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Research Article

PRODUCTION AND PRICE BEHAVIOUR OF WHEAT IN INDIA

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Abstract: The study has analyzed the growth performance of wheat and instability in area and production, impact of MSP on acreage and price behaviour of wheat in India. Based on highest average arrivals of last decade, one market was selected from selected states, as well as from Gujarat state. The compound growth rate and Cuddy-Della Valle Index were used to estimate the growth and instability in area, production and yield of wheat. Nerlovian Lag model was used to analyse acreage response of wheat crop. ARIMA model was used for forecasting. The behaviour of prices and arrivals was examined through multiplicative model. In India, area, production and yield indicated a significant and positive growth with high stability. The results of acreage for wheat revealed that irrigated area found positive (0.4891). The results of forecasting area and production of wheat in Gujarat and India will increase in the next five years. High degree of inter year fluctuation in arrivals of wheat during study period for both the markets.

Keywords: *Growth rate of cereals, MSP impact on acreage, Market integration, Behaviour of prices and arrivals*

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Introduction

Agriculture plays a major role in the economy of India. Agriculture is the largest sector of economic activity and has a crucial role to play in the country's economic development by providing food and raw materials, employment to a very large proportion of the population, capital for its development and surpluses for national economic development. It provides a source of livelihood for around 55 per cent of the population. The share of agriculture and allied sectors in Gross Value Added (GVA) of the country has increased during the last three years at current prices from 17.60 per cent (2018-19) to 18.40 per cent (2019-20) to 20.20 per cent in 2020-21 [1]. The growth of agriculture depends on the monsoon and the production of farm products. The growth rate of agriculture production is generally judged by the performance of food grains and non-food grains production. As we all know, the Indian agriculture sector is now moving towards other Green Revolution. The transformations in the sector are being induced by factors like the new concept of the organized sector, new and improved technologies, mechanized farming, rapid growth of contract farming, easy credit facilitie [2-5].

Objectives of study

1.To estimate the growth and instability in area and production of wheat in India
2.To assess the impact of MSP and other non-price factors on wheat crop
3.To forecast the area and production of wheat in India
4.To analyze the behaviour of prices and arrivals of wheat

Materials and Methods

The purposive sampling technique was adopted for the study. Total 10 major producing states of India and 5 major producing districts of Gujarat for wheat crop were selected for the study. Based on highest average arrivals of last decade, one market was selected for wheat from selected states, as well as from Gujarat state. The study was based on secondary data. The required data for achieving the various objectives of the study pertain to the area, production, yield, price, arrival, MSP, FHP and rainfall, etc. were collected. Wheats' area, production and productivity collected for the period from 1990-91 to 2019-20. The duration of study was separated into four periods *viz*., period I (1990-91 to 1999-00), period II (2000-01 to 2009-10), period III (2010-11 to 2019-20), overall period (1990-91 to 2019-20). The data on monthly wholesale prices and arrivals of wheat was compiled for the period from January 2010 to December 2019 [6-10].

Compound Growth Rate

Exponential function of the following specification:

$Y_t = ab^t$

Where,

Y_t= Dependent variable; (Area, Production and Yield)

t=Time variable in years taking the value of 1, 2,.,n;

a=Intercept;

b=Regression coefficient (1+r);

For the aim of estimation, the equation was expressed in logarithmic form.

Log Y_t = Log a + t log b

$$\text{Log b} = \frac{(\sum t \text{ Log Y} - (\sum t . \sum \text{Log Y} / N))}{\sum t^2 - \left(\frac{\sum t^2}{N}\right)}$$

Where,

N = Number of years.

Subsequently, the compound growth rate (%) was computed using the formula,

Compound growth rate (r) = [(Antilog of log b) -1] *100

Instability Analysis

Cuddy-Della Valle Index was used to estimate the instability in total area, production and yield of cereals. The index was originally developed by John Cuddy and Della Valle (Cuddy and Della Valle, 1978).

