International Journal of Agriculture Sciences
ISSN: 0975-3710 & E-ISSN: 0975-9107, Volume 7, Issue 3, 2015, pp.-474-481.
Available online at http://www.bioinfopublication.org/jouarchive.php?opt=&jouid=BPJ0000217

STUDY OF INSTABILITY AND FORECASTING OF FOOD GRAIN PRODUCTION IN INDIA

MISHRA P.*, SAHU P.K., PADMANABAN K., VISHWAJITH K.P. AND DHEKALE B.S.

Department of Agriculture Statistics, Bidhan Chanda Krishi Vishwavidyalaya, Nadia - 741 252, WB, India.
*Corresponding Author: Email- pradeepjnkvv@gmail.com

Received: May 14, 2015; Revised: June 15, 2015; Accepted: June 18, 2015

Abstract- For food and nutritional security, forecasting production behaviours of the major food crops play vital role. Planners should have idea about the past and likely production scenario of the major crops. In this paper attempt has been made to examine the performance of total food grains production in India and its major states during the period (1950-2009). Stability in production behavior with respect to area, production and yield of total food grains has been studied. This study also focuses on forecasting the area and production of total food grains in India using Autoregressive Integrated Moving Average (ARIMA) model. The success of agriculture depends on many factors from formulation of policy to its implementation, availability of inputs, climatic conditions etc. In an attempt to increase forecast accuracy, the study incorporated the factors of production in the ARIMA model as auxiliary variables. The study reveals that by and large estimated figures are closer to the observed figures when different factors are included in the model. Forecasting figures worked out using the best fitted ARIMA models with and or without the incorporation of factors of production indicate that Uttar Pradesh will be the leading state in India in total food grains production, with a production of 49455 thousand tonnes from an area of 19982 thousand hectare with 2718 kg/ha yield during year 2020.
Keywords- ARIMA, Forecasting, Instability, Production

Citation: Mishra P., et al. (2015) Study of Instability and Forecasting of Food Grain Production in India. International Journal of Agriculture Sciences, ISSN: 0975-3710 & E-ISSN: 0975-9107, Volume 7, Issue 3, pp.-474-481.

Introduction

World population, particularly the population of developing countries is increasing at an alarming rate. To feed this ever increasing population remains a challenging task to the planners of these countries and also the world bodies. Crop yield is the ultimate result of the interaction of weather factors, irrigation, fertilizer, plant protection, management technique and of course the market, especially the prices of inputs and outputs etc. Thus, study of all the associated factors are also needed for effective crop forecasting in years to come. Weather factors (viz. rainfall, temperature, relative humidity, and day length, etc.) play vital role in crop growth and production. Agricultural production also depends on other inputs like fertilizer, pesticide and irrigation etc. At present Indian population is approximately about 1,287,474,430 [1], providing food to this population is very challenging. With the population projection in one hand, planners are well aware about the likely demand for food and other commodities. Thus, forecasting production behaviours of the major crops play vital role towards food and nutritional security. In Indian agriculture, year to year fluctuations in output and spatial variations in productivity across states have remained significant concern for researchers as well as policy makers. The adoption of green revolution technologies not only led India towards self-sufficiency in food production but also have resulted in variations in agricultural production, regional variations and scarcity of various natural resources along with increasing pressure on environmental health. Several attempts are found in literature to measure such instability e.g. [2] measured the change and instability in area, production and yield of maize in India. Keeping in mind the ecogeographic and regional diversity of India, study of production and forecasting behavior of individual crop as well as, food grain as a whole is also of much importance. With this background, the present study attempted at analyzing the production behavior of total food grains, its instability and future behavior for India and its major growing states for food security of the country. Use of Autoregressive Integrated Moving Average (ARIMA) in analysis and forecasting purpose has been proved worthy, time and again. [3] studied forecasting the production import-export (both in quantity and value) and trade balance of total spices in India and China along with world using Autoregressive Integrated Moving Average (ARIMA) model using time series data covering the period of 1961-2009 and forecasted for year 2020. [4] studied forecasting the area, production productivity and total seed in rice and wheat in SAARC countries. But most of the studies have used time series data without providing/ including much importance to the factors of production mentioned earlier. In this study attempt has been made to model and forecast the production of total food grain with/without using these factor in the model.

Method and Methods

Five major food grain producing states were selected based on their shares towards food grain basket of India; the selected states were Punjab, Uttar Pradesh, West Bengal, Bihar and Andhra Pradesh.

Availability of consistent data is a challenging problem, the researchers has to face while dealing with time series data. Information related to crop wise use of fertilizer, pesticide etc are not easy to get, as such this study has used total fertilizer and pesticide consumption in the states and the country. In this study also, though objective was to take care of the period since 1950 as the study period but uniform data on area, production, productivity, irrigation, fertilizer and pesticide consumption etc. could not be collated for the whole period.

The data collected from various published sources are area, production, yield of total food grains in major states and India from 1950-2013, total pesticide consumption for 1989 to 2010; total fertilizer consumption from 1975-2010 [5], meteorogical data for 1961-2010 and irrigation data for different crops or different states for the period 1965-2009 [6] could be used for this study.

