Agriculture in Future: Demand-Supply Perspective for the Ninth Five-Year Plan

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This paper provides information on demand for agricultural commodities and suggests the required yield growth in Ninth and Tenth Five-Year Plans. The study identifies the regions which must be explored to meet domestic and exports needs.

THE introduction and rapid spread of high-yielding varieties in the late 1960s and early 1970s resulted in a steady output growth for foodgrains. Public investment in infrastructure, research and extension along with crop production strategy has significantly helped to expand foodgrain production and stocks. Foodgrain production, which was 72 million tonnes (mt) in 1965-66, rose to 191 mt in 1995-96. Buffer stocks, which were just 2.2 mt in 1965-66, rose to 31 mt in 1995. However, the current concern is that the earliest gains from the green revolution have already been reaped and future growth in production can only be input-based in many regions of the country. Also the growth in total factor productivity is declining. Urbanisation, higher economic growth as well as sizeable additions to population will increase the food demand in future. Diversified food basket is exhibited both in rural and urban areas with significantly higher levels of per capita consumption of milk and milk products, fruits and vegetables, and meat [Kumar 1996]. Agricultural trade liberalisation may attract greater investments in agriculture and thereby accelerate the growth process. These emerging scenarios will change the supply and demand prospects for food in the next century. The present paper provides information on the demand for agricultural commodities in Ninth and Tenth Five-Year Plans (FYP) and suggests the supply policies to attain the food security.

I
Demand Projections

A number of demand models are available for estimating the income and price elasticities of demand for a commodity. Recent demand studies are centred around complete demand systems which take into account mutual interdependence of a large number of commodities in the budget decisions of the consumer. The important models which have received considerable attention are the linear expenditure demand system (LEDS) [Stone 1954], and almost ideal demand system (AIDS) [Deaton and Muellbauer 1980]. These models are generally used for estimating demand equations for a group of commodities and not for commodities at a disaggregate level. Also these models do not allow increasing or decreasing income elasticities. The normalised quadratic demand system (NQDS), generalised Leontief demand system (GLDS) and transcendental logarithmic demand system (TLDS) suggested by Swamy and Binswanger (1983) are the models which satisfy all general restrictions of demand theory and also allow for estimation of cross-price elasticities within a group of close substitutes or complements, and do not assume additivity. These models also include linear and squared income terms which allow more flexibility in the response of consumer items to changes in income. In contrast to econometric models, Bouis (forthcoming) suggested a non-econometric model based on demand characteristics known as food characteristic demand system (FCDS). This model is based on demand for energy, variety, and tastes of food.

The expenditure (income) and calorie elasticities based on FCDS, TLDS, NQDS and LEDS were compared so that realistic view of demand forecast can be assessed (Table 1). The rice income elasticities are high, followed by wheat and coarse grains. The cheapest source of calories has the lowest income elasticities. The calorie elasticity was the lowest derived from demand parameters of FCDS (0.12) followed by LEDS (0.42-0.46), NQDS (0.49-0.53) and highest in case of TLDS (0.51-0.60). Behrman and Deolalikar (1989) have presented empirical evidence for Indian population, to show that calorie-income elasticities were not statistically significantly different from zero. Thus, one can believe that the demand elasticities obtained from FCDS can give most reliable demand projections for foodgrains and other food commodities.

Demand elasticities vary widely across income groups and by regions as production environments and tastes change [see Alderman 1986 for a review]. The elasticities computed for various expenditure groups[1] for each region[2] for rural and urban areas using FCDS [Kumar et al 1996] are used to arrive at the demand projections for each commodity. As seen in Appendix 1, the expenditure and price elasticities are in accordance with a *priori* expectations. The expenditure elasticities decline with the increase in total expenditure. The expenditure elasticities for cereals were highly inelastic. Own price elasticities for all the commodities are negative. Across commodities and expenditure groups, the magnitude of own price elasticities are highly correlated with the income elasticities. The magnitude of elasticities follow the historical trends in per capita consumption pattern as observed in the NSS data.

The demand projections of our study assume income growth of 5 per cent per year, gradual decline in population growth, with an average annual growth of 1.91 per cent between 1995 and 2000 and 1.8 per cent between 2000 and 2010, rate of urbanisation

TABLE 1: COMPARISON OF EXPENDITURE (INCOME) AND CALORIE ELASTICITIES USING DIFFERENT MODELS OF DEMAND FOR RURAL AND URBAN INDIA

	Rural				Urban			
	LEDS	TLDS	NQDS	FCDS	LEDS	TLDS	NQDS	FCDS
Rice	0.45	0.71	0.57	0.06	0.22	0.46	0.42	0.02
Wheat	0.44	0.63	0.55	–0.06	0.25	0.30	0.32	–0.08
Coarse cereal	0.03	–0.55	–0.09	–0.15	–0.26	–1.62	–1.05	–0.16
Other food	0.89	0.99	0.76	0.50	0.84	0.98	0.88	0.40
Non-foods	1.60	2.63	1.43	2.25	1.51	2.57	1.36	1.87
Aggregate food income elasticity	0.72	0.80	0.65	0.29	0.73	0.80	0.73	0.28
Calorie-income elasticity	0.46	0.60	0.53	0.12	0.42	0.51	0.49	0.12

Note: Other food includes all foods other than cereals

consistent with the recent historical trend, and inequality in the distribution of expenditures across income groups the same as observed in the past. The share of rural population in total population was 74.3 per cent in 1991 which was predicted to be 73.4 per cent in 1995, 72.3 per cent in 2000 and 69.9 per cent in 2010. Distribution of population by expenditure groups given in Appendix 2 revealed that the rural poverty ratio (the sum of population proportion of lower two expenditure groups) declined from 48 per cent in 1987 to 33 per cent in 2000 and 21 per cent in 2010 and urban poverty ratio from 29 per cent in 1987 to 16 per cent in 2000 and 8 per cent in 2010. It is clear that in the long run, food consumption will largely be influenced by the non-poor groups in the rural and the non-poor higher groups in urban areas. Significantly, in 2010 food consumption will be determined by the non-poor higher groups in both rural and urban areas which account for half of the rural and three-fourths of the urban population, respectively.

