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PRODUCTION AND CONSUMPTION OF FOODGRAINS IN INDIA: IMPLICATIONS OF ACCELERATED ECONOMIC GROWTH AND POVERTY ALLEVIATION

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FOREWORD

The role of agriculture in India's economic development continues to be of great importance, as a producer of food, as an employer of about two-thirds of the labor force, and as a source of purchasing power for much of the nonagricultural consumer goods and services in the economy. Thus, rapid growth in agriculture is essential for sustainable growth and development of the economy.

Within agriculture, foodgrain production is by far the major activity, covering about 80 percent of the cropped area in India and providing the main staple source of food. Foodgrains provide almost all the calories and proteins consumed by the poor and provide the rural poor with the bulk of their employment and income. Further, with a population of some 800 million people, what happens to India's foodgrain supply-demand balances has important implications for the global balances. That will be particularly so as India continues to accelerate its overall rate of growth of per capita income.

Government policy in India has always given substantial importance to foodgrain production. Such support, particularly since the beginning of the green revolution in the mid-1960s, has contributed to remarkable growth in this sector despite many constraints. Yet with a growing population, rising incomes, and the substantial latent demand of the poor for foodgrains, the country will require continuing high growth in production.

The past performance and future prospects of Indian foodgrain production and consumption are of considerable importance in Third World and global food considerations. India, which faced food deficits till the mid-1970s, became self-sufficient or marginally surplus thereafter; but even with this remarkable food production performance, rapid economic growth and poverty alleviation have not been achieved. The implications of the achievement of these goals, say by 2000, on the food demand are not very clear, considering the interlinkages between the growth in foodgrain production and that in consumption, particularly in the rural areas. India is fortunately endowed with data that enable these implications to be analyzed.

In this study of foodgrains in India, J. S. Sarma and Vasant P. Gandhi critically examine past growth and performance in foodgrain production as well as developments in the growth and patterns of foodgrain consumption. The study finds that rapid growth in foodgrain production will be necessary but extremely demanding, especially in the context of the dual objectives set by Indian planners—acceleration of economic growth and alleviation of poverty. Within agriculture, these objectives will require not only rapid increase in foodgrain production but even faster growth, through diversification, in the nonfoodgrain sector, including livestock production and horticultural crops, in which income elasticities of demand and employment potential are high. However, even an impressive performance may leave foodgrain deficits that would require imports and an appropriate development strategy if accelerated economic growth and poverty alleviation are to be achieved.

The International Food Policy Research Institute has developed a collaborative research program on the future growth in Indian agriculture under a memorandum of understanding with the Indian Council of Agricultural Research and with funding from the United States Agency for International Development. The overall objective of the research program, undertaken in collaboration with research institutions and scholars in India, is to contribute toward increased understanding of the options and complexities in the future policies for agricultural growth. The present study is a step in this direction. We expect its results to be useful in the policy formulation processes, not only in India but also in other countries, especially since India's richness in data and experience allows analysis that may be difficult to duplicate elsewhere.

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July 1990

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SUMMARY

India has shown an impressive agricultural performance since the mid-1960s. The increasing shortages and inability to cope with growing food demand at that time gave way in the 1980s to occasional marginal surpluses. There are, however, grave doubts on several issues—a major worry being the trend in the growth of foodgrain production, which, according to some studies, shows deceleration in the recent past. This raises questions about the sustainability of the growth and an exhaustion of the potential of the "green revolution." There is also concern that the growth in production has had a narrow geographic and crop base and that substantial production growth may not be possible in other regions and crops. Serious doubts have also emerged about the productivities of modern inputs, which are used in increasing quantities to sustain growth. There is concern about whether these productivities are declining and, if so, whether they will continue to decline, making future growth both difficult and expensive. Yet another puzzle is the emergence of foodgrain surpluses (in the form of large government stocks) with coexisting hunger, even in the wake of impressive agricultural growth.

This study addresses these concerns by analyzing the nature and pattern of past growth in foodgrain production and consumption, using national and regional data on foodgrains. It uses this analysis to carefully extrapolate into the future, examining the prospects for growth in foodgrain production and how these compare with the likely levels of foodgrain consumption in the future. The Government of India has set for the year 2000 the twin principal objectives of acceleration of economic growth and elimination of poverty. The study examines the implications of these objectives for the foodgrain situation and the resulting demands on food and agricultural policy in India.

In examining the growth rates in several subperiods since the early 1950s, the study finds that the growth rate of foodgrain production declined somewhat from the pre-green-revolution period (1949/50-1964/65) to the first half of the green-revolution period (1967/68-1975/76), but from the first to the second half of the green-revolution period (1975/76-1983/84) the growth rate showed a modest acceleration from 1.9 percent to 2.5 percent a year. The overall growth rate for 1949/50-1983/84 was about 2.6 percent. This shows that the growth rate of foodgrain production has recovered and is being sustained.

Comparing the period of the early 1950s to mid-1960s with the mid-1960s to early 1980s, there was a sharp decline in the latter period in the growth rate of foodgrain area, indicating its declining potential. Yield-based growth, however, has sharply increased in importance, contributing over 90 percent of the growth in production during 1975/76-1983/84. Analysis shows that most of the yield-based growth came from wheat and rice—particularly wheat, whose average yield increased two and a half times between the early 1950s and early 1980s. At the national level, growth in the yields of individual crops has been of major importance behind the growth in overall yields and production of foodgrains. This indicates the criticality of policies for sustaining yield- and technology-based growth in the future.

Growth in foodgrain production shows much regional diversity, but this is changing. The rapid growth in the Northern region continues to accelerate, driven by increasing wheat and rice yields and diversion of area from coarse grains and pulses to wheat and rice. In 1975/76-1983/84 the Uttar Pradesh region showed a large increase in the growth rate of production, thus raising it almost to the level of the Northern region. This was also substantially due to increases in wheat and rice yields and diversion of area from coarse cereals and pulses to wheat and rice. The Central region also showed a large increase in the production growth rate in this period, distributed over wheat, rice, and coarse cereals.

On the other hand, the Western, Eastern, and Southern regions showed declining growth rates of foodgrain production. The Western region's decline appears to be mainly due to poor rainfall during 1975/76-1983/84 and possibly to little new, promising technology for the dryland agroclimatic regime. The Southern region's decline was largely due to diversion of area away from foodgrains—its yield growth stayed unchanged. The Eastern region's growth rate continued its decline, turning negative in this period, but the yield growth rate showed a small upturn. A common feature of foodgrain production in these three regions is that the growth rates of cereals declined sharply, whereas the growth rates of pulses remained relatively high and positive. The analysis shows that growth in foodgrain production now comes from a wider regional base than just the Northern region, that it is critically yield-based, and that the recent acceleration appears to be associated substantially with rapid increase in input use, particularly fertilizers.

Examination of all-India input use levels shows large increases in recent years. Among the major inputs, irrigation (gross irrigated area) shows a relatively steady increase, and high-yielding varieties (area under HYVs) shows a very impressive growth until the mid-1970s and then some deceleration. Fertilizer use shows substantial acceleration in the late 1970s and early 1980s. Analysis indicates a decline in the aggregate input productivities between 1969/70-1971/72 and 1981/82-1983/84, apparently beginning around 1977/78. The decline in input response, particularly aggregate fertilizer productivity, may be due in part to persistent concentration of input use in some areas and poor management toward maximizing response in others. This calls for considerable attention from both policymakers and researchers.

From the early 1950s to the early 1980s, the per capita availability of foodgrains for human consumption, on a three-year moving average basis, has fluctuated within a narrow band of 150-170 kilograms a year, with a statistically insignificant trend. Thus, foodgrain production growth seems to have been largely absorbed by population growth, reduction in imports, and increase in stocks. National Sample Survey consumption data indicate a small improvement in the distribution of total expenditure (income) between 1977/78 and 1983 in both the rural and urban areas, and between the rural and urban areas. For the poor population, the data indicate that foodgrain consumption of the rural bottom quartile rose somewhat between 1970/71 and 1983, but that of the urban bottom quartile was virtually stagnant. This is associated with a small increase in the real total expenditure (income) of the rural bottom quartile but near stagnation in that of the urban bottom quartile. The positive effect of development on the rural bottom quartile, though, seems to have been partly annulled by adverse movement of relative foodgrain prices for them.

The overall income elasticities of foodgrain demand are estimated to be 0.48 for rural, 0.23 for urban, and 0.42 for national, but elasticities differ sharply by quartile, being close to 1.0 for the bottom quartiles and about 0.1 for the top quartiles. Viewed in conjunction with the income growth patterns, these figures indicate that a major reason for India's direct foodgrain consumption not increasing more rapidly is that development appears to have had too little effect on raising the incomes of the poor, who have high income elasticities of demand for foodgrains.

Broad calculations and experience from other developing countries indicate that demand for animal feedgrains may rapidly become a major component of growth in the total demand for foodgrains. Livestock output grew at a rate of 4.33 percent a year between 1970/71 and 1984/85, and such a trend may result in a derived demand growth of 5-6 percent a year for feedgrains.

Assuming substantial government emphasis on agriculture, it is possible that past performance in production may be extended into the future. Region by region, crop by crop, area and yield projections on foodgrain production, based on growth rates from 1967/68 to 1983/84 with some necessary restrictions, show that the total production of foodgrains in India by the year 2000 may reach about 220 million metric tons. Different, more aggregative methods of projection indicate possible foodgrain production of 210-215 million tons by year 2000. Achievement of these production levels will, however, be a formidable task and is estimated to require 100 million hectares of irrigated area, 20 million tons of fertilizer (NPK) use a year, and production and distribution of 6 million tons of HYV and improved seeds. It will also require a substantial government commitment to technology-based growth in agriculture.

On the consumption side, the study made particular efforts to examine the implications of the twin objectives set by the Indian planners—acceleration of economic growth and elimination of poverty by 2000. Results showed that the foodgrain consumption (demand) outcome in 2000 can vary from 206 to 240 million tons including seed, feed, other uses, and wastage. The analysis showed that the development outcome could make a large difference in the foodgrain situation in 2000, ranging from India's becoming either self-sufficient or surplus in foodgrains to becoming significantly deficit and an importer. The estimates show, in particular, that achieving the twin objectives is likely to have a substantial impact on the demand for foodgrains. This will call for unrelenting efforts to increase foodgrain production and productivity. But even a remarkable performance on the production side, amounting to a 2.8 percent a year growth rate in foodgrain production compared with 2.6 percent in the past, may still leave a large supply-demand gap and a sizable need for imports. This will in turn call for an open mind toward imports, political courage to make them, and an appropriate economic strategy to support them if acceleration of economic growth and poverty alleviation are to be achieved.

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INTRODUCTION

In the past 25 years the foodgrain situation in India has undergone substantial change. From a position of growing shortages in the mid-1960s, India became able in the 1980s to produce enough to meet its current demand and sometimes generate a small surplus. This shift has led to a growing complacence in some quarters, but concern in others, about several underlying features of production and consumption that may make the present position difficult to sustain over the years. This study addresses growth and patterns in India's foodgrain production and consumption along with some of the major factors influencing them. It then examines how production and consumption are likely to change in the future and what the state of foodgrains might be under alternative scenarios of growth and development.

In an earlier IFPRI report, Sarma and Roy (1979) examined the data on production, availability, and consumption of foodgrains in India during the period 1960/61-1976/77.[1] The report raised concerns about an apparent stagnation or decline in the per capita consumption of foodgrains in the country. The performance of Indian agriculture was reviewed in another IFPRI report (Sarma 1981), which concluded that the new strategy of agricultural production based on high-yielding varieties (HYVs) did contribute to the growth in foodgrain production and productivity. But, since this growth was confined largely to wheat and irrigated areas, its overall impact on aggregate foodgrain production growth was limited. Another IFPRI report (Paulino 1986) examined past global trends in production and consumption of major food crops in the developing countries at the overall and country group levels, and projected them to 2000 to identify the emerging gaps between projected output and estimated demand. Trend analysis of food production and consumption was attempted by Paulino and Sarma (1988) at the country level for two major countries, Nigeria and Brazil, in 1986. With this background, the present work attempts a detailed study on foodgrains in India.