Descriptive Statistics

Descriptive statistics are used to describe the basic features of the data in a study. Statistical tools used to describe the above series are minimum, maximum, average, standard error, skewness, kurtosis. Simple growth rates (SGR) have been calculated using the following formula:

$$SGR\% = \frac{(Y_t - Y_0)}{Y_0 n}.100$$

where, Y_t and Y_0 are the values of the last year and the first year of the series; n is the number of years.

Instability

Since independence, India has passed through different stages of agricultural production, as such the whole period under study is divided into three periods viz. period- I from 1950 to 1967(pre-green revolution period), period-II from 1968 to 1988(early adoption or green revolution period) and period III from 1989-2009 (post green revolution or widespread adoption period) during the study of instability.

For measuring the instability in area, production and yield the index given by [7] and [8]as given below has been used.

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

where,

CV_t = CV around trend, $C.V. = \frac{\sigma}{\overline{X}}x100$

where σ = Standard deviation

$\bar{x}$ = Mean

More general option is to use ordinary CV value but in presence of trend, ordinary CV fails to explain the inherent trend component in a time series properly [9] and [2] As such, this study opted for CV around trend i.e. CV_t.

Modeling and Forecasting

Modeling technique has got tremendous use in literature in time series modeling and forecasting [10]. Several workers like, [11] and [2] have used this technique.

Autoregressive Model

ARIMA models stands for Autoregressive Integrated Moving Average models. Integrated means the trends has been removed; if the series has no significant trend, the models are known as ARMA models.

The notation AR (*p*) refers to the autoregressive model of order *p*. The AR (*p*) model is written:

$$X_t = c + \sum_{i=1}^{P} \alpha_i X_t + \mu_t$$

where $\alpha_1, \alpha_2 .... \alpha_p$ are the parameters of the model, *c* is a constant and μ_t is white noise. Sometimes the constant term is omitted for simplicity.

Moving Average model: The notation MA (*q*) refers to the moving average model of order *q*:

$$X_t = \mu + \sum_{i=1}^{q} \theta_i \varepsilon_{t-i} + \varepsilon_t$$

Model Selection and Diagnostic Check

Among the competitive models, best models are selected based on minimum value of Root Mean Square Error (RMSE), Mean Absolute Error (MAE), Mean Square Error (MSE) and Mean Absolute Percentage Error (MAPE), maximum value of Coefficient of Determination (R^2) and of course the significance of the coefficients of the models. Best fitted models are put under diagnostic checks through auto correlation function (ACF) and partial autocorrelation function (PACF) of the residuals [10].

$$MAE = \frac{\sum_{i=1}^{n} | X_i - \hat{X}_i |}{n}, \quad R^2 = \frac{\sum_{i=1}^{n} (X_i - \hat{X}_i)^2}{\sum_{i=1}^{n} (X_i - \overline{X}_i)^2}$$

$$RMSE = \sqrt{\frac{\sum_{i=1}^{n} (X_i - \hat{X}_i)^2}{n}}, \quad MAPE = \frac{\sum_{i=1}^{n} \left| \frac{X_i - \hat{X}_i}{X_t} \right|}{n} X100$$

Diagnostic checks of the fitted models are made through ACF and PACF graphs of the residuals. If the residuals are white noise, then only the model is taken for forecasting purpose.

The whole period under consideration has been divided into two parts.

The Model Formulation Period: Whole period, excepting the data for last three years.

Model Validation Period: Last three years data, left out during the model formulation period.

On the basis of best fitted model forecasting values are worked out.

The success of agriculture depends on so many factors; starting from formulation of policy to its implementation, availability of inputs, climatic conditions etc. Effective forecasting process should take all these factors in to consideration. Instead of using univariate ARIMA models, the study feels inclusion of factors of production may improve the quality as well as forecasting power of the model. In this study, all the factors of production have been incorporated in the model as auxiliary variables. Initially, all the factors of production are modelled individually to get the estimated values for the observed data points and to forecast its future values based on the best fitted models in respective series. In the second step, these forecasted input and climatological factor values are used as auxiliary/independent variables in the ARIMA models for area, production and productivity series. With the help of the best fitted models in second step forecasting values are generated for each series. Comparison has been made between forecasted values with simple ARIMA model and the models with input and other factors. In majority of the cases the forecasting power of the model with auxilia-independent factor are found to be better. On the basis on best fitted models predictions have been made for individual series.

Results and Discussion

Per se Performance of Food Grain Production in India

From [Table-1A], one can find that in India, since 1950 the area under total food grains has increased from 96.96 million hectare (1950) to 158.06 million hectare (2008) registering a simple growth rate of almost 79.90%. The effect of expansion in area is clearly visible in the production scenario of total food grains. From a mere 50.82 million tons (1950) of production it has reached to 234.23 million tonnes during the year 2009 registering a growth of 194.88%. From food deficient country, India has become a food sufficient country.