Domestic Demand for Foodgrains

Several studies done in the past provide the demand projections for foodgrains in the year 2000 (Table 2). Among the most recent ones, the demand estimates given by Radhakrishna and Ravi (1990) are on higher side as they use high expenditure elasticities. Similarly, projections by Sarma and Gandhi (1990) are on the higher side because of double counting in estimation of wastage and livestock feeding[3]. Bansil (1996) projected the demand for foodgrains at 198 mt in 2000 which is on the lower side. This study is based on the incremental approach, providing additional requirements for household and non-household demand over the base year's production of foodgrains. It does not account for regional variations in consumption pattern and changes in income distribution. Rosegrant et al (1995) provided food projections for IFPRI's 2020 vision based on the International Model for Policy Analysis of Agricultural Commodities and Trade (IMPACT). The demand for rice and coarse cereals is on the higher side and demand for wheat is on the lower side in this study as the model does not account for regional variations in consumption pattern and the changes in income distribution. It uses demand supply elasticities and technical coefficients synthesised from other sources, primarily from past studies. The results are not the true reflection of ground realities. The demand projections based on FCDS [Kumar et al op cit] are close to reality as these projections account for regional variations in consumption pattern and changes in income distribution besides taking into account the energy requirements and changes in tastes and preferences of consumers for food varieties.

According to our estimates, the household demand of foodgrains will reach 186 mt in the year 2001-02 with a break-up of about 83 mt of rice, 64 mt of wheat, 23 mt of coarse grains, and 16 mt of pulses (Table 3). By the year 2006-07, foodgrains demand will grow to 205 mt with a breakup of about 91 mt for rice, 71 mt for wheat, 24 mt for coarse

Table 2: Comparison of Studies for Demand Projections for Foodgrains in 2000

(Million tonnes)

Studies	Human Demand	Domestic Demand
National Commission on Agriculture, 1976		205 - 225
World Bank, 1981		191 - 205
IFPRI study, 1984		210
Planning Commission, 1985		240
Radhakrishna and Ravi, 1990	205[b]	234[e]
Sarma and Gandhi,	176[a]	220[c]
IFPRI 1990	183[b]	227[c]
P C Bansil, 1996		198[d]
Praduman Kumar, 1996	182[b]	209[e]
IARI -IFPRI study		205[c]
Mark W Rosegrant et al, 1996 IFPRI 2020 Vision study		IARI-IFPRI study

Foodgrains	1990	2020	2000[f]	2000
Rice	74.8	144.8	93.0	88.2
Wheat	47.9	95.6	60.1	71.1
Coarse cereals	36.4	63.9	43.9	32.3
Total cereals	159.1	304.3	197.0	191.6
Pulses	–	–	17.8[g]	17.8
Total Foodgrains	–	–	214.8	209.4

Notes: a Without change in income distribution.
b With change in income distribution.
c Projected the requirements for seed, feed, industrial use and wastage. Feed demand is computed using the feeding ratio (that is, the quantity of feed required to produce one unit of livestock products).
d Using incremental demand model by providing additional requirement for household and non-household over the base year demand.
e Using a grossing factor of 1.143 to account for non-household demand.
f Interpolated for the year 2000.
g As the demand projection for pulses was not available in the study, the pulse demand projections of IARI-IFPRI study are used to arrive at the foodgrain demand for comparison purpose.

Table 3: Domestic Demand for Foodgrains in India

(Million tonnes)

Items / Plan End	1991-92 (Base Year) VII	1996-97 VIII	2000-01 –	2001-02 IX	2006-07 X
Household Demand					
Rice	67.1	75.0	81.5	83.0	91.3
Wheat	50.8	57.1	62.5	63.7	70.9
Coarse cereals	20.3	21.6	22.7	22.9	24.2
Total cereals	138.2	153.7	166.7	169.6	186.4
Pulses	11.7	13.9	15.6	16.1	18.8
Foodgrains	149.9	167.6	182.3	185.7	205.2
Domestic Demand[a]					
Rice	72.6	81.2	88.2	89.8	98.8
Wheat	57.8	65.0	71.1	72.5	80.7
Coarse cereals	28.9	30.7	32.3	32.6	34.4
Total cereals	158.0	175.7	191.6	194.9	213.1
Pulses	13.4	15.9	17.8	18.4	21.5
Foodgrains	171.3	191.6	209.4	213.3	234.5

a Domestic demand = Household (human) demand plus allowances for seed, feed and wastage which is taken as 7.6 per cent of gross rice production, 12.1 per cent of wheat, 29.7 per cent of coarse cereals, 12.5 per cent of total cereals, 12.5 per cent of pulses, and 12.5 per cent of foodgrains. Thus the grossing factor used is 1.082 for rice, 1.138 for wheat, 1.422 for coarse cereals, and 1.143 for total cereals, pulses and total foodgrains to account for non-household demand.

cereals and 19 mt for pulses. Apart from the foodgrain demand for direct human consumption, an increasingly important component is the indirect demand for livestock consumption.[4] Increasing demand for livestock products (milk, meat and eggs) will drive up demand (including feed, seed, industrial use and wastage) for foodgrains to 213 mt in 2001 and 235 mt in 2006. In 2001, domestic demand for rice will be about 90 mt, wheat 73 mt, coarse cereals 33 mt and pulses 18.4 mt. In the year 2006, demand will reach to 99 mt for rice, 81 mt for wheat, 34 mt for coarse cereals and 22 mt for pulses. During the Ninth Five-Year Plan period, domestic demand will grow at the annual compound growth rate of 2.11 per cent for rice, 2.21 per cent for wheat, 1.21 per cent for coarse cereals and 2.96 per cent for pulses. The demand of total foodgrains will grow at the rate of 2.17 per cent.

Domestic Demand for Non-Foodgrains

In the year 2001-02, the demand for vegetables will be 92 mt, fruits 53 mt, edible oils 7.9 mt, cotton 2.4 mt and sugar 16.8 mt (Table 4). Among livestock products, the demand of milk will reach 93 mt, meat and eggs 5 mt and fish 7 mt. In 2006-07, total demand will reach 109 mt for vegetables, 69 mt for fruits, 120 mt for milk, 9.5 mt edible oils, 15 mt for eggs, meat and fish, 2.9 mt for cotton and 19.6 mt for sugar. During Ninth FYP, the total demand will grow at the annual rate of 5.2 per cent for milk, 4 per cent for edible oils, 3.5 per cent for vegetables, 5.4 per cent for fruits, 5.1 per cent for meat and eggs, 5.6 per cent for fish, 3 per cent for sugar, and 3.6 per cent for cotton. Thus increase in demand for non-foodgrains will be much higher than the growth in population.