The formula of the Cuddy-Della Valle Index is bellowed:

$CV(\%) = SD/\bar{x} \times 100$
$Ix = CV\sqrt{(1-R^{-2})}$
Where,
Ix = Instability Index;
CV = Coefficient of variation;
R^{-2}= Adjusted coefficient of multiple determination;

Acreage Supply Response Model (Nerlovian Model)
The long-run supply A_t^* is assumed, in the Nerlovian framework, to be related to Pt (the price) in a simple linear manner:
$A_t^* = a + bP_{t-1} + U_t$
Using the adjustment lag model as the basic frame of analysis, the response relationship in the study was estimated with consideration of the following different variables.
A_t^*= The desired area in year t (ha)
A_t = The actual area in year t (ha)
A_{t-1}= Area in the previous year (ha)
AC_t= Area under competing crop in period t (ha)
P_{t-1}= Farm harvest price in period t-1 (Rs/ Qtl.)
MSP_t= Minimum Support Price of current year (Rs/ Qtl.)
GI_{t-1}= Gross income in period t-1 (GI_{t-1} = Yield $_{t-1}$ * FHP $_{t-1}$)
Y_{t-1}= Yield in period $_{t-1}$
I_t= Irrigated area current year
σ_y= Yield risk, the standard deviation of the preceding three years' yield of the crop
σP= Price risk, the standard deviation of the preceding three-year' price of the crop
e_t= Random error term
t = Year
$A_t = a + b_1A_{t-1} + b_2AC_t + b_3P_{t-2} + b_4MSP_{t-1} + b_5GI_{t-1}+b_6Y_{t-1} +b_7I_t+ b_8\sigma Y+b_9\sigma P + e_t$
Based on these models, coefficient of adjustment (γ), short-run (SR) and long-run (LR) elasticities (E) was calculated as below.
γ = 1- Regression coefficient of one year lagged acreage (A_{t-1}).
E(SR)= Regression coefficient of price x (Mean prices (P_{t-1}) / Mean acreage(A_t))
E(LR)= SR/Y

Auto-Regressive Integrated Moving Average (ARIMA)
(1) Autoregressive (AR) process:
If model P_{1t} as,
$P_{1t} = \varphi_1P_{1t-1} + \varphi_2 P_{1t-2} + \ldots + \varphi_p P_{1t-p} + \acute{\varepsilon}_{1t}$
Where,
$\acute{\varepsilon}_{1t}$ = Uncorrelated random error term with zero mean and constant variance σ2 or white noise error term.
P_{1t} = p^{th} – order autoregressive or AR (p), process.
(2) Moving Average (MA) process:
If model P_{1t} as,
$P_{1t} = \mu + \theta_0 \acute{\varepsilon}_{1t} + \theta_1 \acute{\varepsilon}_{1t-1} + \ldots + \theta_q \acute{\varepsilon}_{1t-q}$
Where,
μ = Constant.
έ = White noise error term
P_{1t} = q^{th} – order moving average or MR (q), process.
(3) Autoregressive and Moving Average (ARMA) process:
If P_{1t} has characteristics of both AR and MA process as follows:
$P_{1t} = \mu + \varphi_1P_{1t-1} + \varphi_2 P_{1t-2} + \; + \varphi_p P_{1t-p} + \theta_0 \acute{\varepsilon}_{1t} + \theta_1\acute{\varepsilon}_{1t-1} + \; + \theta_q \acute{\varepsilon}_{1t-q}$
Where,
μ = Constant term.
P_{1t}=ARMA (p, q) process with p autoregressive and q moving average.
Then after identified the values of p, d, and q. These values were determined by using Autocorrelation and Partial Autocorrelation Functions (ACF and PACF).

Multiplicative Model
The behaviour of prices and arrivals for the entire period was calculated using the following empirical approaches.
The seasonal variations are short term fluctuations that occur within a year, which could be isolated from the original composite series and to study them separately, the decomposition of the time series data was calculated through multiplicative model.
P = TxCxSxI
Where,
P = Monthly prices/arrivals
T = Trend values
C= Cyclical variations
S = Seasonal variations
I = Irregular variations
This multiplicative model assumes the interaction among the different components.
The whole period together seasonal indices were work out for each crop. To remove the effect of trend and cyclical variations, the twelve months moving average method was calculated. Further ratios of original price indices to centered moving average was calculated to obtain the combined effect of S × I. To remove the effect of I, these ratios were averaged and adjusted seasonal indices obtained.