In past literature on Indian agricultural performance there were concerns in the early 1980s about a possible deceleration in foodgrain production (Alagh and Sharma 1980; Desai and Namboodiri 1983). Mehra (1981) and Hazell (1982) examined the question of instability in foodgrain production and found that instability had increased after the green revolution. Bhalla and Alagh (1978) studied the growth rates at the district level between 1962-65 and 1970-73; their main finding was that the yield effect was the major component of growth in most of the 48 high-growth districts. Dev (1985) extended this analysis to 1975-78. More recently, Bhalla and Tyagi (1989) have examined growth in agriculture at the district and state levels using averages of 1962/63-1964/65, 1970/71-1972/73, and 1981/82-1983/84. They examined spatial aspects of association between growth and modern input use, and changes in regional concentration.

[1] In reference to production, area, and yield, the split years such as 1983/84 refer to the crop year from July 1983 to June 1984. The availability data relate to calendar years. The output of agricultural year 1983/84 is treated as available for consumption in calendar year 1984.

Narain (1977) studied the growth rate of productivity by decomposing it and segregating the effects of changes in cropping pattern and the spatial shifts of crops. Although the contribution of new technology to the acceleration of wheat production is well recognized, there has been some controversy over its contribution to overall foodgrain and agricultural production (Mitra 1968; Minhas and Srinivasan 1968; Srinivasan 1972, 1979; Rao 1975; Rudra 1978; Dantwala 1978). Dantwala found that the HYV technology brought about significant improvement in the productivity of cereal crops, but its overall effect on foodgrain production, especially when evaluated in per capita terms, is not significant.

Trends and projections for foodgrains in India have also been made by a number of national and international organizations such as the National Commission on Agriculture, the World Bank, and the Indian Planning Commission. These studies, however, were mainly based on analysis of national aggregate data. A study (IFPRI 1984) that examined Asian Development Bank countries, including India, also falls in this category.

The present study extends IFPRI's trend analysis to policy research for foodgrains in India. It uses national data disaggregated into regions and relevant time periods on the output side and into rural and urban areas and income groups on the demand side. But the primary focus is on policy research based on the following questions: Has the trend in India's foodgrain production decelerated in recent years? What has been the performance of different regions and different crops and how has it changed over time? What has been the contribution of area, yield per hectare, and the cropping pattern on the one hand and inputs such as irrigation, HYVs, fertilizers, and rainfall on the other to the increase in production? Has there been any decline in the productivity of yield-increasing inputs over time? What have been the trends in the consumption of foodgrains over time in rural and urban areas? In light of this analysis, what are the prospects for growth in foodgrain output by 2000, and how does the projected level of production compare with the likely level of consumption in that year? What would be the implications for foodgrains of the objectives of faster economic growth and elimination of poverty envisaged in the Perspective Plan of the Government of India (India, Planning Commission 1985, vol. 1, chap. 2).

The total geographical area of India is about 329 million hectares, of which nearly 47 percent is cultivated. The gross area under foodgrains in 1983/84 was estimated at about 131 million hectares, or nearly three-fourths of the gross cropped area. Foodgrain output in the same year was 152 million metric tons,[2] giving an average yield per hectare of about 1.16 tons.[3] About 31 percent of the area under foodgrains was irrigated, and around 54 million hectares were covered by HYV cereals in 1983/84. The total consumption of chemical fertilizers was 7.7 million tons (NPK), of which 60 percent was endogenously produced. The share of foodgrains in fertilizer use is estimated at about 75 percent. The estimated midyear population of India in 1984 was 736 million, of which about 77 percent were in the rural areas. The total net availability of foodgrains, excluding the allowances for seed, feed, and wastage, and including imports and changes in government stocks, was about 129 million tons, giving a per capita availability of 175 kilograms in that year.

Chapter 3 examines the trends and changes in production of rice, wheat, coarse cereals, pulses, and total foodgrains at the all-India aggregate level and at the regional

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[2] All tons in this report are metric tons.

[3] Foodgrains include rice, wheat, maize, sorghum, *bajra*, *ragi*, small millets, barley, gram, and other pulses. The area and output data relate to crop year July to June, divided into *kharif* and *rabi* seasons.

level.[4] The time span of the analysis, 1949/50-1983/84, is divided into the pre-green-revolution period (1949/50-1964/65) and the green-revolution period (1967/68-1983/84).[5] The second period is subdivided into two subperiods, 1967/68-1975/76 and 1975/76-1983/84. The country is divided into six regions, Northern, Uttar Pradesh, Central, Western, Eastern, and Southern, mainly on the basis of geographical location, agroclimatic conditions, cropping pattern, and approximately equal shares in total foodgrain production.

Input productivity and production behavior of foodgrain output are examined in Chapter 4 using response coefficients, factor analysis, and production function analysis. An attempt is made to find the timing and magnitude of the change in input productivities and to separate the effects of fluctuations in rainfall on production by using a specially constructed all-India foodgrain rainfall index.

Chapter 5 examines the changes over time in per capita availability of foodgrains for human consumption, based on data from the Ministry of Agriculture, and in per capita direct consumption, using National Sample Survey data. Changes in the patterns of consumption are also examined. Alternative scenarios of production and consumption in 2000 and the resulting supply-demand balances are discussed in Chapter 6, while Chapter 7 reviews the important conclusions of this study and their policy implications.

[4] Coarse cereals include maize, sorghum, *bajra*, *ragi*, small millets, and barley. Rice, wheat, and coarse cereals together form the cereals group.

[5] The years 1965/66 and 1966/67 were highly abnormal drought years and hence were not included in this analysis.

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TRENDS AND CHANGES IN FOODGRAIN PRODUCTION

The past performance of the growth in foodgrain production in India is examined here in the aggregate and with some principal underlying disaggregations into time periods, major crops, area and yield, and six major growing regions. Examination of the overall aggregate time-series data shows that, with some fluctuations, and possibly with changes in contributory factors, the long-term growth of foodgrain production has been sustained at about 2.6 percent a year for over three decades.[6] Analysis indicates that about 30.0 percent of this growth came from area increase and about 70.0 percent from higher yields per hectare. This shows that yield increase has played a major role in the growth of foodgrain production, and policies to sustain yield growth will be crucial for the future.

The initial rapid increase in cropped area continued until the early 1960s (Table 1). Of the total increase in average gross cropped area from 97.3 million hectares in

Table 1—Area, yield, and production of foodgrains, 1949/50-1983/84

	Three-Year Average				
Item/Period	**Rice**	**Wheat**	**Coarse Cereals**	**Pulses**	**All Food-grains**
Cropped area (million hectares)					
1949/50-1951/52	30.5	9.7	38.3	18.9	97.3
1962/63-1964/65	36.1	13.5	44.2	24.1	117.8
1967/68-1969/70	37.0	15.9	46.9	22.0	121.8
1981/82-1983/84	39.9	23.5	41.7	23.4	128.5
Yield (kilograms/hectare)					
1949/50-1951/52	763	688	464	501	587
1962/63-1964/65	1,014	812	557	471	708
1967/68-1969/70	1,060	1,160	577	518	790
1981/82-1983/84	1,332	1,784	746	517	1,076
Production (million metric tons)					
1949/50-1951/52	23.3	6.6	17.8	9.5	57.1
1962/63-1964/65	36.6	11.0	24.6	11.3	83.5
1967/68-1969/70	39.3	18.4	27.1	11.4	96.2
1981/82-1983/84	53.3	41.9	31.1	12.1	138.4

Sources: Based on data from India, Ministry of Agriculture, Directorate of Economics and Statistics, *Area and Production of Principal Crops in India*, various issues (Delhi: Controller of Publications, various years).
Notes: 1965/66 and 1966/67 were highly abnormal drought years and therefore have been excluded from the analysis. Parts may not add to totals because of rounding.

[6] In computing this long-term growth rate, the production estimates for the abnormal drought years 1965/66 and 1966/67 were involved. If a dummy is used instead for these years, the resulting change in the output growth rate is marginal, from 2.5643 percent without the dummy to 2.5586 percent with the dummy.

1949/50-1951/52 to 128.5 million hectares in 1981/82-1983/84, two-thirds came during the pre-green-revolution period, that is, up to 1962/63-1964/65. With the green revolution (beginning in 1967/68), the major source of growth became the yield, and almost three-fourths of the overall increase in average yield—from 587 kilograms in 1949/50-1951/52 to 1,076 kilograms per hectare in 1981/82-1983/84—occurred after 1967/68. Thus, over the years there has been a change toward increased importance of yield-based growth.

Based on three-year averages among the crops, wheat played a very important role in raising foodgrain production. The yield or per unit area productivity of wheat at 688 kilograms per hectare was below that of rice at 763 kilograms per hectare (measured as milled rice) in 1949/50-1951/52. However, the productivity of wheat rose more than two and a half times and by 1981/82-1983/84 reached a level (1,784 kilograms per hectare) substantially higher than that of rice (1,332 kilograms per hectare). From the beginning of the green revolution, average yields increased by 55 percent for wheat, 25 percent for rice, and 30 percent for coarse cereals. The average yield of pulses remained relatively stagnant at the all-India level. Thus the yield-based growth of the green-revolution period was substantially due to wheat, with smaller contributions from rice and coarse cereals, and almost no contribution from pulses.

It is important to note that the area under wheat also rose nearly two and a half times from 9.7 million hectares in 1949/50-1951/52 to 23.5 million hectares in 1981/82-1983/84, substantially enhancing its contribution to production. The area under rice, coarse cereals, and pulses increased relatively little, especially after the green revolution. The annual average overall foodgrain production in India increased from 57.1 million tons in 1949/50-1951/52 to 138.4 million tons in 1981/82-1983/84, a fairly impressive increase of 142 percent. About half of this increase, to which rice contributed 40 percent and wheat another 30 percent, came before the green revolution. Between 1967/68-1969/70 and 1981/82-1983/84, wheat contributed 55 percent and rice 33 percent of the increased foodgrain output, which grew at an average rate of 3 million tons a year.

Given the large differences in yield as well as changes in area under different crops, particularly rice, wheat, and coarse grains (coarse cereals plus pulses), it was important to at least broadly investigate which part of the large overall increase in yield came from what can be called the "pure yield effect" (see Narain 1977) and which part came from the "cropping pattern effect." The analysis was carried out for fine grains (wheat and rice) and coarse grains (coarse cereals and pulses), following methodology described in Appendix 1. The results, based on all-India data, show that in the pre-green-revolution period as much as 97 percent of the yield increase came from the pure yield effect, and only about 2 percent came from the cropping pattern effect (Table 2). In the green-revolution period the share of the cropping pattern effect rose to 11 percent, but the share of the pure yield effect remained high at 83 percent. The analysis shows that even though cropping pattern changes can have a large effect on yield increase (and possibly did so in some regions), the all-India yield increase seems to have been driven substantially by pure increases in the individual crop yields. This may in part be because of rigidities on account of basic agroclimatic conditions as well as constraints from consumption patterns that may have limited the cropping pattern changes. The analysis indicates that, within the importance of yield-based growth, input-based pure yield growth for each major crop may be of considerable significance in overall growth of yield and production. This may call for a research and extension focus on each of the major crops.

Table 2—Decomposition of yield increase into pure yield effect and cropping pattern effect, 1949/50-1983/84

Category[a]	Three-Year Averages 1949/50-1951/52	1962/63-1964/65	1967/68-1969/70	1981/82-1983/84
Area (million hectares)				
Fine grains	40.1	49.6	52.9	63.4
Coarse grains	57.1	68.3	68.9	65.1
All foodgrains	97.3	117.8	121.8	128.5
Yield (kilograms/hectare)				
Fine grains	745	959	1,090	1,499
Coarse grains	477	526	558	664
All foodgrains	587	708	789	1,076
Area share (percent)				
Fine grains	0.4126	0.4205	0.4342	0.493
Coarse grains	0.5874	0.5794	0.5658	0.506
Change in area share (percent)				
Fine grains	...	0.0079	...	0.059
Coarse grains	...	−0.0080	...	−0.592
Change in yield (kilograms/hectare)				
Fine grains	...	214	...	409
Coarse grains	...	50	...	106
All foodgrains	...	121	...	287
Pure yield effect (kilograms/hectare)	...	117.45	...	237.17
Pure yield effect (percent)	...	97.22	...	82.79
Cropping pattern effect (kilograms/hectare)	...	2.08	...	31.40
Cropping pattern effect (percent)	...	1.72	...	10.96
Interaction (kilograms/hectare)	...	1.29	...	1.07
Interaction (percent)	...	17.91	...	6.25

Sources: Based on data from India, Ministry of Agriculture, Directorate of Economics and Statistics, *Area and Production of Principal Crops in India,* various issues (Delhi: Controller of Publications, various years).
Note: Methodology is discussed in Appendix 1.
[a]Fine grains are rice and wheat. Coarse grains are coarse cereals and pulses.

