Indian Agricultural Scenario and Food Security Concerns in the Context of Climate Change: a Review

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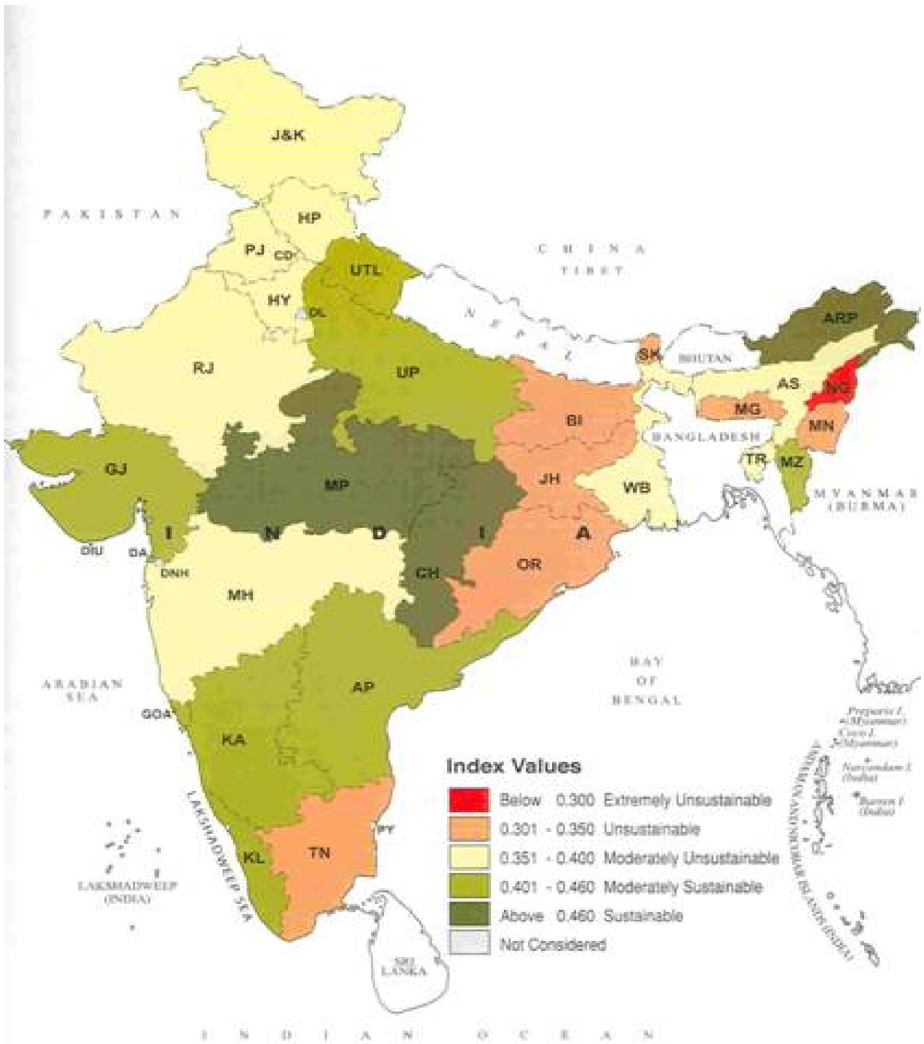
Introduction

It is well known that agriculture has been a way of economic life and main source of livelihood for the vast majority of households in rural India. Shouldering the onus of providing food to teeming millions, in the past five and a half decades of planned economic development in India, the agriculture sector has come a long way from food grain production level of only 51 million tonnes in 1950-51 to 231 million tonnes in 2007-08. The concern and vision for achievement of food security is amply reflected in various discussions and documents of national and international importance. The long-term trends in global hunger show that in 2003-05, the number of chronically hungry people were 848 million, of which about 28% (231 million) were in India (FAO, 2008a). The unprecedented surge in food prices during 2006-07, aggravated food insecurity, increasing the number of chronically hungry people at the global level by 75 million during 2003/05 to 2007 (FAO, 2008b). Given the continued drastic price rises in staple cereals and oil crops well into the first quarter of 2008, it is very likely that the number of people suffering from chronic hunger would have gone up further both, at the global and national level.

There are many causes that explain food insecurity. In India, fluctuations in food production are experienced in several states even under current climatic conditions. Apart from variations in rainfall, factors such as land and forest degradation also contribute in causing water shortages and instability of production, at times despite having good rainfall. The classification of Indian states according to food security sustainability index demonstrates highly unsustainable status of the eastern region of the country (Map 1). The index is generated keeping note of environmental sustainability, including future availability of water and forest cover, apart from factors directly relating to current food security such as current food production and access. Based on the criterion, even the northern parts of the country, comprising of the agriculturally developed states of Punjab and Haryana show moderate instability.

Map 1: Sustainability of Food Security in India



Source: Atlas of the Sustainability of Food Security (2004)

The recent food crisis has highlighted the fragility of the world's food systems and their vulnerability to shocks. Coping with the short-run challenges to food security posed by food price volatility is indeed a daunting task. But what is far serious is the longer-term challenge of avoiding a perpetual food crisis under conditions of global warming. The last two centuries have witnessed excessive accumulation of greenhouse gases in the atmosphere which threaten to change climate in an unprecedented manner. Climate change will be one of the important environmental factors influencing the future food security as agriculture is highly sensitive to changes in climate. Most international studies that examine the impact of global warming on this sector conclude that in many instances agriculture will be disadvantaged, particularly in tropical countries, like India (Reilly, 1996; Cline, 1992; Evenson, 1999; Rosenzweig and Iglesias, 1998; Saseendran et al., 2000).

In this backdrop, in the first section, this paper presents a brief overview of the trends in foodgrain production in India and the determinants of its growth. This, together with review of studies on domestic supply projections, would help to draw inferences about the future foodgrain production trends in the second section. In the third section, the foodgrain supply forecasts are examined in relation to the likely demand of foodgrains to answer whether India would have a situation of food surplus or deficit. Finally, the concluding section summarizes the supply and demand side aspects of food security in the context of climate change- covering on one hand, the climate change impact on availability and stability of food supplies and on the other, its likely influence on the access and utilization dimensions of food demand.

Food-grain Production: Trends and Sources of Growth

Production and Productivity Trends The progress of Indian agriculture has not been consistent over time and can be classified into four distinct phases.