Results 1
The details regarding the compound growth rate and instability in area, production and yield of India and major wheat producing states are given in [Table-1] and [Table-2], respectively. The result revealed that during Period-I, the highest positive and significant rate of growth (4.92 %) was observed in the state of Rajasthan followed by the significant rate of increase in area under wheat in Madhya Pradesh (3.00 %), Haryana (2.24 %) and Bihar (0.95 %) during Period-I. The growth rate of production and yield of wheat during Period-I were found positive in all the states. In India, growth rate of area, production and yield of wheat were found positive at the significant rate of 1.72, 3.57 and 1.82 per cent per annum respectively, during Period-I. The growth rate of area for wheat crop was found positive in all the states, except in Himachal Pradesh in the Period-II. The growth rate of production of wheat during Period-II was significantly increased at the highest rate of (17.27 %) per annum in Gujarat followed by Maharashtra (8.90 %) and Madhya Pradesh (3.90 %) states.
In overall study period, the compound growth rate of area under wheat was found positive and statistically significant in India and in all the selected states, except Uttarakhand and Himachal Pradesh. The compound growth rates of production and yield of wheat in India as a whole and selected states except in Himachal Pradesh were found positive and statistically significant during overall study period. This indicated continuous increase in area, production and yield of wheat in most of the states of India.
The highest stability of area (1.83), production (5.34) and yield (5.04) under wheat crop was observed in Uttar Pradesh, Punjab and Haryana states, respectively in the overall period. This is very obvious because, these states have assured irrigation facilities. In India, the magnitude of instability indices of area (3.19), production (5.62) and yield (4.63) showed that wheat crop is relatively stable in terms of area, production and yield. In India, overall performance of the wheat crop in terms of area, production and yield indicated a significant and positive growth with high stability.
The details regarding the compound growth rate and instability in area, production and yield of Gujarat and major wheat producing districts are given in [Table-3] and [Table-4], respectively. The result revealed that during Period-I, the compound growth rates of area and production for wheat crop was found positive in all the districts. The highest positive and significant rate of growth (12.28 %) was observed in the Kheda followed by the significant rate of increase in area under wheat in Ahmedabad (10.71 %) and Mehsana (4.18 %) during Period-I. The growth rate of yield of wheat during Period-I were found negative in all the districts, except in Junagadh.
In Gujarat, the area, production and yield of wheat were found positive i.e., 0.62, 1.70 and 1.08 per cent per annum respectively, during Period-I. The growth rate of area, production and yield for wheat crop was found positive in all the districts in the Period-II. The compound growth rates of area were found negative in all the districts in Period-III.

Table-1 Compound growth rates in area, production and yield of India and major wheat producing states (% / annum)

SN	State name	Period-I			Period-II			Period-III			Overall		
		(1990-91 to 1999-00)			(2000-01 to -2009-10)			(2010-11 to 2019-20)			(1990-91 to 2019-20)		
		CGR			CGR			CGR			CGR		
		A	P	Y	A	P	Y	A	P	Y	A	P	Y
1	Bihar	0.95**	3.53**	2.56**	0.4	0.58	0.18	0.06	3.72*	3.64*	0.18**	1.13**	0.94**
2	Gujarat	0.62	1.7	1.08	14.93**	17.27**	2.04	-4.11*	-4.15	-0.02	3.16**	4.61**	1.39**
3	Haryana	2.24**	3.78**	1.51**	0.89**	1.53*	0.63	0.06	0	-0.06	1.14**	2.14**	0.98**
4	Madhya Pradesh	3.00**	5.55**	2.47**	1.7	3.90*	2.17*	3.01*	8.19**	5.02**	1.54**	4.09**	2.51**
5	Maharashtra	3.44	5.23	1.72	6.07**	8.90**	2.66*	-0.18	-0.36	-0.19	1.41**	2.43**	1.01**
6	Punjab	0.27	2.26**	1.98**	0.42**	0.25	-0.17	0	0.74	0.73	0.32**	1.20**	0.89**
7	Rajasthan	4.92**	6.47**	1.46	1.72	3.77**	2.01**	0.89	2.73*	1.83**	1.41**	2.90**	1.46**
8	Uttar Pradesh	0.91**	3.17**	2.24**	0.39	1.23	0.83	0	1.23	-0.33	0.40**	1.54**	0.84**
9	Uttarakhand	-	-	-	0.29	1.52	1.22	-1.76**	0.88	2.69	-1.16**	1.11**	2.29**
10	Himachal Pradesh	-0.08	0.77	0.86	-0.17	0.86	1.03	-2.11**	-0.17	1.97*	-0.54**	0.37	0.91
11	All India	1.72**	3.57**	1.82**	1.20**	1.90**	0.69	0.3	1.86**	1.55*	0.87**	2.11**	1.22**

