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An analysis of growth and instability in area, production, yield and price behaviour of rice in India

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Abstract
To studied the growth performance of rice and instability in area and production, impact of MSP on acreage and price behavior of rice in India. Total 10 major producing states of India and 5 major producing districts of Gujarat for rice crop were selected for the study. Based on highest average arrivals of last decade, one market was taken from selected states, as well as from Gujarat state.
The data of area, production and productivity were collected for the period 1990-91 to 2019-20. The data on monthly wholesale prices and arrivals of rice was compiled for the period from January 2010 to December 2019.
The compound growth rate and Cuddy-Della Valle Index were used to estimate the growth and instability in area, production and yield of rice. Nerlovian Lag model was used to analyse acreage response of rice crop. ARIMA model was used for forecasting. The behaviour of prices and arrivals was examined through multiplicative model.
The result revealed that the growth rate of area under rice was found negative but significant in most of the selected states. The growth rate of production and yield of rice was found positive and significant in most of the selected states as well as for India as a whole. In Gujarat, the growth rate of area, production and yield of rice was found positive and significant during overall study period. In India, the results of instability indices found to have low instability in area, production and yield of rice. In Gujarat, the instability of area and yield under rice found lower, while it was moderate in case of production during overall period. The study on impact of price and non-price factors on acreage allocation revealed that rice growers are more sensitive to non -price factors than price factors. The results of forecasting area and production of rice in Gujarat and India will increase in the next five years. The prices of rice showed less degree of irregular fluctuations, while arrivals of Vadodara market showed comparatively higher irregular fluctuation. The arrivals of Burdwan market showed less degree of irregular fluctuation. In selected markets not found any cyclical variation in the price indices.

Keywords: Growth rate of cereals, MSP impact on acreage, market integration, behaviour of prices and arrivals, rice

1. Introduction
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. 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 facilities, etc.
Indian agriculture is dominated by the cultivation of food grains which occupy 76 per cent of the total cropped area and account for 80 per cent of the total agricultural production of the country. This includes rice, wheat, millets, gram, maize and pulses which are grown to meet the food requirements of India's vast population. However, food grains particularly rice and wheat continue to be the main pillars of India's food security. On the supply side, stimulated by the public investment in irrigation and rural infrastructure and rapid spread of high yielding varieties of rice and wheat, together with improved crop production practices, India has achieved impressive growth in food grain production.

Rice is the most important and extensively grown food crop in the World. It is the staple food of more than 60 per cent of the world population. Rice is mainly produced and consumed in the Asian region. India has the largest area under paddy in the world and ranks second in production after China. The country has also emerged as a major rice consumer. West Bengal is the largest rice producer state with 15 per cent of total production during 2022-23 followed by Uttar Pradesh, Punjab, Andhra Pradesh and Odisha (Anon, 2021) [4].

1.1 Objective

- To estimate the growth and instability in area and production of rice in India
- To assess the impact of MSP and other non-price factors on rice crop
- To forecast the area and production of rice in India
- To analyze the behaviour of prices and arrivals of rice

2. Methodology

The purposive sampling technique was adopted for the study. Total 10 major producing states of India and 5 major producing districts of Gujarat for rice crop were selected for the study. Based on highest average arrivals of last decade, one market was selected from selected states, as well as from Gujarat. Data on rice arrivals and prices were collected from Burdwan and Vadodara market (Anon, 2022) [5].

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. Area, production and productivity of rice collected for the period from 1990-91 to 2019-20. The duration of study was separated into four period *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 rice was compiled for the period from January 2010 to December 2019.

2.1 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, 3, ., n;
A = Intercept;
B = Regression coefficient (1+r);

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

$\text{Log } Y_t = \text{Log } a + t \log b$

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

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

2.2 Instability Analysis: Cuddy-Della Valle Index was used to estimate the instability in total area, production and yield of rice. The index was originally developed by John Cuddy and Della Valle (Cuddy and Della Valle, 1978) [13].
The formula of the Cuddy-Della Valle Index is bellowed.

$$CV(\%) = \frac{SD}{\bar{X}} \times 100$$

$$Ix = CV\sqrt{(1 - \bar{R}^2)}$$

Where,
Ix = Instability Index.
CV = Coefficient of variation.
$\bar{R}^2$ = Adjusted coefficient of multiple determination;

2.3 Acreage Supply Response Model (Nerlovian Model)

The long-run supply A_t* is assumed, in the Nerlovian framework, to be related to P_t (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
σ_P = 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 (ϒ), short-run (SR) and long-run (LR) elasticities (E) was calculated as below.

