



The World's Largest Open Access Agricultural & Applied Economics Digital Library

This document is discoverable and free to researchers across the globe due to the work of AgEcon Search.

Help ensure our sustainability.

Give to AgEcon Search

AgEcon Search

<http://ageconsearch.umn.edu>

aesearch@umn.edu

*Papers downloaded from **AgEcon Search** may be used for non-commercial purposes and personal study only. No other use, including posting to another Internet site, is permitted without permission from the copyright owner (not AgEcon Search), or as allowed under the provisions of Fair Use, U.S. Copyright Act, Title 17 U.S.C.*

No endorsement of AgEcon Search or its fundraising activities by the author(s) of the following work or their employer(s) is intended or implied.

Presidential Address

Food and Nutrition Security in India: The Way Forward[§]

Praduman Kumar

Division of Agricultural Economics, ICAR-Indian Agricultural Research Institute, New Delhi-110 012

I am extremely thankful to all the esteemed members of Agricultural Economics Research Association (AERA) for honouring me as the President of 2016 Conference. I am associated with AERA since its formation in 1986, and I got wonderful opportunities to work with the AERA family during the past three decades. Professionally, I got outstanding opportunities to contribute in diverse areas working with a large number of students and colleagues in NDRI, IARI and international research organizations and got overwhelming support from my teachers and students in shaping my future. I have been conducting research for almost 40 years now and I have contributed to different sectors of agriculture including water management, livestock, crops, and fisheries. I have developed some econometric models for policy analysis and have written extensively in the areas of total factor productivity, demand supply projections, price models and household food and nutrition security. The theme I have chosen for my presidential address is “Food and Nutrition Security in India: The Way Forward”.

Introduction

India has a huge population pressure on land and other natural resources to meet its food and development needs. Food production and socio-economic status of rural people determine the growth of agriculture and rural prosperity. During the past four decades, the country has made remarkable progress in food and agricultural production. These changes have

been triggered by the Green, White and Blue Revolutions involving development and diffusion of varieties, breads, and fish species turnover in the country. This has been accompanied by increased levels of inputs-use, mechanization and policy support. Public and private investments in infrastructure, research and extension, coupled with price support and other policies have significantly helped in increasing food production and its availability.

India had a population of 1.03 billion in 2001 which increased to 1.21 billion in 2011 (Census of India, 2011). The proportion of population below poverty line (BPL) grew at the rate of 2.12 per cent per annum in the decade of 1991 to 2001, but it declined to 1.76 per cent per annum during the decade of 2001 to 2011. During the past few decades, the country has also witnessed a decline in the magnitude of population below the poverty line (BPL). The percentage of BPL population declined from 35.97 per cent in 1993-94 to 27.5 per cent in 2004-05 and further to 21.9 per cent in 2010-11 (NSSO Statistics, different rounds).

As per estimates, some 293 million undernourished and 266 million poor people live in India. India is home to one-fourth of the world's undernourished and poor people. It is found that poverty in India is mainly a rural phenomenon; urban poverty is also an indirect effect of rural poverty. The percentage of population under the poverty line might have declined but the overall food and nutrition security has remained the focus of agriculture and food policy. Food security has been a very sensitive issue in India as it has the largest concentration of poor in the world. After nearly achieving self-sufficiency in staple food production, the Government of India has launched a number of programs under production (supply side), distribution and consumption (demand side) across the country.

* Email: pkumariari@gmail.com

§ Based on the Presidential Address delivered at 24th Annual Conference of Agricultural Economics Research Association (India) held during 15-17 December, 2016 at ICAR-Indian Veterinary Research Institute, Izatnagar, Uttar Pradesh.

Currently, around half of India's population is covered by one or the other scheme in which subsidized staple food is made available to the people.

India has made a substantial progress in foodgrains production by adopting a new agricultural strategy. As a result, foodgrain production in the country increased from 115.6 Mt in 1960-61 to 241.4 Mt in 2010-11. Despite such an achievement, India lags much behind on nutrition security frontier. Horticulture has emerged as an indispensable part of agriculture, offering a wide range of choices to the farmers for crop diversification and much-needed nutrition to the people. The crop diversification is driven by rising population, economic growth, increasing urbanization and changing tastes and preferences. Thus, the demand for non-cereal crops is growing continuously in the country. The changing consumption pattern is not only a result of demand side factors but from the nutrition point of view also, it is important to diversify the food consumption basket.

Coupled with the general increase in consumption expenditure, there have been changes in food diversity by the people over time. The consumption of cereals, particularly of coarse cereals, has been declining with time and this decline is being compensated by the increasing consumption of high-value commodities such as milk, vegetables, fruits, meat, fish, eggs, etc. (Kumar, 1998; Kumar and Mathur, 1996; Kumar *et al.*, 2007a; 2007b). The decline in cereals consumption is being attributed to the changes in consumers' tastes—from food to non-food items and, within the food group, from cereals to non-cereals food items and from 'coarse' to 'fine' cereals. Several other studies (Chand and Kumar, 2002; Mittal, 2007) have also acknowledged the growing demand for non-food grain, high-value commodities and have called for a shift in resource allocation so as to meet the growing demand for horticultural, livestock and fisheries products.

In this context, a pertinent question that arises is how the changing dietary pattern has influenced the nutrients intake of people in India? It has been found (Kumar *et al.*, 2007b; Chand and Kumar, 2002) that the decline in per-capita consumption of cereals, particularly of coarse cereals, has worsened the nutritional status of the rural poor. This indicates that at the aggregate level, the decline in calorie intake from cereals has, to a certain extent, been compensated by higher intake of calories from milk, vegetables, fruits, meat, etc.

The National Family Health Survey (NFHS) III (2005-06) has reported the key facts related to the health and nutritional status of the sample households in the country. It has estimated that nearly 40.4 per cent of the children under than three are underweight and 44.9 per cent are stunted; 36 per cent of adult women and 34 per cent of adult men suffer with chronic energy deficiency; and 79 per cent of children and 56 per cent of women are anaemic (IIPS and Macro International, 2007). During the period 2000 to 2016, the share has declined of undernourished population from 17 per cent to 15.2 per cent, wasted children (over 5 years) from 17.1 to 15.1 per cent, stunted children (less than 5 years) from 54.2 to 38.7 per cent and under-5 mortality has declined from 9.1 to 4.8 per cent. However, the rank of India slipped from 83 to 97 in the past 15 years among 118 countries covered in the Global Hunger Index 2016. Today, India's ranking is lower than what it was 15 years ago, with the food security status reaching an alarming stage.

Food Basket in India: Nutrition and Food Trends

It is well known that a wide range of nutrients such as proteins, fat, carbohydrates, vitamins and minerals are needed to carry the normal activities of human body. These nutrients are present in most foods consumed daily in various proportions. However, some foods provide only a few nutrients like sugar, edible oils, etc. Vitamins and minerals do not supply energy but they play an important role in the metabolic functioning of the body. Thus, our diet must be well-balanced as to provide all nutrients in proper proportions. Dietary habits of people in different regions of the country are determined mainly by the availability of foods locally and traditional practices.

The dynamics of food consumption and nutrient intake of Indian households was investigated over the past three decades based on nationally representative sample survey data obtained from the NSSO. Disparities in nutrition intake arise due to income differentials of the households. The food basket has become more diversified in all income groups in both rural and urban households. The per capita consumption of cereals as food is declining while that of non-cereals, such as horticultural, livestock and fisheries products, is increasing (Table 1). A declining trend has been observed in pulses consumption largely

Table 1. Changing consumption pattern: India
(kg/capita/year)

Food groups	1983	2011	Change (%)
Cereals	168.0	133.4	-20.6
Pulses	11.8	10.0	-15.6
Sugar	11.4	10.0	-12.2
Edible oils	4.5	8.7	+78.5
Vegetables	47.9	56.2	+17.3
Fruits	3.3	11.9	+260
Milk	45.0	64.9	+44.3
Meat, fish & eggs	5.4	7.5	+39.7

Source: Calculated from various rounds of NSS consumer expenditure survey

because of high prices of pulses. Dietary shifts towards high-value food commodities have profound impact on agricultural production, food demand and nutritional security in the country. With the changing consumption pattern, there is a decline in intake of dietary nutrients and intake of calories, proteins and iron has decreased during the period 1983-2011. On the other hand, there is a substantial improvement in intake of calcium, zinc, beta carotene and fats (Table 2). The dietary diversification from cereals to horticultural, livestock and fisheries products has not been able to compensate the nutritional intake adequately.

