

Growth and Trend in Area, Production, and Yield of Wheat Crops in Uttar Pradesh: A Johansen Co-integration Approach

Abstract

This study investigated wheat crop area, production, and yield in Uttar Pradesh. Wheat crop data from 1990-91 to 2019-20 were obtained. Compound growth rate and trend analysis show that wheat crop area has reduced due to shifting to rabi crops. The growth in Uttar Pradesh's per-hectare yield boosted wheat production from 1990-91 to 2019-20. The methods were calculated using Johansen cointegration results, which reveal that number of irrigations affects wheat production. The study finds that cropping Intensity, negative fertilizer, and transportation positively affect wheat production.

Keywords: *Fertilizer, Growth, semi-log model, trend, wheat,*

Introduction

Wheat is the second crop after maize; in the year 2020-21, India produced 107.6 million tonnes of wheat, which was second only to China's production of 134.3 million tonnes (WDI, 22). Wheat is a northern staple. Indian wheat-growing states include Uttar Pradesh, Punjab, Madhya Pradesh, Haryana, and Rajasthan. Uttar Pradesh had 9.85 million hectares of wheat land and 35.50 million tonnes of wheat output in 2020-21 (UPDES, 2022.). Western, eastern, and central Uttar Pradesh are wheat-producing regions. Wheat is a main food and energy source in India. India is the world's second-largest wheat producer. Since independence, wheat production has risen from 6.60 to 107.6 million tonnes (WDI, 2022). Uttar Pradesh has the most land (35.1%) but the lowest productivity (2.7 tonnes/ha); hence it contributes the most to national production (35.03 percent). Wheat is grown in UP's west (3.29 million ha), east (5.24 million ha), and center (0.68 million ha). The protest and farmer fields yielded 1.35 tons/ha less. 2.7 tons/acre on 9.2 million acres. Despite stable farmland, production and productivity have fallen. Critical production constraints in western Uttar Pradesh after growing sugarcane-wheat and potato, decreasing soil organic carbon, mining for nutrients, inconsistent fertilization, crop waste burning that loses nutrients and organic carbon, and lowering the water table and water availability.

Investigating the area's instability linked it to foodgrain output and yields. Decomposition analysis showed dominance interaction had the most impact (Ansari. et al., 2022). State policies have helped sugarcane farming. Proper utilization of limited resources can raise production and profitability, doubling revenue and improving farmers' lives (Ansari. et al., 2022). Early-maturing sugarcane is sustainable. Mumias Sugar Company should research

profitable recovery strategies, and farmers should manage well (Khaemba et al., 2021). Location affected production more than yield (Ansari. et al., 2022). J&K's 2020 apple acreage was 177.258 million hectares. Time and area effect production. Improve apple production and productivity in India and Jammu & Kashmir by analysing the area, output, and yield of apple fruit (Shah 2020).

Review of literature

(Ansari. et al., 2022) results showed that location had a greater impact on production than yield did on the state. The study placed a strong emphasis on expanding the area planted with pulse crops and enhancing pulse crop output through technical interventions. Wheat was found to be one of the most popular crops among major food grains, with the biggest yearly growth in area, production, and yield. This discovery led to the conclusion that wheat was one of the most important crops. In spite of this, efforts should be made to increase the area under other major food grains (rice and wheat) with high-quality seeds of improved varieties, improved food grain production technology, price, marketing support, and effective extension mechanisation in order to raise the overall productivity of major food grains (Ansari. et al., 2023). (Ansari. et al., 2022) The amount of land that is irrigated, the amount of land that is not irrigated, and the amount of rainfall all have a favourable impact on rice output. On the other hand, non-irrigation and average annual rainfall both indicated a favourable but statistically negligible impact on rice output during the course of the study. In the short run, all of the determinants had a negative and significant effect on the total rice production's convergence towards equilibrium, but in the long run, none of the determinants did. It has been found that the region experiences a higher level of volatility in comparison to the production and yields of food grains. The findings of the decomposition analysis demonstrated that the dominance interaction had the most significant influence((Ansari. et al., 2022.)