Exports of Agricultural Commodities

The countries of south Asia, south-east Asia, west Asia, North Africa, sub Saharan Africa and the former Soviet Union and eastern Europe offer India the advantages of locational proximity and product acceptability for the exports of agricultural products. Based on the estimates of production for 2020 [Rosegrant et al 1995], it is expected that there would be a deficit of 63.7 million tonnes of wheat in south Asia, China, south-east Asia, west Asia and North Africa and sub Saharan Africa in the year 2001 and 71.5 million tonnes in 2006 (Table 5). India can easily capture 5 per cent of this potential wheat market. Thus the exports of wheat from India can be targeted at 3.2 mt in 2001 and 3.6 mt in 2006. India is currently exporting about 1 million tonnes of wheat.

There has been a remarkable progress in the rice exports during the current year. This assumes larger significance with increased buying interests from quality-conscious markets of Europe, America, Korea, etc. The Indian non-basmati rice export figures have touched an all-time high of 3 mt during 1994-95. Total rice exports (basmati and non-basmati) from India attained a level of 3.51 mt. A deficit of 8.4 mt in the year 2001 and 9.4 mt in 2006 is expected in west Asia and North Africa, sub Saharan Africa and the former Soviet Union. India has a diversified export market for rice which includes a large number of countries in south and south-east Asia, west Asia, Africa and Europe. India can capture 50 per cent of these markets and can aim to export 4.2 mt in 2001 and 4.7 mt in 2006.

In addition to foodgrains, India has the potential for exporting cotton, vegetables, fruits and marine products. Assuming likely exports to be 10 per cent of cotton production, 2 per cent of fruits and vegetables, and 5 per cent of fish production, India can aim to export 0.24 mt cotton, 1.9 mt

Table 7: Total Factor Productivity Growth

(*Per cent*)

Crop	1971-80	1981-88	1971-88
Rice	1.31	0.97	1.03
Wheat	1.42	1.08	1.26
Coarse grains	1.09	0.92	1.01

Source: Mruthyunjaya and Kumar (1994).

Table 4: Demand for Non-Foodgrains in India

(*Million tonnes*)

Items / Plan End	1991-92 (Base Year) VII	1996-97 VIII	2000-01 –	2001-02 IX	2006-07 X
Milk	56.1	72.4	88.6	93.1	119.5
Edible oil	5.4	6.5	7.6	7.9	9.5
Vegetables	64.8	77.3	88.7	91.7	108.5
Fruits	30.8	40.4	50.0	52.6	69.1
Meat and eggs	2.7	3.6	4.4	4.6	6.0
Fish	4.1	5.4	6.7	7.1	9.3
Sugar	12.1	14.5	16.3	16.8	19.6
Cotton	1.64	2.0	2.3	2.4	2.9

Table 5: Indian wheat and rice export market

(*Million tonnes*)

Commodity	Regions	Deficit 1990	2001	2006	2020
Wheat	South Asia	3.3	6.6	8.9	21.3
	China	14.9	18.3	20.0	25.8
	South-East Asia	4.6	6.2	6.9	9.8
	West Asia and North Africa	26.8	31.6	33.8	41.5
	Total	49.6	63.7	71.5	98.4
Rice	Former Soviet Union	0.6	0.5	0.8	0.9
	Sub-Saharan Africa	2.8	3.9	4.5	6.8
	West Asia and North Africa	3.3	3.8	4.1	5.0
	Total	6.7	8.4	9.4	12.7

Source: Mark W Rosegrant, et al (1995).

Table 6: Domestic Demand, Export and Total Demand for Agricultural Commodities in India

(*Million tonnes*)

Items	Domestic Demand 2001-02	2006-07	Export 2001-02	2006-07	Total Demand 2001	2006-07
Rice	89.8	98.8	4.2	4.7	94.0	103.5
Wheat	72.5	80.7	3.2	3.6	75.7	84.3
Coarse cereal	32.6	34.4	–	–	32.6	34.4
Total Cereals	193.9	213.1	–	–	202.3	222.2
Pulses	18.2	21.0	–	–	18.2	21.0
Foodgrains	212.3	234.5	7.4	8.3	220.5	243.2
Edible Oil	7.9	9.5	–	–	7.9	9.5
Vegetables	91.7	108.5	1.9	2.2	93.6	110.7
Fruits	52.6	69.1	1.1	1.4	53.7	70.5
Sugar	16.8	19.6	–	–	16.8	19.6
Cotton	2.4	2.9	0.24	0.29	2.64	3.19
Milk	93.4	119.5	–	–	93.4	119.5
Meat and eggs	4.6	6.0	–	–	4.6	6.0
Fish	7.1	9.3	0.37	0.49	7.47	9.79

vegetables, 1.1 mt fruits, and 0.37 mt marine products in the year 2001.

Total Demand for Agricultural Commodities

The demand for foodgrains (including feed, seed, wastage and exports) in the years 2001 and 2006 will be 220.5 mt and 243.2 mt, respectively (Table 6). In the year 2001, the demand for rice will be 94 mt, wheat 75.7 mt, coarse cereals 32.6 and pulses 18.2 mt. Among non-foodgrains, the demand for edible oils will be 7.9 mt, vegetables 93.6 mt, fruits 53.7 mt, sugar 16.8 mt and cotton 2.64 mt (15.53 million bales of 170 kg each) in 2001. In the same period, demand for milk will be 93.4 mt, meat and eggs 4.6 mt and marine products 7.5 mt.

II
Supply of Agricultural Commodities

Technological Change

Indian agriculture has undergone a technological change at different rates in different regions and among different crops which has resulted in substantial increases in marketable surplus of wheat and rice and contributed to achieving food security mainly by inducing a decline in real prices of rice (2.2 per cent) and wheat (3.3 per cent). The new technologies increased the dependence of farmers on modern inputs and substantially increased the cost of production per unit of land at constant prices. But the increase in yield has been much higher than the increase in real cost of production and hence the cost per unit of output has declined for rice (at the rate of 1.1 per cent in eastern region, 2.14 per cent in northern region and 3.9 per cent in the southern states) and wheat (ranging from 2.0 per cent to 2.8 per cent in different wheat growing states) [Kumar and Mruthyunjaya 1992; Kumar and Rosegrant 1994]. The benefits of higher efficiency in the use of inputs and low unit cost of production that the MVs and improved farming practices have generated have quickly passed on from farmers to consumers in the form of lower prices. The fall in prices has benefited the urban and rural poor much more than the upper income groups, because the former spend a much larger proportion of income on cereals than the latter.