All-India Growth in Foodgrain Production

In the recent literature on Indian agricultural performance, there have been serious concerns about a possible deceleration in the growth of foodgrain production in the late 1970s and early 1980s (see Alagh and Sharma [1980], Desai and Namboodiri [1983]). Later data permit a critical reexamination of this issue. For this purpose, the period 1949/50-1983/84 is divided into two periods, 1949/50-1964/65 (before the green revolution) and 1967/68-1983/84 (the green-revolution period)[7], and the latter period is further divided into two equal subperiods: 1967/68-1975/76 and 1975/76-1983/84.

Analysis shows that compared with the pre-green-revolution period, growth rates in foodgrain output in 1967/68-1975/76 were lower, at 1.9 percent a year, but in 1975/76-1983/84 growth accelerated to 2.5 percent a year (Table 3).[8] The drop in the

[7] The years 1965/66 and 1966/67 were years of abnormal drought and have been omitted from the growth rate calculations in this section.

[8] Computation of reliable growth rates in crop production where seasonal factors cause annual fluctuations is difficult. Depending upon the length of the period covered, its beginning and end points and the computation formula adopted, the rates of growth differ greatly, even after the production data are adjusted for changes in coverage and methods of estimation.

Table 3—Growth rates in area, yield, and production of foodgrains, 1949/50-1983/84

Category/Period	Rice	Wheat	Coarse Cereals	Total Cereals	Pulses	All Food-grains
			(percent/year)			
Area						
1949/50-1964/65	1.34	2.69	0.89	1.30	1.87	1.41
1967/68-1975/76	0.67	3.20	−1.07	0.31	0.77	0.40
1975/76-1983/84	0.22	1.94	−0.46	0.31	−0.32	0.19
1967/68-1983/84	0.62	2.71	−0.83	0.39	0.42	0.39
1949/50-1983/84	0.91	2.82	0.07	0.84	0.33	0.74
Yield						
1949/50-1964/65	2.23	1.27	1.25	1.77	−0.41	1.41
1967/68-1975/76	1.21	2.18	1.35	1.90	−1.27	1.50
1975/76-1983/84	1.75	3.72	1.14	2.45	0.11	2.28
1967/68-1983/84	1.59	2.88	1.84	2.41	−0.21	2.14
1949/50-1983/84	1.52	3.12	1.40	2.04	−0.13	1.81
Production						
1949/50-1964/65	3.49	3.99	2.16	3.09	1.44	2.84
1967/68-1975/76	1.89	5.47	0.27	2.22	−0.51	1.91
1975/76-1983/84	1.97	5.72	0.68	2.77	−0.22	2.48
1967/68-1983/84	2.23	5.67	1.00	2.80	0.21	2.54
1949/50-1983/84	2.45	6.02	1.46	2.90	0.20	2.56

Sources: Based on data from India, Ministry of Agriculture, Directorate of Economics and Statistics, *Area and Production of Principal Crops in India,* various issues (Delhi: Controller of Publications, various years).
Note: 1965/66 and 1966/67 were abnormally severe drought years and therefore have been excluded from the subperiods.

output growth rate in 1967/68-1975/76 can be largely attributed to a drop in the area growth rate, but in 1975/76-1983/84 the growth in yield per hectare accelerated from 1.5 percent to 2.3 percent, thereby compensating for the declining growth in area under foodgrains. Thus, contrary to the concerns about deceleration, there appears to have been some acceleration in foodgrain production from the first to the second half of the green-revolution period. More recent preliminary data show that for the succeeding three years, foodgrain production broadly hovered around the 1983/84 level of 152.4 million tons.

The difference in production growth rates between 1967/68-1975/76 and 1975/76-1983/84 when tested by a Chow F-test is not statistically significant. In this connection, Mellor (1988) has noted that there are insurmountable statistical problems in detecting and substantiating small changes in the rates of growth of agricultural production. Year-to-year weather-induced fluctuations in production are very large relative to the economically significant changes in the trend that are important to detect. Choosing a period with a few more good or bad years at either end in a time series can substantially alter the results. This is illustrated in a table (Mellor 1988, 66) on which Mellor notes that an alternative would be to compute rates of growth across peaks and troughs in production that are selected for equivalency in weather variables. For instance, on this basis Mellor finds a growth rate as high as 3.0 percent between the excellent years of 1971/72 and 1983/84. Using this approach, he states that the foodgrain production growth rate in India may have accelerated between the mid-1970s and mid-1980s from somewhat under 2.8 percent to about 3.0 percent. The findings in the present study substantiate this acceleration using time-series growth rates.

The analysis here also shows that there are large differences in the growth rates across different crops (Table 3). Between 1967/68 and 1983/84, wheat output grew at a rate of 5.7 percent a year, which is more than double the overall growth rate in foodgrain output. Both area and yield per hectare contributed almost equally to this growth. The pre-green-revolution growth rate in wheat was around 4.0 percent, to which area contributed about two-thirds. The growth in rice output was 3.5 percent before the green revolution and in 1967/68-1983/84 was 2.2 percent, of which 70 percent was contributed by yield growth. The output of coarse cereals was rising more slowly. There was a decline in the area under coarse cereals in the green-revolution period, but this was more than compensated for by the yield increase. Pulse production continued to be stagnant. The overall rate of increase in area under foodgrains between 1967/68 and 1983/84 was less than 0.4 percent a year, which may continue into the future. This implies that future increases in production will need to come largely from yield increases.

The long-term (1949/50-1983/84) growth rate in foodgrain production came to more than 2.6 percent, to which wheat contributed a large share with a production growth rate of more than 6.0 percent, followed by rice at about 2.5 percent. About half of the growth in wheat production came from its area growth. Given the slow growth in overall foodgrain area, this indicates an increasing share for wheat, mainly through substitution away from coarse cereals to wheat. Production of coarse cereals grew more slowly at about 1.5 percent, primarily due to yield growth, whereas pulses showed a growth rate of only 0.2 percent with a negative yield growth rate. Slow growth in these crops, particularly when demand patterns cannot change, begins to be reflected in their relative prices, and this is increasingly apparent for pulses. Coarse cereals may follow suit if feedgrain demand increases. Poor growth in coarse cereals also affects agricultural growth in dryland regions, where they continue to be the principal crops.

Regional Growth in Foodgrain Production

India has substantial regional heterogeneity in many aspects such as agroclimatic conditions, resource endowments, development, and cropping patterns. Agriculture therefore varies significantly across different parts of the country. This diversity makes it meaningful to divide the country into regions for examination of production performance. Such division also makes possible a study of underlying regional performance over time, comparison of production growth across regions, and crop performance within and across regions, all of which can help address important issues pertaining to the extent and nature of regional concentration of growth and its persistence.

Division into Regions

The 31 states and union territories of the country have been grouped into six broad regions: Northern, Uttar Pradesh, Central, Western, Eastern, and Southern. The criteria adopted for this grouping were geographic location, agroclimatic conditions, cropping pattern, and division of the total foodgrain production into somewhat equal parts. The composition and important characteristics of the regions are shown in Tables 4 and 5.

The Northern region, consisting of the far northern states and territories, contributed about 16 percent of the all-India foodgrain production in 1980/81 with a share of only 8 percent in foodgrain area, giving it a relatively high average yield of 1.9 tons per hectare. Wheat predominates among foodgrains in the region, with a 58 percent share of foodgrain production.

Table 4—Composition of regions and regional shares of foodgrain production, 1980/81

Region	States and Union Territories	Share of Population	Share of Foodgrain Production	Relative Share of Crops in Foodgrain Production: Wheat	Rice	Coarse Cereals and Pulses	Total
				(percent)			
Northern	Punjab, Haryana, Jammu and Kashmir, Himachal Pradesh, Delhi, Chandigarh	6.8	15.9	58	25	17	100
Uttar Pradesh	Uttar Pradesh	16.2	19.2	54	22	24	100
Central	Madhya Pradesh, Rajasthan	12.6	14.6	29	22	48	100
Western	Maharashtra, Karnataka, Gujarat, Goa, Daman and Diu, Dadra and Nagar Haveli	19.7	15.7	12	26	62	100
Eastern	Bihar, West Bengal, Orissa, Assam, Tripura, Manipur, Meghalaya, Arunachal Pradesh, Nagaland, Sikkim, Mizoram, Andaman and Nicobar Islands	26.0	21.7	11	75	14	100
Southern	Andhra Pradesh, Tamil Nadu, Kerala, Pondicherry, Lakshadweep	18.7	13.0	...	74	26	100
All India	...	100.0	100.0	28	41	31	100

Sources: Based on data from India, Ministry of Agriculture, Directorate of Economics and Statistics, *Area and Production of Principal Crops in India,* various issues (Delhi: Controller of Publications, various years); and India, Ministry of Agriculture, Directorate of Economics and Statistics, *Indian Agriculture in Brief,* various issues (Delhi: Controller of Publications, various years).
Note: Parts may not add to totals because of rounding.

Table 5—Regional foodgrain yields and shares of area and major inputs, 1980/81

Region	Yield per Hectare of Foodgrains	Gross Cropped Area	Area Under Foodgrains	Area Under High-Yielding Varieties	Fertilizer Consumption	Irrigated Area
	(kilograms)			(percent)		
Northern	1,940	7.8	8.4	16.2	19.1	19.6
Uttar Pradesh	1,219	16.0	16.2	20.5	21.3	22.9
Central	627	22.1	23.8	11.7	6.2	12.5
Western	803	23.0	19.9	19.2	20.9	13.2
Eastern	1,061	19.0	20.9	17.9	10.8	15.6
Southern	1,227	12.1	10.9	14.5	21.8	16.2
	(kilograms)		(million hectares)		(million metric tons)	(million hectares)
All India	1,023	162.2	126.7	43.1	5.5	49.6

Sources: For area and yield, India, Ministry of Agriculture, Directorate of Economics and Statistics, *Area and Production of Principal Crops in India,* various issues (Delhi: Controller of Publications, various years); and for fertilizers, high-yielding varieties, and irrigation, Fertilizer Association of India, *Fertilizer Statistics* (New Delhi: FAI, 1985 and 1986).

The state of Uttar Pradesh, which because of its size and total production is here considered a region by itself, contributed almost 20 percent of India's foodgrain production with a 16 percent share in area. Its crop production pattern is similar to that of the Northern region, with wheat holding a 54 percent share in the foodgrain output of Uttar Pradesh. Coarse cereals and pulses are somewhat more important and rice somewhat less important here than in the Northern region.

The Central region comprises the states of Madhya Pradesh and Rajasthan and produced about 15 percent of the country's foodgrains with a 24 percent share in the area. Coarse grains and pulses are much more important in this region than in the Northern and Uttar Pradesh regions, but wheat is also fairly important with a share of 29 percent. The average foodgrain yield is relatively low at 627 kilograms per hectare.

The Western region contributed about 16 percent of India's foodgrains with a share of 20 percent in area. Coarse grains and pulses predominate and together hold a share of more than 60 percent in the region's production. The average foodgrain yields are low, at 803 kilograms per hectare, because of the predominant share of coarse grains and pulses. Wheat is not important but rice holds a significant share.

The Eastern region, composed of all the eastern states, had a 22 percent share in the country's foodgrain production. It is predominantly a rice-growing area, with that crop holding a 75 percent share of the region's foodgrain production. The remaining 25 percent is distributed among wheat and other foodgrains. The average foodgrain yield per hectare is about 1,060 kilograms.

The Southern region contributes 13 percent of the national output of foodgrains and is predominantly a rice-producing area but has almost no wheat. Coarse grains and pulses have a 26 percent share in the region's production. Rice yields here are the second highest among the regions at 1,880 kilograms per hectare, and the overall foodgrain yield of 1,227 kilograms per hectare is also the second highest after that of the Northern region.