Trends are summarised using time-series growth rates. Growth rates assess wheat productivity indices. These growth estimates inform policy. Crop forecasting and planning can benefit from trend rate estimations with and without fluctuations.

This study analyses regional growth. UP's wheat harvest. policy-maker

Material and method

The study used secondary sources. The Uttar Pradesh Directorate of Economics and Statistics provided data on wheat area, production, and productivity from 1990-1991 to 2018-2019. Eview10 displayed the results as tables and diagrams. Johnson cointegration was used to determine wheat production parameters.

This study examines semilinear growth over 30 years using compound growth rates and t-values. Excel and SPSS were used to analyse and handle data throughout.

The semi-log trend function was used to estimate Uttar Pradesh wheat crop growth.

$$\ln X = \beta_0 + \beta_1 Z + e \quad \text{-----} \quad 1$$

Where X = dependent variable (area, yield and production);

Z = trend over specific period

β_1 = coefficient of trend;

ln = natural logarithm; and e = error term

measures β_1 (the constant proportional or relative change in x for a given absolute change in the value of the regressor z.

$$\beta_1 = \frac{\text{relative change in regressand}}{\text{absolute change in regressor}}$$

If 100 multiply the relative change in x, give the percentage change, or the growth rate, in x for an absolute change in z, the regressor. That is, 100 times β_1 gives the growth rate in x; 100 times β_1 is known in the literature as the semi-elasticity of x with respect to z and gives the instantaneous (at a point in time) rate of growth, to find out the compound (over a period of time) rate of growth, the following formula was applied.

$$\beta_1 = \ln (1+ r)$$

Where β_1 = Instantaneous rate of growth; ln = Natural logarithm; r = Compound rate of 1, subtract β_1 growth. Hence taking antilog of from it and multiply the difference by 100, would give compound rate of growth.

Model Specification (Johnson)

Given the nature of the data, following model is specified:

$$WP_t = \beta_0 + \beta_1 IRR_t + \beta_2 FERT_t + \beta_3 CROP_t + \beta_4 TRN_t + e_t \dots \dots \dots 1$$

Where,

t=time periods

WP_t = Wheat Production t (thousand tonne)

IRR_t = Irrigation.

FCT_t = fertilizer.

$CROP_t$ = Cropping Intensity

TRN_t = Transportation

Agricultural Statistics of India Yearly Book and Indian Economic Survey provided these factors' data. Wheat Production is reliant. Johansen The results are obtained using

cointegration. Granger dubbed non-stationary processes having stationary linear combinations Co-integration. Granger used it to check long-term econometric relationships. Long-run relationship between variables is described by cointegration. Since the 1990s, cointegration has been used to examine the link between time series variables. Soren Johansen's cointegration test tests time series variables for cointegration. All variables integrating in order is ideal. In models with a combination of I(0), I(1), and I(2) variables, co-integrating connections may arise. 16 Vector autocorrelation model of order p performs Johanson cointegration:

$$Y_t = \mu + A_1 y_{t-1} + \dots + A_p y_{t-p} + \varepsilon_t \quad (1)$$

In above equation Y_t represents n-by-1 vector of variables which are supposed to be the integrated at order 1.

The above model can also be represented in following form:

$$\Delta Y_t = \mu + \pi y_{t-1} + \sum_{i=1}^{\rho-1} r_i \Delta y_{t-1} + e_t \dots \dots \dots 2$$

where

$$\pi = \sum_{i=1}^{\rho} A_i - I \text{ and } R_i = \sum_{j=i+1}^{\rho} A_j \dots \dots \dots 3$$

If we decrease to rank r smaller than n, we get n-by-r matrices and with the same rank of r such that equals ' and 'y, which are stationary. r displays the number of co-integrating relationships. VEC model adjustment parameters are and. For any given r, MLE of displays y_{t-1} capitulates r with highest canonical correlations of y_t with y_{t-1} when examined and corrected for lagged differences and deterministic variables. Johansen cointegration strategy uses two likelihood ratio significance tests. Trace test and maximal eigen value test.