ϒ = 1- Regression coefficient of one year lagged acreage (A_{t-1}).

$$E\,(SR) = \text{Regression coefficient of price} \times \frac{\text{Mean prices } (P_{t-1})}{\text{Mean acreage } (\bar{A}_t)}$$

$$E(LR) = \frac{SR}{\gamma}$$

2.4 Auto-Regressive Integrated Moving Average (ARIMA)

2.4.1 Autoregressive (AR) process

If model P_{1t} as,

$P_{1t} = \phi_1 P_{1t-1} + \phi_2 P_{1t-2} + \ldots + \phi_p P_{1t-p} + \acute{\varepsilon}_{1t}$

Where,
$\acute{\varepsilon}_{1t}$ = Uncorrelated random error term with zero mean and constant variance σ^2 or white noise error term.

P_{1t} = p^{th} – order autoregressive or AR (p), process.

2.4.2 Moving Average (MA) process: If model P_{1t} as,

$$P_{1t} = \mu + \theta_0 \boldsymbol{\acute{\varepsilon}}_{1t} + \theta_1 \boldsymbol{\acute{\varepsilon}}_{1t-1} + \ldots + \theta_q \boldsymbol{\acute{\varepsilon}}_{1t-q}$$

Where,
μ = Constant.
$\boldsymbol{\acute{\varepsilon}}$ = White noise error term
P_{1t} = q^{th} – order moving average or MR (q), process.

2.4.3 Autoregressive and Moving Average (ARMA) process

If P_{1t} has characteristics of both AR and MA process as follows.

$$P_{1t} = \mu + \phi_1 P_{1t-1} + \phi_2 P_{1t-2} + + \phi_p P_{1t-p} + \theta_0 \boldsymbol{\acute{\varepsilon}}_{1t} + \theta_1 \boldsymbol{\acute{\varepsilon}}_{1t-1} + + \theta_q \boldsymbol{\acute{\varepsilon}}_{1t-q}$$

Where,
μ = Constant term.
P_{1t}=ARMA (p, q) process with p autoregressive and q moving average.

The identification steps involve the use of the techniques for determining the value of p, d, and q. These values were determined by using Autocorrelation and Partial Autocorrelation Functions (ACF and PACF).

2.5 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.

$$P = T*C*S*I$$

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.

3. Results and Discussion

3.1 Growth and instability in area and production of rice in India

The details regarding compound growth rate in area, production and yield of India and major rice producing states are given in Table 1. The result revealed that during Period-I, the compound growth rates of area for rice crop was found positive in all the states. The highest positive and significant rate of growth 2.48 per cent was observed in the state of Punjab during Period-I. The growth rate of production and yield of rice during Period-I were found positive in all the states, except in Madhya Pradesh, Odisha and Tamil Nadu states. In India, the area, production and yield of rice were found positive *i.e.*, 0.68, 2.00 and 1.32 per cent per annum respectively, during Period-I. The compound growth rates of area were found negative in most of the selected states in period-II and period-III, while the growth rate of production and yield was found positive in all the states, except in Andhra Pradesh state.

The growth rate of area, production and yield of rice in Punjab increased significantly during all the four-study period including overall study period. Over the years the compound annual growth rate of area, production and yield of rice in India though remained positive but showed gradually decline. It might be due to some meteorological and hydrological droughts occurred in India in the time span of 1871 to 2018.

The instability indices for area, production and yield of rice in India and major rice producing states are presented in Table 2. The instability indices of area of rice ranged from 1.10 to 7.48 in Period-I, indicated that the area remained stable during this period. The highest stability indices of area (1.10) and production (3.32) were observed in Madhya Pradesh and West Bengal states, respectively. While highest stability index of yield of rice was found in Assam state in Period-I. In Period-II, the highest stability in area (0.81) was found in Chhattisgarh, while the highest stability in production (3.31) and yield (2.29) was observed in Punjab. The highest instability indices of area of rice were found in Andhra Pradesh in Period- I, II and III. In India, the magnitude of instability indices of area (2.37), production (5.55) and yield (4.12) showed that rice crop was stable in terms of area, production and yield in India. The highest stability of area (1.56), production (5.41) and yield (3.49) were observed in Chhattisgarh, Punjab and West Bengal states, respectively in the Overall study period.