The distribution of input use is also unequal among the regions (Table 5). The Uttar Pradesh region had the largest share in gross irrigated area and in area under HYVs, while the Southern region accounted for the largest share in consumption of fertilizers in 1980/81. The Central region had the smallest shares in each of these three inputs. Uttar Pradesh, with 23 percent, is followed closely by the Northern region in the share of gross irrigated area. Barring the Central and Uttar Pradesh regions, the share of the other four regions varied from 15 to 19 percent in total area under HYVs. Of the total consumption of 5.5 million tons of chemical fertilizers (NPK), four of the six regions used 19-21 percent each. The share of the Eastern region was only about 10 percent despite a large share in area. On a per hectare basis, fertilizer consumption in the Northern region was more than double that of the national average.

Assembling consistent and comparable data for the regional study of production posed many problems. First, it involved putting together data from the present 31 states and union territories over some 30 years. Many new states have been created during this period, and the boundaries of many states have been redefined, resulting in changes in the distribution of cropped area. The system of crop reporting has been extended to new areas, thus bringing in an element of noncomparability in the reported estimates over time. Traditional methods of yield estimation based on eye estimates of the condition of the crop have been gradually replaced by systematic and objective crop-cutting techniques, state by state. The effects of all these changes pose great problems for time-series data analysis and valid regional comparisons. Appendix 2 describes the way in which these problems were overcome. On this basis, largely consistent and comparable time-series statistics for cropped area, yield, and production could be assembled for rice, wheat, coarse cereals, total cereals, pulses, and total foodgrains from 1952/53 to 1983/84 for the six regions of the country.

Comparison of Regional Growth Performance

The time span from 1952/53 to 1983/84 is divided into three appropriate subperiods: 1952/53-1964/65 is considered the pre-green-revolution period, 1967/68-1975/76 the first part of the green-revolution period, and 1975/76-1983/84 the second part of the green-revolution period. The years 1965/66 and 1966/67 were excluded from the growth rate analysis because they were highly abnormal, severe, and consecutive drought years, which would strongly affect growth rate estimates and their comparability.

Semilogarithmic trend equations were fitted to the annual time-series data to obtain compound growth rates. The growth rate estimates are given in Table 6, and a few salient growth rates are illustrated in Figures 1 and 2. The growth rate t-statistics are in Appendix 3. Some broad figures on input levels in the six regions at three appropriate time points in the green-revolution period are provided in Table 7. These may help in observing some possible associations behind differences and changes in these growth rates. The growth rate results indicate striking differences in growth across regions and over time.

Overall Foodgrain Growth Rates

In the Northern region, production of foodgrains has been growing at a rapid rate of 3.5-5.0 percent throughout the postindependence period. The overall foodgrain growth rates (Table 6) show that the contribution of area to this growth gradually declined in the 1952/53-1983/84 period, whereas the contribution of yield substantially increased. From 1967/68-1975/76 to 1975/76-1983/84 there was a large acceleration in the production growth rate, from 3.3 percent to 5.1 percent. This came mainly from an increase in yield growth rate, from 2.0 percent to 4.2 percent, which was substantially spurred by an increase in the yield growth rate of wheat as well as rapid area growth in both rice and wheat—apparently at the expense of other cereals and pulses. This indicates that the cropping pattern effect made an important contribution to yield growth in this region. The input data in Table 7 show that all inputs have contributed to this growth, but rapid increase in fertilizer use during 1975/76-1983/84 may have influenced the acceleration in production growth.

In this respect the Uttar Pradesh region shows a dramatic change. Its production growth rate was the lowest among the six regions in both the pre-green-revolution period (0.79 percent) and the first half of the green-revolution period (0.52 percent). From this it jumped to 4.8 percent in the second half of the green-revolution period. This is an enormous change for the region and very significant for India, since Uttar Pradesh has a large share in the country's foodgrain production and area. Eighty percent of this high growth rate is attributable to yield growth, since foodgrain area rose at only around 1 percent a year. Table 7 shows that a large contribution to this increase may have come from fertilizers—the annual rate of increase in fertilizer use quadrupled in this period, whereas the rates of increase in irrigation and HYVs did not show a large change.

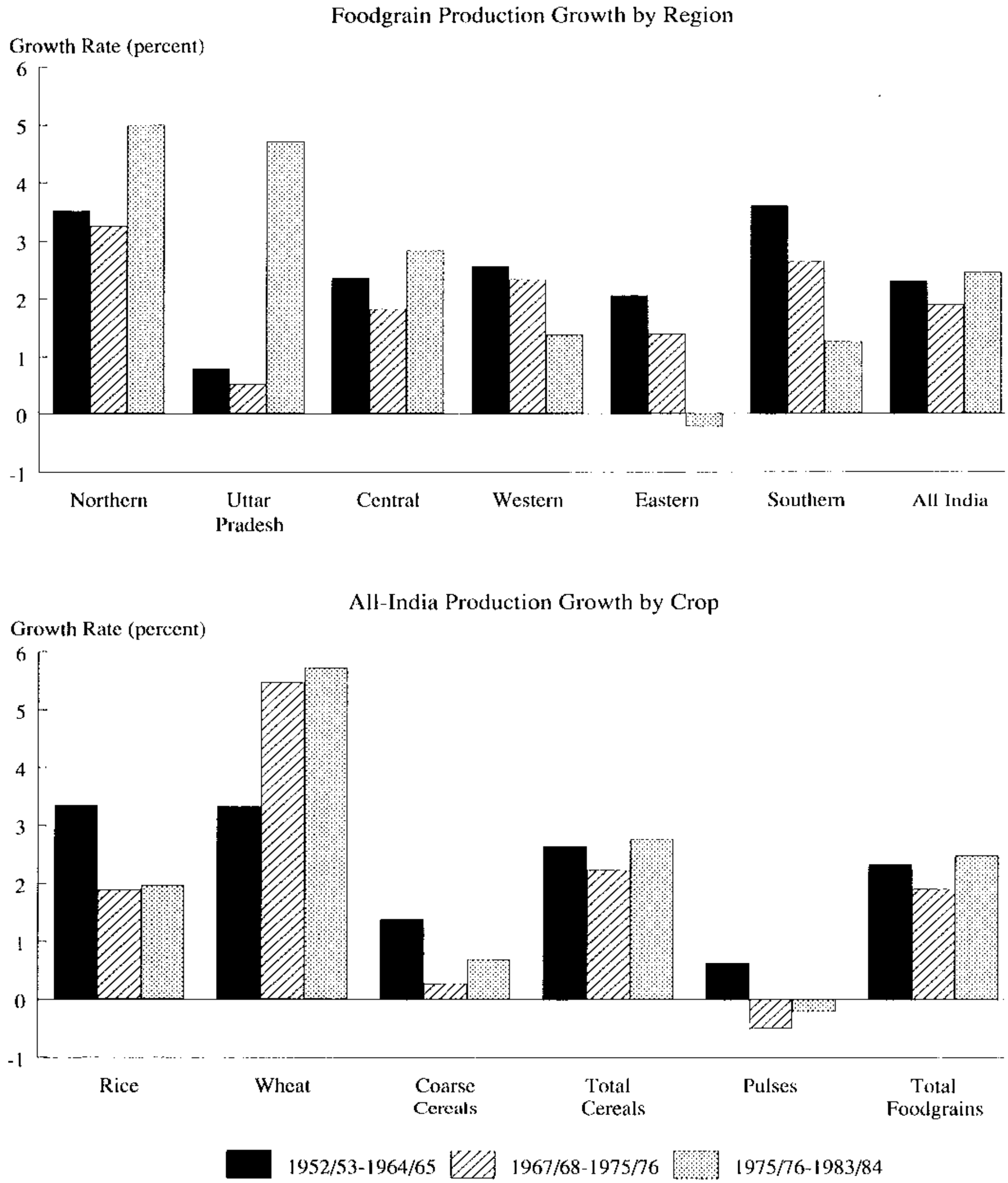
A positive change also took place in the Central region, where the growth in output of foodgrains increased from 1.8 percent to 2.9 percent between the first and the second parts of the green-revolution period. Both area and yield increases contributed to this growth. Input data show that these could have come from significant increases in irrigation and fertilizer use.

Table 6—Regional growth rates of area, production, and yield of foodgrains, 1952/53-1983/84

Region/Period	Rice			Wheat			Coarse Cereals			Total Cereals			Total Pulses			Total Foodgrains		
	Area	Production	Yield	Area	Production	Yield	Area	Production	Yield	Area	Production	Yield	Area	Production	Yield	Area	Production	Yield
	(percent/year)																	
Northern																		
1952/53-1964/65	4.64	5.99	1.29	3.30	5.25	1.89	−0.17	2.45	2.62	1.84	4.39	2.52	1.37	1.23	−0.14	1.64	3.58	1.91
1967/68-1975/76	4.54	10.24	5.45	2.75	4.49	1.69	0.21	0.85	0.65	1.98	4.38	2.36	−1.98	−5.77	−3.85	1.26	3.30	2.02
1975/76-1983/84	8.38	11.36	2.75	3.20	6.36	3.07	−3.69	−2.03	1.73	2.16	6.19	3.95	−7.55	−14.42	−7.43	0.89	5.13	4.21
Uttar Pradesh																		
1952/53-1964/65	1.83	4.29	2.42	0.84	1.54	0.70	−0.93	−0.61	0.33	0.38	1.46	1.08	0.53	−1.20	−1.72	0.42	0.79	0.37
1967/68-1975/76	0.22	2.90	2.66	2.86	3.14	0.27	−1.87	−1.74	0.13	0.44	1.69	1.25	−3.51	−5.36	−1.92	−0.32	0.52	0.84
1975/76-1983/84	1.81	4.83	2.97	3.83	8.34	4.33	−3.23	−1.97	1.30	1.36	5.51	4.09	−0.95	−0.70	0.24	1.01	4.81	3.77
Central																		
1952/53-1964/65	1.30	2.17	0.86	3.49	2.74	−0.73	1.30	2.27	0.95	1.72	2.34	0.60	2.08	2.62	0.53	1.82	2.38	0.56
1967/68-1975/76	1.12	0.57	−0.54	2.08	5.02	2.88	−1.34	−0.72	0.63	−0.08	1.26	1.34	2.61	4.09	1.43	0.66	1.84	1.17
1975/76-1983/84	0.73	1.85	1.11	1.24	5.62	4.34	1.94	3.16	1.20	1.49	3.74	2.21	−0.77	−0.48	0.30	0.83	2.87	2.02
Western																		
1952/53-1964/65	1.87	4.29	2.38	1.19	3.48	2.28	0.01	2.41	2.41	0.34	2.98	2.63	−0.34	−0.27	0.07	0.22	2.59	2.37
1967/68-1975/76	−0.43	1.38	1.82	1.75	8.24	6.39	−1.20	1.57	2.82	−0.84	2.22	3.09	1.86	3.56	1.68	−0.39	2.36	2.76
1975/76-1983/84	0.78	1.42	0.63	−1.02	1.13	2.17	0.04	1.19	1.15	0.04	1.23	1.19	1.59	2.87	1.26	0.32	1.38	1.05
Eastern																		
1952/53-1964/65	0.69	2.19	1.49	0.71	2.23	1.51	0.72	2.21	1.48	0.70	2.20	1.49	0.57	1.10	0.52	0.68	2.07	1.38
1967/68-1975/76	0.72	0.64	−0.08	9.61	15.11	5.01	−0.11	−2.26	−2.16	1.33	1.73	0.41	0.60	−2.66	−3.24	1.23	1.39	0.15
1975/76-1983/84	−0.73	−0.58	0.15	−1.87	−0.89	1.02	−1.32	0.99	2.35	−0.91	−0.48	0.43	0.42	3.19	2.75	−0.74	−0.22	0.52
Southern																		
1952/53-1964/65	2.62	4.64	1.96	1.61	1.15	−0.46	−0.60	2.12	2.74	0.87	3.82	2.92	0.28	−0.18	−0.46	0.79	3.67	2.84
1967/68-1975/76	0.46	2.88	2.40	9.24	28.94	18.02	−0.58	1.62	2.21	−0.03	2.56	2.58	1.79	6.07	4.21	0.20	2.66	2.46
1975/76-1983/84	−0.68	1.93	2.63	−4.90	−4.64	0.27	−2.98	−1.29	1.76	−1.72	1.12	2.89	1.55	5.24	3.63	−1.28	1.27	2.58
All India																		
1952/53-1964/65	1.57	3.34	1.74	2.29	3.32	1.02	0.21	1.38	1.16	0.99	2.63	1.62	1.36	0.62	−0.73	1.07	2.33	1.25
1967/68-1975/76	0.67	1.89	1.21	3.20	5.47	2.18	−1.07	0.27	1.35	0.31	2.22	1.90	0.77	−0.51	−1.27	0.40	1.91	1.50
1975/76-1983/84	0.22	1.97	1.75	1.94	5.72	3.72	−0.46	0.68	1.14	0.31	2.77	2.45	−0.32	−0.22	0.11	0.19	2.48	2.28