Phase 1 (1947/48-1965-66): The first phase stretching from Independence to mid-sixties, emphasized on consolidation and organization of agricultural sector. Development was spearheaded through industrial front and it was expected to have a spread- effect on agriculture. The increase in agricultural production at the annual rate of about 3% was dominated by growth in non-foodgrains. A slower increase in food-grain production came about due to shift in cropping pattern in favour of superior cereals (wheat and rice) particularly in the better endowed regions. The share of rice and wheat in production of total foodgrain increased from 52.5 percent in TE 1952-53 to 57.5 percent in TE 1965-66, but the yield remained low at 991 and 823 kg./hectare (TE 1965-66) for rice and wheat, respectively. The lack of emphasis on technological change during this phase culminated in extreme food scarcity in mid sixties.

Phase 2 (1966/67-1979/80): The advent of new technology changed the situation dramatically in the second phase spanning mid sixties to decade of 70s. The growth rate of foodgrains was impressive (over 3%) and it came about partly due to improvement in yield of rice and wheat (by 26 and 87 percent, respectively during TE 1965/66- TE 1980/81) and partly due shift in area towards these major cereal crops. During this period, the area under rice and wheat increased by 11.5 and 70 percent, respectively, while a corresponding decline took place in the area under coarse cereals and pulses. From the situation of acute food shortages at the beginning of the phase, the country surged ahead in achieving self-sufficiency in food-grain production. The per capita domestic production of food grains was about 186.5 kg/annum during the 70s. Besides the new technology, the strengthening of the institutional backup also contributed to the productivity growth, and the transformation in the agrarian structure was an important component of agricultural development in the second phase.

Phase 3 (1980/81-1989/90): During the decade of 80s, the growth rate of crop production touched an all-time high of 3.2 percent. The two distinct features of this third phase were, increased foodgrain production coming almost entirely from productivity enhancement and diversification towards non-foodgrain crops. The area under both the major foodgrain crops, viz. rice and wheat nearly stagnated (Table 1), but the average annual production growth was over 3.5% on account of substantial yield improvement. Even in case of coarse cereals and pulses, the increase in yield more that compensated for the decline in acreage under these crops, to register a positive growth in production, marginally for coarse cereals and moderately for pulses.

Table 1: Performance of Indian Agriculture: 1980/81-1989/90

Crop	**Compound Annual Growth rate (%)**		
	Area	***Production***	***Yield***
All Crops	**0.10**	**3.19**	**2.56**
Foodgrains	***0.23***	***2.85***	***2.74***
Cereals	–0.26	3.03	2.90
Rice	0.41	3.62	3.19
Wheat	0.46	3.57	3.10
Coarse Cereals	–1.34	0.40	1.62
Pulses	–0.09	1.52	1.61
Non-Foodgrains	***1.12***	***3.77***	***2.31***
Oilseeds	1.51	5.20	2.43
Cotton	–1.25	2.80	4.10
Sugarcane	1.44	2.70	1.24
Tobacco	–2.79	–1.05	1.79

Source: Deshpande et al. (2004)

The net sown area nearly stagnated at the decadal average of 140.5 million hectares but there was some increase in cropping intensity from 123.30 percent in 1980-81 to 128.05 percent by the end of the decade. The total cropped area under non-foodgrain crops, specially oilseeds and sugarcane registered over 1 percent growth. Together with acreage expansion, the yield level of non foodgrain crops also increased at a compound annual growth rate of 2.31 percent. However, except for cotton, the rate of yield growth for all other major non-foodgrain crops was lower than what was achieved for rice and wheat.

Phase 4 (1990/91 onwards): The growth momentum observed in the third phase could not be sustained in the subsequent period (Table 2). Thus, the fourth phase, from the beginning of 90s, has been marked by considerable slackening of agricultural output due to continuous deceleration in rate of production growth of most of the food and non-food grain crops. The observed trends after 2000/01 are particularly worrisome with virtual stagnation in production of rice, wheat and total food grains. Among the non food grain-crops, there has been a quantum jump in the productivity of cotton, after introduction of BT cotton in the country. But for the other non foodgrain crops, the yield growth has been moderate for oilseeds and declined marginally for sugarcane.

Table 2: Recent Trends in Area, Production and Yield of Major Crops

Crops	**Compound Annual Growth rate (%) TE 1990/91 to TE 2000/01**			**Compound Annual Growth rate (%) TE 2000/01 to TE2007/08**		
	Area	***Production***	***Yield***	***Area***	***Production***	***Yield***
Rice	0.60	1.82	1.22	-0.56	0.78	1.36
Wheat	1.48	3.40	1.90	0.39	0.11	0.31
Coarse Cereals	-2.23	-0.37	1.92	-0.31	2.29	2.61
Pulses	-0.60	0.30	0.46	1.33	1.65	2.14
Total Foodgrains	-0.20	1.86	2.06	0.05	0.84	0.79
Cotton	2.37	1.86	-0.49	0.21	12.36	12.05
Oilseed	0.60	2.44	1.80	2.49	4.94	2.43
Sugarcane	1.82	2.82	0.99	0.65	0.06	-0.64

Note: Growth rates have been computed taking 3-year moving averages

Source: Computation based on data from Agricultural Statistics in India 2008

Considering that the country identifies its food security with foodgrain availability, it is indeed worrisome to note that the per capita production of cereals has declined by 7 kg and pulses production by 3 kg during the last decade (Table 3).

