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Research Article

STATISTICAL INVESTIGATION OF FOOD GRAINS DEMAND AND SUPPLY IN INDIA

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Abstract: Agricultural development policies and agriculture scientist in India have aimed to reducing hunger, food insecurity, malnourishment and poverty at a rapid rate. The population of India goes to 1.32 billion, accounts for 17 per cent of world's population. Its size, in terms of consumers, is many-times larger than the average size of rest of the countries, except China. The state of food insecurity and hunger in India is of considerable significance for the global situation. In this present study, projected population and food grains production is investigated by using ARIMA model and making decision for forecast. Demand projection is also estimated by using almost ideal demand system (AIDS). The condition of demand-supply gaps is presented under this paper. It is found that total food grains production will be increased 281.12 Mt in the year 2020 as well as the population will be 1345 million. The demand-supply scenarios present an alarming situation at present especially for pulses. The demand-supply gap for pulses is going to more adverse condition which strongly affects our food and nutritional security. Demand of pluses in 2020 will be 22.92 Mt whereas the pulses supply in that year will be 19.68 Mt. So, it is confirmed that the demand-supply gap of pulses goes in negative. So better technology, improved mechanism makes minimizing the demand-supply gap of pulses in India.

Keywords: Demand-supply, ARIMA, Population, Production

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Introduction

Agriculture plays an important role in Indian economy, 65% of Indian population depend agriculture and allied sectors. During the last forty years, the share of Indian agriculture in gross domestic product has decreased, but extensive use of HYV seeds, modern irrigation and technology and fertilizer have contributed in increasing the agricultural productivity and achieving self- sufficiency in meeting food demand. Availability refers to the physical availability of food stocks in desired quantities. Using food grains as a proxy for food, availability of food grain is given by domestic production net of feed, seed and wastage plus net imports plus draw-down of stocks. Demand describes as a consumer's need or desire and willingness to pay a price for a specific good or service. Demand and supply prospects of food commodities are important indicators to the country's food security concerns. Therefore, analyzing and forecasting demand and supply of agricultural commodities is a challenging task. Such study depends on growth in population and income and change in productivity levels. Higher income and urbanization in India are the main cause of changing lifestyle; international market integration and trade liberalization are expected to increase the demand for livestock products like milk, eggs, meat and fish and horticultural products even further. On the other hand, population trends project India to emerge as the most populous country in the world in the coming decades. Goyal, *et al*., (2001) studied on demand versus supply of food grains in India by using the present food supply and the trend for future, food consumption pattern over year and food demand projection [1]. It was revealed that cereals production (mainly rice and wheat) increased but decline in the percentage share of course grains and pulses in total food grains production is witnessed since 1960s. Kumar, *et al*. (2009) made an attempt on demand projection for food grains in India for the years 2011-12, 2016-17, 2021-22 by the accounting for the factors like urbanization, regional variation in consumption pattern, shift in dietary pattern and income distribution, limit on energy requirement and changes in testes and performance of consumers for food varieties [2]. Therefore, demand and supply of food commodities has become important for country's food security concerns in the future. Because, the imbalance between production and demand impacts the prices and profitability, which intern adversely affect the poor population and farming community and calls for policy interventions to tackle the situation in future.The present study covers the demand and supply estimates for food items like rice, wheat, coarse cereals, and pulses as well as to estimate the total food grains and population projection. A comparison of supply and demand projection done by other studies is also presented in this discussion [3-5].

Materials & Methodology

Data series with respect to total food grains production and population are collected for the period of 1951-52 to 2012-13. Data are collected from main website of Indiastat.com. Data for per capita consumption of food grains, expenditure, and income are collected from various NSSO round. Production data series of food grains are considered as supply of food grains [6-14].
The methodology including all tools and techniques are described as follows:

Descriptive Statistics

Descriptive statistics is the term given to the analysis of data that helps to describe, show or summarize data in a meaningful way. If we simply presented our raw data it would be hard to visualize what the data was showing, especially if there was a lot of it, but descriptive statistics makes it easier and meaningful. Descriptive statistics therefore enables us to present the data in a more meaningful way, which allows simpler interpretation of the data. Descriptive statistics are presented on the basis of mean, standard error, skewness, kurtosis, simple growth rate, Jarque-Bera test.