The details regarding the compound growth rate and instability in area, production and yield of Gujarat for rice crop and major rice producing districts are given in Table 3 and 4, respectively. In Gujarat, growth rates of area, production and yield were found positive and statistically significant *i.e.*, 1.53, 3.73 and 2.17 per cent per annum, respectively, during overall study period. Over the years, the compound annual growth rate of area, production and yield of rice in Gujarat though remained positive but declined gradually.

The instability indices of area of rice ranged from 4.29 to 36.50 in Period-I, indicated that the high variation during this period. The highest stability of area (4.29) and production (14.11) was observed in Kheda, while highest stability of yield of rice was found in Valsad (9.98) in Period-I. In Gujarat, the magnitude of instability indices of area (8.26), production (19.13) and yield (14.26) showed that rice crop was stable in terms of area and yield, but moderate instability was observed in production. Instability analysis showed that in rice, production recorded more variations in growth followed by the yield and area, respectively.

Instability analysis showed that rice production recorded more variations followed by the instability of yield and area, respectively. The stability in the area under rice cultivation implies that the crop holds a significant portion in cropping pattern of the country as well as in Gujarat. It may be due to high yielding varieties introduced in rice, various other development schemes launched by the government to increase production and improve Indian agriculture. Along with new

technology, new institutional structure enabled the farmers to adopt improved methods of cultivation.

These results are in agreement with work carried out by Elumalai *et al.* (2009) [17], Ramdas *et al.* (2012) [29], Anjum and Madhulika (2018) [2], Jain (2018) [21], and Dey *et al.* (2020) [16].

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

Sr. No.	State name	Period-I (1990-91 to 1999-00)			Period-II (2000-01 to -2009-10)			Period-III (2010-11 to 2019-20)			Overall (1990-91 to 2019-20)		
		CGR			CGR			CGR			CGR		
		A	P	Y	A	P	Y	A	P	Y	A	P	Y
1	Andhra Pradesh	0.55	1.69	1.13	1.17	2.51	1.32	-6.75*	-3.93	2.81**	-1.95**	-0.54	1.45**
2	Assam	0.10	1.06	0.96**	-0.93	-0.26	0.67	-0.95**	0.90	1.79**	-0.13	1.83**	1.97**
3	Bihar	0.11	3.05	2.94	-0.87	-2.30	-1.45	-0.08	4.30	4.30	-2.01**	0.68	2.75**
4	Chhattisgarh	-	-	-	-0.30**	4.58	4.90	-0.25	0.24	0.50	-0.07	3.67**	3.74**
5	Madhya Pradesh	0.74**	-0.12	-0.85	-1.41*	1.85	3.31	3.36**	10.84**	7.24**	-4.18**	-1.91	2.37**
6	Odisha	0.16	-1.29	-1.45	-0.02	4.69	4.72	-0.91*	1.97	2.91	-0.55**	1.22**	1.78**
7	Tamil Nadu	1.06	-0.14	-1.19	0.22	-0.08	-0.30	-0.07	0.51	0.58	-0.83**	-0.30	0.53
8	Uttar Pradesh	0.95*	3.19**	2.22**	-0.44	0.08	0.53	-0.09	1.51	1.60	0.19*	1.2**	1.04**
9	West Bengal	0.55*	2.49**	1.93**	-0.02	0.79	0.80*	0.46	1.57*	1.14	-0.34**	1.10**	1.45**
10	Punjab	2.48**	2.50**	0.01	0.89**	2.67**	1.76**	0.85**	1.88**	1.02*	1.37**	2.29**	0.91**
11	All India	0.68**	2.00**	1.32**	-0.02	1.59	1.60*	0.17	1.87**	1.69**	0.08	1.55**	1.47**

Note: 1. CGR - Compound Growth Rate
2. A- Area, P- Production and Y-Yield
* and ** indicate significance at 5% and 1% levels, respectively.

