as evidence of substitution or cause and effect. Districts level panel data and econometric techniques should be used in future research.

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