Table 3: Per Capita Production of Foodgrains

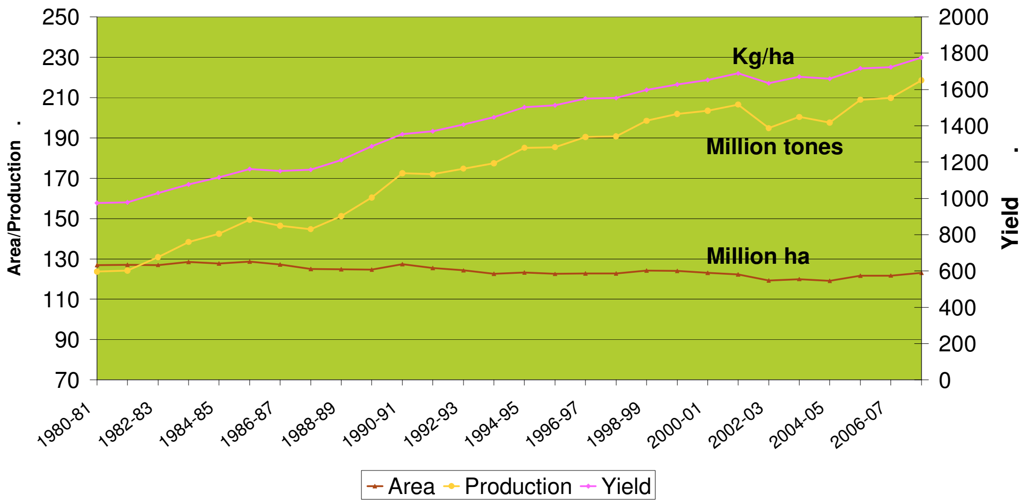
(in kg.)

Period	*Cereals*	*Pulses*	*Foodgrains*
1971-75	164	19	183
1976-80	172	18	190
1981-85	179	17	196
1986-90	182	16	198
1991-95	192	15	207
1996-00	191	14	205
2001-05	177	12	189
2004-07	175	12	186

Source: Chand (2007)

During early 1970s to mid-1990s, per capita production of foodgrains increased by 24 kgs., even though India's population increased by more than 50 per cent. But thereafter, foodgrain production has failed to keep pace with population growth, due to stagnating and/or tapering yields and acreage under predominant foodgrain crops (Figure 1- 3).

Figure 1: Area, Production and Productivity of Total Foodgrains in India (3 year moving averages)



Source: Agricultural Statistics in India 2008

Figure 2: Area, Production and Productivity of Rice in India

(3 year moving averages)

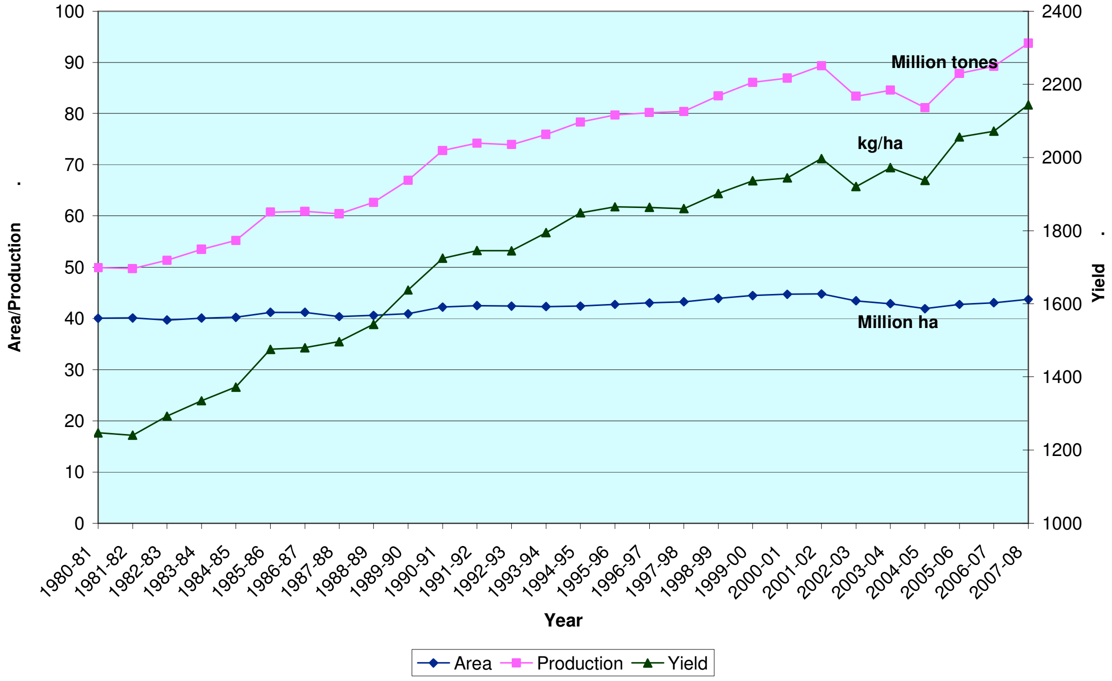
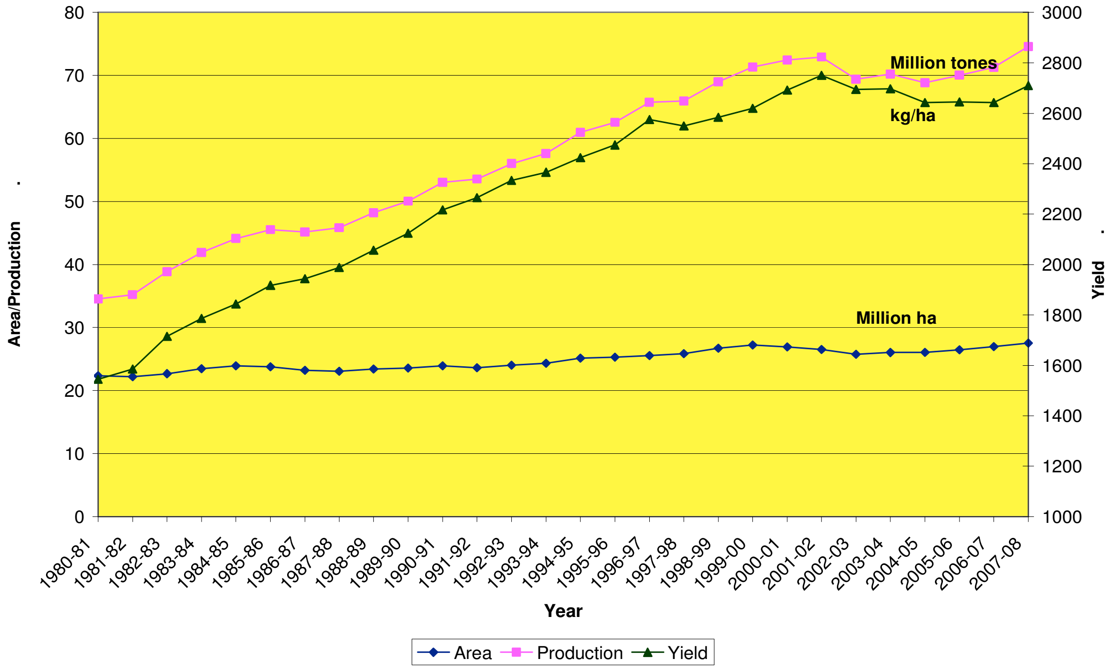


Figure 3: Area, Production and Productivity of Wheat in India

(3 year moving averages)



Source: Agricultural Statistics in India 2008

Sources of Growth Studies on decomposition of crop output growth for examining the contribution of various sources of growth (area, yield, cropping pattern) and inputs (irrigation, HYV seeds, fertilizer, etc.), have broadly concluded that, in India the most important factor causing substantial increase in agricultural productivity has been the introduction of land-augmenting farm technology through the use of High Yielding Varieties (HYV) along with fertilisers, irrigation and improved management practices.