Table 2: Instability in area, production and yield of India and major rice producing states

Sr. No.	State name	Period-I (1990-91 to 1999-00)			Period-II (2000-01 to -2009-10)			Period-III (2010-11 to 2019-20)			Overall (1990-91 to 2019-20)		
		CDVI			CDVI			CDVI			CDVI		
		A	P	Y	A	P	Y	A	P	Y	A	P	Y
1	Andhra Pradesh	7.48	9.85	4.55	15.56	18.38	5.71	25.42	27.83	6.40	18.17	21.86	6.08
2	Assam	2.50	4.58	2.37	4.83	11.57	7.35	1.57	4.66	4.66	3.68	10.06	7.44
3	Bihar	5.10	24.50	23.27	5.05	23.49	20.17	6.21	21.51	17.46	11.00	27.00	23.45
4	Chhattisgarh	-	-	-	0.81	23.68	23.02	1.91	13.24	13.04	1.56	18.74	18.30
5	Madhya Pradesh	1.10	11.40	11.39	3.98	20.26	17.32	8.03	8.76	6.20	40.12	53.01	29.31
6	Odisha	1.37	12.93	12.26	1.67	18.68	17.68	2.83	12.81	11.46	3.30	15.87	16.18
7	Tamil Nadu	6.32	29.58	27.67	13.12	25.72	15.82	10.94	29.37	22.23	10.95	27.28	21.35
8	Uttar Pradesh	2.65	5.61	4.98	6.20	11.92	7.11	1.98	8.20	8.74	4.15	9.96	7.79
9	West Bengal	1.61	3.32	4.01	3.19	5.19	2.73	3.60	4.17	1.68	3.72	5.52	3.49
10	Punjab	4.21	5.45	4.07	2.22	3.31	2.29	2.28	5.01	3.28	3.71	5.41	4.18
11	All India	1.35	3.18	2.64	3.55	8.00	5.31	1.12	2.71	2.63	2.37	5.55	4.21

Note: 1. CDVI - Cuddy Della Valle Index (%), 2. A- Area, P- Production and Y-Yield

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

Sr. No.	District name	Period-I (1990-91 to 1999-00)			Period-II (2000-01 to -2009-10)			Period-III (2010-11 to 2019-20)			Overall (1990-91 to 2019-20)		
		CGR			CGR			CGR			CGR		
		A	P	Y	A	P	Y	A	P	Y	A	P	Y
1	Ahmedabad	1.95	1.37	-0.56	4.14	17.50 *	12.83**	2.00	-3.19	-5.09*	3.62**	6.86 **	3.12**
2	Valsad	26.88 **	19.99 **	-5.43**	-6.01	-4.28	1.85	1.79*	4.09 **	2.26*	2.86*	2.96**	0.10
3	Kheda	6.88**	7.53**	0.61	2.03	7.64	5.49	3.04 *	6.60**	3.45**	-0.15	1.75*	1.90*
4	Panchmahal	29.47**	26.47**	-2.31	-2.77*	14.40	17.66*	-3.75	-5.14	-1.45	1.36	3.43*	2.04
5	Anand	-	-	0.00	1.74	3.82	2.05	3.09 **	5.95 **	2.78**	2.88**	5.33**	2.38**
6	Gujarat	1.97**	3.73**	1.73	2.94	10.14*	7.00*	1.34	2.73**	1.37	1.53**	3.73**	2.17**

Note: 1. CGR - Compound Growth Rate, 2. A- Area, P- Production and Y-Yield, 3.* and ** indicate significance at 5% and 1% levels, respectively

Table 4: Instability in area, production and yield of Gujarat and major rice producing districts

Sr. No.	District name	Period-I (1990-91 to 1999-00)			Period-II (2000-01 to -2009-10)			Period-III (2010-11 to 2019-20)			Overall (1990-91 to 2019-20)		
		A	P	Y	A	P	Y	A	P	Y	A	P	Y
1	Ahmedabad	17.46	51.62	41.89	17.34	33.21	30.48	9.19	24.23	17.00	15.16	38.80	32.71
2	Valsad	36.50	33.34	9.98	30.18	30.91	10.20	7.07	10.52	6.66	36.70	31.81	16.12
3	Kheda	4.29	14.11	12.05	76.92	32.06	38.29	8.69	11.79	6.53	48.05	28.28	25.52
4	Panchmahal	33.27	49.28	38.97	11.05	42.06	41.77	21.55	39.66	23.87	42.69	54.83	40.90
5	Anand	-	-	-	9.43	15.49	11.39	6.22	9.58	5.57	7.29	11.82	7.70
6	Gujarat	4.47	6.94	7.57	10.72	22.47	17.42	5.88	5.68	5.22	8.26	19.13	14.26