Table-2 Instability in area, production and yield of India and major wheat producing states

SN	State name	Period-I			Period-II			Period-III			Overall		
		(1990-91 to 1999-00)			(2000-01 to -2009-10)			(2010-11 to 2019-20)			(1990-91 to 2019-20)		
		CDVI			CDVI			CDVI			CDVI		
		A	P	Y	A	P	Y	A	P	Y	A	P	Y
1	Bihar	1.6	6.3	5.93	2.94	13.02	10.77	2.59	11.91	11.59	2.66	13.99	13.17
2	Gujarat	20.55	27.49	10.15	22.24	27.43	10.18	14.99	19.74	6.7	27.95	32.96	8.99
3	Haryana	3.03	5.11	2.8	2.11	5.48	3.83	1.91	6.68	6.87	3.98	7.03	5.04
4	Madhya Pradesh	4.14	8.25	5.92	6.99	14	7.41	7.85	13.76	8.72	13.78	28.87	14.64
5	Maharashtra	14.51	23.33	16.2	15.11	19.69	7.89	18.82	27.46	14.8	17.7	25.38	13.07
6	Punjab	1.51	5.72	4.79	0.66	4.06	3.82	0.27	5.62	5.45	1.35	5.34	5.13
7	Rajasthan	6.25	13.57	11.12	10.25	9.05	5.15	7.86	7.49	3.57	11.85	12.92	7.16
8	Uttar Pradesh	1.1	3.59	3.9	1.94	6.24	4.77	1.14	1154	12.26	1.83	8.2	8.32
9	Uttarakhand	-	-	-	2.28	6.65	7.01	1.15	10.19	10.44	3.77	8.47	9.19
10	Himachal Pradesh	2.01	12.23	11.81	1.06	28.94	28.64	3.91	9.55	7.3	3.71	17.98	18.3
11	All India	1.99	3.37	3.31	2	4.69	3.28	2.67	4.58	5.9	3.19	5.62	4.63

Table-3 Compound growth rates in area, production and yield of Gujarat and major wheat producing districts (% / annum)

SN	District name	Period-I			Period-II			Period-III			Overall		
		(1990-91 to 1999-00)			(2000-01 to -2009-10)			(2010-11 to 2019-20)			(1990-91 to 2019-20)		
		CGR			CGR			CGR			CGR		
		A	P	Y	A	P	Y	A	P	Y	A	P	Y
1	Ahmedabad	10.71*	5.37*	-4.82	8.27*	11.88**	3.33	-6.83**	-6.68**	0.16	4.41**	6.39**	1.90**
2	Kheda	12.28**	8.75**	-3.15*	4.85*	5.45	0.57	-1.74	0.01	1.79*	2.35**	3.54**	1.16**
3	Mehsana	4.18*	2.73	-1.4	2.83	3.76	0.9	-2.81*	-1.66	1.18*	0.37	0.8	0.42*
4	Sabarkatha	3.55	2.85	-0.67	20.85**	25.15**	3.56	-8.78**	-6.51*	2.50 **	3.51**	5.01**	1.45**
5	Junagadh	1.74	3.02	1.26	34.00**	37.25*	2.42	-20.44*	-19.5	1.18	1.48	2.46	0.96**
6	Gujarat	0.62	1.7	1.08	14.93**	17.27**	2.04	-4.11*	-4.15	-0.05	3.17**	4.61**	1.40**

Table-4 Instability in area, production and yield of Gujarat and major wheat producing districts