The majority of population in India still faces the problem of nutrition deficiency (Table 3). This is true for the population below the poverty line (BPL) and also for the population above the poverty line (APL). Both BPL and APL groups have deficiency of different

Table 2. Change in dietary-intake of nutrients: India

Nutrients	1983	2011	Change (%)
Calories (kcal/capita/day)	2153	2104	-2.3
Protein (g/capita/day)	60.8	56.5	-7.1
Fat (g/capita/day)	29.3	44.5	51.8
Calcium (mg/capita/day)	489	579	18.3
Iron (mg/capita/day)	40.6	35.9	-11.7
Zinc (mg/capita/day)	8.4	9.9	16.9
Beta-carotene (µg/capita/day)	1358	1676	23.5

Source: Calculated from various rounds of NSS consumer expenditure survey

Table 3. Status of undernourished BPL and APL population in India in 2011 and change in undernourished Indian population between 1983 and 2011

(Per cent of population)		
Nutrient deficiency	Below poverty line (BPL) population (2011)	Above poverty line (APL) population (2011)
Calories	87	55
Proteins	53	20
Calcium	97	48
Fats	62	10
Zinc	76	52
Iron	15	2
Beta-carotene	100	98
Change in undernourished Indian population		
	1983	2011
Calories	65	68
Proteins	32	31
Calcium	77	68
Fats	62	27
Zinc	77	61
Iron	10	5
Beta-carotene	98	99

Source: Computed from NSS consumer expenditure data GoI (1983) and (2011)

nutrients, which is an alarming situation towards nutritional security. The estimated gaps between the recommended daily allowances (RDA) and real time intake of nutrients have widened. The calorie-deprived households have increased over time. Similarly, the households belonging to the lower-income groups have exhibited higher levels of calorie-intake gaps. The same trend of widening nutrient gap has been observed for other nutrients such as proteins, calcium and Vitamin A, particularly among the low-income rural households. The proportion of population with under-intake of fats, iron and zinc has decreased over time, thereby indicating improvements in the nutritional outcomes with respect to these nutrients.

Pulses and Nutrition

The pulses constitute a major source of quality protein for millions of consumers in the country and

Table 4. Cross-price elasticities of pulses with other major food groups in India, 2004 and 2011

	Year	Cereals	Vegetables	Milk	MFE
All India	2004	-0.89	0.29	-0.02	-0.04
	2011	-0.77	0.23	-0.07	-0.06
Rural India	2004	-1.13	0.29	-0.04	-0.11
	2011	-0.97	0.22	-0.12	-0.13
Urban India	2004	-0.58	0.23	0.02	0.04
	2011	-0.51	0.19	0.00	0.03

MFE= Meat, fish and eggs

contain 2 to 3-times more protein than cereals and are the rich source of minerals and vitamins. The share of pulses in total calorie-intake in India accounted for 3.80 per cent in 2004 and 4.47 per cent in 2011. The contribution of pulses to total protein-intake is estimated to be 10.9 per cent and has shown an increasing trend. The cross price elasticities estimated food demand system given in Table 4 revealed that pulses and cereals are complimentary, pulses and vegetables are substitutes and pulses and livestock products (milk and MFE) are independent sources. Pulses adorn an undisputed prominence in Indian diets for millions of poor consumers across the length and breadth of the country.

Poverty Alleviation and Nutritional Security

Although several factors affect the extent and depth of poverty and hunger, some of them have overwhelming impact under the Indian setting (Kumar and Dey, 2006). These include irrigation, farming system, livestock-rearing and literacy level. Generally, there is a higher concentration of poor and hungry people in the rainfed areas vis-à-vis in irrigated zones. Even with 20 per cent of the irrigation intensity, there is a sharp fall in the proportion of hunger and poverty and it exists irrespective of further intensification of irrigation. It is, therefore, argued that that extensive irrigation rather than intensive irrigation will prove more effective in the alleviation of poverty. Such a strategy will not only reduce poverty and hunger, but will also promote equity and environmental protection and natural resource conservation.

Across the cropping systems, there is a higher concentration of poverty and hunger under cropping systems based on coarse grains, followed by those

under rice-based and wheat-based cropping systems. The rice-wheat system is the most effective for reducing hunger.

Livestock have the highest effect on reducing poverty and hunger in our country. In rural India, 43 per cent of the people who do not own even a single livestock are largely malnourished. Addition of one cattle or buffalo to the household assets reduces the prevalence of hunger by 16 percentage points in cattle and 25 percentage points in buffalo. In India, the land: man ratio is small and the distribution of land is skewed. The diversification of crop-based rural economy into animal husbandry mixed farming system must be encouraged for rapid economic development and generation of equitable income and employment in the country. The cross-breeding program made a significant contribution to increasing the productivity of milch cattle. Feed management over the entire cycle of milk production is essential for full exploitation of the genetic potential (Kumar and Singh, 1980). The returns to investment on cross-breeding program are estimated to be 40 per cent (Kumar *et al.*, 1977). The research and extension investments on the crop and fishery sectors have improved over time at the expense of the livestock sector (Joshi *et al.*, 2015). The relative neglect of the livestock sector is a matter of concern and should be considered while making resource allocations in future.

Literacy has a very high impact on poverty alleviation as well as on hunger reduction in India. The illiterate people are largely poor and malnourished. Education, even up to the primary level, is extremely effective in reducing both poverty and hunger. Therefore, educational policy of the country must be geared to remove illiteracy as soon as possible. Free

education coupled with mid-day meal in the schools will go a long way in reducing both poverty and hunger (Kumar and Dey, 2006). The skill development of people in both agriculture and non-agriculture sectors is essential for achieving economic and social goals in the country (Mittal and Kumar, 2000).

At the national level, Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA) has facilitated the largest employment-providing program ever started by a country in the world. Its benefits have reached 22.5 per cent of the rural households [30% BPL households, 37% agricultural labourers, 27% sub-marginal farmers (holding < 0.5 ha land) and 21% landless households]. The program has been successful in reducing the poverty level in the country by 4 per cent and making substantial increase in calorie-intake as well as protein-intake, leading to a decrease in the numbers of undernourished and nutrition-deficit households by 8-9 per cent (Kumar and Joshi, 2013). The economically weaker states of the country have benefited more having implemented the schemes under MGNREGA more vigorously.

Food Demand and Supply

Achieving food self-sufficiency has always been the primary objective of agricultural policy in India. Driven by the rising population, growing economy, expanding urbanization and changing tastes and preferences, the demand for food is continuously increasing in the country. This scenario raises several questions like: Will India be able to produce enough to meet its growing food demand? or Will it be open to imports of food commodities over the next two decades (2010-2030)? What would be the likely trends in future demand for various food commodities? Will the supply of key food commodities continue to keep pace with their demand? In this address, attempt has been made to answer these questions, so as to evolve appropriate strategy and meet the future demand for food commodities in India. The demand and supply for different food commodities have been projected and presented in the subsequent sections under different scenarios.

Food Demand

A review of past studies has revealed wide variations in food demand projections due to their

dependence on the type of data used and magnitudes of demand elasticities, income distribution, regional dietary pattern, and dietary diversification. These estimates for food demand have some limitations also like (i) the model specification ignores theoretical restrictions of demand relationship, (ii) aggregate analysis is done at the national level, ignoring the effect of structural changes on economy such as urbanization and regional variations, (iii) national income growth assumption is superimposed on the regions and income groups, (iv) per capita income growth is used which ignores the population growth in the projected years and underestimates the income effect on demand because of declining population growth, and (v) ignores the surge caused in 'home-away demand' for food by the sustained rise in per capita income, fast growing urban population and increasing employment opportunities for urban women. In the recent analysis (Kumar and Joshi, 2016), these issues have been addressed while projecting the demand to 2030 for foodgrains, and horticultural, livestock and fisheries products at the disaggregated level.

Food Demand Elasticity

To estimate the income and price elasticities of demand for food commodities, several models are reported in literature. The expenditure (income) and calorie elasticities based on linear expenditure system (LEDS), transcendental logarithmic demand system (TLDS), normalized quadratic demand system (NQDS), food characteristic demand system (FCDS), and three-stage quadratic almost ideal demand system (3-stage QUAIDS) models have been compared to get a realistic view of demand elasticities (Table 5). These estimates have shown that expenditure elasticities are low for urban than rural consumers. The magnitude of expenditure elasticities for cereals is much higher on using LEDS, TLDS, and NQDS models compared to those obtained from FCDS and three-stage QUAIDS models. It is strange to note that once the expenditure elasticities for rice and wheat are found positive and significantly high in magnitude, why the actual per capita cereal consumption does not increase with total expenditure!

A comparison of demand elasticities calculated by different models (Table 5) reveals that the value for calorie-income elasticity is lowest on using FCDS model. Bouis and Haddad (1992) have presented

Table 5. A comparison of food-income and calorie-income elasticities across different demand models, for rural and urban India

Food commodities	Households	Models				
		LEDS	TLDS	NQDS	FCDS	3-Stage QUAIDS
Food-income elasticity						
Rice	Rural	0.45	0.71	0.57	0.03	0.02
	Urban	0.22	0.46	0.42	0.01	0.01
Wheat	Rural	0.44	0.63	0.55	0.07	0.03
	Urban	0.25	0.3	0.32	0.08	0.02
Coarse cereals	Rural	0.03	-0.55	-0.09	-0.12	-0.02
	Urban	-0.26	-1.62	-1.05	-0.17	0.00
Other foods	Rural	0.89	0.99	0.76	0.81	0.89
	Urban	0.84	0.98	0.88	0.67	0.77
Aggregate food-income elasticity						
All food commodities	Rural	0.72	0.8	0.65	0.29	0.35
All food commodities	Urban	0.73	0.8	0.73	0.28	0.32
Calorie-income elasticity						
All food commodities	Rural	0.46	0.6	0.53	0.12	0.14
All food commodities	Urban	0.42	0.51	0.49	0.12	0.14

FCDS = Food characteristic demand system, LEDS = Linear expenditure system, TLDS = Transcendental logarithmic demand system, NQDS = Normalized quadratic demand system, 3-stage QUAIDS = Three-stage quadratic almost ideal demand system

empirical evidences for the Indian and Philippine population, that calorie-income elasticity is not significantly different from zero across income-groups and regions. The poor households spend a high proportion of their income on food, and a large share of their total food expenditure is on a low-cost-calorie staple, to avoid going hungry. The rich households can afford to substitute a part of low-cost-calorie staple with high-cost-calorie food without increasing calories. Thus, calorie-income elasticity would be highly inelastic, nearly to zero. Therefore, one can assume that the demand elasticities obtained from the FCDS model predict the consumer behaviour as observed in the data and may predict most reliable demand for food commodities. The studies which used FCDS-based elasticities could predict food demand within a highly credible range (see Kumar, 1998; Paroda and Kumar, 2000; Kumar *et al.*, 2007b; 2009).