The increase in area and production of crops is highly associated with their relative profitability. Rice gained area mainly through substitution effect at the cost of coarse cereals and wheat mainly through expansion effects because of phenomenal growth of tubewell irrigation in the wheat belt. For rice, during 1967/68-1989/90, the area increased at the annual rate of 0.6 per cent per annum and

Table 8: Production Targets at the End of Ninth and Tenth Five-Year Plans in India

Items	TE 1994-95		Year 2001-02		Year 2006-07	
	Area (Mha)	Prod (MT)	Area (Mha)	Prod (MT)	Area (Mha)	Prod (MT)
Crops						
Rice	42.19	78.1	42.18	94.0	42.18	103.5
Wheat	25.13	60.8	26.24	75.7	26.24	84.3
Coarse cereals[a]	33.25	32.6	30.69	32.6	30.69	34.4
Jowar	12.25	11.1	10.52	10.4	10.52	10.4
Bajra	10.09	7.0	9.27	6.6	9.27	6.6
Maize	6.02	9.6	6.12	11.4	6.12	13.2
Total cereals	101.57	171.5	99.11	202.3	99.11	222.2
Pulses[c]	22.59	13.4	21.69	18.2	21.69	21.0
Gram	6.69	5.2	6.53	7.1	6.53	8.2
Arhar	3.49	2.4	3.43	3.3	3.43	3.8
Foodgrains	124.16	184.9	120.80	220.5	120.80	243.2
Oilseeds[b]	25.80	21.0	28.62	28.0	28.62	33.8
Groundnut	8.14	8.2	7.82	9.6	7.82	11.5
Mustard and rapeseed	6.24	5.3	7.36	7.4	7.36	8.9
Soybean	4.05	3.9	7.11	6.6	7.11	7.9
Sugarcane	3.60	243.0	3.71	297.0	3.71	352.8
Vegetables	5.10	71.0	5.28	93.6	5.28	110.7
Fruits	3.20	33.0	3.20	53.7	3.20	70.5
Cotton	7.60	1.94	7.69	2.64	7.69	3.19
Livestock and Poultry Products						
Milk	-	60.5	-	93.1	-	119.5
Meat and eggs	-	3.2	-	4.6	-	6.0
Marine products	-	4.6	-	7.5	-	9.8

Notes: TE 1994-95: Average triennia ended 1994-95.
Prod: Production target which is equal to human demand plus non-human demand (seed, feed, wastage) plus export.
The area is projected for the year 2001-02 based on compound annual rate of change between the triennias ending 1988 and 1994 with the assumption that the area under crop will stabilise after 2001-02.

a It is assumed that the share of jowar in total coarse cereals will decline from 34.2 to 32.3 per cent in the year 2001-02, share of bajra from 21.5 to 20.2 per cent; the share of maize in total coarse cereals will increase from 29.4 per cent in TE 1994-95 to 35 per cent in 2001-02 and to 40 per cent in 2006-07.
After end of 2001-02, the demand for coarse cereals will be met from maize.

b The groundnut and rapeseed and mustard will meet 34 and 31 per cent of the edible oil requirement respectively. The share of soybean in total edible oil is 5.9 per cent in TE 1994-95 which is likely to increase to a level to 15 per cent by 2001-02. The conversion factor from oilseed to oil is 28 per cent for groundnut, 33 per cent for rapeseed and mustard, and 18 per cent for soybean.

c Gram and arhar will meet 39 per cent and 18 per cent respectively of the total pulse demand.

Table 9: Required Yield (kg/ha) Target by Crops at the End of Ninth and Tenth Five Year Plans in India

Items	Achieved TE 1994-95	Required Yield Level		Per Cent Irrigated Crop Area 1992-93
		2001-02	2006-07	
Rice	1851	2229	2454	46.8
Wheat	2420	2885	3213	84.3
Coarse cereals	979	1062	1121	10.2
Jowar	888	989	989	6.3
Bajra	688	712	712	5.8
Maize	1590	1863	2157	21.8
Pulses	593	839	968	10.4
Gram	774	1087	1256	21.9
Arhar	688	962	1108	5.0
Oilseeds	815	1104	1646	23.9
Groundnut	1007	1228	1471	19.2
Rapeseed and mustard	849	1005	1209	57.5
Soybean	963	928	1111	na
Cotton	255	343	415	33.2
Sugarcane	67354	80054	95094	87.9
Vegetables	17915	17727	20966	na
Fruits	10281	16781	22031	na

Note: na - not available

production showed an increase of 2.7 per cent mainly because of yield growth. The area under rice has increased only slightly during the 1980s. The gains in rice production have come essentially from the improved utilisation of the available infrastructure and from the resulting increase in yield per unit of land. Acceleration in yield growth need not imply that the potential productivity from the inputs has been fully realised. Spread of inputs in the new areas where the existing level of application is relatively low will contribute to the increase in the productivity per unit of input as well as ensuring more equitable distribution of benefits.

The rapid growth in irrigated area under wheat and spread of modern varieties during 1967-72 resulted in a extraordinarily high rate of growth in wheat production (9.7 per cent). Nearly half of this increase was contributed by yield gains. In the following decade, the rate of production increase declined to 2.4 per cent per year with yield gains slowing down to 2.6 per cent annually. This is because the use of modern inputs in wheat reached ceiling levels, particularly in the frontline states. The scope for further expansion of area under wheat is bleak even in the northern states. Coarse grains gained growth in production (1.4 per cent for maize, 1.3 per cent for sorghum and 0.4 per cent for pearl millet) through yield effects in spite of a declining trend in area of sorghum and pearl millet.