$$J_{trace} = -T \sum_{i=r+1}^n \ln (1 - \hat{P}_i) \dots \dots \dots 4$$

$$J_{max} = -T \sum_{i=r+1}^n \ln (1 - \hat{P}_{r+1}) \dots \dots \dots 5$$

Whereas, T represents the size of sample and \hat{P}_i denotes the ith largest canonical correlation. In case of trace test, we shall test the null hypothesis that there are r co-integrating vectors versus the alternative hypothesis that there are n co-integrating vectors. Whereas in case of max eigen value test, we test the null hypothesis that there are r co-integrating vectors versus the alternative hypothesis that there are r+1 co-integrating vectors. Critical values for

both of the tests can be observed in Johansen and Juselius tables. Although Johansen's methodology is typically used in a setting where all variables in the system are $I(1)$. Yet, Johansen explains that before applying the test we need to test order of integration of the variables in the given system.

First study checks the level of integration of variables in the model. For this purpose study uses Augmented Dickey Fuller (ADF) test. All the variables are found to be integrated at order 1.

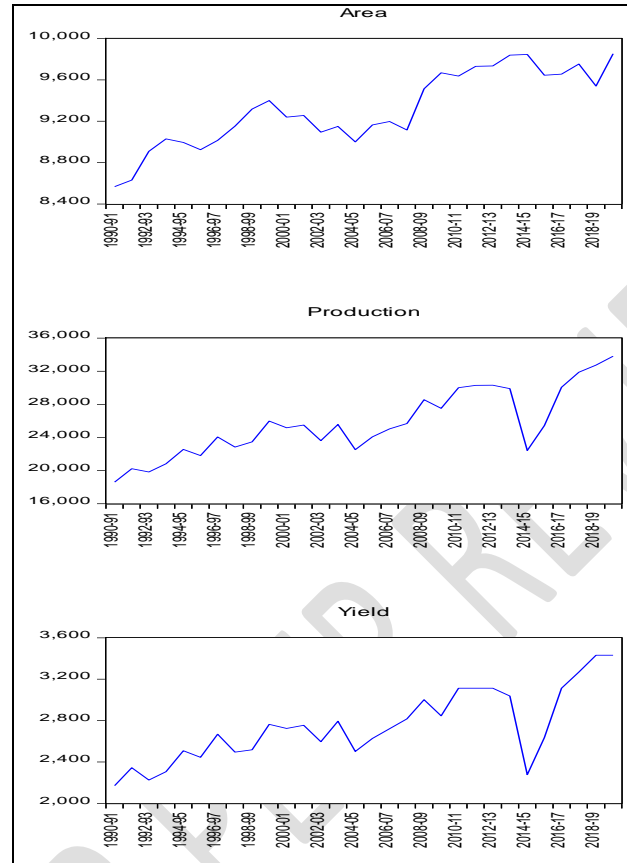
Results and Discussion

Trend and rate of growth in wheat crop of Uttar Pradesh Wheat is grown extensively in India as well as in Uttar Pradesh on a subsistence basis for Figure 1, the total area of land in Uttar Pradesh that was used for growing wheat in the 1990-1991 crop year was 8567.7 thousand hectares. When compared to the 9853 thousand hectares that were cultivated in the year 2019-2020, this area shows that the land area devoted to wheat cultivation has increased over the passage of time. Wheat crop production in the year 1990-1991 was 18600.1 thousand tonnes, and it is anticipated to expand to 15215.4 thousand tonnes to 33815.5 thousand tonnes over the year 2019-2020. Wheat production dropped to 22417.4 thousand tonnes (TT) during the crop year 2014-2015 (July-June) as a result of insufficient rainfall and unseasonably warm and dry weather conditions. And finally, this suggests that the yield for wheat crops in Uttar Pradesh during the year 1990-1991 was 2171 per hectare, but the yield for wheat crops during the year 2019-20 was 3234 per hectare. This was the case due to the fact that the yield for wheat crops in Uttar Pradesh during the year 2019-20 was 3234 per hectare.