In the present study, FCDS model was used for computing demand elasticities of various food commodities, viz. rice, wheat, coarse grains and major

commodity groups, such as pulses, edible oils, vegetables, fruits, milk, meat, fish and eggs and other food and non-food commodities across regions, rural/urban households and income groups. The national level estimates of income and own price elasticities have been computed as the weighted averages of the disaggregated elasticity (Table 6).

A perusal of Table 6 reveals that demand elasticities vary widely across regions, rural/urban households and income groups due to the changes in production environment, tastes and food preferences. The demand elasticities for staple food (rice, wheat, coarse cereals) have been found highly inelastic, close to zero, and even negative for coarse cereals. The magnitude of elasticity has shown a decline with rise in income across all income groups and is higher for rural than urban households. The expenditure elasticities have been found much higher for high-value food commodities, viz. livestock and horticultural products. With growth in economy, the demand will increase faster for high-value food commodities than for the cereals.

Table 6. Expenditure and own price elasticities for food commodities across household level by income groups in India

Food commodity	Expenditure elasticity				Own price elasticity			
	Poor households	Middle-income households	High-income households	All households	Poor households	Middle-income households	High-income households	All households
Rural households								
Rice	0.157	0.041	-0.017	0.049	-0.463	-0.291	-0.163	-0.289
Wheat	0.128	0.087	0.057	0.083	-0.531	-0.400	-0.251	-0.367
Coarse cereals	-0.178	-0.147	-0.091	-0.142	-0.353	-0.203	-0.102	-0.228
Pulses	0.499	0.285	0.111	0.248	-0.686	-0.507	-0.300	-0.448
Edible oils	0.657	0.389	0.174	0.333	-0.751	-0.576	-0.373	-0.509
Sugar	0.277	0.113	0.023	0.097	-0.580	-0.387	-0.222	-0.340
Vegetables	0.597	0.358	0.164	0.322	-0.729	-0.552	-0.359	-0.504
Fruits	0.716	0.508	0.286	0.408	-0.795	-0.660	-0.493	-0.583
Spices & beverages	1.150	0.972	0.720	0.880	-0.955	-0.929	-0.909	-0.924
Milk	0.799	0.558	0.288	0.423	-0.828	-0.690	-0.475	-0.577
Meat, fish & eggs	1.045	0.863	0.580	0.752	-0.911	-0.865	-0.786	-0.833
Urban households								
Rice	0.130	0.015	-0.029	0.008	-0.477	-0.330	-0.222	-0.293
Wheat	0.078	0.052	0.101	0.083	-0.485	-0.410	-0.342	-0.389
Coarse cereals	-0.163	-0.200	-0.109	-0.153	-0.415	-0.279	-0.167	-0.264
Pulses	0.501	0.260	0.090	0.176	-0.723	-0.557	-0.381	-0.462
Edible oils	0.572	0.310	0.123	0.208	-0.751	-0.586	-0.404	-0.479
Sugar	0.260	0.085	-0.010	0.040	-0.610	-0.440	-0.268	-0.346
Vegetables	0.525	0.296	0.127	0.211	-0.728	-0.587	-0.421	-0.496
Fruits	0.674	0.486	0.284	0.341	-0.814	-0.734	-0.610	-0.644
Spices & beverages	1.055	0.839	0.561	0.649	-0.956	-0.944	-0.913	-0.922
Milk	0.758	0.510	0.264	0.343	-0.840	-0.741	-0.577	-0.627
Meat, fish & eggs	0.946	0.726	0.469	0.578	-0.911	-0.872	-0.817	-0.840
All households								
Rice	0.146	0.028	-0.024	0.026	-0.469	-0.309	-0.200	-0.291
Wheat	0.104	0.071	0.082	0.083	-0.508	-0.404	-0.303	-0.379
Coarse cereals	-0.171	-0.176	-0.102	-0.148	-0.381	-0.244	-0.144	-0.248
Pulses	0.500	0.274	0.098	0.206	-0.699	-0.530	-0.349	-0.456
Edible oils	0.630	0.353	0.143	0.259	-0.751	-0.580	-0.392	-0.492
Sugar	0.271	0.100	0.004	0.064	-0.591	-0.411	-0.249	-0.343
Vegetables	0.573	0.330	0.141	0.256	-0.729	-0.568	-0.397	-0.499
Fruits	0.704	0.499	0.285	0.368	-0.801	-0.689	-0.562	-0.620
Spices & beverages	1.126	0.916	0.621	0.736	-0.955	-0.935	-0.912	-0.923
Milk	0.785	0.538	0.275	0.377	-0.832	-0.712	-0.533	-0.605
Meat, fish & eggs	1.009	0.800	0.515	0.651	-0.911	-0.868	-0.805	-0.837

Notes: Poor households: The households below the poverty line; Middle-income households: The households having income between poverty line and up to 150 per cent above poverty line; High-income household: The households having income more than 150 per cent of poverty line

Table 7. Supply response elasticities for different crops in India

Crop	Output price (P)	Input price				
		w/P	b/P	m/P	r/P	i/P
Rice	0.2357	-0.0017	-0.0004	0.0004	0.0001	0.0017
Wheat	0.2164	0.0163	-0.0288	0.0095	-0.0095	0.0125
Coarse grains	0.5333	-0.1105	0.0952	0.0198	0.2791	0.0500
Pulses	0.1695	-0.0007	-0.0012	0.0020	-0.0013	0.0012
Edible oilseeds	0.5079	-0.0011	0.0021	0.0168	0.0062	-0.0240
Sugarcane	0.1216	0.0021	-0.0002	-0.0020	0.0045	-0.0044

Here, w = Wage (₹/hour), b = Cost on animal labour (₹/hour), m = Cost on machine labour (₹/hour) P = Price of crop (₹/100 kg), r = Cost of fertilizer (NPK) (₹/kg), i = Cost of irrigation (₹/ha)

Food Supply

The food supply challenges are formidable considering the non-availability of favourable factors of fast growth, declining factor productivity in major farming systems and shrinking natural resource base. Also, the capital investment in agriculture is invariably declining. Managing the rice-wheat production system, enhancing the yield of major food commodities, arresting deceleration in factor productivity, improving productivity in rainfed agriculture, integrated nutrient management and post-harvest management and value addition will be the major strategies for the nation.

To project the supply of food commodities, one needs reliable empirical knowledge about the degree of responsiveness of input demand and crop output supply to input-output prices and technological changes. The econometric application of production theory based on the duality relationship between production functions and variable profit/ cost function represents a major step towards generating appropriate empirical estimates of input demand functions and agricultural commodity supply which are crucial for the application of economic theory for agricultural development policy (Binswanger, 1974). Further, the development of flexible functional forms by several authors (Chand and Kumar, 1986; Kumar, 1998) permits the application of duality theory for a more disaggregated analysis of the production structure than has been possible by the traditional approaches.

Each supply response model has its specific merits and limitations. Ideally, the methodological framework should be based on a profit function or cost function, but this approach requires data on output quantities

and prices, and also on input quantities and prices. Limitations regarding availability of data are often a major constraint to adoption of this approach to model supply at the national level. In the present study, the crop-related data were culled from the “Comprehensive Scheme for the Study of Cost of Cultivation of Principal Crops” of the Directorate of Economics and Statistics, Government of India (DES, 2009). It provides time series-cum-cross-section data on yield, and use of inputs and their prices. This data set is useful in estimating the profit function or cost function to derive the factor demand and output supply elasticities (Table 7).

The output supply elasticities have shown the response of output prices and input prices on the supply of major crops of India (Kumar and Joshi, 2016). Among crops, the highest supply elasticity with respect to its price was for the coarse grains (0.53), followed by edible oils (0.51), cotton (0.33), jute (0.25), rice (0.24), wheat (0.22), groundnut (0.22), rapeseed & mustard (0.22), pulses (0.17), sugarcane (0.12), and onion and potato (0.05). The input response elasticities were highly inelastic, nearly zero. The input-price subsidy is likely to have a weak effect on food supply. The crop price has shown a dominating response on the supply of commodities and therefore, a positive price policy will enhance domestic supply of food commodities. The public policies like investments in irrigation, rural literacy, research and extension will induce total factor productivity (TFP) and neutralize factor price inflation, with a positive effect on input use, food supply and farm income.