Table 1A- *Per se* performance of total food grains production in major states of India during 1950-2010

	Uttar Pradesh	Punjab	Andhra Pradesh	West Bengal	Rajasthan	India
			Area ('000 ha)			
Minimum	16763	3099	6265.67	5040	5222	96961
Maximum	20862.2	7262	9820	8658	15708.6	158064
Mean	19350.5	5151.17	8265.94	6152.44	11692.5	121764
SE	133.622	133.374	136.637	95.817	248.75	1409.7
Kurtosis	-0.477	-0.868	-1.328	2.768	3.019	4.261
Skewness	-0.536	0.013	-0.27	1.224	-1.302	1.129
SGR (%)	8.252	35.565	-9.869	14.233	14.034	79.901
			Production ('000t)			
Minimum	10965	3308	4165	4432	1278	50825
Maximum	46729.3	27329.8	20421	16501.2	24945	234231
Mean	26068.7	13662.1	10055.2	9467.44	10160.3	134541
SE	1554.18	1041.02	481.17	524.661	741.433	7019.73
Kurtosis	-1.537	-1.456	0.041	-1.29	-0.421	-1.316
Skewness	0.261	0.295	0.683	0.445	0.588	0.206
SGR (%)	163.886	435.533	168.288	141.868	389.122	194.889
			Yield(kg/ha)			
Minimum	453	568	526	877	244	522
Maximum	2365	4255	2744	2561	1288	1909
Mean	1275.47	2301.35	1274.13	1515.8	652.983	1122.17
SE	78.471	170.749	77.32	74.47	33.65	53.935
Kurtosis	-1.555	-1.731	-0.623	-1.277	-0.431	-1.274
Skewness	0.355	0.122	0.69	0.551	0.712	0.265
SGR (%)	137.093	378.169	213.246	103.121	132.78	146.667

Platykurtic nature of production indicates that there have been continuous efforts on maintaining the production of total food grains. Increased production of total food grains has also been contributed by substantial increase in per hectare yield. Starting with only 552kg (1950) of total food grains per hectare, it has reached to 1909 kg/ha during the year 2009. State wise figures show that Uttar Pradesh has increased its production by four fold; from mere 10.96 million tonnes (1951) to 46.72million tonnes (2008) during the period under study. Punjab has increased production from 33.08 million tonnes (1950) to 273.29 million tonnes (2009) registering a growth of almost 435.55% with an average productivity of 2301kg/ha from an average area of 51.51million hectare. In Andhra Pradesh, since 1950 the production of total food grains increased from 41.65 million tonnes to 204.21 million tonnes (2008), registering a growth of almost 168.28% with an average yield of 1274.13 kg/ha. In West Bengal, area has increased from 5.04 million hectare to 8.66 million hectare registering a growth of only 14.23% but due to increased growth of per hectare yield the state could reach to a production figure of 165.01 million tones during the year 2009 from a mere 44.32 million tonnes (1951). The average production of total food grains in Rajasthan being 642.92 kg/ha accompanied by a moderate growth rate of 132.78% during the period; since 1950 the per hectare yield of total food grains in Rajasthan has increased from 244 kg/ha to 1288 kg/ha Thus, from the average performances of the major total food grains growing states one can find a wide spectrum of variations in simple growth rates in area, production and productivity. High growth rates are clearly the effect of green revolution on production scenario of total food grains. Among the major states, Punjab is found to have recorded maximum improvement during the period followed by Andhra Pradesh. One of the most interesting result from the study of the analysis of simple growth rates of total food grains in India among the major contributing states is that out of five major contributors, as many as three states are found to have growth rates of per hectare yield less than the all India average growth rate. Under the given shrinking land under agriculture per hectare production of major contributing states need to be geared up for food and nutritional security of the country.

Irrigation, fertilizers and pesticides are three major components of food production and the behaviour of these three have been studied [11] results are summarized in [Table-1B]. It is found that irrigated area under total food grains in Uttar Pradesh is estimated at an average of 9871 thousand hectare with highest and lowest being 13435 and 5065 thousand hectare respectively during (2008 and 1950). The irrigated area under total food grains in Punjab varied between 5091 thousand hectare in 2003 to 1346 thousand hectare in 1965 with an average of 3757 thousand hectare. In Andhra Pradesh, irrigation under total food grains has increased from 346 thousand hectare to 6740 thousand hectare registering highest growth rate of almost 305%. Like other states, the irrigated area under total food grains in West Bengal has also increased from 1172 thousand hectare to 3025 thousand hectare with an average of 2397 thousand hectare, thereby registering a growth of 59.76%. As we know without assured irrigation facilities, it is not possible to adopt modern crop harvesting technology and thereby improving the per hectare productivity, so the state should provide greater emphasis of irrigation expansion.

In Rajasthan irrigated area under total food grains was highest at 5091 thousand hectare in 1986 and lowest at 1346 thousand hectare in 1965, thereby registering more than 94% growth during the period under study. For whole India irrigated area of total food grains has increased from 22963 thousand hectare during (1965) to 63740 thousand hectare during the period registering a growth rate of (-6.8) (2008). Likewise to that of irrigation, fertilizer consumption also recorded positive growth rates in all the states as well as for whole India; maximum growth rate of 427% is recorded in Andhra Pradesh followed by West Bengal (418%), Rajasthan 295% and so on; clearly there has been many fold increase in the use of fertilizer consumption which has several impact on farm economy as well as on environment. From a mere 35674 metric tonnes (1950) of production it has reached to 75033 metric tonnes during the year 2009.