Note: 1. CDVI - Cuddy Della Valle Index (%), 2. A- Area, P- Production and Y-Yield

3.2 Impact of MSP and other non-price factors on rice crop

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 revealed that in case of rice crop, regression coefficient (1.6901) for area under competing crop was found positive and statistically significant at 5 per cent level. This indicates that increase in area under competing crop sugarcane increase the acreage under rice which is not obvious. It meant that they do not acting as competing crop. The same results regarding competing crop were also noted in the study of (Khunt and Antani, 1989) [] in case of cotton crop. The regression coefficient for farm harvest price (0.0412), minimum support price (0.2480) and irrigated area (0.0081) found positive. It indicates positive impact on the acreage under rice crop in Gujarat. Other all variables found to have negative and non-significant impact on acreage under rice crop. It indicates that rice growers are indifferent to these factors. The negative regression coefficient of yield risk and price risk indicates the risk aversion nature of rice growers.

The variation in the magnitude of short run and long run price elasticity factors for rice in Gujarat is presented in Table 6. The coefficients of adjustment for the rice (1.4373) crop were found greater than one implies over adjustment towards the price and other factors. It also indicates that the desired adjustment in acreage was more rapidly made and that the price inducement operated rather quickly.

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 rice crop. In spite of the improvement in the price over time, the area under rice crop has not responded positively in Gujarat.

Table 5: Regression estimates of acreage response function of rice in Gujarat

Particulars	Regression coefficient (Rice)
Constant	571.4511
One year lagged area (A_{t-1})	-0.4373 (0.3812)
Area under competing crop (AC_t)	1.6901*** (0.7959)
One year lagged farm harvest price (P_{t-1})	0.0412 (0.3551)
Minimum support price (MSP_t)	0.2480 (0.2583)
One year lagged gross income (GI_{t-1})	-0.0001 (0.0002)
One year lagged yield (Y_{t-1})	-0.0433 (0.1640)
Irrigated area (I_t)	0.0081 (0.0441)
Yield risk (σ_y)	-0.0593 (0.0735)
Price risk (σ_P)	-0.1568 (0.2542)
R^2	0.83

****, ***, ** and * indicate statistically significant at 1%, 5%, 10% and 20%, respectively.
Figures in parentheses are standard errors.
Competing crop for rice is gram.

Table 6: Price elasticity and coefficient of adjustment of rice in Gujarat

Crop	Coefficient of adjustment Y	SR	LR
Rice	1.4373	0.0581	0.0404

3.3 Forecast the area and production of rice in India

The ARIMA model include three parameters *viz*., p, d and q where 'p' is the number of lag in Autoregressive (AR) terms, 'd' is the number of times the series is to be differenced in order to make it stationary and 'q' is the lag of error term in Moving Average (MA). The parameter 'd' was calculated by unit root test (ADF), where for the area and production of rice, the order of integration was found to be one, *i.e*., I (1) or 'd = 1'. The series is stationary at first difference. The parameter 'p' and 'q' are identified with the help of Partial Autocorrelation Function (PACF) and Autocorrelation Function (ACF). Thereby, the parameters 'p' and 'q' were traced in the order of 0 and 3 sacred order, respectively. Accordingly, for rice area the parameters 'p''d' and 'q' were identified as ARIMA (0, 1, 3), ARIMA (3, 1, 0) and (1, 1, 3) models, based on the information given by PACF and ACF of the first difference series. Accordingly, for rice production the parameters 'p' and 'q' were identified as 0 and 1 i.e., ARIMA (1, 1, 1), ARIMA (0, 1, 1) and ARIMA (1, 1, 0) models were identified based on the information given by PACF and ACF of the first difference series.

The values of AIC, SBC, MAPE and MAE are lowest and value of coefficient of determination (R2) is highest for the ARIMA (0, 1, 3) and ARIMA (1, 1, 0) for rice area and production, respectively. In addition, all the coefficients under these models were found to be statistically significant at 5 per cent level as shown in Table 7 Hence, the ARIMA (0, 1, 3) and ARIMA (1, 1, 0) models were identified as the best fitted model to forecast the future values of area and production of rice in Gujarat, respectively.