SN	District name	Period-I			Period-II			Period-III			Overall		
		(1990-91 to 1999-00)			(2000-01 to -2009-10)			(2010-11 to 2019-20)			(1990-91 to 2019-20)		
		CDVI			CDVI			CDVI			CDVI		
		A	P	Y	A	P	Y	A	P	Y	A	P	Y
1	Ahmedabad	24.87	15.35	31.26	22.32	20.92	15.28	13.19	11.52	9.01	28.1	29.55	22.18
2	Kheda	18.76	20.24	10.73	15.6	21.35	13.96	17.81	20.95	7.06	22.09	21.74	12.47
3	Mehsana	11.15	13.29	8.92	27.08	30.6	9.81	10.34	11.37	4.27	21.68	24.29	9.34
4	Sabarkatha	18.48	29.32	11.86	20.51	30.28	15.55	21.83	23.58	4.83	41.06	45.72	14.5
5	Junagadh	50.18	56.44	13.03	40.05	43.34	14.46	70.97	80.47	12.4	78.64	84.8	13.21
6	Gujarat	20.55	27.49	10.16	22.24	27.43	10.18	14.99	19.74	6.66	27.95	32.96	8.99

It might be due to shift in other cash crop like cotton, cumin, coriander, onion and garlic, etc. The growth rate of production of wheat during Period-III was found negative in all the districts, except in Kheda. The compound growth rates of yield were found positive in all the districts in Period-III. In overall study period, growth rate of area and production under wheat was found positive and significant in Gujarat and all the selected districts, except in Mehsana and Junagadh.

The highest stability of area (21.68) and yield (9.34) was observed in Mehsana district in the overall study period. While highest stability in production was found in Kheda (21.74). In Gujarat, the high magnitude of instability indices of area (27.95) and production (32.96) showed that wheat crop was unstable in terms of area and production. While instability index of yield (8.99) for wheat crop showed stability. The contribution to historic production (4.61 %) is attributed to yield growth (1.40 %) and area (3.17 %). Increased yield due to the factor like adoption of high yielding genotypes through well-established coordinated research system coupled with increase in area under irrigation and favorable weather factors during crop season, new technology, new institutional structure enabled the farmers to adopt improved methods of cultivation. Ramdas *et al*., (2012) [11], Anjum and Madhulika (2018) [12] and Dey *et al*., (2020) [13].

Results 2

With a view of estimating the acreage response of area towards price and non-price factors, the actual area in the current year was expressed as a linear function of one year lagged area, area under competing crop, one years lagged farm harvest price, current year minimum support price, one year lagged gross income, one year lagged yield, irrigated area, yield risk and price risk. The regression coefficients of these explanatory variables are presented in [Table-5].

The results of acreage response model for wheat revealed that the regression coefficient for irrigated area found positive (0.4891).

It's obvious because wheat is irrigation-intensive crop. Moreover, regression coefficient for minimum support price was found negative (-0.8650) and statistically significant at 5 per cent level. This showed the irrational behaviour of wheat growers as they are responding negatively toward the minimum support price.

The variation in the magnitude of short run and long run price elasticity factors for wheat in Gujarat is presented in [Table-6]. The magnitude of short run and long run elasticities were found positive for wheat crop. On the whole, price and non-price factors viz., area under competing crop and irrigated area were found to have strategic role in acreage allocation decision, while farm harvest price and minimum support price has not exerted any positive significant influence on the acreage under wheat crop. In spite of the improvement in the price over time, the area under wheat crop has not responded positively in Gujarat [14].

Table-5 *Regression estimates of acreage response function of wheat in Gujarat*

Particulars	Regression coefficient (Wheat)
Constant	-2084.91
One year lagged area (A_{t-1})	0.0311(0.2465)
Area under competing crop (AC_t)	0.8060(0.6943)
One year lagged farm harvest price (P_{t-1})	1.4558(1.4075)
Minimum support price (MSP_t)	-0.8650***(0.3666)
One year lagged gross income (GI_{t-1})	-0.0003(0.0005)
One year lagged yield (Y_{t-1})	0.4091(0.5292)
Irrigated area (I_t)	0.4891***(0.2171)
Yield risk (σ_y)	-0.0740(0.3838)
Price risk (σ_P)	0.4569(0.8595)
R^2	0.9

Table-6 *Price elasticities and coefficient of adjustment of wheat in Gujarat*

Crop	Coefficient of adjustment Y	SR	LR
Wheat	0.9689	1.8834	1.9438

Results 3

The lowest values of AIC, SBC, MAPE and MAE and highest value of coefficient of determination (R2) are for the ARIMA (0, 1, 1) for wheat area and production. In addition, all the coefficients under this model are found to be statistically significant at 5 per cent level as shown in [Table-7]. Hence, the ARIMA (0, 1, 1) model was identified as the best fitted model to forecast the future values of the wheat area and production for Gujarat.