Table 1B- *Per se* performance of climatological and some input factor of production of total food grains

	ARF	$T_{max.}$	$T_{min.}$	IA	TFC	PC
Uttar Pradesh						
Minimum	534.269	31.348	17.856	5065	223.06	1855
Maximum	1260.773	32.992	19.661	13435	4032.76	9563
Mean	894.736	32.174	18.9	9871.659	2059.759	7533.9
S.E.	26.664	0.06	0.05	383.285	183.539	356.938
Kurtosis	-0.82	-0.766	0.637	-1.098	-0.832	8.431
Skewness	-0.225	0.039	-0.362	-0.291	-0.076	-2.362
SGR(%)	371.393	0.193	2.128	72.711	248.622	1.466
Andhra Pradesh						
Minimum	718.099	30.23	18.107	346	78.67	62
Maximum	1392.897	33.048	21.54	6740	1661.17	5000
Mean	988.687	32.118	19.329	3514.932	675.642	1680.85
S.E.	24.403	0.093	0.105	304.049	87.802	277.822
Kurtosis	-0.516	1.569	2.002	-1.471	-1.601	1.54
Skewness	0.232	-1.323	1.429	0.229	0.428	1.321
SGR(%)	-11.134	-1.562	5.729	305.102	427.851	-15.632
Rajasthan						
Minimum	578.973	34.341	22.779	1346	149.56	2400
Maximum	1269.307	36.45	24.981	5091	2566.11	6450
Mean	993.662	35.204	23.606	3761.068	1007.668	3845.85
S.E.	21.306	0.07	0.069	111.521	125.754	229.375
Kurtosis	-0.07	0.262	0.282	2.12	-1.106	0.866
Skewness	-0.142	0.58	0.29	-1.124	0.64	1.165
SGR(%)	94.407	-15.011	2.939	94.407	295.026	-9.262
Punjab						
Minimum	290.751	30.948	16.312	1346	311.3	5610
Maximum	785.423	32.774	18.042	5091	2100.6	7400
Mean	512.852	31.77	17.102	3757.568	1280.119	6694.6
S.E.	19.187	0.07	0.055	111.217	81.853	126.602
Kurtosis	-0.89	-0.56	-0.255	2.151	-0.516	-1.016
Skewness	0.142	0.203	0.353	-1.123	-0.586	-0.571
SGR(%)	457.233	11.658	0.085	-44.014	159.052	-0.8
West Bengal						
Minimum	279.606	30.644	17.284	1172	96.92	42.88
Maximum	796.138	34.09	19.42	3025	1667.2	5265
Mean	561.281	31.791	18.355	2397.614	666	4688.844
S.E.	18.16	0.103	0.074	83.657	76.945	251.156
Kurtosis	-0.624	2.255	-0.462	-0.33	-0.264	17.629
Skewness	-0.226	1.236	0.31	-0.921	0.832	-4.099
SGR(%)	-4.417	5.183	2.974	59.761	418.247	-19.817
India						
Minimum	848.9	30.948	16.312	22963	2080	35674
Maximum	1314.2	32.774	18.042	63740	24909.3	75033
Mean	1100.506	31.744	17.107	42644	11386	53436.46
S.E.	15.209	0.068	0.056	1795.274	1119.01	2742.646
Kurtosis	-0.642	-0.49	-0.363	-1.285	-1.174	-1.073
Skewness	-0.382	0.164	0.326	0.098	0.393	0.485
SGR(%)	38.654	-4.482	0.072	-6.8	254.117	-7.799

Note: ARF=Annual rainfall (1961-2009) in mm, T_{max} and T_{min}=Average maximum and minimum temperature (1961-2009) in ^{o}C, IA=Irrigated area in '000 ha, TFC=Total fertilizer consumption (1975-2009) in '000 tonnes, PC=Pesticide consumption (1989-2009) in MT (Metric tonnes), Pl check the data, particularly for ARF, T_{Max}, T_{Min}

Instability

Analysis of instability indicates that both the methods (CV and CV around trend) result in almost same pattern of instability. Total food grains in Punjab recorded highest instability for whole period [Table-2], this is mainly attributed to the instability during the initial periods. Rest of the states including whole India show higher instability in the period III (late and post green revolution period) compared to period-I (pre green revolution) and period -II (green revolution period).

Table 2- Instability in area, production and yield of total food grains in major states of India