On the basis of the state level data for the period 1955-56 to 1975-76 and 1973-83 to 1983-93, the estimates by Joshi and Haque (1980) showed that fertilizer consumption and area under HYVs were the most important determinants of agricultural growth in majority of the states. Next in order were the technological parameters (time as a proxy), irrigation, rainfall and credit. The relationship between fertiliser consumption and agricultural productivity was found positive and statistically significant in eleven out of the fifteen states. The percentage of area under HYVs influenced agricultural productivity positively and significantly in seven states, although the coefficients were positive in all fifteen states.

Bhalla and Singh (2001) attempted the decomposition of growth in agricultural production in terms of area, modern inputs and infrastructure for two periods, viz., 1973 to 1983 and 1980-83 to 1990-93. The results show that the increasing use of modern inputs was the major contributor to growth in production both, during the 1970s and 1980s, accounting for 73.58 per cent of growth during the 1970s and slightly lower at 64.14 per cent during the 1980s. Infrastructure emerged as the other important source of growth in production contributing for 25.9 per cent of growth in the first period and 14.8 per cent growth in the second period. Under infrastructure, the contribution of irrigation declined from 13.7 per cent in the first period to 7 per cent in the second period.

The total factor productivity (TFP) concept has also been extensively used for examining the determinants of growth in agricultural output. The analysis by Kalirajan and Shand (1997) concluded that by mid-eighties technological change and gains due to technical efficiency contributed only around 15 per cent of the aggregate agricultural growth, the remaining contribution came from input growth. A recent study by Kumar and Mittal (2006), brought out that the TFP growth has declined during 1986-00 as compared to 1971-86 for all the food crops (except paddy), indicating that after the mid 80s, output growth per unit increase in input has decelerated. In case of paddy also, the increase in TFP growth has been confined to Eastern and Western regions of the country, while a drastic slow down was observed in the North and near stagnation in the South.

It clearly emerges from the above discussion that, the technological change initially impacted food productivity trends significantly to usher-in self-sufficiency in food sector. However, over the period of time, there has been deceleration in growth as the increase in crop output has become more and more dependent on raising the input levels and the contribution of technological progress has declined.

On the basis of long term growth rates in production and major contributing factors to these growth rates, the major food crops can be categorized into three groups, namely, (i) crops which have high growth rates in production, contributed by high productivity growth; (ii) crops with high growth rates in production, contributed by area expansion, and (iii) crops with declining production or slow growth crops contributed by productivity or area (Table 4).

Table 4: Classification of Selected Food & Edible Oil Crops according to Source of Growth

Source of Growth		
Group I:* *Productivity Increase	***Group II:* *Area expansion***	***Group III:* *Slow Growth Crops***
Wheat, Paddy, Maize, Groundnut, Rape Seed & Mustard, Nine Oilseeds.	Tur, Sugarcane, Sunflower, Soya bean, Potato	Jowar, Bajra, Ragi, Small Millets, Barley, Gram, Pulses, Sesamum

In addition to the differential impact across crops, the technological parameters also showed regional specific behaviour. Some of the states could take full advantage of the technology in the initial phase itself whereas; a few other states joined the mainstream production growth later. The differential experience of the regions has its roots in the divergent structural parameters that influence the absorption of growth initiatives.

The process of technology adoption was influenced by four important factors, status of resource endowments of farm groups and regions, attitude of farmers towards risk , the livelihood system and culture of the community and the availability of suitable region specific technology. It is important to emphasise that these structural factors that have influenced the adoption in agricultural technology will also have important bearing in shaping the adaptation responses for mitigating the impact of climate change in agriculture production.

Foodgrain Supply Projections

The medium and long term supply projections for foodgrains have been made by several research workers under different sets of assumptions of yield growth, input use, area expansion, market response, etc. The results of some of these studies have been synthesized in this section and discussed under three broad categories:

Business-as-Usual Scenario The projections that are based on trend growth rates of crop output and yield, without taking into account the possibility of any policy and/or technological intervention have been termed as business-as -usual (BAU) scenario and presented in Table 5.

Kumar et al. (1995) projected the supply of cereals to be 270.4 million tonnes in 2020, if the declining trend in TFP of cereals observed in the 80s vis-à-vis the 70s was to continue in future due to further slowing in public investment. Goyal and Singh (2002) also arrived at similar figure for the year 2019-20, by assuming that crop output growth achieved during 1990-99 would reduce by 20% till 2020. The estimates by Mittal (2008) and Bhaduri et al. (2006) are on the lower side, while simplistic projection of cereal supply based on extrapolation of observed trends during 1962/65-1993 gives a very high estimate of 347 million tonnes (Bhalla et al. 1999), which is unlikely under current BAU scenario .