Mean: $\bar{x} = \frac{1}{n}\sum_{i=1}^{n} x_i$; where are observation value of dataset and n is no of observation of the dataset.

Standard deviation: $\sigma = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(x_i - \mu)^2}$; where, $\mu = \frac{1}{N}\sum_{i=1}^{N} x_i$

Standard error:

Skewness: $S.E(\bar{x}) = \frac{\sigma}{\sqrt{n}}$; where and are the 2nd,3rd and 4th central moment respectively.

Kurtosis: $\beta_2 = \frac{m_4}{m_2^2}, \gamma_2 = \beta_2 - 3$

Simple Growth rate: $SGAR(\%) = \frac{X_t - X_0}{X_0 \times n} \times 100$; Where Xt is the value of series for the last period, X0 is the value of the series of first period and n is the number of the periods.

Jarque-Bera test: $JB = \frac{n-k+1}{6}\left(S^2 + \frac{(C-3)^2}{4}\right)$; Where n is the number of observations (or degrees of freedom in general); S is the sample skewness, C is the sample kurtosis, and k is the number of regressors.

Parametric trend model and time series model also used for estimating the modeling and forecasting of India's population and total food grains production data series. Box and Jenkins (1976) methodology of univariate ARIMA has been used to forecasting fruits area and production in India for few coming years [3]. Details of this methodology are as follows: According to Box-Jenkins (1976), a non-seasonal ARIMA model denoted by ARIMA (p,d,q). This model is a combination of Auto Regressive (AR) and Moving Average (MA) with an order of integration or differencing (d), where p is order of autocorrelation and q is order of moving average. Box and Jenkins (1976) ARIMA methodology consist these four steps i.e., model identification, model estimation, diagnostic checking and forecasts respectively. Identification: Model identification by ARIMA (p, d, q) is based on the concepts of time- domain analysis i.e. autocorrelation function (ACF), partial autocorrelation function (PACF). Estimation: After identifying the appropriate p and q value, the next stage is called estimation. In this model we have to estimate the parameter of the autoregressive and moving average terms. Statistical software like SAS, SPSS etc., are available to estimate relevant parameters using iterative procedure.

Diagnostic checking

The estimated model must be checked to verify if it adequately represents the series or not. For evaluating the adequacy of ARIMA process, various reliability statistics are there. Different researchers mentioned different criteria for selection of model. There are not any hard and fast rules for selection of appropriate model in the time series studies. Model selection criteria using goodness of fit statistics: Among the competitive Box- Jenkins ARIMA model and parametric model, best model is selected on the basis of maximum R^2, minimum root mean square error (RMSE), minimum mean absolute percentage error (MAPE), and minimum value of Akaike Information Criteria (AIC), Bayesian Information Criteria (SBC). Any model which has fulfilled most of the above criteria is selected. This section provides definitions of the goodness-of-fit measures used in time series modeling.

Estimation of demand elasticity

A multi-stage budgeting framework is mostly used for estimating demand of various food commodities. An almost ideal demand system (AIDS) model is suitable for demand analysis for different commodities. This model is used to estimate the price and expenditure elasticity using the geometric stone price index which is approximated as $\ln \times I = \sum_i \bar{w} \ln P_i$; where is the mean of the expenditure share of the i^{th} commodity and Pi is the unit value of i^{th} commodity.

For demand projection, Income growth makes an important factor. Growth rates in per capita income were obtained by subtracting population growth rate from economic growth and were used in predicting the per capita consumption. Estimated per capita consumption is multiplied by population, and aggregated by regions, income group and lifestyles to obtain the total demand. The projected demand for future is estimated using the demand in base year as under:

$$D_{ijkt} = d_{ijk0} \times N_{ijkt}(1 + y \times e_{ijk})^t$$

Where, D_{ijkt} is the demand for a commodity for the subgroup of 'i' lifestyles (rural, urban), 'j' region, 'k' income group in't' period.

d_{ijk0} is per capita consumption for 'i' lifestyle, 'j' region, 'k' group in the base year.