States	Component	Statistics	Period I	Period II	Period III	Whole Period
Uttar Pradesh	Area	R^2	0.899	0.845	0.753	0.904
		CV	2.735	2.812	2.131	4.92
		CV_t	0.869	1.107	1.059	1.524
	Production	R^2	0.742	0.968	0.802	0.983
		CV	6.804	24.243	7.337	45.059
		CV_t	3.456	4.337	3.265	5.875
	Yield	R^2	0.577	0.951	0.909	0.939
		CV	4.497	35.083	8.074	46.738
		CV_t	2.925	7.766	2.435	11.543
Punjab	Area	R^2	0.573	0.995	0.951	0.592
		CV	21.145	13.15	5.029	18.23
		CV_t	13.817	0.93	1.113	11.644
	Production	R^2	0.669	0.993	0.952	0.989
		CV	15.282	33.451	11.418	57.742
		CV_t	8.792	2.799	2.502	6.056
	Yield	R^2	0.986	0.96	0.95	0.951
		CV	24.802	41.3	6.819	56.308
		CV_t	2.935	8.26	1.525	12.464
Andhra Pradesh	Area	R^2	0.877	0.896	0.466	0.916
		CV	4.232	7.856	4.641	12.191
		CV_t	1.484	2.534	3.392	3.533
	Production	R^2	0.96	0.864	0.843	0.946*
		CV	13.618	15.857	15.848	34.322
		CV_t	2.724	5.848	6.279	7.976
	Yield	R^2	0.972	0.961 *	0.958	0.986
		CV	10.292	21.142	15.435	45.081
		CV_t	1.722	4.175	3.163	5.334
West Bengal	Area	R^2	0.823	0.716	0.869	0.824
		CV	2.92	3.801	8.825	10.979
		CV_t	1.228	2.026	3.194	4.606
	Production	R^2	0.679	0.875	0.986	0.973
		CV	7.633	14.725	10.819	41.802
		CV_t	4.324	5.206	1.28	6.869
	Yield	R^2	0.726	0.931	0.99	0.976
		CV	5.093	16.466	10.466	37.14
		CV_t	2.666	4.325	1.047	5.754
Rajasthan	Area	R^2	0.995	0.488	0.193	0.834
		CV	16.86	3.961	6.161	12.396
		CV_t	1.192	2.834	5.535	5.051
	Production	R^2	0.97	0.838	0.69	0.462 *
		CV	19.796	41.066	15.16	50.649
		CV_t	3.429	16.529	8.441	37.151
	Yield	R^2	0.792	0.539	0.877	0.954
		CV	8.417	13.04	14.061	36.859
		CV_t	3.839	8.854	4.931	7.905
India	Area	R^2	0.979	0.758	0.773	0.719
		CV	5.147	1.842	7.769	7.366
		CV_t	0.746	0.906	3.701	3.905
	Production	R^2	0.932	0.969	0.915	0.99
		CV	12.375	15.848	8.376	38.961
		CV_t	3.227	2.79	2.442	3.896
	Yield	R^2	0.869	0.913	0.968	0.987
		CV	7.697	12.061	8.965	36.012
		CV_t	2.786	3.558	1.604	4.106

*Indicates that the best fitted model is exponential

In case of production of total food grains Uttar Pradesh, West Bengal and Rajasthan show higher instability in the period II (green revolution period),while Punjab and whole India in period I (pre green revolution). Andhra Pradesh showing maximum instability in phase III. Rajasthan is the state which has maximum instability (37.151) in production of total food grains during the 1950 to 2009 (whole period). In productivity of total food grains all the states including whole India show higher instability in the period II (period of green revolution) compared to other two periods. Punjab is the state which has maximum instability (12.464) in productivity of total food grains during the 1950 to 2009 (whole period). The results of instability study are well expected because with the changing behaviour of any series variations is bound to be associated.

Modelling and Forecasting

Up on checking the series for stationary it was observed that none of the series was stationary. So all the series have made stationary using first difference in the present study. Using Box - Jenkins methodology and with the help of SPSS10 software forecasting models for all the series were developed and checked for satisfying maximum criteria. Model, in each series, which satisfied the maximum criteria [12] were selected and used for diagnostic check, followed by model validation and ultimately used for forecasting purpose. [Table-3] presents the selected models for each series. Also from [Table-4] it is found that the inclusions of different factors of productions in the best fitted univariate ARIMA models are found to increase the accuracy compared to simple ARIMA models.

Table 3- ARIMA models for area, production and yield of total food grains in India including with factors and without factors

		ARIMA models	R^2	RMSE	MAPE	MAE	MaxAPE	MaxAE	Normalized BIC
					Uttar Pradesh				
	A	(0,1,3)	0.888	172.42	0.64	123.56	2.7	542.53	10.58
Without factors	P	(1,1,3)	0.985	853.16	2.91	652.68	10.84	2239	13.85
	Y	(1,1,2)	0.989	42.28	3.09	31.22	15.06	140.03	7.77
	A	(0,1,2)	0.966	175.637	0.55	110.816	1.868	375.372	11.502
With factors	P	(1,1,5)	0.995	1104	2.257	717.849	10.836	2194	14.967
	Y	(1,1,2)	0.995	59.076	2.903	39.523	13.284	123.537	9.005
					Punjab				
	A	(1,1,3)	0.996	310.85	2.24	224.48	16.54	868.08	11.83
Without factors	P	(0,1,2)	0.997	305.88	2.26	227.83	15.93	835.65	11.66
	Y	(0,1,3)	0.99	76.07	3	50.06	17.63	292.53	8.95
	A	(1,1,5)	0.999	44.838	0.513	28.296	1.796	97.139	8.878
With factors	P	(1,1,3)	0.999	343.905	1.286	226.599	3.984	667.29	12.74
	Y	(1,1,0)	0.997	97.039	2.58	63.956	13.707	270.328	9.892
					Andhra Pradesh				
	A	(0,1,4)	0.943	484.45	3.17	330.14	8.9	1324	12.72
Without factors	P	(0,1,5)	0.955	478.87	3.17	328.5	10.17	1408	12.77
	Y	(1,1,5)	0.991	43.31	2.39	30.24	7.12	119.28	8.03
	A	(1,1,5)	0.981	237.715	2.041	154.458	7.559	579.284	11.79
With factors	P	(1,1,4)	0.982	646.742	3.599	437.612	8.444	1085	14.109
	Y	(0,1,4)	0.995	50.936	2.43	37.276	5.882	75.285	8.921
					West Bengal				
	A	(1,1,5)	0.933	297.67	3.02	236.4	9.67	576.53	11.89
Without factors	P	(1,1,5)	0.99	287.67	2.02	233.4	9.77	576.53	11789
	Y	(1,1,5)	0.994	35.93	2.12	27.62	6.12	73.92	7.66
	A	(1,1,3)	0.995	174.168	1.662	111.093	5.343	429.125	11.38
With factors	P	(1,1,2)	0.995	370.133	2.522	269.519	7.779	663.413	12.781
	Y	(1,1,5)	0.996	45.896	1.918	30.24	7.178	86.28	8.924
					Rajasthan				
	A	(1,1,2)	0.993	1279	8.56	893.62	34.6	4309	14.59
Without factors	P	(1,1,4)	0.962	1325	8.39	863.77	34.53	4784	14.8
	Y	(1,1,5)	0.964	40.39	5	31.15	15.9	87.76	7.89
	A	(1,1,1)	0.941	673.318	3.573	435.409	18.802	1981	13.872
With factors	P	(0,1,4)	0.939	1666	9.221	1135	33.824	4068	15.79
	Y	(1,1,5)	0.974	47.317	4.534	33.825	15.876	80.494	8.985
					India				
	A	(1,1,4)	0.692	3597	2.19	2707.99	8.505	11600	16.8
Without factors	P	(1,1,4)	0.987	3432.77	3.14	2654.64	7.05	15300	15.765
	Y	(0,1,5)	0.987	25.72	1.85	19.101	7.308	59.6	6.92
	A	(1,1,4)	0.996	4825	2.027	2675	9.549	14980	17.811
With factors	P	(1,1,3)	0.996	4494	1.738	2925.99	6.602	9513	17.881
	Y	(1,1,1)	0.996	35.354	1.882	25.034	5.269	86.353	7.873