The growth in total factor productivity (TFP) during 1971-88 is estimated at about 1.03 per cent for rice, 1.26 per cent for wheat and 1.01 per cent for coarse grains (Table 7) . More than one-third of output growth in cereals is contributed by TFP. TFP and growth in crop inputs have contributed significantly to the production of rice and wheat, and have enabled India to increase availability of foodgrains per capita in the presence of high population growth rates and limited land resources. Deceleration in the growth of TFP is observed. This slow-down process has been explored in more details by Kumar and Rosegrant (1994) in case of rice, by Kumar and Murthyunjaya (1992) in case of wheat, and Rosegrant and Evenson (1992) for Indian crop sector as a whole. Market infrastructure, research, irrigation, and balanced use of fertilisers are identified as the most important sources of growth in TFP. Other authors have attributed this slow-down to a reduction of growth following exploitation of early productivity gains from adoption of modern varieties and declining trend of investment in agriculture during 1980s. Real investment in irrigation by the public sector declined during the 1980s at the rate of 1.73 per cent per annum [Rao 1993]. Increasingly, soil salinity and waterlogging problems also contribute to declining productivity [Joshi and Agrihotri 1982; Joshi and Jha 1991].

Yield Growth in Ninth Plan

Future increases in the production of food and non-food agricultural commodities have to be essentially achieved through increases in productivity as possibilities of area expansion are minimal. Around three million hectare crop area is predicted to the shifted from foodgrains to non-foodgrains. To meet the growing domestic and export needs, the average yield at national level is required to be improved by 30 to 50 per cent for various commodities by the end of the Ninth Five-Year Plan (2001-02) (Tables 8 and 9). The country should attain a per hectare yield of 2.2 tonnes for rice, 2.9 tonnes for wheat, 1.1 tonnes for coarse grains, 0.84 tonnes for pulses, 1.1 tonnes for oilseeds, 0.34 tonnes for cotton, 80 tonnes for sugarcane, 17.7 tonnes for vegetables and 16.8 tonnes for fruits by 2001-02. It requires an annual yield growth of about 2.5 per cent for foodgrains, 4.5 per cent for pulses, 3.9 per cent for oilseeds, 3.8 per cent for cotton, 3.5 per cent for vegetables, around 6 per cent for fruits and

Table 10: Per Cent Targeted Annual Growth in Yield/Production to Attain Self-Sufficiency in Food during the Ninth and Tenth Five Year Plan

Item	Growth Achieved			Target Growth	
	1980-90	1990-94	1980-94	2001-02	2006-07
Crops					
Rice	3.70	1.79	3.06	2.35	2.19
Wheat	3.28	2.23	2.93	2.22	2.20
Coarse cereals	2.52	2.71	2.58	1.01	1.04
Jowar	2.08	2.89	2.35	1.36	0.83
Bajra	2.08	1.47	1.94	0.43	0.26
Maize	3.70	1.23	2.42	2.00	2.37
Pulses	2.01	0.83	1.46	4.45	3.86
Gram	0.97	2.36	1.44	4.34	3.79
Arhar	0.64	–1.58	–0.61	4.28	3.73
Oilseeds	3.58	1.19	2.33	3.88	5.56
Groundnut	2.67	0.80	2.04	2.51	2.96
Rapeseed and mustard	5.91	–0.69	3.50	2.13	2.76
Soybean	3.57	1.77	2.60	–0.46	1.11
Sugarcane	1.40	1.30	1.36	3.07	3.20
Cotton	4.58	3.08	4.10	3.78	3.82
Vegetables	na	na	na	3.53	3.20
Fruits	na	na	na	6.04	6.04
Livestock products					
Milk	5.31	4.26	4.95	5.54	5.37
Fish	5.56	4.27	5.96	6.25	5.98
Meat and eggs	8.55	4.55	6.90	5.54	4.95

Table 11: Adoption of Technology and Production in LYS and HYS of India

Items	Per Cent Irrigated Crop Area		Per Cent HYV of Crop Area		Per Cent Share of Crop Area		Per Cent Share of Production		Yield (kg/ha) TE 1994-95	
	LYS	HYS	LYS	HYS	LYS	HYS	LYS	HYS	LYS	HYS
Rice	32	89	61	87	76	24	63	37	1528	2867
Wheat	78	96	83	98	79	21	66	34	2032	3838
Coarse cereals	6	13	–	–	57	43	44	56	791	1298
Jowar	6	7	52	99	96	4	95	5	886	1025
Bajra	2	10	32	75	51	49	34	66	459	936
Maize	11	36	36	73	80	20	69	31	1368	2495
Pulses	5	10	–	–	85	15	77	23	527	861
Gram	–	–	–	–	100	0	100	0	778	–
Arhar	–	–	–	–	82	18	73	27	612	1028
Oilseeds	20	45	–	–	92	8	87	13	831	1399
Groundnut	16	33	–	–	86	14	78	22	916	1566
Rapeseed and mustard	61	79	–	–	83	17	77	23	795	1176
Soybean	–	–	–	–	–	100	0	100	–	938
Cotton	23	100	–	–	85	15	72	28	218	459
Sugarcane	87	100	–	–	73	27	63	37	57921	91431

Notes: LYS-States which achieved yield below the required national average in 2001-02, HYS-States which achieved yield above the required national average in 2001-02.

milk and livestock products and 3.1 per cent for sugarcane (Table 10). In case of soybean, production targets will be achieved as a result of area expansion, even though there may be a slight decline in yield per hectare.

Looking at the past performance of 1990-94 we have achieved a yield growth which is much lower than needed during the Ninth FYP. This is not a simple task and serious efforts will have to be made by the agricultural scientists and extension agencies to improve production. More than half of the required growth in yields must be met from research efforts by developing location-specific and low-input-use technologies. The productivity increases need to be achieved from all the states of India. However, required increments in yield levels cannot be expected from high yield states (HYS), which are the states in which current yield levels are above the required national average in 2001-02, as these states account for only around one-fifth of the crop area for most of the crops (Table 11). Hence yield improvements must come from the low yielding states (LYS), which are the states in which current yield levels are below the required national average yield in 2001-02. The classification of HYS and LYS by crop is presented in Appendix 3. Under the scenario of yield improvement from the HYS ranging from 0 to 2.5 per cent, the required yield target for the LYS is presented in Table 12. The most likely scenario for HYS is 0 to 1 per cent per annum improvement in yield. Thus, to ensure future food security, efforts must be made to improve the yield for LYS from existing levels of 1.53 tonnes to 2 tonnes for rice, 2 tonnes to 2.63 tonnes for wheat, 0.79 tonnes to 0.92 tonnes for coarse cereals, 0.53 tonnes to 0.83 tonnes for pulses, 0.83 tonnes to 1.07 tonnes for oilseeds, 0.22 tonnes to 0.32 tonnes for cotton and 57.9 tonnes to 76 tonnes for sugarcane by 2001. This means there is a need to increase the per hectare yields substantially (30-50 per cent) in the next five years. Thus there is a need to attain the higher yield growth during Ninth FYP than attained during 1980-94. The yield growth target for LYS needs to be fixed at 3.6 per cent for rice, 3.3 per cent for wheat, 1.87 per cent for coarse cereals, 5.92 per cent for pulses, 3.27 per cent for oilseeds, 3.43 per cent for sugarcane and 5.02 per cent for cotton (Table 13). The required growth in yield from the LYS is substantially higher for pulses, oilseeds, sugarcane and cotton than achieved in the past.