N_{ijkt} is population in 't' year based on lifestyles 'i' region 'j' and income group 'k'.

y is the growth in per capita income.

e_{ijk} is the expenditure elasticity for the subgroup population based on lifestyles 'i' region 'j' and income group 'k'.

Dt is the aggregate demand in year t, which is the sum up of i,j,k, for . Dt makes income and population effects on consumption pattern.

In the absence of these effects, the demand for a commodity can be presented as

$$D_{*t} = d_0 \times N_t(1 + y \times e)^t$$

Where, D_{*t} is the household demand of the commodity for the selected region for the year 't'.

d_0 is the per capita consumption of the commodity during the base year.

N_t is the projected population during the year 't'.

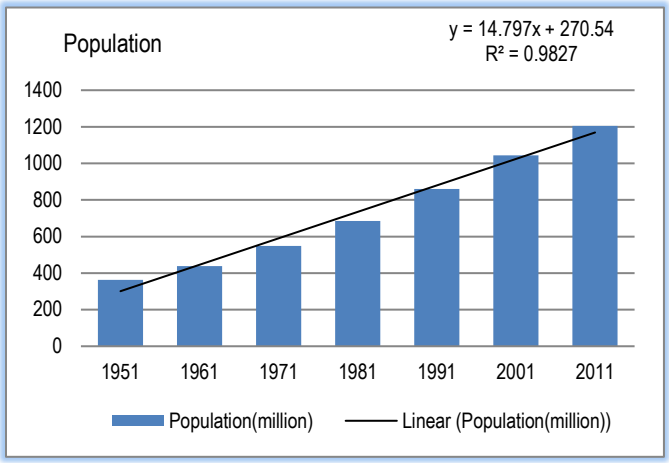
y is the growth per capita income.

e is the expenditure elasticity of demand for commodity.

This is the commonly used method for estimating demand studies because it requires less number of information and parameters.

Results

The per se performance of India's population and food grains production are computed in table-1. The population of India varied from 363 million to 1236 million with an average of 744 million registering a positive growth rate 3.8% per annum, whereas food grains production is registered higher growth rate 6.68% per annum. Positive skewness and negative kurtosis of population data series indicates that there has been increasing order during early half of the study period and it's remain steady for a long time and the same result also observed in case of food grains production. It is also observed that both data series have normally distributed from the Jarque-Bera test. The graphical presentation of population and production are visualized in figure-1. It is observed that India's population shows linear trend with a significant R^2 value 0.982 and total food grains production goes to quadratic trend significant R^2 value 0.974. From table-2, it is observed that ARIMA (1,1,1) is selected for best fitted model for production data series and ARIMA(0,1,1) for total food grains data series on the basis of maximum R^2 value, minimum value of AIC, SBC, RMSE, MARE, MAE. Moving average coefficient is estimated at 0.81 and 0.75 for population and food grains production respectively. From table-3, it is found that the population would be increased 1345 million in the year 2020, whereas the food grains production is increased 281.12 Mt in that year. The forecasted value lies between upper confidence limit and lower confidence limit which confirm that good fit of trend models. By estimating the population projection, the projected rural and urban populations are also considered for estimating the demand projection. From table-4, it is confirmed that rural area population would be increased 923 million, whereas the urban areas population 421 million in the year 2020. The average growth rate percentage is calculated 1.14% from the year 2018 to 2020. The annual growth rate percentages are computed in figure-2. Netting out the population growth rates during different five-year plans from GDP, growth provides under this study a growth rate of 8.50% in per capita income during 2010 and 7.91 per cent in 2015 [15,16].