Table 5: Supply projections under BAU Scenario

(in million tones)

Crop	Kumar et al.[1] (1995)	Bhalla et al.[2] (1999)	Goyal & Singh[3] (2002)		Bhaduri et al.[4] (2006)		Mittal[5] (2008)	
	Projected Supply for the year							
	2020	*2020*	*2019-20*	*2029-30*	*2025*	*2050*	*2021*	*2026*
Rice	120.5	-	-	-	-	-	105.8	111.2
Wheat	107.6	-	-	-	-	-	91.6	97.9
Coarse Cereals	42.3	-	-	-	-	-	-	-
Total Cereals	270.4	347.1	271.7	319.2	-	-	242.2	260.2
Pulses	-	-	19.7	21.5	-	-	17.6	18.4
Total Foodgrains	-	-	-	-	268.9	271.7	-	-

Notes: [1] Continuation of the observed declining trend in TFP in the 80s as compared to the 70s due to slowing down of public investment

[2] Extrapolated 1962/65–93 trend (2.7 percent production growth per year)

[3] 20% reduction by 2019-20 in crop output growth achieved during 1990-99

[4] Extrapolated irrigated area under foodgrains and fertilizer use based on observed trends during 1990-2000. Projected input level used in estimated production function to forecast foodgrain output

[5] Extrapolated 1993-2003 growth trends in yield and area expansion assumed nil

Policy and Technology Intervention Scenario Policy interventions in the form of higher public investment in agriculture for increasing the access to growth enhancing facilities such as, irrigation, agricultural R&D, extension etc. can be instrumental in raising the productivity of farm produce. Similarly, technological interventions leading to intensification of input use have the potential to enhance production.

Table 6: Supply projections with Policy and Technology Interventions

(in million tones)

Crop	Kumar et al.[1] (1995)	Bhalla et al.[2] (1999)						Bhaduri et al.[3] (2006)	
	Projected Supply for the year								
	2020	*2020*						*2025*	*2050*
		Option 1	*Option 2*	*Option 3*	*Option 4*	*Option 5*	*Option 6*		
Total Cereals	309.3	287.5	236.3	389.6	279.4	251.0	281.0		
Total Foodgrains								322.65	334.79
Rice	134.0								
Wheat	127.3								
Coarse Cereals	48.0								

Note: [1]Sustaining productivity growth at level attained in 1980s through increased public investment in agriculture

[2]Option 1: High fertilizer use – Tripling of 1993 fertilizer use to reach agronomic optimum national average of 334 kilograms/hectare

Option 2: Exploiting full irrigation potential- 50 percent of gross cultivated area is irrigated

Option 3: High fertilizer use and exploiting full irrigation potential

Option 4: Doubling fertilizer use and irrigating 41.5 percent cultivated area

Option 5: 50% increase in fertilizer use and irrigating 41.5 percent cultivated area

Option 6: Option 5 plus genetic and technical efficiency improvements

[3] Rate of increase in the proportional irrigated area for foodgrain is 50% more than time trend.

The supply projections made under alternate policy and technology intervention scenarios (Table 6), anticipate the cereal production to reach a level of about 390 million tonnes under most optimistic fertilizer and irrigation scenario (Bhalla et al., 1999). The estimates show the theoretical possible supply levels with the existing technology. However, given the very high costs of exploiting optimum irrigation and fertilizer levels (that is, completely closing the gaps in both, irrigated area and fertilizer use) the projected levels may not be economically viable without a technological breakthrough. With less optimistic assumptions about expansion of irrigation and fertilizer use, viz. closing irrigation and fertilizer gaps by 50 per cent, the total production of cereals was projected to be 279 million tons in 2020. As HYVs are an important source of productivity enhancement, the study maintained that the spread of current generation of modern varieties of cereals is anticipated to further increase production by an additional 30 million tons. Public investment in irrigation and other infrastructural facilities have emerged as vital determinants of agricultural growth. Hence, considering the positive impact of public investment in agriculture sector, Kumar et al. (1995) anticipated the cereal supply to be about 40 million tonnes more under the scenario of government intervention as compared to the business as usual scenario.

Market Driven Scenario IFPRI's International Model for Policy Analysis of Agricultural Commodities and Trade (IMPACT) has also made projections for cereal supply in India (Rosegrant et al., 1995). The model endogenously determines the area under cultivation, while yield growth is based on exogenous and endogenous components. The exogenous component is based on various assumptions about future conditions in public and private research and extension, and the spread of markets, infrastructure, and irrigation. The endogenous yield growth component is based on price response, with prices set to clear markets. The projected annual yield growth rates of 1.53 and 1.43 per cent for wheat and rice respectively would raise yields to 3.6 and 2.7 tons per hectare, respectively by 2020. The projected supply estimates of 256.2 million tonnes arrived at in market driven IMPACT model are lower than the once arrived at under most of the policy and technology intervention scenarios.

Recent production forecasts by FAPRI (2009) take into account the market turbulence experienced by the world nations during 2006-08, bioenergy mandates of countries, existing farm policy, and policy commitments under current trade agreements and custom unions. The production of rice and wheat is anticipated to be 111.06 and 91.40 million tonnes, respectively in 2018/19 - an increase of about 16% from the current production level of 174.83 million tonnes. The rise in production is largely attributable to growth in yield, with expected productivity of 3.11 tons/hectare for wheat and 2.42 tons/hectare for rice. The production of corn is also projected to rise on account of yield increase, though the study projects decline in the area under corn. In case of other coarse cereal, sorghum, a notable acreage expansion has been projected, that would lead to substantial increase in its production.

Summing Up The cereal production forecasts made by the studies for the year 2020 generally lie in the range of 250-275 million tonnes - that is, an addition of 35-60 million tonnes over the existing level of production in next 13 year period. Considering average annual increase of 3-4 million tonnes, by 2030 the cereal production is likely to be around 300 million tonnes. Under the assumptions of intensive technology intervention the anticipated production is at a higher level than the projections based on prevailing trends and market scenario. This is so as there are several structural and market factors that constrain the realization of full yield potential on the famers' fields.

Outlook of Foodgrain Demand

The long-term trends in household consumption pattern show diversification in rural and urban food baskets in favour of non-foodgrain crops. The intake of foodgrains, particularly cereals has been declining and that of fruits, vegetables and food from animal origin has been increasing. The declining trend in per capita consumption of cereals had set in from early 70s. But, it was after the early 80s that the modest decline observed during 1973/74 to 1983/84 became fairly rapid. The per capita foodgrain consumption has come down largely on account of reduced consumption of coarse cereals, while for superior cereals like, rice and wheat the decline is marginal in 2004-05 as compared to 1983 (Table 7).

Despite the observed shifts in the dietary pattern, the aggregate demand of foodgrains has increased over time, on account of, rise in food demand (direct demand) due to population and income growth, and higher demand of foodgrains for other uses such as, seed, animal feed and industrial purposes.