Emphasis needs to be given for yield improvements in paddy in the states of Bihar, Orissa, Assam, West Bengal and Uttar Pradesh (Table 14). For wheat we must focus mainly on Uttar Pradesh, Madhya Pradesh, Bihar and Rajasthan. For coarse cereals, major emphasis must be given to

TABLE 12: YIELD (KG/HA) TARGET FOR LOW YIELD STATES OF INDIA AT THE END OF NINTH FIVE-YEAR PLAN

Crop	Growth in Yield for HYS						Yield in LYS TE 1994-95
	0 Per Cent	0.5 Per Cent	1 Per Cent	1.5 Per Cent	2.0 Per Cent	2.5 Per Cent	
	Required yield in LYS						
Rice	2028	1991	1952	1913	1872	1830	1528
Wheat	2632	2590	2547	2503	2457	2409	2032
Coarse cereals	917	885	851	817	781	744	791
Jowar	988	986	984	982	980	978	886
Bajra	497	460	422	383	342	300	459
Maize	1705	1680	1653	1626	1598	1569	1369
Pulses	835	829	823	816	809	802	527
Gram	1087	1087	1087	1087	1087	1087	778
Arhar	947	937	927	916	905	894	612
Oilseeds	1075	1069	1063	1057	1051	1045	831
Groundnut	1168	1157	1145	1133	1121	1108	916
Rapeseed and mustard	967	957	946	934	923	911	795
Soybean	928	928	928	928	928	928	938
Cotton	323	319	316	312	309	305	218
Sugarcane	75846	74469	73044	71568	70041	68460	57921

TABLE 13: YIELD GROWTH TARGET FOR LOW YIELD STATE OF INDIA AT THE END OF NINTH FIVE-YEAR PLAN

Crop	Growth in Yield for HYS						Growth Achieved during 1980-94	
	0 Per Cent	0.5 Per Cent	1 Per Cent	1.5 Per Cent	2.0 Per Cent	2.5 Per Cent	LYS	HYS
	Required annual yield growth in LYS (Per cent)							
Rice	3.60	3.36	3.11	2.85	2.57	2.28	3.51	2.09
Wheat	3.29	3.08	2.86	2.64	2.40	2.15	2.49	3.06
Coarse cereals	1.87	1.41	0.92	0.40	–0.16	–0.77	nc	nc
Jowar	1.36	1.34	1.32	1.30	1.27	1.24	1.77	4.70
Bajra	0.99	0.03	–1.04	–2.24	–3.60	–5.16	0.99	2.43
Maize	2.79	2.60	2.40	2.18	1.96	1.73	2.49	2.28
Pulses	5.92	5.83	5.72	5.62	5.50	5.39	nc	nc
Gram	4.27	4.27	4.27	4.27	4.27	4.27	1.44	–
Arhar	5.60	5.46	5.32	5.17	5.01	4.85	–0.38	–1.24
Oilseeds	3.27	3.20	3.13	3.06	2.98	2.90	nc	nc
Groundnut	3.09	2.96	2.83	2.70	2.56	2.41	–0.10	3.20
Rapeseed and mustard	2.48	2.34	2.20	2.05	1.89	1.72	1.50	2.89
Soybean	–0.13	–0.13	–0.13	–0.13	–0.13	–0.13	–	1.44
Cotton	5.02	4.88	4.74	4.60	4.44	4.28	3.23	5.33
Sugarcane	3.43	3.19	2.94	2.68	2.40	2.11	1.88	–0.01

Note: nc – not computed.

TABLE 14: POLICY SCENARIOS

Commodities	Target Growth Per Cent	Priority States	Per Cent Share of Priority States in Total Crop Area
Rice	2.35	BH, OR, AS, WB, UP	66
Wheat	2.22	UP, MP, BH, RJ	68
Jowar	1.36	MH, KN, MP, AP	82
Bajra	0.43	RJ	47
Maize	2.00	BH, UP, MP, RJ	60
Gram	4.34	MP, RJ, UP, MH	83
Arhar	4.28	MH, GJ, KN, AP, MP	72
Groundnut	2.51	AP, GJ, KN, MH	76
Rapeseed and mustard	2.13	RJ, UP, MP, WB	74
Soybean	1.11	MP, RJ	83
Cotton	3.78	MH, GJ, KN, RJ, AP	74
Sugarcane	3.07	UP	51

Notes: AP: Andhra Pradesh, AS: Assam, BH: Bihar, GJ: Gujarat, HP: Himachal Pradesh, KN: Karnataka, MP: Madhya Pradesh, MH: Maharashtra, OR: Orissa, RJ: Rajasthan, UP: Uttar Pradesh, WB: West Bengal.