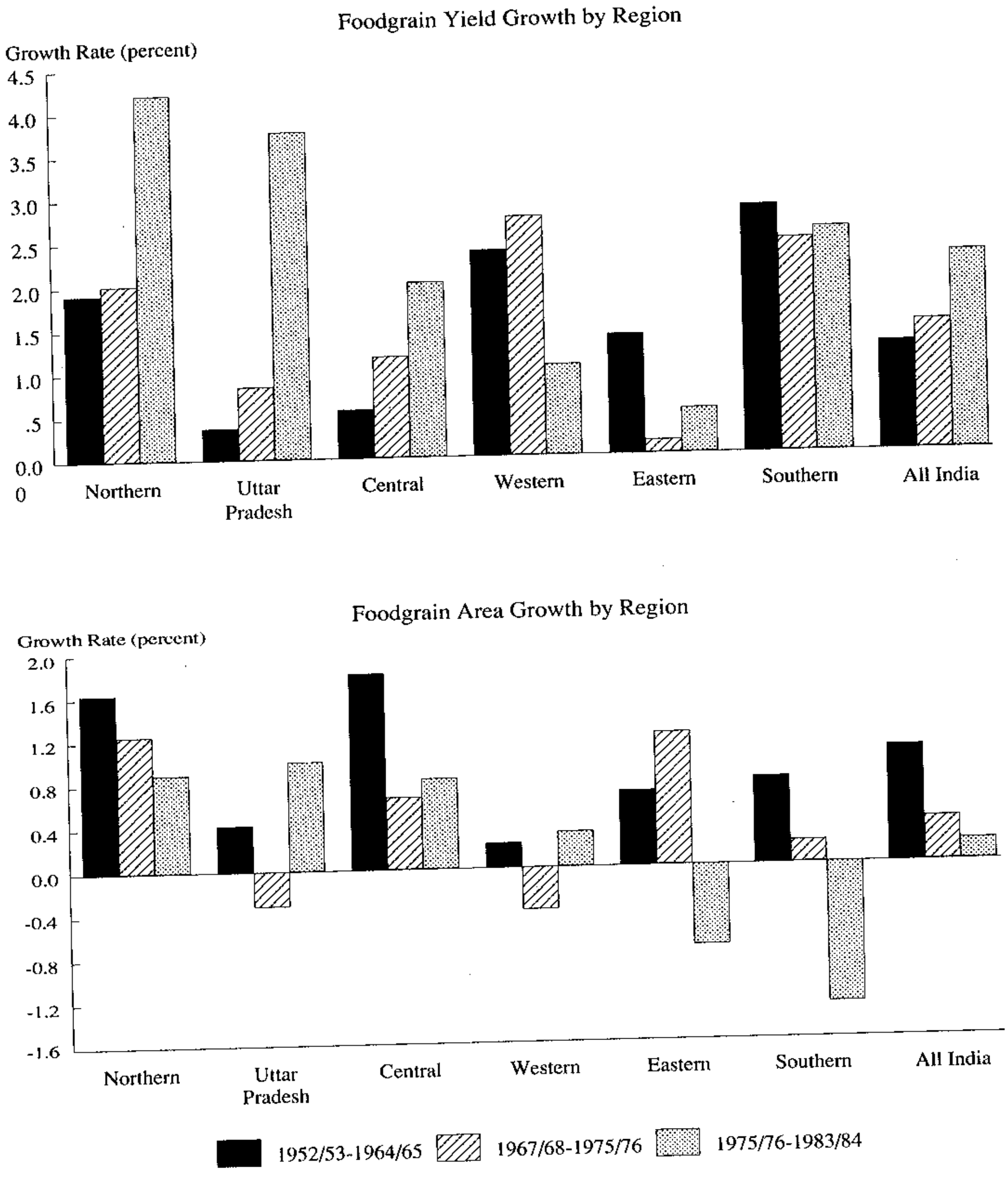
Sources: Based on data from India, Ministry of Agriculture, Directorate of Economics and Statistics, *Area and Production of Principal Crops in India*, various issues (Delhi: Controller of Publications, various years); see Appendix 2 for modifications to this data.

Figure 1—Regional and all-India growth rates in foodgrain production, 1952/53-1983/84



Sources: Based on data from India, Ministry of Agriculture, Directorate of Economics and Statistics, *Area and Production of Principal Crops in India*, various issues (Delhi: Controller of Publications, various years); see Appendix 2 for modifications to this data.

Figure 2—Regional and all-India growth rates in foodgrain yield and area, 1952/53-1983/84



Sources: Based on data from India, Ministry of Agriculture, Directorate of Economics and Statistics, *Area and Production of Principal Crops in India*, various issues (Delhi: Controller of Publications, various years); see Appendix 2 for modifications to this data.

Table 7—Gross irrigated area, total fertilizer consumption, and total area under high-yielding varieties, 1967/68-1983/84

Region/Input	1967/68	1975/76	1983/84	Annual Increase, 1967/68-1975/76	Annual Increase, 1975/76-1983/84
Northern					
Irrigation (1,000 hectares)	5,727	7,944	10,495	277	319
Fertilizer (1,000 metric tons)	146	434	1,362	36	116
High-yielding varieties (1,000 hectares)	929	5,095	8,278	521	398
Uttar Pradesh					
Irrigation (1,000 hectares)	6,352	9,231	12,148	360	365
Fertilizer (1,000 metric tons)	196	485	1,643	36	145
High-yielding varieties (1,000 hectares)	1,848	6,332	10,145	560	477
Central					
Irrigation (1,000 hectares)	3,303	4,830	6,881	191	256
Fertilizer (1,000 metric tons)	47	186	525	17	42
High-yielding varieties (1,000 hectares)	287	3,485	6,962	400	435
Western					
Irrigation (1,000 hectares)	3,765	5,422	7,259	207	230
Fertilizer (1,000 metric tons)	323	639	1,637	40	125
High-yielding varieties (1,000 hectares)	1,188	6,424	11,000	655	572
Eastern					
Irrigation (1,000 hectares)	5,817	7,178	8,408	170	154
Fertilizer (1,000 metric tons)	104	322	795	27	59
High-yielding varieties (1,000 hectares)	830	5,105	9,901	534	599
Southern					
Irrigation (1,000 hectares)	8,057	8,339	8,740	35	50
Fertilizer (1,000 metric tons)	341	782	1,638	55	107
High-yielding varieties (1,000 hectares)	972	5,309	7,299	542	249
Other					
Irrigation (1,000 hectares)	2	. . .	6	. . .	. . .
Fertilizer (1,000 metric tons)	10	46	111	. . .	. . .
High-yielding varieties (1,000 hectares)	. . .	126	154	. . .	. . .
All India					
Irrigation (1,000 hectares)	33,023	42,944	53,937	1,240	1,374
Fertilizer (1,000 metric tons)	1,166	2,894	7,711	216	602
High-yielding varieties (1,000 hectares)	6,055	31,877	53,739	3,228	2,733

Sources: Based on data from Fertilizer Association of India, *Fertilizer Statistics*, various issues (New Delhi: FAI, various years).

The Western region, however, showed a slowdown in the growth rate of production from 2.4 percent to 1.4 percent, or by nearly half between the first and second parts of the green-revolution period. Of even more concern is a drop from 2.8 percent to 1.1 percent in the yield growth rate in this region. Input data do not explain this decline, particularly since the annual rate of increase of total fertilizer use actually tripled in the last period. Since this decline in production growth is very large and the region is significant in its size, population, and contribution to the total foodgrain production, the issue is further examined below.

To study this decline, the Western region was disaggregated into its three major states: Gujarat, Karnataka, and Maharashtra (Table 8). The individual growth rates indicate that Gujarat apparently did not contribute to the decline. Its production growth in fact accelerated from 1.1 percent to 3.0 percent between the first and second parts of the green-revolution period, and even the yield growth shows slight acceleration. However, Gujarat has only about a 20 percent share in the region's production. The major impact appears to have come from Karnataka, whose production growth rate declined from about 4.0 percent to 1.0 percent and yield growth rate from 4.8 percent to −0.3 percent. Even Maharashtra's production growth rate declined from 1.4 percent to 1.0 percent, and this had a sizable effect given Maharashtra's share of 50 percent in the region. Since the Western region's production is substantially rainfed, an investigation was made into whether the decline was related to poor rainfall. For this purpose, broad state rainfall indices were computed using available zonal rainfall data (the procedure is discussed in Chapter 4). Karnataka's production showed a close association with the rainfall index, and it appears that Karnataka's production was indeed affected by poor rainfall. Maharashtra's rainfall index also showed a negative trend in this period until 1982/83, and this was probably responsible for dampening production growth in the state. The above analysis indicates that the Western region's production performance in the second half of the green-revolution period was actually heterogeneous among states but may have been substantially affected by poor rainfall in two of them, indicating the vulnerability of this region's production to the rainfall situation.

Foodgrain production in the Eastern region historically has been somewhat slow-growing (Table 6). The rate of growth dropped from 2.1 percent to 1.4 percent between 1952/53-1964/65 and 1967/68-1975/76, and in 1975/76-1983/84 the output actually declined, though mainly because of a decline in the area under foodgrains. There was a slight upturn in the yield growth rate from 0.2 percent to 0.5 percent between these two periods, possibly related to a doubling of the annual increase in fertilizer use. The adoption of HYVs was also proceeding at a brisk pace (Table 7). These changes indicate that growth performance in this region may improve in the future.

In the Southern region, the growth rate in foodgrain output was rapid before the green revolution at 3.7 percent a year. This declined to 2.7 percent between 1967/68 and 1975/76 and further to 1.3 percent in 1975/76-1983/84. However, during 1975/76-1983/84, yield per hectare continued to grow at around 2.6 percent a year. This may be related to a doubling of the rate of annual increase in fertilizer use as well as an increase in the rate of spread of irrigation. The rate of growth in foodgrain area, however, declined from 0.8 percent a year during 1952/53-1964/65 to 0.2 percent during 1967/68-1975/76 and became negative (at −1.3 percent) in the second part of the

Table 8—Growth rates of foodgrain area, production, and yield in states of the Western region, 1952/53-1983/84

State/Period	Total Foodgrains		
	Area	Production	Yield
		(percent/year)	
Gujarat			
1952/53-1964/65	−1.34	2.15	3.54
1967/68-1975/76	−1.50	1.12	2.65
1975/76-1983/84	0.00	2.98	2.98
Karnataka			
1952/53-1964/65	1.03	3.53	2.48
1967/68-1975/76	−0.80	3.96	4.79
1975/76-1983/84	1.28	1.01	−0.27
Maharashtra			
1952/53-1964/65	0.36	2.09	1.72
1967/68-1975/76	0.17	1.44	1.27
1975/76-1983/84	−0.02	0.97	0.99
Western region			
1952/53-1964/65	0.22	2.59	2.37
1967/68-1975/76	−0.39	2.36	2.76
1975/76-1983/84	0.32	1.38	1.05

Sources: Based on data from India, Ministry of Agriculture, Directorate of Economics and Statistics, *Area and Production of Principal Crops in India,* various issues (Delhi: Controller of Publications, various years); see Appendix 2 for modifications to this data.

green-revolution period. Since the total area is not showing a decline, this indicates a movement away from foodgrains in the Southern region.

Crop Trends within Regions

Estimates of growth rates by crop and region (Figures 3, 4, and 5) show that in the Northern region, growth in foodgrain production came primarily from growth in rice and wheat. More than one-fourth of the foodgrain production was rice, which rose at a surprising rate exceeding 10 percent a year during the entire green-revolution period. However, a large part of this growth came from area, which rose at 8.4 percent in the 1975/76-1983/84 period. Wheat production during this period also grew rapidly at 6.4 percent a year, about half of which came from area. Coarse cereals production has stagnated since the green revolution, and in 1975/76-1983/84 there was a significant shift out of coarse cereals, as shown by an area growth rate of –3.7 percent, though yields still rose at 1.7 percent a year. There was a substantial movement out of pulses, which is reflected in growth rates of –7.6 and –14.4 percent in area and production, respectively, in 1975/76-1983/84.