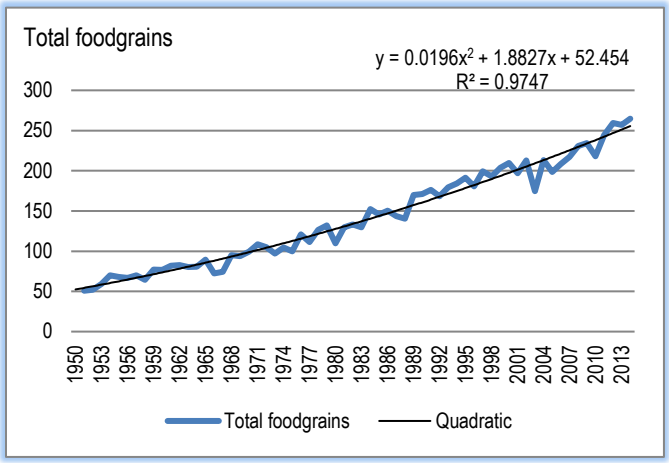


Fig-1 Graphical representation of India's population and food grains production

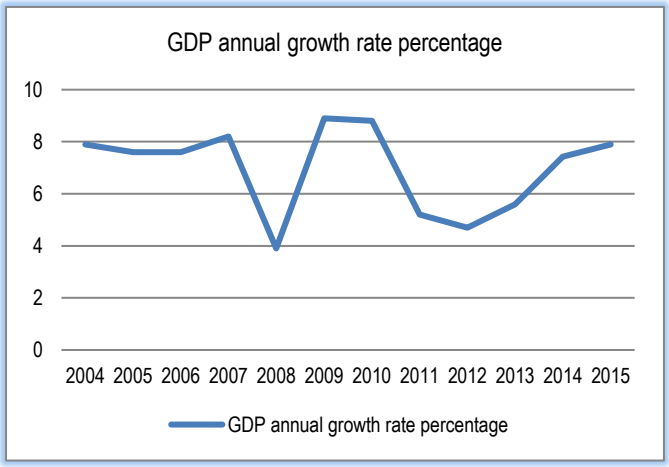


Fig-2 Annual GDP growth rate percentage

Table-1 Per se performance of India's population and food grains production

	Population	Food grains production
Mean	744.053	142.23
Standard Error	34.396	7.57
Kurtosis	-1.255	-1.11
Skewness	0.274	0.29
Jarqua-Bera(p)	0.088	0.122
Minimum	363.211	50.83
Maximum	1236.7	264.77
SAGR%	3.8	6.68
Note-SAGR=Simple average growth rate, p=prob. Value million, million tons		

Table-4 Base year and projected population

Year	Rural	Urban	Total	Average annual Growth rate percentage
2004	770.00	323.00	1093	
2010	821.70	369.30	1191	1.49
2013	862.40	374.60	1237	1.29
2016	870.10	413.90	1284	1.27
2018	901.60	413.40	1315	1.21
2020	923.70	421.30	1345	1.14
				million

In table-5 it is observed that per capita consumption of food grains will be 153.50 kg/year in rural areas where as 134.00 kg/year in urban areas in 2020. In rural areas per capita rice consumption pattern will be increased 77.83 kg/year to 79.40 kg/year in year 2018 to 2020 whereas in urban areas it will be 57.40 kg/year to 58.90 kg/year. In 2020 pulses consumption pattern will be 11.40 kg/year and 12.90 kg/year in rural and urban areas respectively. In rural areas per capita wheat consumption pattern will be increased 47.69 kg/year to 47.80 kg/year in year 2018 to 2020 whereas in urban areas it will be 56.86 kg/year to 57.30 kg/year. By calculating the projected population, per capita consumption of rural and urban areas, the total household demand of food grains for rural and urban areas are estimated which is shown in table-6. The direct household demand for food grains as 133.44 Mt, with a grain mix of 68.34 Mt rice, 42.44 Mt wheat, 13.68 Mt coarse cereals and 8.98 Mt pulses in case of rural areas in 2013. In rural areas the direct household demand for food grains would increase to 144.79 Mt by 2020. In case of urban areas, the direct household demand for food grains as 49.20 Mt, with a grain mix of 22.07 Mt rice, 21.36 Mt wheat, 1.90 Mt coarse cereals and 3.87 Mt pulses in the year 2013. The demand for food grains are projected in the range of 53.61 Mt for the year 2016 and 56.45 Mt for the year 2020 in urban areas. The demand in rural areas are found to be higher than the urban areas in all the scenarios due to higher quality of per capita food grains consumption and more population in rural areas in all the region of the country. Total household demand and supply in India comparison is computed in table-7. From this table it is observed that the direct household demand for food grains would increase to 227.35 Mt by 2020 comprising 98.16 Mt rice, 86.44 Mt wheat, 19.83 Mt coarse cereals and 22.92 Mt pulses. The demand-supply scenarios present an alarming situation at present especially for pulses. It is observed that the supply of pulses will be 19.68 Mt in 2020, where the demand will be 22.92 Mt on that year. So, the demand-supply gap for pulses is going to more adverse condition which strongly affects our food and nutritional security. The demand of cereals may be concerned, as per our assumptions regarding the population growth, income elasticities, production growth rate of food grains, etc. confirming that there will have a good situation in our food security. The graphical presentation of demand vs. supply is computed in figure-3.