Rajasthan, Maharashtra, Karnataka, Madhya Pradesh, Andhra Pradesh and Uttar Pradesh. To meet the demand for pulses greater emphasis is needed in almost all the states with particular focus on Madhya Pradesh, Maharashtra, Rajasthan, Gujarat, Andhra Pradesh, Karnataka and Uttar Pradesh which have three-fourths of total pulse area. The target growth in pulse yield from these states annually must be 6 per cent; otherwise the nation will experience shortage of pulses for all times to come. The task of attaining self sufficiency in pulse production looks difficult without area expansion and irrigation. In case of oilseeds greater emphasis is needed for all the LYS states which occupy 92 per cent of the area with special emphasis on Andhra Pradesh, Madhya Pradesh, Rajasthan, Maharashtra, Karnataka, West Bengal and Uttar Pradesh to increase the yield by about 4 per cent. The possibilities of developing processing industry for extracting edible oils from non-oilseeds commodities, like rice bran, etc, need to be explored. The introduction of palm cultivation for oil production may release the pressure on traditional oilseeds crops to meet future edible oil demand. In case of sugarcane research and development efforts are to be strengthened in Uttar Pradesh and Bihar to increase the yields per hectare by about 4 per cent per annum. The demand for sugar can also be met by developing mini sugar mills so that substantial sugarcane production can be diverted from khandsari to sugar production. This may also help release some sugarcane area to other crops. 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.

III
Conclusions

Vast untapped potential exists for increasing the production of all the commodities. What is needed are serious efforts on the part of scientists, and extension and development agencies to attain the targeted growth in yields from LYS and transcending the yield levels in HYS. Most LYS have low level of irrigation and technology. Greater research emphasis needed for dryland agriculture.

The challenge to sustain food security will be difficult for any country that has a large proportion of rainfed and unfavourable food-growing environment. Rainfed areas, which account for about 70 per cent of India's cultivated land, play a key role in meeting future food needs, in generating employment, and in promoting national economic growth. Resource-poor farmers in the rainfed ecosystems practise less-intensive agriculture, and since their incomes depend on local agriculture, they benefit little from increased food production in irrigated areas. To help them, efforts must be increased to disseminate available dryland technologies and to generate new ones. It will be necessary

APPENDIX 1: EXPENDITURE AND PRICE ELASTICITIES BASED ON FCDS BY EXPENDITURE GROUP FOR RURAL AND URBAN POPULATION, INDIA

Food	Rural					Urban				
	I	II	III	IV	ALL	I	II	III	IV	All
Expenditure elasticities										
Rice	0.183	0.106	0.035	–.018	0.064	0.148	0.078	0.010	–.029	0.016
Wheat	–.026	–.055	–.072	–.057	–.056	0.005	–.078	–.125	–.101	–.080
C cer	–.173	–.170	–.153	–.097	–.151	–.135	–.213	–.207	–.119	–.165
Pulses	0.611	0.454	0.310	0.121	0.309	0.612	0.442	0.275	0.095	0.214
Milk	0.895	0.740	0.573	0.299	0.458	0.878	.681	0.525	0.272	0.372
Oilseeds	0.768	0.578	0.399	0.178	0.389	0.675	0.488	0.320	0.122	0.234
Vegetables	0.742	0.568	0.408	0.194	0.385	0.669	0.487	0.337	0.152	0.253
Fruits	0.826	0.661	0.524	0.293	0.442	0.782	0.610	0.499	0.293	0.360
Meat	1.136	1.007	0.887	0.600	0.848	1.076	0.880	0.755	0.489	0.633
Sugar	0.369	0.234	0.125	0.025	0.133	0.350	0.199	0.088	–.013	0.057
OFood	1.241	1.107	0.996	0.739	0.945	1.198	0.979	0.868	0.585	0.695
Non Food	2.547	2.634	2.505	1.998	2.251	2.488	2.338	2.160	1.757	1.874
Uncompensated own price elasticities										
Rice	–.472	–.360	–.245	–.133	–.282	–.464	–.402	–.302	–.205	–.288
Wheat	–.400	–.317	–.227	–.140	–.242	–.319	–.312	–.216	–.143	–.217
C cer	–.389	–.308	–.214	–.111	–.286	–.451	–.392	–.281	–.166	–.309
Pulses	–.775	–.686	–.545	–.334	–.524	–.784	–.738	–.597	–.406	–.516
Milk	–.897	–.838	–.727	–.510	–.636	–.894	–.870	–.777	–.605	–.667
Oilseeds	–.832	–.740	–.600	–.386	–.567	–.798	–.757	–.622	–.422	–.522
Vegetables	–.826	–.747	–.618	–.415	–.601	–.803	–.762	–.640	–.475	–.567
Fruits	–.872	–.805	–.703	–.520	–.641	–.856	–.845	–.767	–.640	–.683
Meat	–.962	–.945	–.912	–.806	–.879	–.950	–.950	–.917	–.854	–.885
Sugar	–.686	–.572	–.424	–.237	–.405	–.681	–.622	–.477	–.288	–.394
OFood	–.995	–.990	–.975	–.942	–.967	–.993	–.990	–.985	–.957	–.967
Non Food	–1.32	–1.35	–1.30	–1.18	–1.241	–1.31	–1.35	–1.31	–1.21	–1.235

Notes: I: Very poor, II: moderately poor, III: non-poor low, IV: non-poor high.
The elasticities for each expenditure group for rural and urban areas are derived as the weighted average of the elasticities of the regions. The ratio of the consumption of ith region to the aggregate consumption of all regions for each expenditure class in the rural/urban areas is used as weight. Similarly aggregated elasticities for rural and urban areas have been derived as the weighted average of the elasticities of the expenditure groups.

APPENDIX 2: PROJECTIONS OF POPULATION (MILLION) BY EXPENDITURE GROUPS

(Million)

Year	Very Poor	Moderately Poor	Non-Poor Lower	Non-Poor High	All Groups
Rural					
1987	158.33	120.33	168.29	138.60	585.55
	(0.27)	(0.21)	(0.29)	(0.24)	
1991	146.79	122.45	184.68	173.39	627.31
	(0.23)	(0.20)	(0.29)	(0.28)	
1995	132.54	123.96	202.00	211.92	670.42
	(0.20)	(0.18)	(0.30)	(0.32)	
2000	113.35	121.11	218.93	272.26	725.65
	(0.16)	(0.17)	(0.30)	(0.37)	
2010	72.11	102.09	232.88	432.44	839.52
	(0.09)	(0.12)	(0.28)	(0.51)	
Urban					
1987	28.67	27.42	50.85	83.07	190.01
	(0.15)	(0.14)	(0.26)	(0.49)	
1991	26.78	27.88	55.68	106.67	217.01
	(0.12)	(0.13)	(0.26)	(0.49)	
1995	23.32	27.44	59.79	132.90	243.45
	(0.10)	(0.11)	(0.24)	(0.55)	
2000	18.93	25.49	62.05	172.36	278.83
	(0.07)	(0.09)	(0.22)	(0.62)	
2010	10.46	18.57	57.67	273.95	360.58
	(0.03)	(0.05)	(0.16)	(0.76)	

Source: Radhakrishna and Ravi (1990). Figures in parentheses are the share of total population.

to enlarge the efforts for promoting available dry land technologies, increasing the stock of this knowledge, and removing pro-irrigation biases in public investment and expenditure, as well as credit flows, for technology-based agricultural growth. Research problems in rainfed unfavourable ecosystems and breaking of the current irrigated yield ceiling are more complex and challenging. To make headway on them will require mobilising the best of science and the best of scientists in national agricultural systems through partnership research.