Trends of Wheat Crop in Uttar Pradesh

Figure 1.0

Area (Thousands Hectare)
Production (Thousands tonne)
Yields (Kg per Hectare)



Source: Handbook of Statistics on Indian States - Reserve Bank of India

Growth rate of Area, Production and Yield of Wheat in Uttar Pradesh,

Area (Thousands Hectare)
Production (Thousands tonne)
Yields (Kg per Hectare)

List 1

Particular	Area	Production	Yield
F-Statistic	104.81**	78.20**	47.24**
Trends Coefficient	9.077	9.90	7.73
t- Statistics	10.23**	8.84**	6.87**
Instantaneous Growth Rate	0.39	0.15	1.12
Compound Growth Rate	0.40	1.5	1.1
R- Square	0.789	0.736	0.627
Adjusted R ²	0.781	0.726	0.614

***Significant at 1 percent level of significance **Significant at 5 percent level of significance.

Table 1 presents the findings of the semi-log model for the area, production, and yield of wheat crops from the years 1990-1991 to 2019-2020. The findings of the F-static test indicate that the models were significant for the number of wheat area crops, wheat production, and wheat yield in Uttar Pradesh. The findings showed that the trend co-efficient for wheat area, production, and yield was positive. This was demonstrated by the findings. The positive sign of the compound growth rate indicates that the area, production, and yield of the wheat crop were falling and then increasing at a rate of 0.39 percent per year, 0.15 percent per annum, and 1.12 percent per annum; accordingly, during the period of study. The area, production, and yield of wheat crops fell at rates of 0.78 percent, 0.73 percent, and 0.62 percent, respectively, as shown by the r square.

Table 1. Unit Root Test (ADF) at 1st difference

At First Difference						
		d(LNWP)	d(LNIRR)	d(LNFER)	d(LGCRIN)	d(LNTRAN)
With Constant	t-Statistic	-6.3009	-7.1953	-6.5809	-5.5893	-5.9995
	Prob.	0.0000	0.0000	0.0000	0.0001	0.0000
		***	***	***	***	***
With Constant & Trend	t-Statistic	-6.1688	-7.6554	-6.6589	-6.3029	-5.8788
	Prob.	0.0001	0.0000	0.0000	0.0001	0.0003
		***	***	***	***	***
Without Constant & Trend	t-Statistic	-6.1108	-5.4789	-5.6578	-6.6358	-7.533
	Prob.	0.0000	0.0000	0.0000	0.0000	0.0000
		***	***	***	***	***

*** significant

As can be seen in Table 1, all of the variables that were utilised in the research were included in the same manner. Following the testing for the study's unit root, the Johansen Co-integration test is used to investigate the study's variables in terms of their long-term relationships. Before applying the Johansen Co-integration test, study finds the optimal lag length.

Table 2. VAR Lag Order Selection Criteria

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-932.9452	NA	1.03e+24	69.47742	69.71739	69.54878
1	-864.3214	106.7482	4.21e+22	66.24603	67.68585*	66.67416
2	-830.1967	40.44414*	2.65e+22*	65.57012*	68.20979	66.35503*
* indicates lag order selected by the criterion						
LR: sequential modified LR test statistic (each test at 5% level)						
FPE: Final prediction error						
AIC: Akaike information criterion						
SC: Schwarz information criterion						
HQ: Hannan-Quinn information criterion						

Table 2 indicates that the AIC criteria recommend setting the best lag length to be equal to two; hence, the study makes use of two lags in its investigation of the cointegration of the variables.

Table 3. Johansen Cointegration Test (Trace Statistics)

Hypothesized No. of CE(s)	Eigen value	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.780778	101.5622	76.97277	0.0002
At most 1 *	0.680944	60.58509	54.07904	0.0118
At most 2	0.474292	29.74060	35.19275	0.1720
At most 3	0.278053	12.37934	20.26184	0.4154
At most 4	0.124264	3.582643	9.164546	0.4778
Trace test indicates 2 cointegrating eqn(s) at the 0.05 level				
* denotes rejection of the hypothesis at the 0.05 level				

Table 3 presents the two co-integrating vectors along with their trace statistics. This provides compelling evidence for a long-run link between the model's variables.