Crop area, total factor productivity, supply elasticity and input-output price environments are the

major sources of supply growth (Kumar *et al.*, 2010). Thus, we may write

$$S = f(P, p, \text{AREA}, \text{TFP}) \quad \dots(1)$$

where, S is the supply of a commodity, P is the price of that commodity, p is the vector of input price, AREA is the acreage under commodity and TFP is the total factor productivity of the commodity.

The supply growth equation for the commodity can be expressed as per Equation (2):

$$S_g = E_s^p P_g + \sum E_{s_i}^{p_i} p_{ig} + \text{AREA}_g + (\text{TFP}_{gt} - \text{TFP}_{g0}) \quad \dots(2)$$

where,

- S_g = Supply growth for the commodity,
- E_s^p = Output supply elasticity with respect to the product price,
- P_g = Output price growth,
- $E_{s_i}^{p_i}$ = Elasticity of factor demand for the *i*th input,
- p_{ig} = Input price growth of the *i*th input,
- AREA_g = Area growth under crop,
- TFP_{g0} = TFP growth in the base year, and
- TFP_{gt} = TFP growth in the projected year *t*.

The supply growth equations were used to predict the supply of various commodities under the following three growth scenarios:

S1 = Baseline assumptions on area growth and TFP growth.

S2 = Baseline assumptions plus 50 per cent acceleration in TFP growth by the projected year 2030.

S3 = Baseline assumptions plus 50 per cent deceleration in TFP growth by the projected year 2030.

The average production during 2009-2010 (TE 2010) was used as the base year domestic supply. The domestic supplies of major commodities have been explored to 2030 by using expression (3):

$$S_t = S_{t-1} * (1 + S_g) \quad \dots(3)$$

where, S_t is the supply for a commodity in the year *t*, and S_g is the predicted growth under various scenarios.

The factor demand and output supply elasticities for cereals, pulses, edible oilseeds, sugarcane, onion, potato, cotton and jute have been used to project the domestic supply of these commodities. For livestock (milk, meat), poultry (chicken meat, eggs), and horticultural commodities (vegetables and fruits), input-output data were not available; therefore, supply projections for these commodities have been based on the past growth trend in their production. The supply growth was projected for major crops by using supply response elasticities and baseline assumption for input and output prices, crop acreage and TFP growth under the three TFP growth scenarios and the results are given in Table 8.

Table 8. Supply growth for major food commodities under different TFP growth scenarios in India: 2010-2030

Commodity	Baseline scenario (S1)	2010	2020	2030
S2: Baseline growth + 50% acceleration in TFP growth by 2030				
Rice	1.227	1.240	1.385	1.562
Wheat	2.146	2.157	2.278	2.426
Coarse grains	2.450	2.457	2.530	2.619
Pulses	2.479	2.483	2.516	2.539
Edible oilseeds	4.357	4.365	4.454	4.562
Sugarcane	1.890	1.891	1.901	1.915
S3: Baseline growth + 50% deceleration in TFP growth by 2030				
Rice	1.227	1.205	1.023	0.892
Wheat	2.146	2.128	1.975	1.866
Coarse grains	2.450	2.439	2.347	2.282
Pulses	2.479	2.475	2.433	2.399
Edible oilseeds	4.357	4.343	4.232	4.152
Sugarcane	1.890	1.888	1.874	1.865

Food Demand Projections

The demand projections have been made under several alternative assumptions of rate of income growth and change in income distribution. The assumptions vary across population in rural India and urban India and different income groups. The direct demand for food is driven by population growth, income growth and changes in income distribution. The total demand for foodgrains, except for export, was arrived by adding their direct demand (human food consumption at home and outside home) and indirect demand (seed, feed, industrial uses, and wastages). The demand for each foodgrain has been projected and presented in Table 9.

In the year 2020, the demand is worked out to be about 112 Mt for rice, 98 Mt for wheat, 36 Mt for coarse grains, 22 Mt for pulses, 252 Mt for total cereals, and 274 Mt for total foodgrains. By the year 2030, the total foodgrains demand will grow to the level of 311 Mt, comprising 122 Mt of rice, 115 Mt of wheat, 47 Mt of coarse grains and 27 Mt of pulses.

The demand projections for high-value commodities include the demand for edible oils, sugar and horticultural, livestock, poultry, and fishery products. The demand for edible oils will grow faster than the growth in population and foodgrains production. The total domestic demand for edible oils is projected to be 17 Mt in 2020 and 21.3 Mt in 2030. The requirement of edible oils is and will continue to

Table 9. Demand, supply and demand-supply gap projections to 2030 for major foodgrains , edible oils and sugar, India

(Million tonnes)

Commodities	Year	Supply scenario			Demand Baseline	Demand-supply gap	
		S1	S2	S3		Minimum	Maximum
Rice	2010	95.69	95.69	95.69	98.7	-3.01	-3.01
	2020	108.10	109.09	106.73	111.8	-2.71	-5.07
	2030	122.12	126.35	117.29	122.4	3.95	-5.11
Wheat	2010	84.24	84.24	84.24	83	1.24	1.24
	2020	104.16	104.95	103.07	98.3	4.77	6.65
	2030	128.80	132.48	124.56	114.6	9.96	17.88
Coarse cereals	2010	39.55	39.55	39.55	36.4	3.15	3.15
	2020	50.38	50.61	50.06	42.5	7.56	8.11
	2030	64.18	65.27	62.90	47.2	15.70	18.07
Total cereals	2010	219.48	219.48	219.48	218.1	1.38	1.38
	2020	240.02	264.65	259.86	252.6	7.26	12.05
	2030	315.10	324.11	304.75	284.2	20.55	39.91
Pulses	2010	16.17	16.17	16.17	18	-1.83	-1.83
	2020	20.65	20.70	20.59	21.9	-1.20	-1.31
	2030	26.38	26.57	26.14	26.6	-0.03	-0.46
Foodgrains	2010	234.03	234.03	234.03	236.2	-2.17	-2.17
	2020	281.23	283.26	278.40	274.4	4.00	8.86
	2030	338.84	348.02	328.27	310.8	17.47	37.22
Edible oils	2010	8.15	8.15	8.15	13.63	-5.48	-5.48
	2020	12.49	12.56	12.39	16.97	-4.41	-4.58
	2030	19.13	19.52	18.68	21.26	-1.74	-2.58
Sugar	2010	27.70	27.70	27.70	27.62	0.08	0.08
	2020	33.41	33.43	33.37	33.1	0.27	0.33
	2030	40.28	40.39	40.16	39.21	0.95	1.18

Note: S1 is the baseline scenario, S2 is the accelerating TFP growth scenario, S3 is the decelerating TFP growth scenario

Table 10. Demand, supply and demand-supply gap projections to 2030 for high-value food commodities in India
(Million tonnes)

Commodities	Supply, demand & gap	Production			Availability			Post- harvest losses, %
		2010	2020	2030	2010	2020	2030	
Vegetables	Supply	140.6	186.4	210.5	106.9	141.7	160.0	23.99
	Demand	124.7	154.8	192.0	124.7	154.8	192.0	
	Gap	15.9	31.6	18.5	-17.8	-13.1	-32.0	
Fruits	Supply	73.5	97.7	116.4	58.8	78.2	93.1	20.00
	Demand	64.8	80.9	103.0	64.8	80.9	103.0	
	Gap	8.7	16.8	13.4	-6.0	-2.7	-9.9	
Milk	Supply	116.5	156.6	188.7	110.6	148.7	179.2	5.03
	Demand	111.9	138.3	170.4	111.9	138.3	170.4	
	Gap	4.6	18.3	18.3	-1.3	10.4	8.8	
Poultry & bovine Meat	Supply	4.4	6.6	8.4	4.2	6.3	8.0	4.98
	Demand	5.2	6.8	9.2	5.2	6.8	9.2	
	Gap	-0.7	-0.2	-0.7	-0.9	-0.5	-1.2	
Eggs	Supply	3.1	4.7	6.2	2.9	4.5	5.9	5.02
	Demand	3.5	4.4	5.8	3.4	4.4	5.8	
	Gap	-0.4	0.3	0.4	-0.5	0.1	0.1	
Fish	Supply	7.4	10.2	13.9	6.3	8.7	11.9	15.05
	Demand	6.4	8.2	11.1	6.4	8.2	11.1	
	Gap	1.0	2.0	2.8	-0.1	0.5	0.8	

remain much higher than the domestic production in the country and we shall have to depend on their import in large quantities. The sugar demand at the national level is estimated to be 33 Mt in the year 2020 and it will grow to 39 Mt by the year 2030. In the year 2020, the demand for vegetables is projected as 155 Mt. This demand will grow to the level of 192 Mt by the year 2030.

The demand for fruits is projected to be 81 Mt in 2020 and 103 Mt in 2030. The total milk demand in the country is projected to be 138 Mt by 2020 and 170 Mt by 2030 (Table 10). The total fish demand including indirect demand is assessed to be in the range of 8.2 Mt by 2020 and 11 Mt by 2030. The national demand for eggs is projected to be 4.4 Mt by 2020 and 5.8 Mt by 2030. The demand for eggs will grow much faster than the population growth and will increase pressure on the supply of coarse grains and oilcakes as poverty feed.