Phosphorus deficiency is now the most widespread soil fertility problem in both irrigated and unirrigated plots in the country [Kumar and Desai 1995]. Correcting the distortion in relative prices of primary fertilisers could help correct the imbalances in the use of primary plant nutrients – nitrogen, phosphorus, and potash. Recent initiatives taken by the goverenment to remove such imbalances in fertiliser use are a welcome move. To improve efficiency of fertiliser use, what is really needed is enhanced location-specific research on efficient fertiliser practices (such as balanced use of nutrients, correct timing and placement of fertilisers, and, wherever necessary, use of micronutrients and soil amendments), improvement in extension services, development of improved fertiliser supply and distribution systems, and development of physical and institutional infrastructure [Desai 1986].

The scope for influencing long run productivity growth through manipulation of crop prices is limited. Reforms of trade and macro-economic policy are needed to encourage long-term investment and technological change in agricultural sector. The increasing complexity of production environment demands efficient information dissemination and training in the use of modern technologies. For this, the extension strategies need to be reoriented to stimulate and encourage both top-down and bottom-up flow of information between farmers, extension workers and research scientists to promote the generation, adoption and evaluation of location-specific farm technologies.

Creating infrastructure in less developed areas, Watershed development for raising yields of rainfed crops, widening of seed revolution to cover oilseeds, pulses, fruits and vegetables, improvement of agricultural credit, and technological upgradation of post-harvest handling are areas which need more attention.

Notes

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1 The expenditure strata, four for the rural and four for the urban, are formed on the basis of the poverty lines adopted by the Planning Commission. Based on the expenditure classes of NSS, persons below 75 per cent of the poverty line are defined as very poor, between 75 per cent and poverty line as moderately poor, between poverty line and 150 per cent of the poverty line as non-poor lower, and ex-penditure classes above 150 per cent of poverty line as non-poor higher. Per capita expenditure is taken as a proxy for income and these terms are used interchangeably in the study.

2 In addition to urbanisation and economic status, consumption pattern is also influenced by region. Rice is the main staple food in eastern and southern regions. Wheat is the main staple food in western and northern regions. Sorghum is the second staple cereal in western and southern regions. Demand parameter estimates may vary by region, urbanisation and income group. Thus, for the purpose of analysis, state-wise time series data were aggregated into four regions, namely, eastern region covering the states of Assam, Bihar, Orissa and West Bengal; northern region which includes Haryana, Punjab, Uttar Pradesh, Himachal Pradesh and Jammu and Kashmir; western region covering Gujarat, Maharashtra, Madhya Pradesh and Rajasthan; and southern region covering Andhra Pradesh, Tamil Nadu, Karnataka and Kerala.

3 Major part of the wasted grains are fed to livestock, Feed requirements are calculated by converting the livestock products into Livestock Output Unit (LOU) and using the feeding ratio per unit of LOU. The major part of the meat other than chicken is a by-product of the livestock industry. Even with regards to chicken meat, not more than half is broilers which are fed the concentrates. The remaining half is from the culled layers which again is a by-product.

4 Non-household demand is estimated at 11-12 per cent of human demand for foodgrains or 10-11 per cent of the projected gross output [Kumar et al 1996]. These estimates are close to the allowances (12.5 per cent of foodgrains production) used by the ministry of agriculture, government of India (GOI) while computing the availability of foodgrains for human consumption. Following the norms of GOI, the grossing factor used is 1.082 for rice, 1.138 for wheat, 1.422 for coarse cereals, and 1.143 for total cereals, pulses and total foodgrains to account for non-household demand. Thus, non-household demand works out to 18 mt and 29 mtin 2001-02 and 2006-07, respectively.

Appendix 3: Classification of Low Yield and High Yield States by Crop

Crop	Low Yield States	High Yield States
Paddy	WB, UP, MP, BH, OR, AS, MH, GJ, KR	AP, TN, PB, KN, HY
Wheat	UP, MP, RJ, BH, MH, GJ, HP, WB	PB, HY
Coarse cereals	MH, RJ, GJ, HY, OR	KN, UP, MP, AP, TN, BH, HP, JK
Jowar	MH, KN, MP, AP, RJ, UP, GJ	TN
Bajra	RJ, KN	MH, GJ, UP, HY, TN, MP, AP
Maize	UP, RJ, MP, BH, GJ, JK, MH, OR	KN, AP, HP, PB
Pulses	MP, RJ, MH, AP, KN, BH, GJ, OR, TN, WB	UP, HY
Gram	MP, RJ, UP, MH, HY, KN, BH, GJ, AP	
Arhar	MH, MP, GJ, KN, AP, OR, TN	UP, BH, HY
Oilseeds	MP, AP, RJ, GJ, UP, KN, MH, WB, OR, AS	TN, HY
Groundnut	AP, GJ, KN, MH, MP, RJ, UP, OR	TN
Rapeseed and mustard	RJ, UP, MP, WB, AS, BH	HY, GJ, PB
Soybean	–	MP, MH, RJ, UP
Cotton	MH, GJ, AP, RJ, MP, TN	PB, HY
Sugarcane	UP, AP, GJ, BH, HY, PB, MP, AS	MH, KN, TN

Notes: AP: Andhra Pradesh, AS: Assam, BH: Bihar, GJ: Gujarat, HY: Haryana, HP: Himachal Pradesh, JK: Jammu and Kashmir, KN: Karnataka, KR: Kerala, MP: Madhya Pradesh, MH: Maharashtra, OR: Orissa, PB: Punjab, RJ: Rajasthan, TN: Tamil Nadu, UP: Uttar Pradesh, WB: West Bengal.

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