Conclusion

The food grains production has increased at growth rate of 6.68% per annum during the period 1950-2013 which was mainly because of productivity growth rate 4.03% per annum. The population of India has increased at growth rate of 3.8% per annum. Thus, we may conclude from this study that India has successfully achieved self-sufficiency in food grains production and ensured physical and economic access of the poor to food. Pulses are the most important food commodities in India where a large vegetarian and non-vegetarian population are highly dependent on pulses for protein source. Since India could not meet its growing demand with its production, it has to rely heavily on import. So we have to more concern about to this crop. Technological improvement, better management practices, high government policies like price support programmes etc will enhance the supply and productivity of pulses in India for minimizing the demand-supply gap. Projected food demands for India by different studies are presented in Appendix-1.

Application of research: Research is applicable for economic policy makers as well as statistician to develop demand and supply study.

Table-2 Best fitted ARIMA models for population and total food grains of India

	Best ARIMA Model	parameter estimation			Goodness of Fit					
		Autoregressive Coefficient		Moving Average Coefficient	*AIC*	*SBC*	R^2	*RMSE*	*MAPE*	*MAE*
		AR1	*AR2*	*MA1*						
Population	1,1,1	0.98		0.81	183.58	189.96	0.96	4.19	0.37	2.25
Total food grains	0,1,1			0.75	297.40	301.69	0.97	10.26	6.09	7.99
at 5% level of significant										

Table-3 Forecasted population & food grain production by using best fitted ARIMA models

YEAR	Population (million.)	UCL	LCL	Food Grains (million. Ton)	UCL	LCL
2008	1158	1167	1150	225.12	245.56	204.69
2009	1174	1183	1166	231.54	251.98	211.11
2010	1190	1199	1182	230.31	250.75	209.88
2011	1207	1216	1199	238.36	258.79	217.92
2012	1222	1230	1213	248.67	269.10	228.24
2013	1237	1245	1229	254.79	275.23	234.36
2014	1252	1261	1244	261.43	281.86	240.99
2015	1268	1281	1255	264.71	286.26	243.15
2016	1284	1301	1267	267.99	290.61	245.37
2017	1299	1320	1278	271.27	294.91	247.63
2018	1315	1340	1290	274.55	299.17	249.94
2019	1330	1359	1301	277.83	303.39	252.28
2020	1345	1379	1312	281.12	307.58	254.65

note-UCL=Upper confidence limit, LCL=Lower confidence limit

Table-5 Trend in per capita consumption in India both rural and urban areas

Commodity	*Estimated based on NSS*							*Projected*		
Rural	1987	1993	1995	1999	2004	2010	2013	2016	2018	2020
Rice	85.20	84.00	84.00	81.36	79.70	80.09	79.24	78.39	77.83	79.40
Wheat	58.80	52.80	50.40	54.60	52.20	50.12	49.21	48.30	47.69	47.80
Coarse cereals	24.00	24.30	22.90	20.10	20.20	17.30	15.86	14.42	14.46	14.90
Pulses	10.70	9.30	10.00	10.70	9.90	10.62	10.41	10.19	11.05	11.40
Total Food grains	178.70	170.40	167.30	166.76	162.00	158.14	154.73	151.31	151.03	153.50
Urban	*Estimated based on NSS*							*Projected*		
	1987	1993	1995	1999	2004	2010	2013	2016	2018	2020
Rice	63.60	64.20	64.20	62.64	59.00	59.83	58.92	58.01	57.40	58.90
Wheat	56.40	57.40	57.90	57.24	56.50	57.12	57.02	56.92	56.86	57.30
Coarse cereals	7.20	7.70	6.80	5.10	4.40	4.59	5.06	4.53	4.18	4.90
Pulses	12.10	10.50	11.70	12.00	10.40	10.59	10.32	10.05	12.87	12.90
Total Food grains	139.30	139.80	140.60	136.98	130.30	132.14	131.33	129.52	131.31	134.00