Food Supply Projections

The supply for different commodities has been projected using TE 2010 as the base year production.

The supply projections for various food commodities under different growth scenarios have been presented at 10-year intervals for the period 2010-2030. To provide a glimpse, food supply and demand gaps for foodgrains, edible oils and sugar are presented in Table 9 and for high-value commodities, viz. vegetables, fruits, milk, meat, eggs and fish, are given in Table 10.

Rice

The domestic production of rice under the baseline scenario S1 is estimated to be 108.1 Mt by the year 2020 and 122.1 Mt by the year 2030. A look at the past trend reveals that India has been marginally surplus in rice production and has even been exporting rice, though in small volumes (2-4 Mt). Under the accelerating TFP growth scenario S2, the production of rice is expected to be 109.1 Mt by the year 2020 and 126.4 Mt by 2030. However, under the decelerating TFP growth scenario S3, the rice supply is projected to be lower at 106.7 Mt in 2020 and 117.3 Mt in 2030. As per these projections, India is not likely to remain rice surplus and may even become deficit in rice production to the extent of 3 to 5 Mt in the coming years.

Wheat

The domestic production of wheat under the baseline scenario S1 is estimated to be 104.2 Mt by the year 2020 and 128.8 Mt by 2030. Under the accelerating TFP growth scenario S2, the production of wheat is expected to be 104.9 Mt in 2020 and 132.5 Mt in 2030. Under the decelerating TFP growth scenario S3, the supply of wheat is likely to decline to 103.1 Mt by 2020 and 124.6 Mt by 2030. A perusal at the supply-demand scenario reveals that wheat demand in the country will continue to be met from the domestic production and there may even be marginal surplus of about 4.8-6.6 Mt by the year 2020, which is likely to grow to 9.9-17.9 Mt by 2030. It is observed that a shift in consumption from rice to wheat is taking place even in the traditionally rice-consuming states of India. Therefore, the surplus wheat production is likely to substitute rice, leading to a lower availability of surplus wheat, as predicted in the study.

Coarse Cereals

The domestic production of coarse cereals is estimated to be about 50.4 Mt by the year 2020, which will grow to 63-65 Mt in 2030 under different growth scenarios. The supply-demand gap of coarse grains is projected to be of 8 Mt by the year 2020, which may grow to a higher level of 16-18 Mt by the year 2030. This projection of demand-supply balance of coarse grains has provided some valuable insights about the possible level of self-sufficiency in India in coarse grains production, particularly their availability for meeting the feed requirements of the fast-growing livestock sector in the country in the years to come.

Total Cereals

In India, the domestic supply of total cereals, which is the summation of rice, wheat, and coarse grains, is projected to be 240-264 Mt by 2020, which will rise to 304-324 Mt by the year 2030 under different TFP growth scenarios. A look at the supply-demand balance for the cereals reveals that their demand in future will be met with the national production and there could even be a surplus of 7-12 Mt cereals by 2020 and of 20-40 Mt by 2030.

The contribution of TFP growth in cereals supply is predicted to be about 9 Mt by the year 2030 under the scenario S2 of accelerating TFP growth. On the

other hand, the supply of cereals will decline by 10 Mt under the scenario S3 of decelerating TFP growth over the base line scenario. To maintain cereals security, there is a need to strengthen efforts towards maintaining the TFP growth by enhancing respective TFP growth for rice, wheat and coarse cereals.

Pulses

The domestic production of pulses is projected to be about 21 Mt in 2020 and 26 Mt in 2030, with marginal differences across different scenarios. The supply of pulses will fall short of their demand by about 2 Mt and India will have to continue the imports of pulses in the years to come to meet the domestic needs.

Foodgrains

In India, the domestic supply of total foodgrains, which is the summation of rice, wheat, coarse cereals and pulses, is projected to be about 281 Mt in the year 2020 under the baseline scenario S1 and will grow to 339 Mt by the year 2030. A higher supply is predicted with accelerated TFP growth scenario S2 and is estimated to be 283 Mt in 2020 and 348 Mt in 2030. A lower supply is estimated with decelerated TFP growth assumption under scenario S3 and is predicted to be about 278 Mt by 2020 and 328 Mt by 2030.

A look at the supply and demand balance of foodgrains in India reveals that their future domestic demand will be met with national production and there is likelihood of a marginal trade surplus of say 4-8 Mt in 2020 and 17-37 Mt in 2030.

Edible Oils

The domestic production of edible oils is projected to be about 12.5 Mt by 2020 and 19.0 Mt by 2030, with only marginal differences across different TFP growth scenarios. By looking at the supply-demand scenarios of edible oils, it may be predicted that their domestic production would fall short of demand under all the scenarios. The deficit in edible oils supply is projected to be about 4-5 Mt by the year 2020, and it may reduce to about 2 Mt by the year 2030. Thus, India will continue to depend on imports of edible oils even in the coming decades.

Sugar

The supply of sugar is projected to be about 33 Mt by the year 2020 and it is likely to increase to 40 Mt

by 2030. The domestic supply of sugar will be able to meet its demand in India in the coming years and there could be a marginal surplus of about one million tonne by the year 2030.

High-Value Commodities

The domestic supply projections to 2030 for high-value commodities, viz. vegetables, fruits, milk, eggs, meat and fish, are presented in Table 10. Their availability, viz. domestic supply, has been computed from their production values making adjustments for post-harvest losses.

Vegetables

The domestic supply of total vegetables is projected to be 141 Mt in the year 2020 and 160 Mt by the year 2030. The supply-demand gap in total vegetables reveals that there will be substantial shortage of 12-32 per cent vegetables unless efforts are made to minimize post-harvest losses.

Fruits

The domestic supply of fruits is projected to be 78.2 Mt in 2020 and 93.1 Mt by the year 2030. Looking at the supply-demand gap, it appears that India will have short supply of fruits of 10 Mt by 2030.

Milk

The milk supply in the country is projected to be 149 Mt in 2020 and 179 Mt in 2030. Supply-demand gap in milk reveals that the country will be able to meet its domestic demand with trade surplus of 8.8 Mt by the year 2030.

Meat

The total meat production from cattle, buffalo, sheep, goat, pig and poultry at all-India level increased from 1.85 Mt in 2000 to 4.2 Mt in 2010. The poultry meat has not only accounted for the highest contribution to total meat production but has also witnessed the highest acceleration in production since 2000. Looking at the past growth, the supply of total meat by 2020 is projected to be 6.3 Mt. The total meat supply will grow to 8.0 Mt by 2030. It appears that India will continue to remain deficit in meat production in the years to come.

Eggs

The domestic egg production is projected to be 4.5 Mt in 2020 and 5.9 Mt in the year 2030. It seems that India will be able to meet the domestic demand for eggs with a marginal surplus.

Fish

India is the second largest producer of fish in the world with a contribution of 5.5 per cent to the global fish production. In 2010, the total fish production in India was estimated at 8.03 Mt with a contribution of 5.07 Mt from inland sector and 2.96 Mt from marine sector. The value of output from the fisheries sector at current price during 2010 was 4.9 per cent of total output of agriculture & allied sector. India's exports of marine product have, for the first time, crossed US\$ 2 billion mark. During 2010, the volume of fish and fish products exported was 0.753 Mt registering the highest growth rate of 10 per cent in volume of fish exports in recent years. The projected domestic supply of fish is 8.7 Mt by 2020 and 11.9 Mt by 2030. The supply-demand gap of fish is projected to be 0.4 - 0.7 Mt. It appears that the country will continue to remain self-reliant in fish supply and will also be able to undertake international trade at the present level of fish production.

Climate Change and Food Security

Climate change is posing a serious threat to food security of the country. The drought during *kharif* season affects crop production adversely. The drought elasticities of acreage, production, price, income and food demand have been estimated by Kumar *et al.* (2014). They have also examined the drought effect on crop economy and trade potential for selected food commodities (Table 11). The drought event has revealed a negative effect on acreage, yield and production, leading to a rise in crop prices and reduction in consumer demand. It is estimated that with 10 per cent deficit rainfall, production of rice and pearl millet will fall by more than 10 per cent. For cotton and sorghum, the corresponding fall in production will be 8.4 per cent and 7.6 per cent, respectively. The production of maize, groundnut and pigeon pea will fall by about 4 per cent each. The food prices will have an inflationary trend. Rice being a staple commodity will witness an increase in its prices as high as 23 per

Table 11. Elasticity of acreage, production, price, income and food demand with respect to drought, India

Particulars	Rice	Sorghum	Pearl millet	Maize	Pigeon pea	Groundnut	Cotton
Crop area	-0.437	-0.086	-0.275	-0.113	0.000	-0.055	-0.431
Yield	-0.634	-0.678	-0.765	-0.277	-0.453	-0.363	-0.405
Production	-1.071	-0.764	-1.040	-0.390	-0.453	-0.418	-0.836
Price	2.332	1.384	1.345	1.561	0.980	0.531	0.558
Gross revenue	1.261	0.621	0.305	1.171	0.527	0.113	-0.278
Demand	-0.547	-0.181	-0.176	-0.205	-0.360	-0.222	-0.690

cent, followed by maize (16%), sorghum and pearl millet (13% each), pigeon pea (10%) and groundnut and cotton (about 5 % each).