Table 4 Johanson Cointegration Test (Maximum Eigen Values)

Hypothesized No. of CE(s)	Eigen value	Maximum Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.780778	40.97710	34.80587	0.0081
At most 1 *	0.680944	30.84449	28.58808	0.0253
At most 2	0.474292	17.36126	22.29962	0.2123
At most 3	0.278053	8.796700	15.89210	0.4559
At most 4	0.124264	3.582643	9.164546	0.4778
Maximum Eigen test indicates 2 cointegrating eqn(s) at the 0.05 level				
* denotes rejection of the hypothesis at the 0.05 level				

Table 4 presents, only two co-integrating vectors that can be found in the model; these vectors are strong evidence for the model's variables having a long-term link with one another. Now, let's talk about the model's long-run coefficients in your study.

Table 5. Long Run Coefficients

Cointegrating Eq:	CointEq1
WHEAT_PRODUCTION(-1)	1.000000
IRRIGATION(-1)	0.036085 (0.96839) [0.03726]
FERTILIZER(-1)	-47.43265 (25.0032) [-1.89706]
CROPING_INTENSITY(-1)	1506.256 (482.496) [3.12180]
TRANSPORTATION(-1)	-0.127959

	(0.03376)
	[-3.79065]
C	-232476.2
	(70049.3)
	[-3.31875]

Table 5 demonstrates long-term variable relationships. It reveals that fertiliser boosts wheat output slightly. Better irrigation boosts wheat production. Improved seeds boost wheat production by 0.03 percent per tonne. Wheat production is hampered by cropping Intensity. Transport also affects wheat output. One conveyance boosts wheat productivity by 0.12%.

Table 6 Vector Error Correction Model

Error Correction:	D(WP)	D(IRR)	D(FER)	D(CR IN)	D(TRAN)
CointEq1	-0.45109	-0.000586	-0.00332	-0.000145	5.611920
	(0.24012)	(0.03229)	(0.00052)	(0.00020)	(3.36740)
	[-1.87864]	[-0.01814]	[-6.41869]	[-0.71512]	[1.66654]
D(WP(-1))	0.356658	-0.045487	0.002928	0.000110	-3.86734
	(0.38214)	(0.05139)	(0.00082)	(0.00032)	(5.35909)
	[0.93333]	[-0.88512]	[3.55660]	[0.34286]	[-0.72164]
D(WP(-2))	0.057239	-0.008921	0.002661	-0.000155	-4.990176
	(0.24959)	(0.03357)	(0.00054)	(0.00021)	(3.50031)
	[0.22933]	[-0.26578]	[4.94832]	[-0.73886]	[-1.42564]
D(IRR(-1))	-2.434157	-0.010858	-0.00808	-0.000312	48.16056
	(1.81192)	(0.24367)	(0.00390)	(0.00153)	(25.4105)
	[-1.34341]	[-0.04456]	[-2.07003]	[-0.20444]	[1.89530]
D(IRR(-2))	0.424331	0.030664	-0.017093	0.002675	22.89785
	(1.92822)	(0.25931)	(0.00415)	(0.00163)	(27.0415)
	[0.22006]	[0.11825]	[-4.11499]	[1.64554]	[0.84677]
D(FER(-1))	106.7169	1.058989	-0.173676	-0.039536	-109.7153