kg/year

Table-6 Total household Demand of food grains for Rural and Urban Areas

Rural	2004	2010	2013	2016	2018	2020
Rice	61.37	65.81	68.34	68.21	70.17	73.34
Wheat	40.19	41.19	42.44	42.02	45.00	47.15
Coarse cereals	15.55	14.22	13.68	14.55	15.04	13.76
Pulses	7.62	8.73	8.98	8.87	9.96	10.53
Food grains	124.74	129.95	133.44	133.65	140.17	144.79
Urban	2004	2010	2013	2016	2018	2020
Rice	19.06	22.10	22.07	24.01	23.73	24.81
Wheat	18.25	21.10	21.36	23.56	23.51	24.14
Coarse cereals	1.42	1.70	1.90	1.88	1.73	2.06
Pulses	3.36	3.91	3.87	4.16	5.32	5.43
Food grains	42.09	48.80	49.20	53.61	54.28	56.45

million tonne

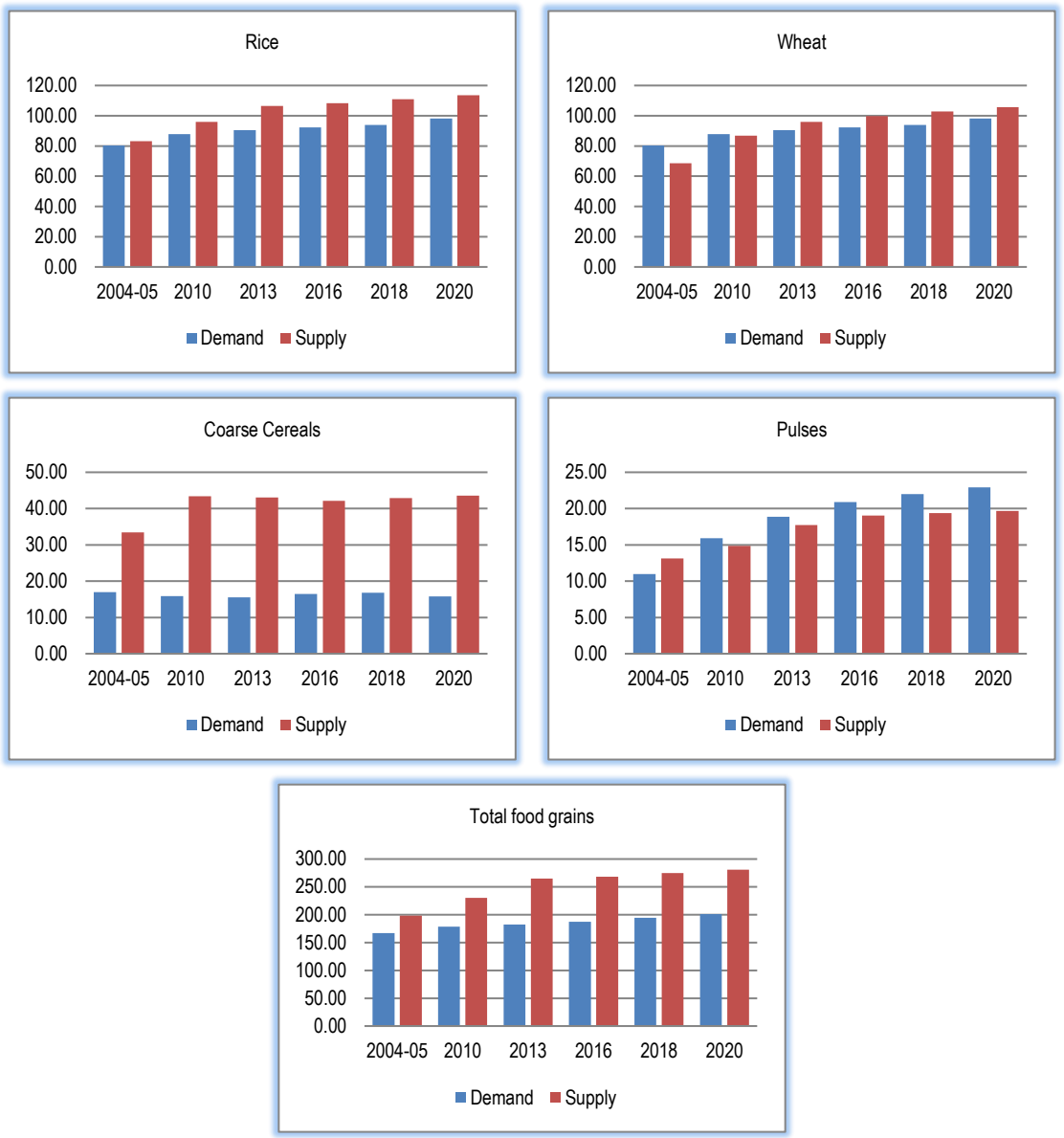


Fig-3 Graphical presentation of demand vs supply of food grains in India

Table-7 Total household demand and supply comparison

Demand	2004-05	2010	2013	2016	2018	2020
Rice	80.43	87.91	90.41	92.22	93.90	98.16
Wheat	58.44	69.53	74.21	79.63	83.03	86.44
Coarse cereals	16.98	22.52	22.90	21.05	20.82	19.83
Pulses	10.98	15.90	18.86	20.91	22.01	22.92
Food grains	166.83	195.86	206.38	213.81	219.77	227.35
Supply	2004-05	2010	2013	2016	2018	2020
Rice	83.13	95.98	106.54	108.34	111	113.66
Wheat	68.64	86.87	95.91	99.89	102.75	105.6
Coarse cereals	33.46	43.4	43.05	42.14	42.87	43.6
Pulses	13.13	14.88	17.73	19.04	19.37	19.68
Food grains	198.36	230.31	264.79	267.99	274.55	281.12