Table-7 *Estimates of the fitted ARIMA (0, 1, 1) model for wheat area and production in Gujarat*

Area				
Variables	Estimate	Std Error	t Ratio	Probability
MA1	0.4346	0.1698	2.56	0.0164*
Intercept	12.7296	22.2468	0.57	0.5719
Production				
Variables	Estimate	Std Error	t Ratio	Probability
MA1	0.5427	0.1604	3.38	0.0022*
Intercept	64.7197	63.2692	1.02	0.3154

The actual and predicted area and production of wheat in Gujarat from 1990-91 to 2019-20 and forecasted from 2020-21 to 2024-25 are presented in [Table-8]. The forecasted values indicated that there will be an increase in total wheat area and production in Gujarat during 2020-21 to 2024-25. It can be seen that forecasted value of area for the year 2020-21 and also for subsequent four years would be more than actual value in 2019-20. The actual area of wheat in Gujarat during 2019-20 was 1018.00 thousand hectares which will rise to 1039.87 thousand hectares in the year 2024-25. The actual value of wheat production in Gujarat during 2019-20 was 3326.82 thousand tonnes, which will rise to 3397.87 thousand tonnes in 2024-25.

The lowest values of AIC, SBC and highest value of coefficient of determination (R2) are for the ARIMA (1, 1, 1) and ARIMA (1, 1, 0) for wheat area and production, respectively. In addition, all the coefficients under these models are found to be statistically significant at 5 per cent level as shown in [Table-9]. Hence, the ARIMA (1, 1, 1) and ARIMA (0, 1, 1) models were identified as the best fitted model to forecast the future values of the wheat area and production for India.

Table-8 *Actual and estimated area and production of wheat in Gujarat*

Year	Area ('000 Hectare)		Production ('000 Tonne)	
	ARIMA (0, 1, 1)		ARIMA (0, 1, 1)	
	Actual	Predicted	Actual	Predicted
1990-91	717		1443.7	
2000-01	286.1	588.6	649	1464.42
2010-11	1274	1007.86	4019.5	2771.09
2011-12	1351	1171.05	4072	3406.73
2012-13	1024	1285.51	2944	3775.69
2013-14	1442	1150.4	4694	3460.06
2014-15	1112	1327.98	3059	4089.09
2015-16	851	1218.61	2484	3682.73
2016-17	995	1023.52	2737	3199.25
2017-18	1059	1020.13	3068.98	3052.57
2018-19	797.16	1054.83	2407.42	3124.79
2019-20	1018	921.89	3326.82	2861.45
2020-21		988.95		3138.99
2021-22		1001.68		3203.71
2022-23		1014.41		3268.43
2023-24		1027.14		3333.15
2024-25		1039.87		3397.87

Table-9 *Estimates of the fitted ARIMA (1, 1, 1) model for wheat area and ARIMA (1, 1, 0) model for wheat production in India*

Area				
Variables	Estimate	Std Error	t Ratio	Probability
AR1	0.51029	0.16717	3.05	0.0052*
MA1	1	0.09448	10.58	<.0001*
Intercept	241.3332	29.66285	8.14	<.0001*
Production				
Variables	Estimate	Std Error	t Ratio	Probability
AR1	-0.372	0.169	-2.2	0.0365*
Intercept	1806.872	567.7082	3.18	0.0037*

The actual and predicted area and production of wheat in India from 1990-91 to 2019-20 and forecasted from 2020-21 to 2024-25 are presented in [Table-10]. The actual area of wheat in India during 2019-20 was 31357.02 thousand hectares which will rise to 32290.17 thousand hectares in the year 2024-25. The actual value of wheat production in India during 2019-20 was 107860.51 thousand tonnes, which will rise to 116224.14 thousand.