The supply-demand projections reveal that there will be a deficit of about 15 million tonnes in rice by 2020 in case of 20 per cent drought if the government intends to maintain the prices stable under deficit rainfall (Tables 12 and 13). The gap will be of about 28 million tonnes under 30 per cent deficit rainfall scenario. These projections suggest that under the situation of 20 per cent drought, there will be a shortfall of 15 per cent in rice in 2020 and 28 per cent under 30 per cent drought, if government intends to maintain prices as of normal rainfall situation. For sorghum and

cotton also there will be deficit in supply-demand in both 2020 and 2030 if there is a drought of 20 or 30 per cent intensity. In the case of rice, the projected huge deficit in supply will have two serious implications: (i) global rice prices will significantly shoot up as India would import rice to meet its demand; and (ii) the market price of rice would rise in India and there would be an adverse effect on food security of the poor which would drag them into poverty trap. Therefore, it is important to evolve appropriate strategies to combat the impact of climate change, especially of drought, and ensure food security of the people, particularly of the poor.

Table 12. Projected effect of droughts of different intensities on *kharif*-crop economy, India

Drought intensity (%)	Rice	Sorghum	Pearl millet	Maize	Pigeon pea	Groundnut	Cotton
Supply of commodity, per cent							
10.0	-10.71	-7.64	-10.40	-3.90	-4.53	-4.18	-8.36
20.0	-21.43	-15.27	-20.81	-7.80	-9.07	-8.36	-16.72
30.0	-32.14	-22.91	-31.21	-11.71	-13.60	-12.54	-25.08
Price of commodity, per cent							
10.0	23.32	13.84	13.45	15.61	9.80	5.31	5.58
20.0	46.65	27.69	26.90	31.22	19.60	10.62	11.15
30.0	69.97	41.53	40.35	46.83	29.39	15.93	16.73
Value of output, per cent							
10.0	12.61	6.21	3.05	11.71	5.27	1.13	-2.78
20.0	25.22	12.41	6.09	23.42	10.53	2.26	-5.57
30.0	37.83	18.62	9.14	35.13	15.80	3.39	-8.35
Demand for commodity, per cent							
10.0	-5.47	-1.81	-1.76	-2.05	-3.60	-2.22	-6.90
20.0	-10.94	-3.63	-3.53	-4.09	-7.21	-4.43	-13.80
30.0	-16.41	-5.44	-5.29	-6.14	-10.81	-6.65	-20.69

Note: It is seen that *kharif* crops are more sensitive to droughts

Table 13. Projected supply-demand gap for selected crops under different drought scenarios by 2020 and 2030
(million tonnes)

Crop	2010	2020			2030		
	Normal rainfall	Normal rainfall	20% deficit	30% deficit	Normal rainfall	20% deficit	30% deficit
Rice	0.27	10.33	-15.05	-27.74	15.6	-13.91	-28.66
Sorghum	0.48	-0.38	-1.31	-1.79	0.09	-0.94	-1.45
Pearl millet	0.72	3.51	0.73	-0.66	6.60	2.84	0.96
Maize	1.65	6.1	3.64	2.41	15.34	11.54	9.63
Cotton	0.00	0.00	-1.27	-1.91	0.00	-2.03	-3.04

The government intervention would be necessary to ensure food and nutritional security of resource-poor consumers and smallholders. In a situation of 20 per cent rainfall deficit, there would be huge deficit (about 15 million tonnes) of rice by 2020. The volume would be more if rainfall deficiency increases. To meet the demand, there would be a need of huge import and such a high level of import would lead to spike in prices of rice and other complementary food commodities in the global market and may further fuel the price rise. It is therefore necessary to have a strategy to minimize the impact of drought on food and nutritional security of poor. This will require strong social safety net program for the targeted population to ensure adequate supply of food to the vulnerable groups, especially economically-weak consumers. In the long-run, technological interventions would be necessary to mitigate the effect of drought and therefore, more research efforts and investment on alternative coping-mechanisms would be necessary to protect poor from the drought impact.

Crop Price Policy

The Commission on Agricultural Costs and Prices takes into account various considerations for balancing the interests of producers, consumers and overall growth and equity in the economy for fixing the crop prices without following a mechanical approach. The National Commission on Agriculture has suggested that prices need to be fixed taking into account the year-to-year changes on cost of production in relation to the movements in input price index. For doing so, one needs price model based on cost of production which can measure the adjustments in crop output prices in relation to factor price inflation, and changes in non-

price factors like irrigation, flow of services, technology, etc. Kumar and Mruthyunjaya (1985) have developed a price policy model and estimated the crop price elasticities with respect to input price inflation and suggested the way to fix crop prices in relation to input price index. For example, based on old data, the prices need to be revised with growth rates of 7.4 - 8.9 per cent for paddy, 7.5- 8.5 per cent for wheat, 8.9-9.9 per cent for chickpea, 4.8- 8.1 per cent for sugarcane, 8.3-9.9 per cent for cotton with 10 per cent input price inflation.

Input Subsidy versus Farm Technology

The input subsidy and technology are the two significant factors for the development of agriculture. Concerns are often expressed about a decrease or increase in input subsidy and inadequate investment in agricultural technology development. Policy planners often face the questions like what would happen to food supply, input use, food prices and farmers' income under alternative input subsidy and farm technology scenarios, and what would be the impact of input subsidy and technological innovation on the welfare of producers and consumers? The partial unified model was designed (Kumar and Joshi, 2014) and simulated to suggest the adjustments needed in price and non-price factors to answer such questions. The withdrawal of fertilizer subsidy will have a negative impact on the supply of commodities and their prices will increase. The technological changes induce commodity supply. The positive and negative impacts can be neutralized exclusively by adjusting the TFP sources. Presenting a scenario of 10 per cent withdrawal on fertilizer subsidies, the study has revealed that for its compensation, investment on agricultural research

and extension would have to be increased at the annual growth rate of 6 per cent, literacy 0.4-0.7 per cent and irrigation 0.3-0.4 per cent. These investments will induce the TFP growth by 0.18-0.20 per cent from the present level and will compensate the impact of 10 per cent reduction in fertilizer subsidy.

Strategies for Meeting the Challenges for Food Security

Producing additional food with limited land, and providing economic access to food at the household level for ensuring food security would continue to be a major challenge for the nation. Policy support, production strategies, public investment in infrastructure, research efforts and transfer of technology for crop, livestock and fisheries sectors will help in increasing productivity, production and availability of food. The appropriate research priority and production strategies are essential to promote future growth in agriculture and ensure sustainable food and nutrition security.

Managing Rice-Wheat Production System

The rice-wheat cropping system has significantly contributed to enhancing foodgrain production and achieving food self-sufficiency in India. The rice-wheat cropping system, spread across the most fertile land, is the backbone of food security in the country. But, this production system is now under threat due to stagnating or declining TFP growth and hard-pressed to maintain even the modest growth in demand for these two commodities. A smaller growth in yield and the decelerating growth in Total Factor Productivity (TFP) in some high input-use areas in the country is a matter of concern. The organic sources of nutrients, like organic manures and legumes, are rapidly declining in this cropping system. Legumes play an important role in improving the sustainability of the system (Kumar *et al.*, 1998). With the availability of high-yielding and short-duration varieties of improved legumes, there is a strong need to incorporate them into the rice-wheat cropping system to improve sustainability of the system and to meet the future foodgrain demand without degradation of the natural resource base.

Yield Enhancing of Major Commodities

The yields of major crops and livestock are much lower in India as compared to China and many other

countries. Considering that the frontiers of expansion of cultivated area are almost closed in the region, the future increase in food production to meet the additional demand of food must come from increase in productivity. There is a need to strengthen adaptive research and technology assessment, refinement and transfer capabilities of the countries so that the existing wide technology-transfer gaps are bridged. For this, an appropriate network of agricultural extension and information services needs to be created to stimulate and encourage both top-down and bottom-up flows of information across farmers, extension workers, and research scientists to promote the generation, adoption, and evaluation of location-specific farm technologies. Ample scope exists for increasing genetic yield potential of a large number of vegetables and fruits as well as other food crops and livestock and fisheries products. Besides maintenance of breeding, greater effort should be made towards developing hybrid varieties as well as varieties suitable for export purposes.

Agronomic and soil researches in a region need to be intensified to address location-specific problems as factor productivity growth is decelerating in major crop production regimes. Research on coarse grains, pulses and oilseeds must achieve production breakthroughs. Crop varieties like hybrid rice, single cross hybrids of maize and pigeon pea hybrids offer new opportunities. Soybean, sunflower and oil palm will help in meeting the future oil demands in the country. Besides, forest cover must be preserved to keep-off climatic disturbances and to provide enough of fuel and fodder. The draught-tolerance capacity of our animals needs to be improved quickly through better management practices to sustain milk and meat supply.