Table 4- Model validation and forecasting of area (000' ha) , production ('000 t) and yield (kg/ha) of total food grains in India

	2006			2007			2008			2010			2013			2015		2020	
	Obs.	Pred.1	Pred.2	Obs.	Pred.1	Pred.2	Obs.	Pred.1	Pred.2	Obs.	Pred.1	Pred.2	Obs.	Pred.1	Pred.2	Pred.1	Pred.2	Pred.1	Pred.2
Uttar Pradesh																			
A	19627	19504	19476	19388	19470	19385	19520	19514	19523	19802	18675	19654	20221	17946	19785	19872	17432	20089	19982
P	41240	41341	41270	43346	44561	43874	44283	44346	44150	47248	45058	45162	50028	47264	47652	48791	48070	51638	49455
Y	2107	2151	2151	2209	2218	2214	2277	2309	2288	2386	2358	2295	2474	2499	2412	2466	2565	2601	2718
Punjab																			
A	6355	6399	6353	6422	6464	6426	6516	6545	6524	6511	6659	6520	6686	6834	6528	6577	6961	6744	7295
P	25771	26809	26284	26486	27464	27312	27155	27232	27207	27866	28343	27733	29480	32230	29760	30166	33085	32194	37837
Y	4086	4196	4141	4168	4269	4235	4211	4190	4248	4280	4313	4255	4409	4389	4435	4555	4427	4855	4582
Andhra Pradesh																			
A	7276	7312	7249	7368	7367	7376	7107	7123	7121	8030	7346	6728	7446	7824	6708	6665	8218	6556	9464
P	17494	17472	17491	18651	18779	18667	18524	18627	18565	20315	20765	16266	19665	23813	16889	17285	25932	18276	28197
Y	2403	2470	2457	2529	2634	2631	2599	2606	2602	2530	2831	2664	2641	3113	2761	2831	3323	3005	3915
West Bengal																			
A	8031	8101	8032	8329	8275	8316	7839	7810	7834	93999	8172	7364	6251	8349	7399	7441	9922	7578	13109
P	15878	16965	16138	16107	16229	16172	16152	16282	16199	244492	17226	16732	17079	18342	17331	17731	19056	18729	25615
Y	2486	2524	2529	2510	2530	2584	2526	2539	2564	2601	2738	2558	2732	2920	2596	2642	3041	2768	3484
Rajasthan																			
A	12918	13116	12954	13170	13218	13161	13362	13273	13289	15078	13345	13367	13123	13567	13732	13986	13740	14620	14215
P	15649	16711	15865	14674	14743	14661	13259	13332	13255	18832	12614	12805	17900	12981	13517	13871	13278	14679	14149
Y	1073	1121	1118	1187	1199	1167	1111	1090	1093	1249	1167	1137	1364	1158	1161	1181	1173	1245	1210
India																			
A	142057	152145	142879	156858	156955	156852	144198	144288	144260	126680	152134	143321	126404	162831	141498	142952	169404	149438	184512
P	218640	228798	218729	227266	237152	227283	226894	226644	226863	244492	229251	230900	265574	234950	239412	245127	240926	259526	259707
Y	1777	1811	1803	1842	1887	1864	1856	1859	1874	1930	1910	1884	2101	1962	1955	2000	2000	2113	2099

Obs.: Observed, Pred.1: Predicated values without factors, Pred.2: Predicated values with factors.