The actual and predicted area and production of rice in Gujarat from 1990-91 to 2019-20 and forecasted from 2020-21 to 2024-25 are presented in Table 8. The results revealed that the actual production of rice increased at higher rate than its actual area in Gujarat and India. The result of forecasted values indicated that the area and production of rice in Gujarat will be increased by 0.16 and 10.15 per cent, respectively in next five years *w.e.f.* 2020-21 to 2024-25. The result of forecasted values revealed that the area and production of rice in India will be increased by 0.79 and 2.82 per cent, respectively in next five years *w.e.f.* 2020-21 to 2024-25. It may be due to increase in rice productivity because of technology intervention in Gujarat.

The values of AIC, SBC, MAPE and MAE are lowest and value of coefficient of determination (R2) is highest for the ARIMA (4, 1, 1) and ARIMA (0, 1, 1) for area and production of rice in India, respectively. In addition, all the coefficients except AR (1), AR (2), AR (3) under these models were found to be statistically significant at 5 per cent level as shown in Table 9. Hence, the ARIMA (4, 1, 1) and ARIMA (0, 1, 1) models were identified as the best fitted

model to forecast the future values of the rice area and production, respectively.

The actual and predicted area and production of rice 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 rice in India during 2019-20 was 43662.30 thousand hectares which will rise to 44005.34 thousand hectares in the year 2024-25. The actual value of rice production in India during 2019-20 was 118870.32 thousand tonnes, which will rise to 122225.99 thousand tonnes in 2024-25. The result of forecasted values revealed that the area and production of rice in India will be increased by 0.79 and 2.82 per cent, respectively in next five years *w.e.f.* 2020-21 to 2024-25. The results of predicted values revealed that the area and production of rice in India will increase for the next five years as compared to their previous years.

The rate of increase was less in India than Gujarat average. This may be attributed to under exploitation of the potential of the India due to low input in agricultural operations and other biotic and abiotic factors. To bridge the gap between existing and potential productivity, rice varieties suitable to different ecologies can be introduced in farmer's field along with the nutrient and agronomic management practices.

These results are similar to the work of Tripathi *et al.* (2014) [31], Borkar (2017) [30] and Choudhury, *et al.* (2017) [12].

Table 7: Estimates of the fitted ARIMA (0, 1, 3) model for rice area and ARIMA (1, 1, 0) model for rice production in Gujarat

Area				
Variables	**Estimate**	**Std Error**	**t Ratio**	**Probability**
MA1	0.9833	0.2137	4.6000	0.0001*
MA2	0.9833	0.3298	2.9800	0.0063*
MA3	-1.0000	0.2135	-4.6800	<.0001*
Intercept	10.5896	0.2033	52.0900	<.0001*
Production				
Variables	**Estimate**	**Std Error**	**t Ratio**	**Probability**
AR1	-0.61947	0.13908	-4.45	0.0001*
Intercept	42.61582	22.12144	1.93	0.0646

Table 8: Actual and predicted area and production of rice in Gujarat

Year	Area ('000 Hectare) ARIMA (0, 1, 1)		Production ('000 Tonne) ARIMA (0, 1, 1)	
	Actual	**Predicted**	**Actual**	**Predicted**
1990-91	530.70		791.10	
2000-01	684.00	666.27	472.70	1073.06
2010-11	808.00	734.12	1496.60	1367.83
2011-12	836.00	825.90	1790.00	1438.86
2012-13	701.00	716.28	1541.00	1677.25
2013-14	788.00	780.78	1636.00	1764.28
2014-15	786.00	814.45	1830.00	1646.16
2015-16	772.00	803.63	1702.00	1778.83
2016-17	837.00	845.16	1930.00	1850.31
2017-18	856.00	858.91	1890.90	1857.76
2018-19	839.00	848.23	1912.10	1984.14
2019-20	904.35	853.72	1983.05	1967.98
2020-21		872.33		2008.11
2021-22		827.79		2061.60
2022-23		884.68		2097.48
2023-24		895.27		2144.27
2024-25		905.86		2184.30

Table 9: Estimates of the fitted ARIMA (4, 1, 1) model for rice area and ARIMA (0, 1, 1) model for rice production in India

Area				
Variables	**Estimate**	**Std Error**	**t Ratio**	**Probability**
AR1	0.1440	0.1569	0.9200	0.3682
AR2	0.1779	0.1607	1.1100	0.2797
AR3	-0.0760	0.1568	-0.4800	0.6323
AR4	-0.4486	0.1548	-2.9000	0.0081*
MA1	1.0000	0.1148	8.7100	<.0001*
Intercept	26.6153	16.8850	1.5800	0.1286
Production				
Variables	**Estimate**	**Std Error**	**t Ratio**	**Probability**
MA1	0.8213	0.1715	4.7900	<.0001*
Intercept	1456.6638	208.6258	6.9800	<.0001*