Emphasis needs to be given on yield improvements in paddy in the states of Bihar, Odisha, Madhya Pradesh and Assam. For wheat, we must focus mainly in Uttar Pradesh, Madhya Pradesh and Rajasthan. For coarse cereals, major emphasis should be given in Rajasthan. To meet the demand for pulses, greater emphasis is needed in almost all the states with a particular focus on Madhya Pradesh, Maharashtra, Rajasthan, Odisha, Andhra Pradesh, Karnataka and Tamil Nadu, which have three-fourths of total pulse area in the country. The target growth in pulse yield from these states annually must be 5-6 per cent; otherwise the nation will experience shortage of pulses for all times to come.

The target of attaining self-sufficiency in pulse production looks difficult without area expansion and irrigation network. In the case of oilseeds, greater emphasis is needed for 92 per cent of crop area with special emphasis on Andhra Pradesh, Madhya Pradesh, Rajasthan, Maharashtra and Uttar Pradesh to increase the yield by about 4 per cent per annum. Extracting oils from non-edible oilseeds needs to be explored. The palm cultivation for oil production may release the pressure on traditional oilseed crops to meet the future demand for edible oils. In the case of sugarcane, research and development efforts are to be strengthened in Uttar Pradesh and Bihar to increase yield by about 4 per cent per annum. The demand for sugar can also be met by developing mini sugar mills so that a substantial volume of sugarcane could be diverted from khandsari and gur to sugar production. This will help release some sugarcane area to other crops which are in short supply. Cotton is emerging as a potential export commodity. It requires greater yield improvement emphasis on 81 per cent of the cotton area in Maharashtra, Gujarat and Andhra Pradesh.

Making Grey Areas as Green

The resource-poor farmers in the rain-fed ecosystems practise less-intensive agriculture, and since their incomes depend on local agriculture, they benefit little from increased food production in the irrigated areas. To help them, efforts must be increased to disseminate the available dryland technologies and generate new ones. It will be necessary to enlarge the efforts for promoting available dryland technologies, increasing this knowledge-stock, and removing pro-irrigation biases in public investment and expenditure, as well as credit flows, for technology-based agricultural growth. Watershed development, widening of seed revolution to cover oilseeds, pulses, fruits and vegetables and strengthening the farming system research to develop location-specific technologies must be intensified in the rainfed areas. Strategy to make grey areas green will lead to second Green Revolution which would demand three-pronged strategy — watershed management, hybrid technology and small farm mechanization.

Integrated Nutrient Management

Attention should be given to the balanced use of nutrients. Phosphorus deficiency is now the most

widespread soil fertility problem in both irrigated and unirrigated areas. Correcting the distortion in relative prices of primary fertilizers could help correct the imbalances in the use of primary plant nutrients — nitrogen, phosphorus, and potash and use of bio-fertilizers. To improve efficiency of fertilizer-use, what is really needed is enhanced location-specific research on efficient fertilizer practices (such as balanced use of nutrients, correct timing and placement of fertilizers, and, wherever necessary, use of micronutrients and soil amendments), improvement in soil testing services, and development of physical and institutional infrastructure.

Diversification of and Value Addition to Agriculture

In India the land: man ratio is quite low and the distribution of land is highly skewed, therefore diversification of crop-based rural economy into animal husbandry mixed farming system must be encouraged for rapid economic development and generating equitable income and employment in the country. Diversification towards these high-value and labour-intensive commodities can provide adequate income and employment to the farmers dependent on small size of farms. Due importance should be accorded to quality and nutritional aspects. High priority should be given to development of post-harvest management, agro-processing and value addition technologies not only to reduce the heavy post-harvest losses and also improve quality through proper storage, packaging, handling and transport. The role of biotechnology in post-harvest management and value addition deserves to be enhanced.

Arresting Deceleration in Total Factor Productivity

Increasing cases of deceleration in total factor productivity growth are being reported. In future, efforts have to be concentrated on breaking the yield plateau, while conserving natural resources and promoting ecological integrity of the agricultural system. Producing more with less of inputs will be the major challenge in the next two decades. Most often, suggested measures to accelerate and sustain growth in TFP are jacking-up investment in research and infrastructural facilities, and increasing input-use efficiency. Biotechnological research should pay more attention to address biotic and abiotic stresses. Given

the declining trend in public investment in agriculture, which can hardly be reversed, the only option to accelerate growth in TFP is increasing yield potential by developing appropriate technology, both for irrigated and rainfed areas. Research problems in rainfed unfavourable ecosystems and breaking of the current irrigated yield ceilings are more complex and challenging. To make headway into them will require mobilization of best of science and the best of scientists in the National Agricultural Systems in partnership mode. This needs higher agricultural research investment which has been convincingly justified in several studies (Evenson and Jha, 1973; Kumar and Mruthyunjaya, 1992; Kumar and Rosegrant, 1994; Fan *et al.*, 1999; Chand *et al.*, 2011). There is also a need to improve the efficiency of public investment in agriculture, especially in irrigation by constructing field channels in the eastern region.

Public Investment in Agricultural Research and Extension

The research and extension (R&E) investments in Indian agriculture have grown consistently over the past five decades, both in absolute terms and as a share of GDP agriculture. In terms of resource allocations to the agricultural sector, the research component has received a higher attention vis-à-vis the extension component, and the gap between the two appears to have widened over the years. Significant structural changes have occurred in the pattern of agricultural R&E investments across sectors and states over the past five decades. The R&E investments on the crop and fishery sectors have improved over time at the expense of the livestock sector. The relative neglect of the livestock sector is a matter of concern and should be taken into consideration while making future allocations. However, the fisheries sub-sector has been receiving higher allocations in consecutive plan periods, whereas the share of soil and water conservation has remained volatile.

Notably, the share of states in the aggregate R&E investments has declined over the years, while that of the centre has improved proportionately. Spatially, significant variations in investment intensity exist across states, with per hectare R&E investments differing by as much as 1:20 between the lowest-intensity and highest-intensity states. Many states that fared low on investment intensity were also found to

be backward in terms of agricultural productivity. The states with higher share of TFP growth as a part of output growth performed better in terms of returns to investment. The states such as Madhya Pradesh, Odisha, Uttar Pradesh and Tamil Nadu have fared better in terms of returns on investments; the low-performing states include Himachal Pradesh, Maharashtra and Assam. The R&E investment in the crop sub-sector in India has been especially rewarding, generating returns that are close to 50 per cent (Joshi *et al.*, 2015).

Conclusions and Policy Suggestions

The demand and supply projections presented in this paper reveal that the demand for rice and wheat will be met with their domestic production in the coming years, and there could even be some marginal surplus. However, it is quite likely that supply of pulses, edible oils and sugar would be short of demand in the coming years, and India will be open for imports of some pulses. The livestock, poultry, fisheries and horticulture sectors are surging ahead in production growth in recent years and will have a rising demand in the future.

The public policies such as investments in irrigation, rural literacy, and agricultural research and extension are crucial to increase food commodity supply at a higher growth rate. The input subsidy has a positive effect on input-use, crop supply and farm income, but technology shifters have a positive and strong influence on commodity supply and a substantial negative effect on farmer's income. Input subsidy to farmers and price subsidy to consumers will not be feasible in the long-run as they involve a substantial share of public resources. A viable solution can only be found with appropriate adjustments in the non-price factors. An effective MSP program is essential to protect farmers' welfare.

The policies that can help maintain TFP growth in the long-run will be able to keep a balance between domestic production and demand for cereals, pulses, edible oils and sugar. This emphasizes the need for strengthening efforts at increasing production potential through public investments on irrigation, infrastructural development, agricultural research and efficient management of water and plant nutrients (Fan *et al.*, 1999; Chand *et al.*, 2011). To meet the food and nutritional requirements of the growing population, the

nation will have to increase its current levels of food production with higher emphasis on better natural resources management, achieving technological breakthroughs and addressing climatic and environmental concerns.

With the availability of high-yielding and short-duration varieties of improved legumes, there is a need to incorporate them into the rice wheat cropping system to improve sustainability of the system so as to meet the future foodgrain demand without degradation of natural resource base.

Poverty is largely a rural phenomenon and urban poverty is also an indirect effect of rural poverty. Education, skill development, livestock status, irrigation facilities, agricultural diversification, infrastructural development, aquaculture enhancement and micro-credit support have tremendous impact on rural employment opportunities and alleviation of hunger and poverty. Science and technology must not bypass the hungry and poor. Science and policies must have a human face as the poor do not want charity; they want opportunity to build their future by enrichment with knowledge, freedom and equity and must be provided a congenial environment.

The Way Forward

In this paper on food and nutritional security in India, education, capacity development, livestock, fisheries, irrigation, agricultural diversification, agricultural technologies, climate-smart agriculture, institutional policy support, and public investments have been identified as the major factors having tremendous impact on strengthening food and nutritional security in the country. To meet such a big challenge, the following measures are suggested:

• Increase Public Investment in Agriculture

The food projections to 2030 for India have revealed supply to be deficit of demand in several important commodities including pulses, sugar, oilseeds, meat, fruits, vegetables, etc. and to utilize their production potential, there is a need to increase public investments in agricultural research and education, irrigation, and infrastructures like roads, markets, etc. Some studies have also shown higher returns from public investments in agriculture.