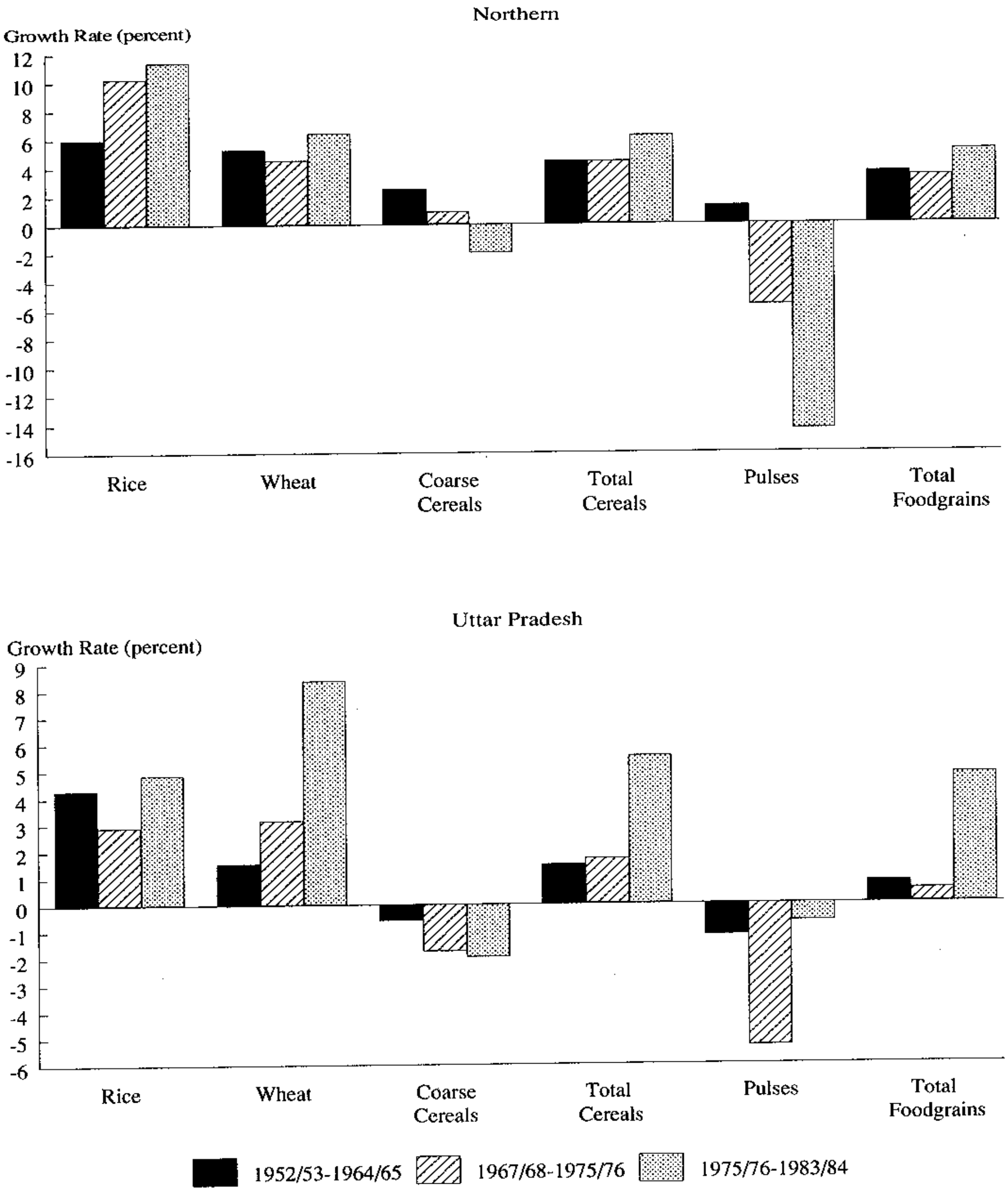
In the Uttar Pradesh region, the rapid increase in the growth rate in 1975/76-1983/84 was fueled mainly by wheat and rice, whose production grew at 8.3 and 4.8 percent, respectively, but unlike that of the Northern region, the bulk of this increase was from yield growth. Like the Northern region, Uttar Pradesh was moving out of coarse cereals and pulses, but in the case of pulses the rate of decline in area was slower, especially during 1975/76-1983/84.

The Central region had a more evenly distributed growth over all the cereals, but wheat continued to be the fastest-growing crop with an annual production growth rate in 1975/76-1983/84 of 5.6 percent, most of which was due to yield growth. Growth in rice production accelerated in the same period. The output of pulses stagnated, however, showing a marginal decline of 0.5 percent a year. Of all the regions, Central had the most rapid growth rate in coarse cereals (3.2 percent a year).

A significant decrease in the growth rate of foodgrain production occurred in the Western region in 1975/76-1983/84, associated with a sharp decline in the growth of wheat in area, production, and yield. Though the share of wheat is not very large in this region (12.0 percent), in the first part of the green-revolution period there was a significant movement into wheat that was reflected in high area and production growth rates (1.8 percent and 8.2 percent, respectively). But in the second part of the green-revolution period there may have been a disillusionment with wheat, as manifested in negative growth in area and much-reduced growth in yield and, consequently, in production. There was also a considerable slowdown in the yield growth rates of rice (from 1.8 percent to 0.6 percent) and coarse cereals (from 2.8 percent to 1.2 percent) and increasing production of pulses (with a growth rate of 2.9 percent), which have lower quantity yields. Pulses have the fastest-rising growth rate of all crops in this region, perhaps indicating a response to the much-improved price environment for pulses.

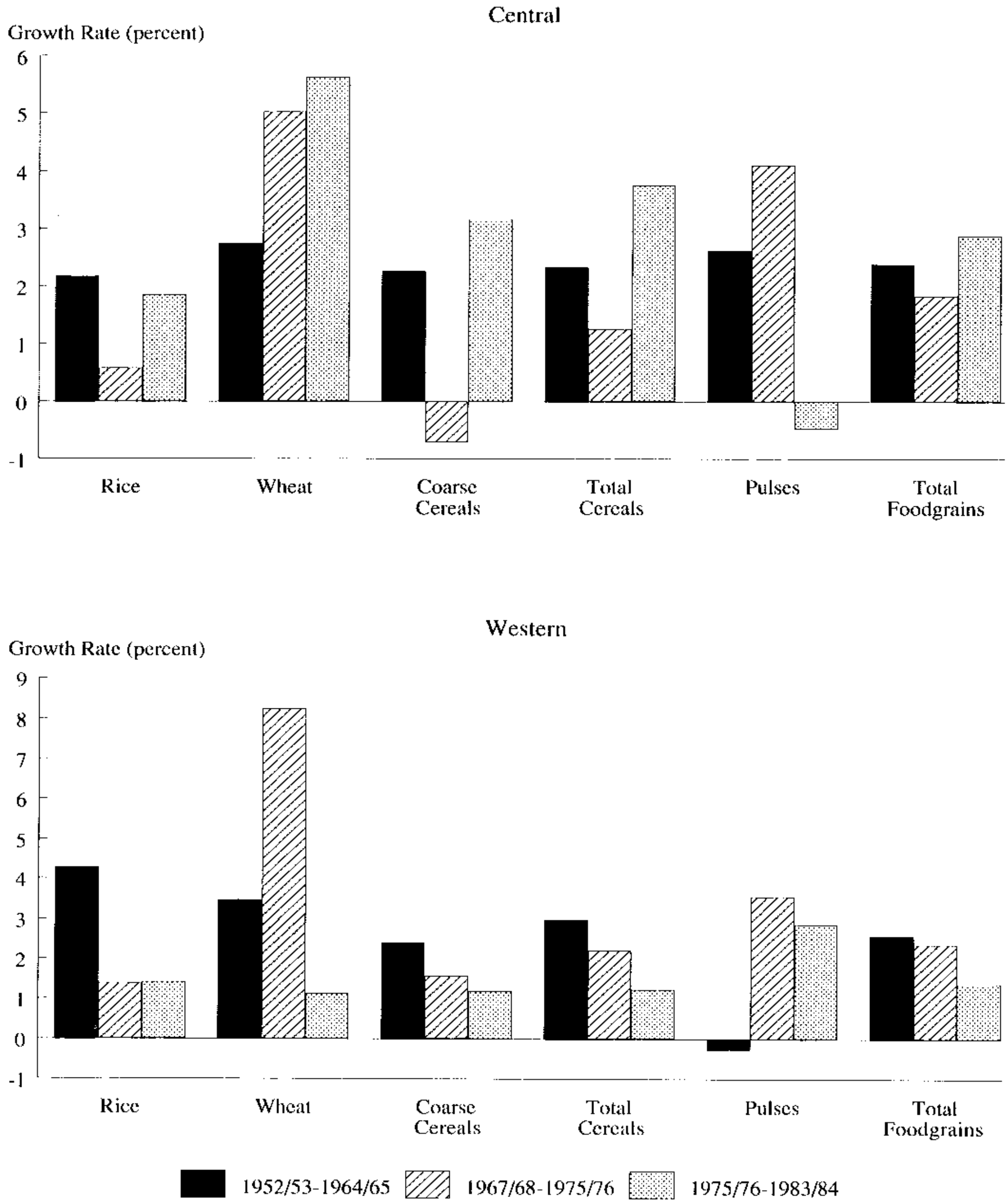
The Eastern region presents a dismal picture, with a decline in growth rate of foodgrain production from 2.1 percent in the pre-green-revolution period to –0.2 percent in 1975/76-1983/84. The only major changes were in wheat and pulses. Wheat has an 11 percent share in the region's foodgrain production. Immediately following the onset of the green revolution there was a great movement into wheat, as shown by the high growth rates of area, yield, and production. However, as in the Western region, during 1975/76-1983/84 there was a change for the worse, with area, yield, and production registering sharp declines in growth rates and even actual decreases. Pulses,

Figure 3—Annual growth rates in foodgrain production in Northern and Uttar Pradesh regions, by crop, 1952/53-1983/84



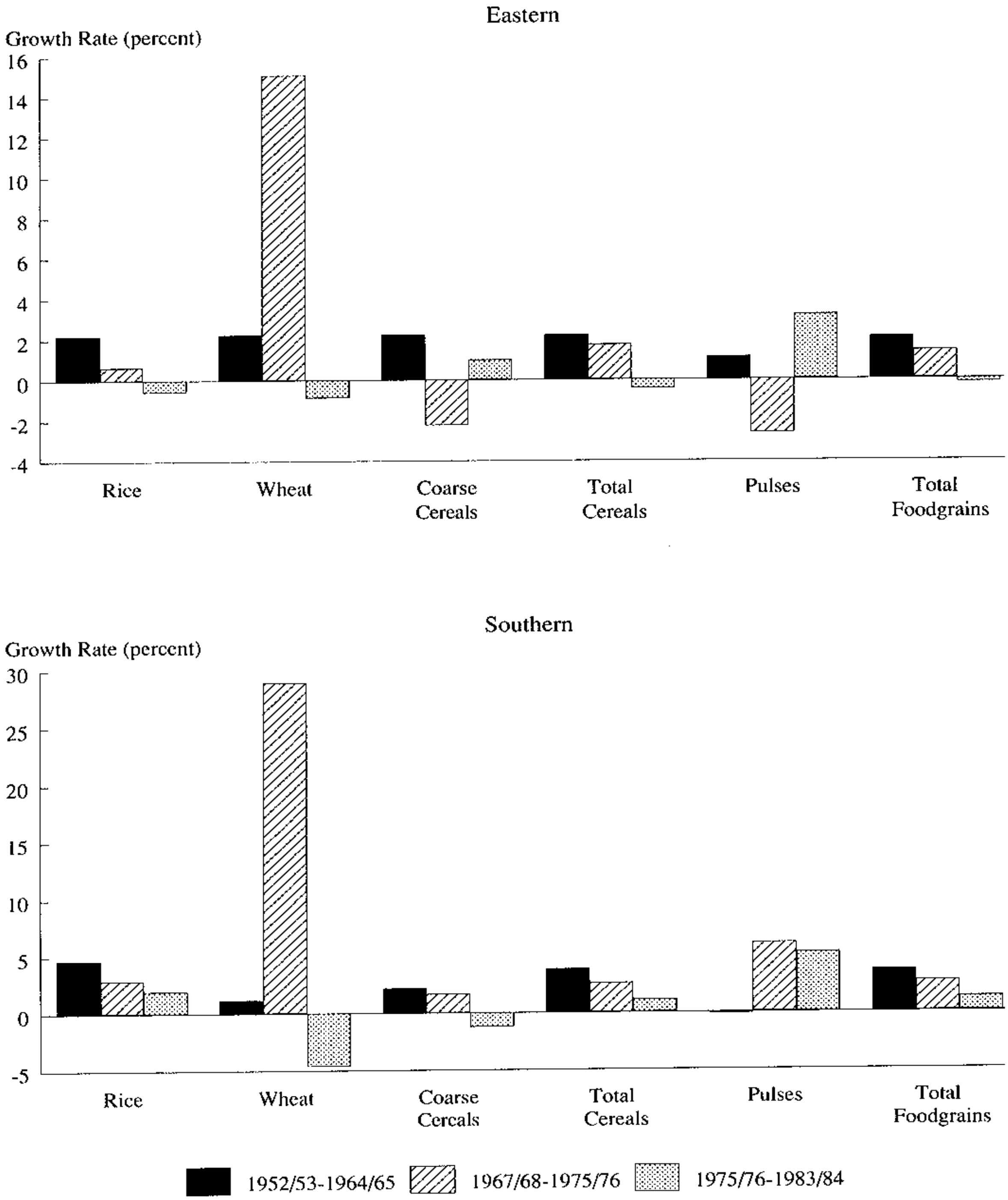
Sources: Based on data from India, Ministry of Agriculture, Directorate of Economics and Statistics, *Area and Production of Principal Crops in India*, various issues (Delhi: Controller of Publications, various years); see Appendix 2 for modifications to this data.