Table 7: Changes in Average Annual Per Capita Consumption of Foodgrains in India

(kg/annum)

Commodities	1983	1993-94	2004-05
Rice[@]	76.87	79.92	73.77
Wheat[@]	55.30	54.55	53.46
Coarse Cereals	37.76	19.77	12.62
Total Cereals	169.94	154.24	139.86
Pulses	10.10	9.56	8.99
Foodgrains	180.04	163.80	148.85

Note: [@] Includes rice and wheat products

Source: NSSO Household Consumption Expenditure Surveys various rounds

The food-grain demand projections for year 2020 (and beyond) have been made by several researchers using varied assumptions of population growth, changes in per capita incomes, urbanization, expenditure elasticity of foodgrain, tastes and preferences, prices etc. As a result of differences in assumptions and base year, the estimates of future foodgrain demand vary widely across studies (Table 8).

The estimated food demand for cereals in 2020, broadly centres around 225 million tonnes, although some available projections are much lower -167 million tonnes (Chand, 2007) or much higher- 267 million tonnes (Bhalla et al., 1999). The total demand for cereals which comprises of direct demand for human consumption, indirect demand for seed, animal feed and other uses and also accounts for wastage, shows much wider variation on account of vastly diverse opinion regarding anticipated demand for foodgrains for use as livestock feed. The IMPACT model forecasts the feed demand to be 13 million tonnes in 2020, while Chand (2007) puts it close to 100 million tonnes. By and large, averaging out the estimates of the studies, the total cereal demand is likely to be about 260 million tonnes in 2020 and shall exceed 300 million tonnes by 2030.

Table 8: Projected Demand for Foodgrains in India

(million tonnes)

Study	Year	Total Demand		Food Demand	
		Foodgrains	*Cereals*	*Foodgrains*	*Cereals*
IMPACT model Rosegrant et al. (1995)	2020		237.3		223.57
Kumar et al. (1995)	2020		293.4		
Kumar (1998)	2020		254.5		237.6
Bhalla et al. (1999)	2020		257.2-374.7		231.5-267.2
Bansil (1999)	2020		258.4		227.8
Dyson and Hanchate (2000)	2020		223.6		193.5
Paroda and Kumar (2000)	2030	264			
Thamarajakshi (2001)	2020		274.0		
Radhakrishna & Reddy (2002)	2020			240.64	221.11
Goyal and Singh (2002)	2020 2030	301.08 330.18	271.89 292.86		
Chand (2007)	2020	280.6	261.5	187.4	166.6
Mittal (2008	2021 2026	281.5-287.6 324.5-334.3	242.8-245.1 273.5-277.2		
Amarasinghe et al. (2007)	2025 2050	276 377		218 241	
GOI (2002)	2020				227
FAPRI (2009)	2019		250.0		215.5

Demand-Supply Hiatus

Given the wide variations in demand and supply projections, the studies have come up with strikingly diverse conclusions about the demand supply gap in foodgrain production and food security outlook for India. The Working Group on PDS and Food Security for the Tenth Plan expressed complacency in future cereal security situation and stated that *"…… The demand projections for cereals which take into consideration changing consumer preferences come out with demand estimates for cereals which match favourably with the supply projections indicating that the requirements of cereals in the country will be adequately met by domestic supplies during the period of at least upto the year 2020"* (GOI, 2001). The projections made by FAPRI also suggest that India would be net exporter of rice, wheat and sorghum in future and will depend on imports for fulfilling domestic demand of corn only.

However, most other studies have reported difficult food security scenario and reiterated the need to gear up to meet the challenge of providing adequate and nutritious food to the country's growing population. For instance, the Report on the Status of Food Insecurity in Rural India (MSSRF, 2008) indicates that in 2004-05, about 13% of the rural population in India consumed less than 1,890 Kcal per consumer unit per day (Table 9).

Table 9: Percentage of Population Consuming less than 1,890 Kcal/cu/day

States	1993 – 94	1999 – 2000	2004 – 05
Andhra Pradesh	14.1	17.3	12.5
Assam	13.3	21.8	8.9
Bihar	14.1	13.7	10.0
Chhattisgarh	*	*	16.2
Gujarat	20.4	20.1	17.1
Haryana	8.7	7.2	7.8
Himachal Pradesh	5.3	2.5	2.8
Jammu and Kashmir	0.8	2.2	2.4
Jharkhand	**	**	13.8
Karnataka	17.4	21.7	20.5
Kerala	23.7	18.7	17.5
Madhya Pradesh	12.2	18.7	16.0
Maharashtra	21.9	17.9	19.7
Orissa	10.4	11.1	15.4
Punjab	6.3	7.1	6.4
Rajasthan	4.2	4.6	5.2
Tamil Nadu	28.2	33.7	23.4
Uttar Pradesh	8.0***	8.5***	8.0
West Bengal	7.4	15.0	11.9
All India	13.4	15.1	13.2

Source: MSSRF (2008)

During the decade 1993/94-2004/05, this percentage has remained constant, although there is a marginal reduction in the same from15.1 in 1999/2000 to 13.2 in 2004/ 05. Across the states, in 9 out of 19 states in 2004-05, this percentage was above 15%, ranging from 15.4% in Orissa to 23.4% in Tamil Nadu, suggesting prevalence of moderate to high level of food insecurity in these states (Table 10).

Table 10: Distribution of States by Level of Food Insecurity based on percentage of persons consuming less than 1,890 Kcal/cu/day

Level of insecurity	1999-2000	2004-05
Very low	Haryana, Himachal, J&K, Punjab, Rajasthan	Haryana, Himachal, J&K, Punjab, Rajasthan, Uttar Pradesh
Low	Bihar, Orissa, Uttar Pradesh	Andhra, Assam, Bihar, Jharkhand, W.Bengal
Moderate	Andhra, Gujarat, Kerala, Madhya Pradesh, Maharashtra, W.Bengal	Chattisgarh, Gujarat, Karnataka, Kerala, Orissa, Maharashtra, Madhya Pradesh
High	Assam, Karnataka	Tamil Nadu
Very High	Tamil Nadu	None

Source: MSSRF (2008)

Food Supply-Demand and Climate Change

The available studies on supply and demand for foodgrain and other food products do not account for the impact of climate change on the production and consumption of food. This section discusses some critical supply and demand side aspects of food security in the context of climate change.