Table 10: Actual and estimated area and production of rice in India

Year	Area ('000 Hectare) ARIMA (1, 1, 1)		Production ('000 Tonne) ARIMA (1, 1, 0)	
	Actual	**Predicted**	**Actual**	**Predicted**
1990-91	42686.60		74291.40	
2000-01	44712.00	43823.62	84976.60	88291.16
2010-11	42862.40	43562.12	95979.80	97843.36
2011-12	44006.30	42879.86	105310.90	98966.90
2012-13	42753.90	42849.38	105241.40	101557.38
2013-14	44136.00	44451.69	106645.50	103672.37
2014-15	44110.60	43934.80	105482.10	105660.29
2015-16	43499.20	43798.83	104408.20	107085.11
2016-17	43993.40	44182.30	109698.40	108063.50

2017-18	43774.10	43550.88	112757.60	109812.26
2018-19	44156.40	43705.86	116477.80	111795.12
2019-20	43662.30	44007.67	118870.32	114088.36
2020-21		43818.90		116399.33
2021-22		43854.91		117856.00
2022-23		43786.01		119312.66
2023-24		44024.27		120769.32
2024-25		44005.34		122225.99

3.4 Behaviour of prices and arrivals of rice

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

The compound growth rate of arrivals in Burdwan and Vadodara markets were found to have decreasing trend but statistically non-significant during study period. It could be observed from the results that the regression coefficients were highly significant at 1 per cent level in the selected markets. This clearly indicated that a considerable amount of variation in the prices could be explained by the linear trend. The results revealed the positive and significant rate of increase in prices of the selected markets for rice during the period under study.

Based on the significance of the coefficient, value of R2, exponential trend function was a better fit over linear and quadratic function for the arrivals of rice. While, in case of prices the linear and exponential trend function were found best fitted.

Mahammadhusen (2016) [26] in their study on price behaviour of major cereals in Gujarat found similar results.

Cyclical variations are long term oscillatory movements with duration of greater than one year. The cyclical component was worked out using multiplicative model. Where applied in order to yearly original price (index) divided by estimated trend value and then taken 3 years moving average from this series.

The cyclical variation of prices of rice in selected markets was presented in Table 14. The result revealed that the price cycle of rice peaked from 2015 to 2019 in Burdwan market and from 2017 to 2019 in Vadodara market. Prices of agricultural commodities are lower during the post-harvest months and higher during the pre-harvest months.

The seasonal nature of arrivals and prices of major cereals in selected markets are shown in Table 15. In Burdwan, market arrivals started to increase from November and reached its peak in December then remained higher up to July month, barring the month of April. This may be due to Kharif and Rabi harvest of rice. The lower value of indices during the period August to October indicated lean period for rice in Burdwan market. In Vadodara market, two peak period were noticed, the first in March and second in October. The high arrivals period in Vadodara market was from October to March, barring the month of January and low arrivals period was from April to September. Thus, the lean period for arrivals was longer in Vadodara market than Burdwan market. In respect of price indices of rice in Burdwan market, high values were found in lean period of arrivals and low values were found during high arrivals periods. Opposite trend was observed in Vadodara market. The highest values of price indices were in November in Burdwan and July in Vadodara markets whereas the lowest values of price indices were in June in Burdwan market and January in Vadodara markets.

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 rice arrivals was higher in month of May (126.62 points) and February (221.42 points) in Burdwan and Vadodara markets respectively. While index of irregular fluctuation of rice arrivals was lowest in October (73.39 points) and December (41.25 points) in Burdwan and Vadodara markets, respectively. In case of index of irregular fluctuation of rice prices was higher in month of June (108.15 points) and January (110.83 points) while it was lower in December (93.80 points) and October (92.87 points) in Burdwan and Vadodara market, severally. The indices of irregular variation were found to have high magnitude and showed high upward and downward trends in arrivals of Vadodara market as compare to Burdwan market.