	(53.5691)	(7.20415)	(0.11540)	(0.04517)	(751.257)
	[1.99214]	[0.14700]	[-1.50502]	[-0.87529]	[-0.14604]
D(FER(-2))	-47.15094	19.33908	0.036139	0.024891	512.0481
	(71.1352)	(9.56651)	(0.15324)	(0.05998)	(997.605)
	[-0.66284]	[2.02154]	[0.23583]	[0.41499]	[0.51328]
D(CR IN(-1))	147.2608	25.10379	3.662599	-0.112387	-60.9803
	(293.348)	(39.4505)	(0.63192)	(0.24735)	(4113.94)
	[0.50200]	[0.63634]	[5.79594]	[-0.45436]	[-0.01482]
D(CR IN(-2))	426.3344	30.55314	1.734284	-0.021668	5008.657
	(271.753)	(36.5463)	(0.58541)	(0.22914)	(3811.09)
	[1.56883]	[0.83601]	[2.96253]	[-0.09456]	[1.31423]
D(TR(-1))	-0.035734	-0.00023	-0.000216	-1.16E-05	-0.131119
	(0.02411)	(0.00324)	(5.2E-05)	(2.0E-05)	(0.33811)
	[-1.48214]	[-0.07095]	[-4.15176]	[-0.56895]	[-0.38780]
D(TR(-2))	-0.048565	0.001171	-0.000293	-4.93E-06	-0.078355
	(0.01831)	(0.00246)	(3.9E-05)	(1.5E-05)	(0.25678)
	[-2.65241]	[0.47551]	[-7.41907]	[-0.31940]	[-0.30515]

Table 6 displays vector error correction model coefficients based on two lag duration and Error Correction Term. The study's model suggests a short-run link since ECM is negative and substantial. 45 percent of short-run disequilibrium is corrected in a year.

Table 7. Model Summary

R-squared	0.582580	0.235424	0.879022	0.452542	0.446665
Adj. R-squared	0.304300	-0.274294	0.798370	0.087569	0.077774
Sum sq. resids	57893446	1047049.	268.6539	41.16130	1.14E+10
S.E. equation	1964.577	264.2030	4.232052	1.656528	27551.36
F-statistic	2.093503	0.461871	10.89895	1.239934	1.210833
Log likelihood	-226.9006	-174.7365	-67.25166	-42.86463	-295.5608
Akaike AIC	18.30005	14.28742	6.019358	4.143433	23.58160
Schwarz SC	18.83232	14.81969	6.551630	4.675704	24.11387
Mean dependent	496.4231	118.0769	3.253846	0.523077	6664.231
S.D. dependent	2355.364	234.0470	9.424828	1.734199	28689.59

Table 7 summarises the models. The model's P-Value is.0000. Over 59% of the endogenous variable variance is explained by external factors, indicating a good model. Examine data difficulties. Diagnostic tests shouldn't be in-depth.

Recommendation and Conclusion

Compound growth rate and trend analysis suggest wheat cultivation has increased. Each hectare produced more wheat in Uttar Pradesh from 1990–1991 to 2018–19. Mechanization helps Uttar Pradesh grow more wheat, reveals research. Modern irrigation, fertilizer, crop number, and transit affect wheat productivity. Fertilizer doesn't affect how much wheat grows, concludes the research. Poor farmers can't read or write, which affects wheat yield. Farmers don't apply fertilizers properly. Where wheat output is low, and development targets must be reached, domestic growth mobilisation (i.e., boosting production effort) is crucial. The study examined Uttar Pradesh's wheat production. The study examined Uttarpradesh's wheat production from 1990-1991 to 2018-2019. Johansen cointegration and vector error correction were utilized. All model variables are stable, according to the ADF test. Wheat production and related factors have long- and short-term relationships. Irrigation, fertilizer, crop number, and transport are vital for cultivating wheat. The external sector (transportation) and government aid boosted Uttar Pradesh's wheat production. Similar to wheat growth. The economy grew. State wheat production increased during this study.

Following study recommendations:

- a) Increase sector transportation. Government should subsidize transportation to expand its number.

- b) The government should advise commercial banks to give low-interest long-term loans to farmers because many impoverished farmers can't afford crop mechanization.
- c) Advertising should be increased to raise knowledge about improved agricultural machinery.
- d) Government should educate farmers. Farmers can employ technology if they're trained and educated. They should also be told how much fertilizer to use so it yields more.
- e) More agricultural universities should be established to boost R&D.

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