• Higher Emphasis on Livestock and Fisheries

In the wake of finding in the paper of development of crop sector at the expense of livestock and fisheries sectors, there is a need to launch missions on livestock and fisheries. Such an effort would strengthen food and nutrition security in the country, particularly of economically-weaker sections of population.

• Rationalize Input Subsidies

A part study on subsidy vs technology in this paper has revealed technology development to have a positive and economic-friendly option than subsidy provision to agriculture. Therefore, efforts need to be made on rationalizing input subsidies and encouraging private sector participation in technology development. The seed sector has already shown the way.

• Revisit Social Programmes like MGNREGA

The study has revealed that launch of different social schemes under MGNREGA has been successful in reducing poverty and strengthening food and nutritional security in the rural areas. But, it cautions also that in the long-run MGNREGA, besides cutting a significant pie of ex-chequer, may have a negative impact and also may help the urban poor more than the rural poor. Therefore, there is a need to revisit the scheme of MGNREGA in terms of its long-term impact.

• Develop Climate-smart Agriculture

Considering the impact of droughts of different intensities, there is a need to develop climate-smart crop varieties and also, region-specific crop varieties for food and nutrition security.

• Strengthen Price Support Policy

The maximum support price (MSP) announced by the Government of India helps the farmers in selling their produce at a better price and will further streamline the payments by transfer of amounts to the farmers' bank account. But its other dimensions like lack of storage space for procured foodgrains, weak procurement arrangement in some places, announcement of MSPs for only a few commodities, lack of basic facilities at procurement sites, etc. need immediate addressal.

References

- Binswanger, Hans P. (1974) A cost function approach to the measurement of factor demand elasticities of substitution. *American Journal of Agricultural Economics*, **56** (20): 377-386.
- Bouis, Howarth and Haddad, Lawrence (1992) Are the estimates of calorie income elasticities too high: A recalibration of the plausible range. *Journal of Development Economics*, **53**(June): 115-137.
- Chand, Ramesh and Kumar, Praduman (1986) Supply response functions for major crops of Punjab in green revolution period — A profit function approach. *The Indian Journal of Economics*, **67**(1): 91-109.
- Chand, Ramesh and Kumar, Praduman (2002) Long-term changes in coarse cereal consumption in India: Causes and implications. *Indian Journal of Agricultural Economics*, **57**(3): 316-325.
- Chand, Ramesh and Kumar, Praduman (2006) *Trade Reforms and Food Security: India Case Studies and Synthesis*, edited by Harmon Thomas. Commodity and Trade Division, Food and Agriculture Organization of the United Nations, Rome.
- Chand, Ramesh, Kumar, Praduman and Kumar, Sant (2011) *Total Factor Productivity and Contribution of Research Investment to Agricultural Growth in India*. Policy Paper 25, National Centre for Agricultural Economics and Policy Research, New Delhi.
- DES (Directorate of Economics and Statistics) (2009) *Agricultural Statistics at a Glance*. Department of Agriculture and Cooperation, Government of India, New Delhi.
- Evenson, R.E. and Jha, Dayanath (1973) The contribution of agricultural research system to agricultural production in India. *Indian Journal of Agricultural Economics*, **28**(4): 212-230.
- Fan, Shenggen, Hazell, Peter and Thorat, Sukhdeo (1999) *Linkages between Government Spending, Growth and Poverty in Rural India*. Research Report No.110. International Food Policy Research Institute, Washington, DC, USA.
- Joshi, P.K., Kumar, Praduman and Parappurathu, Shinoj (2015) Public investment in agricultural research and extension in India. *European Journal of Development Research*, **27**(3): 438-451.
- Kumar, Praduman (1984) Price policy model of sugarcane and its products. *Indian Journal of Agricultural Economics*, **39**(4): 595-613.
- Kumar, Praduman (1998) *Food Demand and Supply Projections for India*. Agricultural Economics Policy Paper 98-01. Indian Agricultural Research Institute, New Delhi.
- Kumar, Praduman and Singh, R.P. (1980) Dynamic feed milk relationship and technological change in milk production. *Indian Journal of Agricultural Economics*, **35**(4): 126-132.
- Kumar, Praduman and Mruthyunjaya (1985) *Price Policy Model for Agricultural Commodities in India: Methodology for Simultaneous Determination of Factor and Product Prices of Crops*. ICAR Agricultural Produce Cess Fund Project. Division of Agricultural Economics, Indian Agricultural Research Institute, New Delhi.
- Kumar, Praduman and Mruthyunjaya (1992) Measurement and analysis of total factor productivity growth in wheat. *Indian Journal of Agricultural Economics*, **47**(3): 451-458.
- Kumar, Praduman and Rosegrant, M.W. (1994) Productivity and sources of growth for rice in India. *Economic and Political Weekly*, Dec. 31: A 183-188.
- Kumar, Praduman and Mathur, V.C. (1996a) Agriculture in Future: Demand-supply perspective for the ninth Five-Year Plan. *Economic and Political Weekly*, **28**: A131-139.
- Kumar, Praduman and Mathur, V.C. (1996b) Structural changes in demand for food in India. *Indian Journal of Agricultural Economics*, **51**(4): 664-673.
- Kumar, Praduman and Dey, Madan M. (2006) Nutritional intake and dynamics of undernourishment of farm households in rural India. *Indian Development Review*, **4**(2): 269-284.
- Kumar, Praduman and Joshi, P.K. (2013) Household consumption pattern and nutritional security among poor rural households: Impact of MGNREGA. *Agricultural Economics Research Review*, **26**(1): 73-82.
- Kumar, Praduman and Joshi, P.K. (2014) Input subsidy vs farm technology — Which is more important for agricultural development? *Agricultural Economics Research Review*, **27**(1): 1-18.
- Kumar, Praduman and Joshi, P.K. (2016) Food demand and supply projections to 2030: India. In: *International Trade and Food Security: The Future of Indian Agriculture*. edited by Floor Brouwer and P.K. Joshi. CABI, Wallingford, UK. pp. 29-63.

- Kumar, Praduman, Maji, C.C. and Patel, R.K. (1977) Returns on investment in research and extension: A study on Indo Swiss cattle improvement project, Kerala. *Indian Journal of Agricultural Economics*, **32**(3): 207-216.
- Kumar, Praduman, Mruthyunjaya and Chand, Ramesh (1985) Stabilisation of prices, supply and income for paddy and wheat in Punjab: A unified approach. *Indian Journal of Agricultural Economics*, **40**(3): 382-389.
- Kumar, Praduman, Joshi, P.K., Johansen, C. and Asokan, M. (1998) Sustainability of rice-wheat based cropping systems in India. *Economic and Political Weekly*, September 26: A152-158.
- Kumar, Praduman, Mruthyunjaya and Dey, Madan M. (2007a) Long-term changes in Indian food basket and nutrition. *Economic and Political Weekly*, **XLII**(35), September 1.
- Kumar, Praduman, Mruthyunjaya and Birthal, Pratap S. (2007b) Changing consumption pattern in South Asia. In: *Agricultural Diversification and Smallholders in South Asia*, Eds: P.K. Joshi, Ashok Gulati and Ralph Cummings Jr. Academic Foundation, New Delhi. pp. 151-187.
- Kumar, Praduman, Mittal, Surabhi and Hossain, Mahabub (2008) Agricultural growth accounting and total factor productivity in South Asia: A review and policy implications. *Agricultural Economics Research Review*, **21**(2): 145-172.
- Kumar, Praduman, Joshi, P.K. and Birthal, Pratap S. (2009) Demand projections for foodgrains in India. *Agricultural Economics Research Review*, **22**(2): 237-243.
- Kumar, Praduman, Shinoj, P., Raju, S.S., Kumar, Anjani, Rich, Karl M. and Msangi, Siwa (2010) Factor demand, output supply elasticities and supply projections for major crops of India. *Agricultural Economics Research Review*, **23**(1): 1-14.
- Kumar, Praduman, Mruthyunjaya and Chand, Ramesh (2010) Food security, research priorities and resource allocation in South Asia. *Agricultural Economics Research Review*, **23**(2): 209-226.
- Kumar, Praduman, Kumar, Anjani, Shinoj, P. and Raju, S.S. (2011) Estimation of demand elasticities for food commodities in India. *Agricultural Economics Research Review*, **24**(1): 1-14.
- Kumar, Praduman, Joshi, P.K. and Aggarwal, Pramod (2014) Projected effect of draughts on supply, demand, and prices of crops in India. *Economics and Political Weekly*, **XLIX**(52): 54.
- Mittal, Surabhi (2007) What affect changes in cereal consumptions?. *Economic and Political Weekly*, February 3: 444-448.
- Mittal, Surabhi and Kumar, Praduman (2000) Literacy, technology adoption, factor demand and productivity: An econometric analysis. *Indian Journal of Agricultural Economics*, **55**(3): 490-499.
- NSSO (National Sample Survey Organization) (Various rounds) *Consumer Expenditure Survey*. Government of India, New Delhi.
- Paroda, R.S. and Kumar, Praduman (2000) Food production and demand in South Asia. *Agricultural Economics Research Review*, **13**(1): 1-24.