Fig. 1A- Observed and forecasted area under total food grains in major states of India (Area (A) in is ' 000 ha)

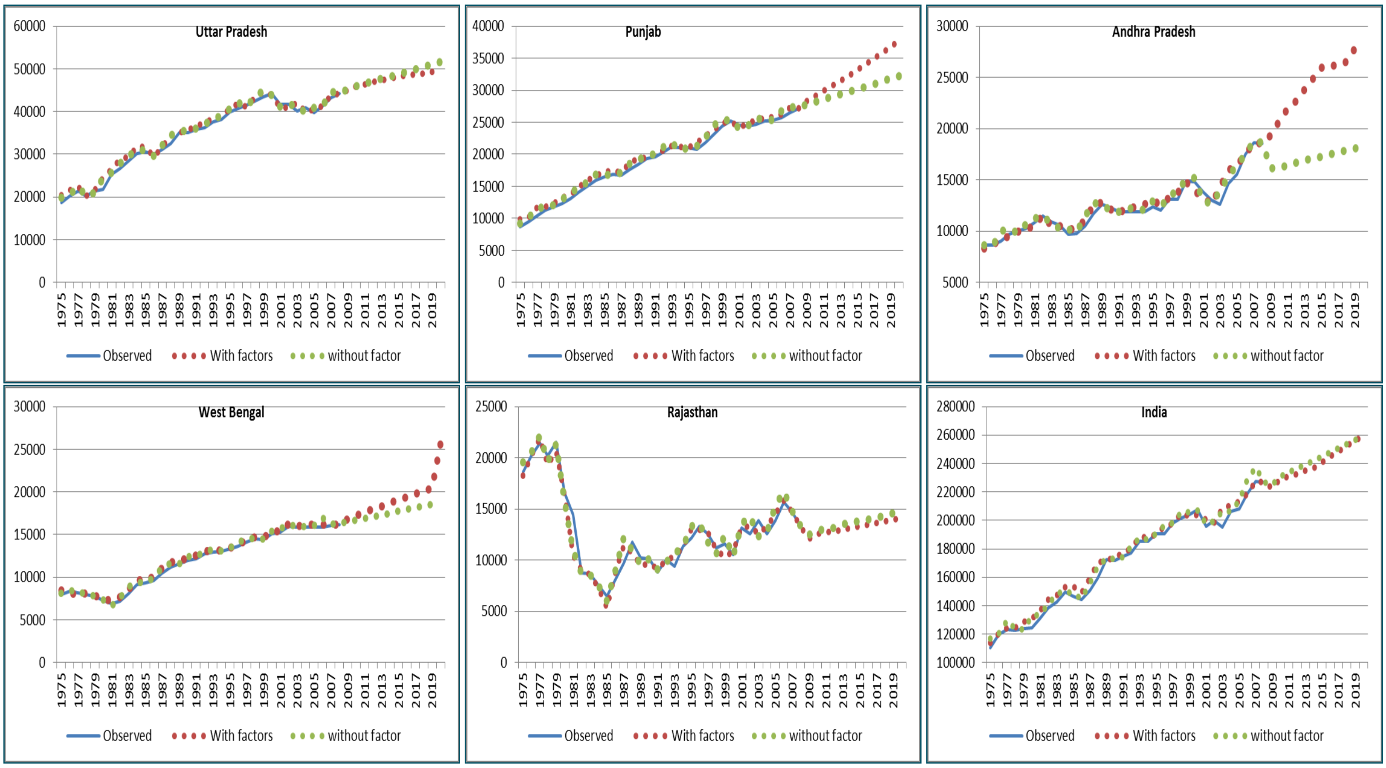

Fig. 1B- Observed and forecasted production of total food grains in major states of India (Productions (P) is in ' 000 t)