Figure 4—Annual growth rates in foodgrain production in Central and Western regions, by crop, 1952/53-1983/84



Sources: Based on data from India, Ministry of Agriculture, Directorate of Economics and Statistics, *Area and Production of Principal Crops in India*, various issues (Delhi: Controller of Publications, various years); see Appendix 2 for modifications to this data.

Figure 5—Annual growth rates in foodgrain production in Eastern and Southern regions, by crop, 1952/53-1983/84



Sources: Based on data from India, Ministry of Agriculture, Directorate of Economics and Statistics, *Area and Production of Principal Crops in India*, various issues (Delhi: Controller of Publications, various years); see Appendix 2 for modifications to this data.

on the other hand, showed a comeback, with relatively high growth rates in yield and production (3.2 percent and 2.8 percent, respectively), perhaps reflecting in part the much-improved national price environment for pulses.

The Southern region continued to show moderate growth in foodgrain production, but the area under foodgrains declined at about 1.3 percent a year in the second part of the green-revolution period, showing a movement out of foodgrains. The decline in area came largely from wheat (–4.9 percent) and coarse cereals (–3.0 percent a year). But the area under pulses increased at 1.6 percent a year. Pulse yield and production rose at annual rates higher than those of any other region, 3.6 percent and 5.2 percent, respectively. This again reflects the effects of much higher relative prices for pulses.

Thus, to recapitulate the regional patterns in the growth of individual crops, wheat and rice production rose most rapidly in the Northern, Uttar Pradesh, and Central regions, but in the Western, Eastern, and Southern regions there was a turn toward pulse production that was reflected in increased area and yields. Whereas coarse cereals declined in almost every other region, their production rose rapidly in the Central region in terms of both area and yield. On an all-India basis, wheat continued to be the fastest-growing foodgrain crop (5.7 percent) in 1975/76-1983/84, followed after a large margin by rice (2.0 percent) and then by coarse cereals (0.7 percent). The all-India output of pulses continued to decline at a rate of –0.2 percent a year. The yield growth rate of rice rose from 1.2 percent to 1.8 percent from the first to the second part of the green-revolution period, and it increased from 2.2 percent to 3.7 percent for wheat. The yield growth rate for coarse cereals declined from 1.4 percent to 1.1 percent, but in the case of pulses the declining trend appears to have been arrested during 1975/76-1983/84. In the green-revolution period the growth seems to have been driven substantially by yield growth, particularly in wheat and rice. This is associated with growing levels of use of all inputs, especially fertilizers. Fertilizer use showed significant acceleration along with the increase in the growth rate of foodgrain production in several regions in the second half of the green-revolution period.

4

INPUT USE AND PRODUCTION BEHAVIOR

Growth of foodgrain production in India has been accompanied by substantial increases in the use levels of modern inputs, especially fertilizers, HYVs, and irrigation (Table 9 and Figure 6). Fertilizer use on foodgrains has grown dramatically from an average of 18,000 tons in 1949/50-1951/52 to an average of almost 5.0 million tons in 1981/82-1983/84. (The sources and methods for arriving at input data are given in Appendix 4.) The increase in fertilizer use has been even more dramatic since the green revolution (post-1967/68). Between 1967/68-1969/70 and 1981/82-1983/84 the estimated quantities of fertilizers applied to foodgrains increased by more than five times. Including the quantities applied to other crops, the total use of fertilizers reached 7.7 million tons in 1983/84.

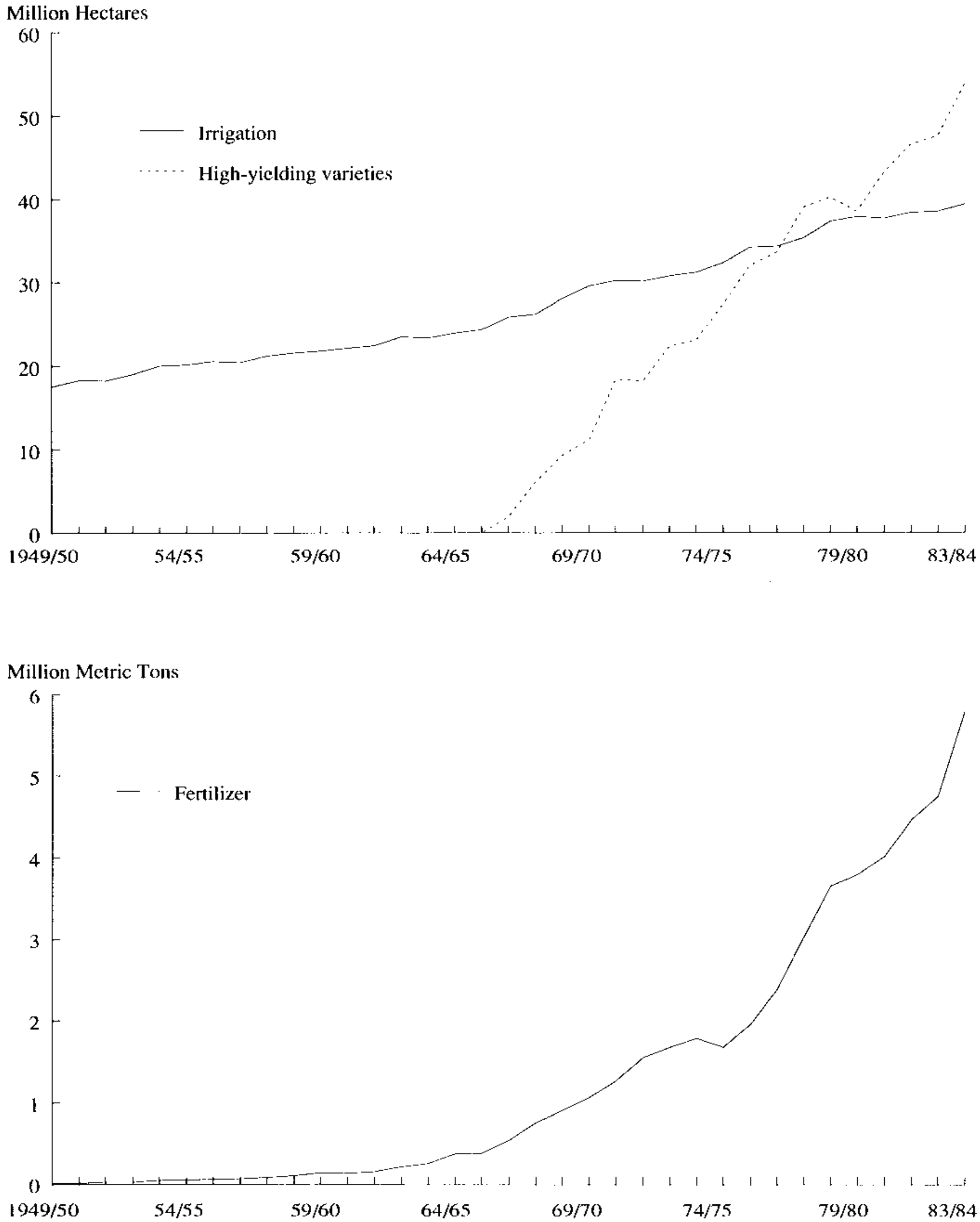
The HYVs that ushered in the green revolution in 1967/68 have also spread rapidly from an average coverage of 8.8 million hectares during 1967/68-1969/70 to 49.2 million hectares during 1981/82-1983/84. The larger part of this growth, nearly 26 million hectares, came between 1967/68-1969/70 and 1975/76-1977/78—an average of 3.2 million hectares a year. Progress was less rapid between 1975/76-1977/78 and 1981/82-1983/84, when less than 14.5 million hectares were added—an average of 2.4 million hectares a year—possibly in part because of the relatively slow growth of irrigated area. The area under HYVs increased rapidly until 1975/76-1977/78, when it became about equal to the irrigated area under foodgrains. Subsequently, the HYV area has expanded slowly, but it has surpassed the irrigated area—showing that HYVs have spread to unirrigated areas. The irrigated area under foodgrains grew very gradually from an average of 18.0 million hectares in 1949/50-1951/52 to 27.9 million hectares in 1967/68-1969/70 and to 38.7 million hectares in 1981/82-1983/84.

Table 9—Average input use levels in foodgrain production, all India, 1949/50-1983/84

Period	Three-Year Averages		
	Fertilizer	Irrigation	High-Yielding Varieties
	(1,000 metric tons)	(million hectares)	
1949/50-1951/52	18.07	18.00	0.00
1962/63-1964/65	281.48	23.53	0.00
1967/68-1969/70	907.42	27.87	8.82
1975/76-1977/78	2,458.40	34.50	34.79
1981/82-1983/84	4,996.41	38.69	49.24

Sources: The basic source is Fertilizer Association of India, *Fertilizer Statistics,* various issues (New Delhi: FAI, various years); for other sources and methods see "Input Data" in Appendix 4.

Figure 6—Inputs in foodgrain production, 1949/50-1983/84



Sources: The basic source is Fertilizer Association of India, *Fertilizer Statistics*, various issues (New Delhi: FAI, various years); for other sources and methods see "Input Data" in Appendix 4.

Between 1975/76-1977/78 and 1981/82-1983/84, fertilizer use grew by 103 percent, whereas HYV area grew by 42 percent and irrigated area by only 12 percent (Table 9). Thus production growth and acceleration in the second part of the green-revolution period may be related largely to rapid increase in fertilizer use. Growth in yields of wheat and rice after the mid-1970s may also have been due to improvements in the range of available HYVs to suit different environments, strengthening of the extension system, and expansion of input supply systems, which facilitated the expansion of input use. Input response will be examined later.

The increase in input use levels for fertilizers and HYVs has not been gradual but has come in spurts and plateaus (Figure 6). Fertilizer increase showed some leveling off around 1965/66, which was the severe drought period, again around 1972/73-1973/74, about the time when the first oil shock resulted in the doubling of fertilizer prices, and yet again around 1979/80, which was a drought year as well as the time of the second oil shock. Growth in the area under HYVs showed a plateau around 1970/71 and again around 1977/78-1978/79. For both fertilizers and HYVs, the early 1980s saw a growth spurt, which is reflected in a spurt in foodgrain output. Irrigation showed a relatively slow and gradual growth throughout the 35-year period from 1949/50 to 1983/84.