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

Particular	Markets	Intercept β_0	Co-efficient for Time (T) β_1	R^2
Arrivals	Burdwan	11950.87	-360.11 (214.07)	0.2613
	Vadodara	9496.69	-47.90 (979.04)	0.0003
Prices	Burdwan	1690.35	72.06** (18.12)	0.6641
	Vadodara	1848.67	144.16** (14.43)	0.9258

Table 12: Estimation of quadratic trend in yearly arrivals and prices of rice 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	Burdwan	7336.67	1946.99** (491.86)	4534.43** (4318.35)	0.8286
	Vadodara	332.04	-209.74 (43.58)	-416.58 (382.59)	0.1451
Prices	Burdwan	1629.72	102.37 (85.62)	-2.76 (7.59)	0.6703
	Vadodara	1587.94	274.52** (46.68)	-11.85** (4.14)	0.9659

Table 13: Estimation of compound rate of increase in rice arrivals and price in selected markets

Crops	Markets	b*	Estimates of β	Compound Rate of Increase (%)	R^2
Arrivals	Burdwan	9.43	0.9557	-4.42	0.2768
	Vadodara	9.07	0.9770	-2.30	0.0174
Prices	Burdwan	7.44**	1.04	3.58	0.6681
	Vadodara	7.55**	1.06	5.85	0.9110

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

Year	Rice	
	Burdwan	Vadodara
2012	136.52	73.75
2013	146.04	80.93
2014	160.85	88.96
2015	165.22	94.47
2016	162.61	99.99
2017	163.31	105.25
2018	176.83	110.32
2019	183.29	111.24

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

Month	Rice			
	Burdwan		Vadodara	
	Arrivals	Prices	Arrivals	Prices
January	118.31	94.20	88.20	93.43
February	107.04	94.13	114.55	93.67
March	105.39	92.73	181.19	98.14
April	93.27	92.94	55.88	98.12
May	108.34	93.66	75.65	93.93
June	104.44	92.02	60.59	93.52
July	109.96	105.28	91.20	107.00
August	91.17	107.20	92.60	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 rice in selected markets (2014)

Month	Rice			
	Burdwan		Vadodara	
	Arrivals	Prices	Arrivals	Prices
January	93.81	104.66	91.22	110.83
February	87.09	105.46	221.42	109.71
March	106.87	106.60	85.25	104.06
April	115.66	107.09	89.13	103.70
May	126.62	106.28	71.85	107.91
June	88.62	108.15	77.00	107.85
July	103.64	97.43	52.18	94.75
August	98.23	96.71	104.03	96.93
September	86.52	96.26	79.23	92.94
October	73.39	97.88	48.35	92.87
November	91.46	97.70	92.01	96.13
December	100.93	93.80	41.25	95.06

4. Conclusion

In Gujarat, the growth rate of area, production and yield of rice were found positive and significant. Over the years, the compound annual growth rate of area, production and yield of rice in India though remained positive but showed gradual decline. It might be due to some meteorological and hydrological droughts occurred in India. The highest instability indices of area of rice were found in Andhra Pradesh in Period- I, II and III. The highest stability of area (1.56), production (5.41) and yield (3.49) were observed in Chhattisgarh, Punjab and West Bengal states, respectively in the overall study period. In Gujarat, the magnitude of instability indices of area (8.26), production (19.13) and yield (14.26) showed that rice crop was stable in terms of area and yield, but moderate instability was observed in production.

The results revealed that in case of rice crop, regression coefficient (1.6901) for area under competing crop was found positive and statistically significant at 5 per cent level. This indicates that increase in area under competing crop of sugarcane increase the acreage under rice which not obvious. It meant that they do not acting as competing crop. The regression coefficient for farm harvest price (0.0412), minimum support price (0.2480) and irrigated area (0.0081) found positive. It indicates positive impact on the acreage under rice crop in Gujarat.

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 exert any positive significant influence on the acreage under rice crop. In spite of the improvement in the price over time, the area under rice crop has not responded positively in Gujarat.

The forecasting of area and production showed that area and production will increase in the next five year for rice crop in Gujarat and India. The prices of rice under study indicated downward trend in post-harvest period and upward trend in pre-harvest period. For both the markets, not found any cyclical variation in the price indices. The prices of rice showed less degree of irregular fluctuations, while arrivals of Vadodara market showed comparatively higher irregular fluctuation. The arrivals of Burdwan market showed less degree of irregular fluctuation.

5. 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 food grains due to introduction of high-value crops, stagnation in food grains productivity and to maintain a buffer stock of the country.

6. 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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