Food Production and Availability The effect of climate change on agricultural production depends on a combination of factors. Higher temperatures can stress plants, but also prolong growing seasons and allow a greater choice of crops to be grown. Higher concentration of CO_2 speed growth and increase resilience to water stress.

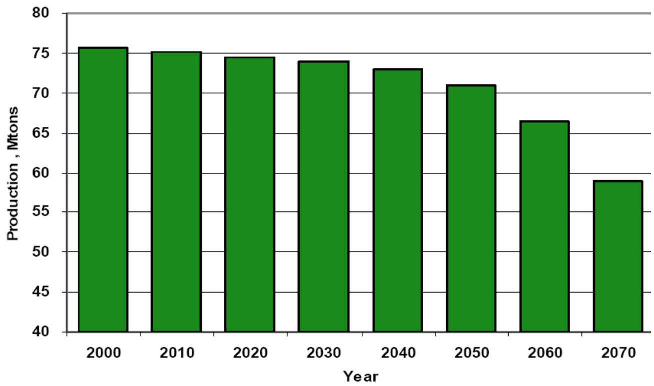
The basic approach used in the studies to quantify the impact of climate change on food production is simulation modeling that predicts the behaviour of crop systems on the basis of quantitative understanding of dynamic processes from experiments in field and controlled environments (eg. Phytotron, Open-top chambers, Free Air CO_2 Enrichment, etc.). A process-based crop simulation model links climate to plant physiological processes. Yield is modeled for a uniform crop and up-scaled to a larger area normally within some form of geographic information system (GIS). Some simulation models also integrate spatial and temporal variability in soil, weather, crop, pests, management factors and socio-economic dimensions. Integrated physiological and economic models allow holistic simulation of climate change effects on agricultural productivity, input and output prices, and risk of hunger in specific regions.

Aggarwal and Mall (2002) caution that the estimates of impact of climate change on crop production could be biased depending upon the uncertainties in climate change scenarios, region of study, crop models used for impact assessment and the level of management. Nevertheless, most of the simulation studies on Indian agro-climatic conditions have projected adverse effects of rising temperatures on productivity of foodgrains (Aggarwal, 2000; Aggarwal, 2003; Rao and Sinha, 1994). Rao and Sinha (1994) use a crop simulation study and observe that under a 2X carbon dioxide climate change scenario, wheat yields could decrease by 28-68% in the absence of carbon dioxide fertilization effects. Higher temperatures and reduced radiation associated with increased cloudiness causes spikelet sterility and reduces yield to such an extent that even increase in dry matter production as a result of CO_2 fertilization proves to be of no advantage in grain productivity (Sinha, 1994).

Simulations of the impact of climate change on rice and wheat yields for several stations in India using dynamic crop growth models (eg. WTGROWS, INFOCROP, CERES) indicated that in north India, a 2°C rise in mean temperature reduced potential grain yields of both the crops by about 15-17% (Aggarwal and Sinha, 1993; Hundal and Kaur, 2007). In Tamil Nadu, during the kharif season, the rice yields are anticipated to reduce by 10-15 percent by 2020 due to temperature and precipitation changes (Geethalakshmi and Dheebakaran, 2008). The magnitude of yield decline would aggravate further to 30-35% by 2050.

At the all-India level, a substantial reduction in wheat production is likely to occur for the scenarios of climate change. The wheat output is expected to barely reach 75 million tonnes in 2020 after incorporating the climate change effect (as against projection of nearly 100 million tonnes without considering climate change impact), if no new technological interventions and adaptation mechanisms are put into place. Beyond 2020, the yield increases that have been projected on the basis of input growth are unlikely to materialize a production would come down sharply (Figure 4).

Figure 4: Possible Impact of Climate Change on Wheat Production in India



Source NATCOM, 2004

Similarly, increased climatic variability may affect rainfed crops, such as pulses and coarse cereals. Decrease in yields have been reported in chickpea, pigeonpea (Mandal, 1998), sorghum (Chatterjee, 1998), other foodgrain crops, fruits and vegetables. In Rajasthan, a 2°C rise in temperature was estimated to reduce production of pearl millet by 10-15 percent (Ramakrishna et. al, 2000). The adverse effect of climate change would be highly pronounced in case of vegetables as these short duration crops are more susceptible to environmental factors, such as temperature changes hamper bulb development in onion and garlic, leads to decrease in fruit set in tomatoes, etc. Besides, changes in the temperature, precipitation and elevated CO_2 levels in the atmosphere, alterations in the soil moisture storage, pests and weeds, water availability and other such factors brought about by climate change will also affect agriculture in India (TERI, 2002). Considering the crop-pest interactions, for an estimated loss of about 30% of crop production due to biotic interference, 10% loss each is attributed to insect pests, pathogens and weeds (Kaur and Hundal, 2008).

The production of food from animal origin that is making increasingly important contribution towards nutritional security, may also suffer a serious setback due to sensitivity of livestock and marine production to climate change. The anticipated rise in temperature between 2.3 and 4.8°C over the entire country together with increased precipitation resulting from climate change is likely to aggravate the heat stress in dairy animals, adversely affecting their productive and reproductive performance, and reducing the total area where high yielding dairy cattle can be economically reared (Sirohi and Michaelowa, 2007).

By and large in the long run, the likely impact of climate change on food productivity in India can constrain attainment of household food security from domestic production.

Stability of Food Supplies Greater variability in the weather conditions together with increased frequency and severity of extreme events such as cyclones, floods, hailstorms, and droughts would bring about higher volatility in crop yields, adversely affecting the stability of food supplies and hence, food security. More frequent extreme events may lower long-term yields by directly damaging crops at specific developmental stages, such as, temperature thresholds during flowering, or by making the timing of field applications more difficult, thus reducing the efficiency of farm inputs (Antle et al., 2004; Porter and Semenov, 2005). The adverse impact of drought on agricultural productivity is well known. During the recent all-India drought in 2002, the foodgrain production fell to 174 million tonnes, about 18% lower than the previous year. The tropical cyclone that hit the state of Orissa in 1999 devastated nearly 2 million hectare of crop and resulted in a death toll of about 55,000 cattle. The impact of extreme events like storms and cyclones could be disproportionately large in case of India as it has a long, low lying, heavily populated coastline.