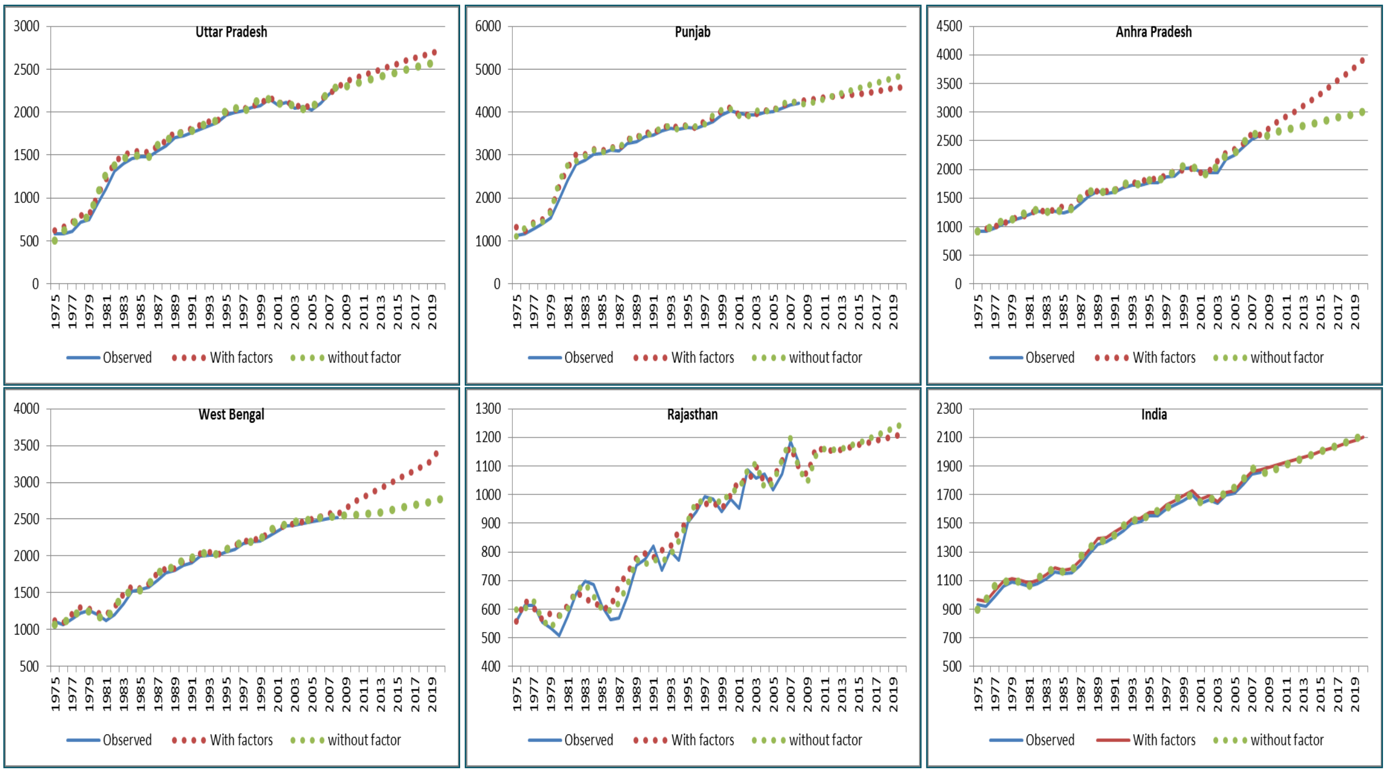

Fig. 1C- Observed and forecasted yield of total food grains in major states of India (Yield (Y) is in kg/ha)

From the forecast values [Fig-1](A-C) obtained with the inclusion of the factors in the models; it can be said that in all the major producing states along with whole India area under total food grains would increase in the future. In case of production, on the basis of expected value it is clear that the major states would have increasing trend in future and will continue to play vital role in total food grain production of India. Uttar Pradesh would be leading state of India in the production of total food grain with a production of 48070 thousand tonnes from an estimated are of 17432 thousand hectare having average productivity of 2565kg/ha during 2015. But among the major growing states, Punjab will have the highest productivity of 4427kg/ha against the average Indian productivity of 2000kg/ha.

Interesting point to note that though UP is expected to have highest area under food grain among major states, it will have almost half of the productivity of Punjab. Thus providing greater emphasis on per hectare yield in UP, India can boost its production many folds. The result of the study thus will help the planners in assessing whether this forecasted figures are sufficient to meet the future demand or not and accordingly action plan may be formulated.

Conclusion

From the above study one can summarize that in spite of positive growth in total food grain production in India since 1950, there have been differential growths among the major contributing states, the instability in production behaviour during different phase of Indian agriculture remains different. Factors of production are to be taken in to consideration while framing forecasting models and there should be concerted efforts in maintaining the crop wise, state wise input use statistics so as to facilitate the model building process.

Acknowledgement: The authors acknowledge and thank to the Department of Science and Technology, Govt. of India for awarding Inspire fellowship for pursuing program authors thankfully acknowledge the editor and anonymous reviewers for their useful comments on the earlier version of this paper.

Conflicts of Interest: None declared.

References

[1] Directorate of Economics and Statistics, Department of Agriculture and Cooperation, Ministry of Agriculture, Govt. of India. (2015) *Agricultural Statistics at a Glance*.

[2] Sahu P.K. & Mishra P. (2014) *International Journal of Agricultural and Statistical Sciences*, 10(2), 425-435.

[3] Sahu P.K. & Mishra P. (2013) *Journal of Agriculture Research*, 51(4), 81-97.

[4] Sahu P.K., Mishra P., Dhekale B.S., Vishwajith K.P. & Padmanaban K. (2015) *American Journal of Applied Mathematics and Statistics*, 3(1), 34-48.

[5] Govt. of India. (2004) *Fertilizer statistics*.

[6] Department of Agriculture and Cooperation, Ministry of Agriculture, Government of India (2012) *Agriculture at a Glance.*

[7] Cuddy J.D.A. & Della V.P.A. (1978) *Oxford Bulletin of Economics and Statistics*, 40(1), 79-85.

[8] Larson D.W., Jones E., Pannu R.S. & Sheokand R.S. (2004) *Food Policy*, 29(3), 257-273.

[9] Hasan M.N., Miah M.A.M., Islam M.S., Islam Q.M. & Hossain M.I. (2008) *Bangladesh Journal of Agricultural Research*, 33(3), 409-417.

[10] Box G.E.P. & Jenkins G.M. (1976) *Time Series Analysis: Forecasting and Control*, Holden-Day, San Fransisco, USA.

[11] Badmus M.A. & Ariyo O.S. (2011) *Asian Journal of Agricultural Sciences*, 3(3), 171-176.

[12] Gill H.K. & Garg H. (2014) *Pesticide: Environmental Impacts and Management Strategies*, Pesticides- Toxic Effects. Intech. Rijeka, Croatia. 187-230.

[13] Brockwell P.J. & Davis R.A. (2002) *Introduction to time series and forecasting*, Springer, New York, USA.