Table-10 *Actual and estimated area and production of wheat in India*

Year	Area ('000 Hectare)		Production ('000 Tonne)	
	ARIMA (1, 1, 1)		ARIMA (1, 1, 0)	
	Actual	Predicted	Actual	Predicted
1990-91	24167.1		55134.5	
2000-01	25730.5	27333.13	69680.8	76958.37
2010-11	29068.6	28731.01	86874	83236.06
2011-12	29864.8	29175.71	94882.1	87095.78
2012-13	29995.3	29728.8	93505.5	94383.48
2013-14	30473.2	29924.2	95845.8	96495.92
2014-15	31465.6	30307.29	86526.6	97454.35
2015-16	30418	30974.66	92287.5	92469.92
2016-17	30785.22	30538.44	98510.22	92624.35
2017-18	29650.58	30852.5	99869.53	98675.37
2018-19	29318.79	30351.73	103596.2	101842.8
2019-20	31357.02	30267.38	107860.5	104689.4
2020-21		31459.61		108753.8
2021-22		31630.14		110900.3
2022-23		31835.35		112580.9
2023-24		32058.25		114434.7
2024-25		32290.17		116224.1

Table-11 *Estimates of linear trend in yearly arrivals and prices of wheat in selected markets (2010-19) (n=10)*

Particular	Markets	Intercept β_0	Co-efficient for Time (T) β_1	R^2
Arrivals	Agra	23111.54	685.12(960.67)	0.0598
	Sanand	34582.13	-3044.65(2123.44)	0.2044
Prices	Agra	1070.95	79.48**(7.31)	0.9366
	Sanand	1244.03	78.88**(13.54)	0.8092

The results of predicted values of wheat revealed that the area and production of wheat in Gujarat and India will increase in the next five years as compared to the previous years. The result of forecasted values revealed that the area and production of wheat in Gujarat will increased by 2.14 per cent in next five years w.e.f. 2020-21 to 2024-25. While in case of India, the area and production of wheat will be increased by 2.98 and 7.75 per cent, respectively in next five years w.e.f. 2020-21 to 2024-25. Shahu (2015) [15] and Choudhury, *et al*. (2017) [16].

Table-12 *Estimation of quadratic trend in yearly arrivals and prices of wheat in selected markets (2010 to 2019) (n=10)*

Particular	Markets	Intercept β_0	Coefficient for Time (T) β_1	Coefficient for Time (T^2) β_2	R^2
Arrivals	Agra	14958.52	4761.63(4300.70)	-370.59(381.03)	0.1717
	Sanand	13989.22	7251.81(9307.68)	-936.04(824.63)	0.3281
Prices	Agra	1060.96	84.48*(34.83)	-0.45(3.09)	0.9368
	Sanand	1133.89	133.95(60.96)	-5.01(5.40)	0.83

Table-13 *Estimation of compound rate of increase in wheat arrivals and price in selected markets*

Crops	Markets	b*	Estimates of β	Compound Rate of Increase (%)	R^2
Arrivals	Agra	10.05	1.0192	1.92	0.0402
	Sanand	10.83	0.7455	-25.45	0.5856
Prices	Agra	7.01**	1.06	5.51	0.9306
	Sanand	7.14**	1.05	5.03	0.7788

Table-14 *Indices of cyclical variation in the prices of wheat in selected markets (2010-19)*

Year	Wheat	
	Agra	Sanand
2012	128.26	126.52
2013	138.59	139.61
2014	151.6	157.55
2015	160.18	164.95
2016	167.38	168.12
2017	172.23	167.18
2018	178.64	173.61
2019	187.93	180.06

Results 4

The estimates of the linear, quadratic and exponential trend in arrivals and prices of wheat in selected regulated markets are presented in [Table-11, 12 and 13].

It revealed that, there were very high degree of inter year fluctuation in arrivals of wheat during study period for both the markets. This may be due to fluctuation in production, which affected the supply. While in case of prices, moderate inter year variation was observed. The cyclical variation of prices of wheat in selected markets are shown in [Table-14]. The result revealed that the price cycle of wheat, prices in Agra and Sanand market were peaked from 2014 to 2019.

The seasonal nature of arrivals and prices of wheat in selected markets are shown in [Table-15]. In Agra market, arrivals of wheat started to increase from April month and reached at the highest in May then remained higher up to October. In Sanand market, the highest value of arrivals of wheat were found in April and the lowest in August month. In respect to price indices of wheat in both the markets, high values were found in lean period of arrivals and low values of price indices during high arrivals periods.