Besides food production, the issue of its distribution is also very critical for food security. If projected increases in climate change induced weather variability materialize, they are likely to lead to increases in the frequency and magnitude of food emergencies for which the global food system is ill-equipped to cope. This is particularly true in case of increased incidence of "sudden onset" disasters (e.g. floods, cyclones, hurricanes, earthquakes and volcanic eruptions) which leave much less time for planning and response than slow-onset ones (e.g. drought or prolonged dry spells).

Access to food The potential impact of climate change on food security is not just confined to reducing production of food, but also extends to adversely influencing the access to food by way of reduction in purchasing power of people. On one hand, climate impacts on income-earning opportunities can affect the ability to buy food, and on the other, potential supply shortages resulting from a change in climate or climate extremes may increase food prices, thus, making it unaffordable for economically weaker sections.

The available estimates of global warming impact suggest that the world GNP damages, in terms of percentages, are relatively low and spread unevenly. In general, developing countries lose more than developed economies. The estimates by Nordhaus (1998), for example, indicate that for a +2.5°C warming one might expect to see global damage amounting to 1.5-1.9% of world GNP. However, in Africa and India that impact might be closer to 4 and 5 percent, respectively. According to the Stern Report on Climate Change, over the next 100 years, in India, GDP loss may be to the tune of 0.67%. In India, where agriculture sector is an important source of income, the economic output from the sector itself is vital contributor to food security. The climate change impact models predict 12% reduction in agricultural net revenues for the country as a whole in the scenario of 2.0^{o} C rise in mean temperature and a 7% increase in mean precipitation level (Dinar et al.,1998). Kumar and Parikh (2001 a,b) estimated a drop in GDP by 1.8 to 3.4 per cent; and rise in agricultural prices relative to non-agricultural prices by 7 to 18 per cent without considering the carbon fertilization effect. Even with carbon fertilization effects, losses would be in the same direction but somewhat smaller. The authors contend that with the adaptation of cropping patterns and inputs from farmers losses would remain significant - a temperature increase of +3.5 °C and precipitation change of +15 per cent, the fall in farm level total net revenue would be nearly 25 per cent. The results broadly indicate that India is likely to face large contraction of agricultural incomes which would mean increasing food insecurity as financial access to food of poorest sections diminishes.

Other than changes in income, the other dimension of potential food access is possible climate change impact on food prices. Based on the review of the studies assessing the likely impacts of climate change on food price, Schmidhuber and Tubiello (2007) highlighted that till 2050, prices of food on an average are expected to rise moderately in line with moderate increases of temperature. After 2050 and with further increases in temperatures, prices are expected to increase more substantially, particularly for some commodities like, rice and sugar wherein prices are forecast to increase by as much as 80% above their reference levels without climate change.

The increase in real prices of food commodities is expected to persist for the next decade or so even though food prices may fall from high levels reached during 2006-08 as some of the short-term factors behind the high prices subside (FAO, 2008b). Besides the changes in socio-economic development paths that would lever this rise, the clamour for 'green fuel' from agricultural produce, a fallout of the international focus on climate change, would further fuel the hike in food prices. As bio-fuels viz. ethanol -blended petrol from cassava, corn and sugarcane, bio-diesel from rapeseed, jatropha, palm-oil, etc. are being looked upon as the new panacea for global warming, the effect of the diversion of arable land to bio-energy crops on food production and food security becomes topical.

Food Utilization The utilization of food consumed affects the nutritional status of human beings. While the indirect effect of climate change on nutrition is likely to be felt through its effects on income and capacity to purchase diverse foods products, especially high value commodities (like, fruits, vegetables, milk, etc.); the direct effects on the ability of individuals to use food effectively comprise of, changing disease pattern from vector, water, and food-borne diseases and alteration in the conditions for food safety. Climate change will cause new patterns of pests and diseases to emerge, affecting plants, animals and humans, and posing new risks for food security, food safety and human health.

Summing Up

IPCC's key observations on impact of climate change on agriculture include the following (although with varying confidence levels):

- Crop productivity is projected to increase slightly at mid to high latitudes for local mean temperature increases of up to 1-3°C depending on the crop, and then decrease beyond that in some regions.
- At lower latitudes, especially seasonally dry and tropical regions, crop productivity is projected to decrease for small local temperature increases (1-2°C), which would increase risk of hunger.
- Increases in the frequency of droughts and floods are projected to affect local production negatively, especially in subsistence sectors at low latitudes.

In the Indian context, the review of studies presented in this paper brought out that the rate of increase in agricultural production, particularly, that of rice and wheat crops, has shown considerable deceleration in the past decade. The supply projections of total cereal production that are largely based on data prior to observed decline in yield after the 90s, estimate the cereal output will lie in the range of 250-275 million tonnes in 2020 and shall be close to 300 million tonnes by 2030. However, considering the slow down in output response to yield improving inputs, and additionally the adverse impact of changing climate on crop production, it is likely that domestic cereal supply may fall considerably short of 300 million tonnes by 2030, if appropriate policy and technology interventions for yield improvements and climate change adaptations are not undertaken. For effective implementation of adaptation strategies, appropriate planning must start before the manifestation of climate change, wherein communication is an important means of preparedness for climate change.

On the demand side, even though the per capita foodgrain demand would decline as consumption basket of income groups becomes more and more diversified, aggregate demand for cereals would rise on account of population growth and rapid increase in cereal demand for livestock feed and uses other than direct human consumption. In the scenario of rising demand on one side, and technological and climate change related constraints impinging on supply on the other, it is likely that for India's food security, the demand –supply gaps in food production have to be increasingly filled through increased imports.

Swaminathan (2002) noted that poor nations have limited capacity to meet Kyoto Protocol regulations and need climate management systems to protect themselves against food insecurity from changes in temperature and precipitation. A Food and Water Security Management System is the best safety net against human induced climate changes. He identifies measures to develop and disseminate an avoidance and adaptation package for climate change in which a proactive monsoon management strategy needs to be developed. The Indian Agricultural Research Institute has promoted an Agricultural Intelligence system and is supporting the development of food banks to manage scarcity. It is imperative that the management and coping strategies presently employed by the local community to deal with adverse climatic conditions are comprehensively documented and existing policy structure is geared to mainstream climate change responses with development policies.

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