Demand-Supply Gap(supply-demand)	2004-05	2010	2013	2016	2018	2020
Rice	2.70	8.07	16.13	16.12	17.10	15.50
Wheat	10.20	17.34	21.70	20.26	19.72	19.16
Coarse cereals	16.48	20.88	20.15	21.09	22.05	23.77
Pulses	2.15	-1.02	-1.13	-1.87	-2.64	-3.24
Food grains	31.53	34.45	58.41	54.18	54.78	53.77

Appendix-1 Projected food demand for India by different studies

Source	year	Rice	Wheat	Total cereals	Pulses	Food grains
Bansil P.C., (1996) [17]	2020					241.4
Mittal, (2006) [10]	2010			175.5	18.8	194.3
	2020			215.7	27.2	243.9
Govt. of India, Planning Commission (2006) [15,16]	2011			224.0	20.0	244.0
Chand, (2007) [5]	2011			218.9	16.1	235.0
	2021			261.5	19.1	280.6
Kumar, *et al.*(2007) [8]	2015	98.1	74.7	210.2	17.8	228.0
	2025	106.6	79.9	226.1	20.2	246.3
Mittal, (2008) [11]	2011	94.4	59.0	188.5	24.1	212.6
	2021	96.8	64.3	245.1	42.5	287.6
	2026	102.1	65.9	277.2	57.7	334.9
Kumar, *et al.*,(2009) [2]	2011	101.1	81.1	211.6	15.5	227.1
	2016	106.8	86.9	223.6	17.5	241.2
	2021	113.3	89.5	233.6	19.5	253.2
Present study	2016	92.2	79.6		20.9	213.8
	2018	93.9	83.0		22.0	219.8
	2020	98.2	86.4		22.9	227.4

Research Category: Statistical study of food security scenario.

Abbreviations:
ARIMA- Autoregressive Integrated Moving Average
AIDS-An almost ideal demand system
SAGR- Simple Average Growth Rate

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