Irregular price variation is random in nature. The index of irregular fluctuation was calculated for the middle year 2014 and depicted in [Table-16]. The index of irregular fluctuation of wheat arrivals was higher in month of October (120.84 points) and December (168.61 points) in Agra and Sanand markets, respectively. The indices of irregular variation were found with high magnitude and showed high upward and downward trends in arrivals of Sanand market as compare to Agra market. The indices of irregular variation of wheat prices were found with less magnitude and showed to a lesser extent in upper and lower values in Agra and Sanand markets. Bodade *et al*., (2017) [17] and Ragade *et al*., (2020) [18].

Conclusion

Growth rate of area under wheat found positive and statistically significant in most of the states as well as in India as a whole.

The production and yield of wheat found positive and statistically significant in most of the selected states as well as for India as a whole. In India, low instability was found in area, production and yield of wheat. In Gujarat, moderate instability of area under wheat was found, while in case of production and yield of wheat was observed low instability in overall period. The study on impact of price and non-price factors on acreage allocation revealed that area under competing crop and irrigated area were found to have strategic role in acreage allocation decision, while farm harvest price and minimum support price has not exerted any positive significant influence on the acreage under wheat. The area and production of wheat will increase in the India as well as in Gujarat in next five-year w.e.f. 2020-21 to 2024-25. The prices showed positive trend and found seasonal in case of wheat for both the markets. The arrivals were decreased and found seasonal in Sanand market.

Table-15 *Indices of seasonal variation in the arrivals and prices of wheat in selected markets (2010-19)*

Month	Wheat			
	Agra		Sanand	
	Arrivals	Prices	Arrivals	Prices
January	74.67	97.22	20.69	95.8
February	73.28	98.97	17.08	95.67
March	77.46	97.35	262.45	99.69
April	82.94	92.59	408.76	97.51
May	129.76	91.68	265.94	93.08
June	121.13	91.79	90.33	90.46
July	109.96	105.28	91.2	107
August	91.17	107.2	92.6	104.82
September	85.33	106.86	80.69	104.01
October	69.35	107.65	147.04	103.52
November	86.07	107.95	106.78	104.31
December	121.32	105.37	105.64	105.54
Total	1200	1200	1200	1200

Table-16 *Indices of irregular variation in the arrivals and prices of wheat in selected markets (2014)*

Month	Wheat			
	Agra		Sanand	
	Arrivals	Prices	Arrivals	Prices
January	98.58	107.45	26.6	105.38
February	87.51	109.68	15.4	105.49
March	113.41	113	98.35	107.72
April	119.64	108.07	141.52	110.12
May	61.19	104.37	83.14	107.89
June	64.45	103.8	86.69	105.76
July	71.19	96.57	67.3	95.38
August	104.96	92.23	96.18	91.66
September	106.33	92.75	75.17	91.62
October	120.84	93.3	94.85	93.6
November	105.83	92.66	137.02	89.15
December	106.07	92.1	168.61	102.12

Policy implication

The government should interfere through adjusting its export-import policy in advance about wheat in response to market lean and market glut in domestics markets, to minimize seasonal inter year fluctuation in the arrivals of wheat.

More efforts are needed to digitalize the major cereals markets through suitable platform like e-NAM for the transparent price discovery mechanism including enough provision for spread of market information and intelligence.

The seasonal pattern of market prices was the result of the farmers' inability to withhold the stocks due to additional cost on storage and urgent needs of cash which leave them to reap the benefits of price fluctuation. Hence, there is need to develop on-farm storage facility supported by subsidy which relieve them from financial pressures and forced selling.

Application of research: The study is very pertinent as India and its states have to face big challenges ahead to feed her ever-growing population with optimum nutritional standards with the situation of continue decline in acreage under foodgrains due to introduction of high-value crops, stagnation in foodgrains productivity and to maintain a buffer stock of the country.

Research Category: Agri-Business Management

Abbreviations: MSP - Minimum Support Prices
FHP - Farm Harvest Price
AIC - Akaike Information Criteria
SBC - Schwarz Bayesian Criteria
GVA - Gross Value Added
AR - Auto-Regressive
MA - Moving Average
ARMA - Auto-Regressive Moving Average
MAPE - Mean Absolute Percentage Error
MAE - Mean Absolute Error
ACF - Auto Correlation Function
PACF - Partial Auto Correlation Function

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Cultivar / Variety / Breed name: Wheat

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