Analysis with Response Coefficients

Since inputs and output have been increasing together, with spurts and plateaus, it is not obvious how input productivities have been changing over time. In order to do a preliminary examination of this issue, an aggregate response analysis was done using prior values of average response coefficients (input-output ratios). The response coefficients were obtained from Sarma and Roy (1979) (see "Basis of Response Coefficients" in Appendix 4). The values are area, 0.45 tons per hectare; irrigation, 0.50 tons per hectare; shift to wheat/rice, 0.33 tons per hectare; and fertilizers, 10 tons per ton of nutrient (NPK). It is assumed in the above coefficients that the fertilizer coefficient includes the effect of HYVs. The analysis was done across three selected time points, and three-year average input and output levels were used to reduce the effect of weather-related fluctuations. Table 10 presents the results of the analysis. For 1969-72 the difference between the output predicted on the basis of input levels and response coefficients and the actual output is only of the order of 2 million tons, or about 2 percent, indicating that the response coefficients are broadly valid and hold in this period. However, for 1981-84 the actual output falls short of the expected output by almost 10 million tons.

This large divergence between the expected and the actual output seems to indicate a decline in one or more of the aggregate input response coefficients. In simulating to find which input coefficient may be mainly in question, it is found that changing the coefficients of area, irrigation, or shift to wheat/rice cannot help resolve the large difference between expected and actual output. This brings the focus to the fertilizer response coefficient. The analysis shown in Table 10 indicates that if the fertilizer response coefficient is reduced from 10 to 7, the difference between expected and actual output is reduced to about 1 million tons. On this basis, the analysis suggests a likely reduction in the aggregate fertilizer response coefficient from the previously assumed level of 10 to the new likely level of about 7.

Table 10—Expected production-level analysis using response coefficients

Input	Assumed Response Coefficient	Three-Year Averages of Input Use Levels[a]			Expected Contribution of the Input to Production		Three-Year Averages					
							Expected Production		Actual Production, Three-Year Average		Difference Between Actual and Expected Production	
		1959/60-1961/62	1969/70-1971/72	1981/82-1983/84	1969-72 Over 1959-62	1981-84 Over 1969-72	1969-72	1981-84	1969-72	1981-84	1969-72	1981-84
					(million metric tons)				(million metric tons)			
Area	0.45 metric tons/hectare	115.79	123.60	128.46	3.47	2.23	...	...	...	...	...	...
Irrigation	0.50 metric tons/hectare	22.10	29.90	38.69	3.90	4.40	...	...	...	...	...	...
Shift to wheat/rice	0.33 metric tons/hectare	47.56	55.68	63.37	2.68	2.54	...	...	...	...	...	...
Fertilizer	10.00 metric tons/ton	0.15	1.29	5.00	11.47	37.04	...	...	...	...	...	...
Total	...	...	...	...	21.52	46.21	102.13	148.34	104.36	138.40	+2.23	−9.94
Fertilizer, alternative	7.00 metric tons/ton	...	1.29	5.00	...	25.93	...	...	...	...	...	...
Total	...	...	...	...	...	35.09	102.13	137.22	104.36	138.40	...	+1.18

Sources: Based on data from India, Ministry of Agriculture, Directorate of Economics and Statistics, *Area and Production of Principal Crops in India*, various issues (Delhi: Controller of Publications, various years); Fertilizer Association of India, *Fertilizer Statistics*, various issues (New Delhi: FAI, various years); and "Basis of Response Coefficients" in Appendix 4.

[a] Area, irrigation, and shift to wheat/rice are in million hectares; fertilizer is in million metric tons.

Since a substantial amount of the increase in fertilizer use is reported to have taken place through increasing concentration of its use in a small number of districts in the country (see Desai 1986, Bhalla and Tyagi 1989, and Fertilizer Association of India 1987/88), this decline in the response seems likely as diminishing marginal returns become more important in weight and strength. As fertilizers are expected to play a crucial role in achieving future growth in production, this decline in productivity is of serious policy concern. It appears that whereas concentration of use would tend to make the diminishing marginal product more important in determining the aggregate response coefficient, diffusion would tend to make the average product, which could be higher, more important. Thus policies for diffusing fertilizer use to areas where its average response is high may be important in raising aggregate fertilizer productivity. The effectiveness of these policies may be aided by an in-depth study of the response function environment across regions. Further, given that much of the fertilizer use is only in the form of nitrogen, the deficiency of other nutrients may be getting critical and contributing to reducing fertilizer productivity, especially in high-use areas. Poor application of organic manures may also be contributing to the decline in the productivity of fertilizers. However, it is observed that during the study period, despite the decline in productivity even without any favorable changes in the price environment, fertilizer use continued to grow rapidly, implying that it was still privately profitable. But the issue of declining productivity remains of considerable national as well as private concern for future growth in foodgrain production.

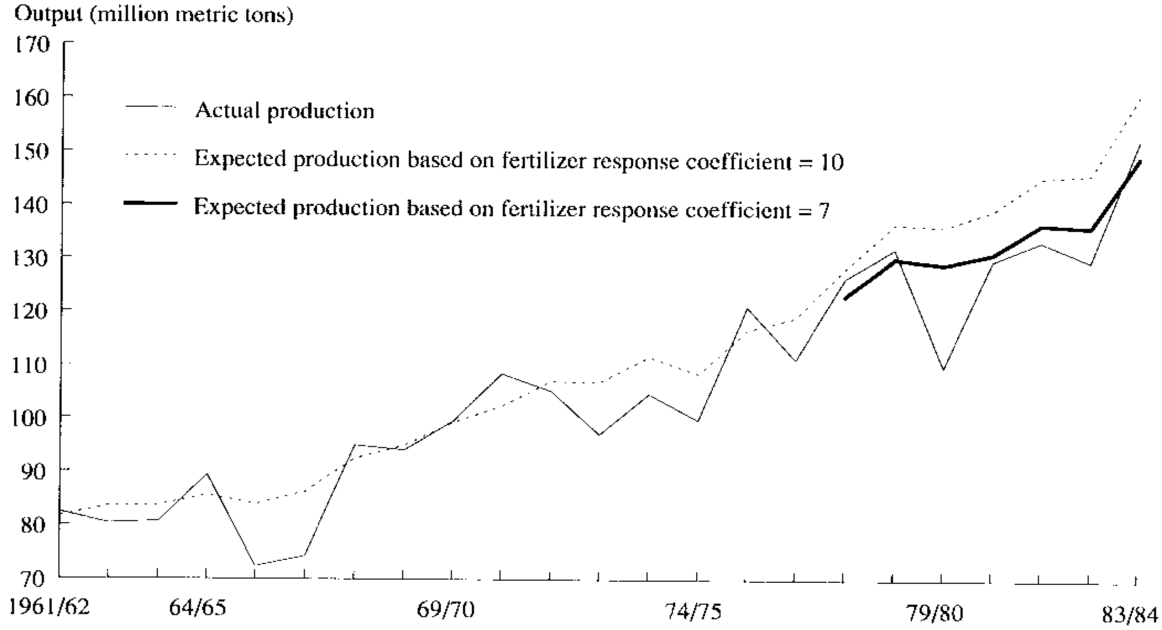
The above analysis is not able to show precisely when and how this decline in productivity came about. To explore the issue further, the expected output was calculated for each year using the annual input data series and the basic response coefficients given above (10 for fertilizer). The expected output thus calculated was plotted with the actual output and this is shown in Figure 7.[9] The plot shows that actual output fluctuated around expected output from year to year (mainly due to weather fluctuations), but until 1977/78 it stayed around the expected output. However, after 1977/78, actual output fell below the expected and stayed below, even in good crop years. This shows that the fall in input productivities is likely to have been relatively recent and appears to have occurred gradually after 1977/78. A plot of expected output using a response coefficient of 7 for fertilizer has also been made for the post-1977/78 period (Figure 7) and appears to be closer to actual output in this period. This is again indicative of the likely decline in fertilizer response from 10 to 7, but shows that the major fall may have come mainly after 1977/78.

Rainfall Index

The time-series analysis of relationships between inputs and outputs for Indian agriculture requires consideration of the effect of rainfall. This is because rainfall can have an important effect on agricultural production in India and because rainfall varies considerably from year to year across agroclimatic regions. Even by 1980/81, less than

[9] Estimating annual utilization of fertilizers using linear rates of increase and relating the production potential created to fluctuating production is open to objection. It can at best give an approximate relationship, and caution is required in reaching conclusions from these data.

Figure 7—Fertilizer input response in foodgrain production, 1961/62-1983/84



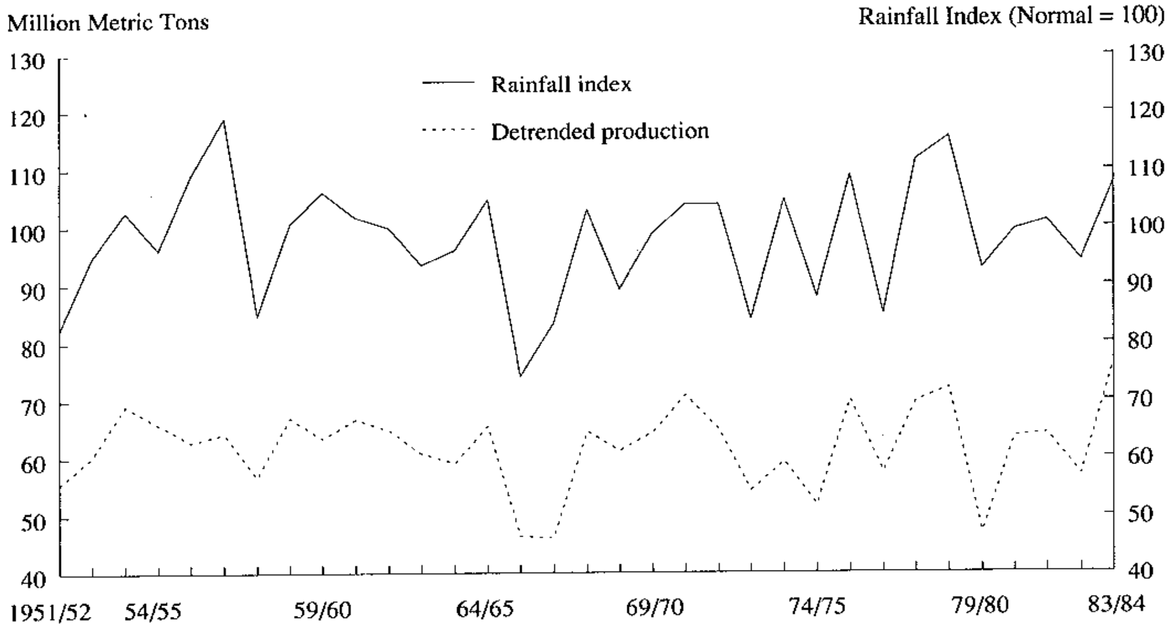
Sources: Based on data from India, Ministry of Agriculture, Directorate of Economics and Statistics, *Area and Production of Principal Crops in India*, various issues (Delhi: Controller of Publications, various years); Fertilizer Association of India, *Fertilizer Statistics*, various issues (New Delhi: FAI, various years); and "Basis of Response Coefficients" in Appendix 4.

30 percent of the cropped area was irrigated, and therefore dependence on rainfall continues to be great.

Though rainfall data are collected throughout the country on a daily basis, until recently very little systematic use has been made of them in crop production studies. One effort to use rainfall data for cereal production analysis in India was that of Cummings and Ray (1969). They used data on rainfall received in different seasons of each year (southwest monsoon, postmonsoon, winter, and premonsoon) in 31 separate rainfall divisions of the country to construct an all-India rainfall index using an elaborate weighting scheme based on cropping pattern and estimates of area and production in different divisions and states. This original index from Cummings and Ray, for which the complete methodology is known, is available from 1951/52 to 1968/69 and has been extended to 1977/78 by Sanderson and Roy (1979) following (as stated by them) the same methodology. In the present study an attempt has been made to develop an improved and updated weighting scheme in constructing a rainfall index for foodgrains. However, due to limitations in the availability of data, the improved indices could be computed only for the period 1973/74-1983/84 (see "Calculation of the Rainfall Index" in Appendix 4). For the earlier period, the Cummings and Ray/Sanderson and Roy indices are used. The overlapping period 1973/74-1977/78 showed that the two indices were highly correlated and close, and therefore there should be little difficulty in merging them.

Figure 8, which gives a plot of the rainfall index along with detrended actual foodgrain production, shows that the index has a close relationship with the actual

Figure 8—Rainfall index and detrended foodgrain production, 1951/52-1983/84



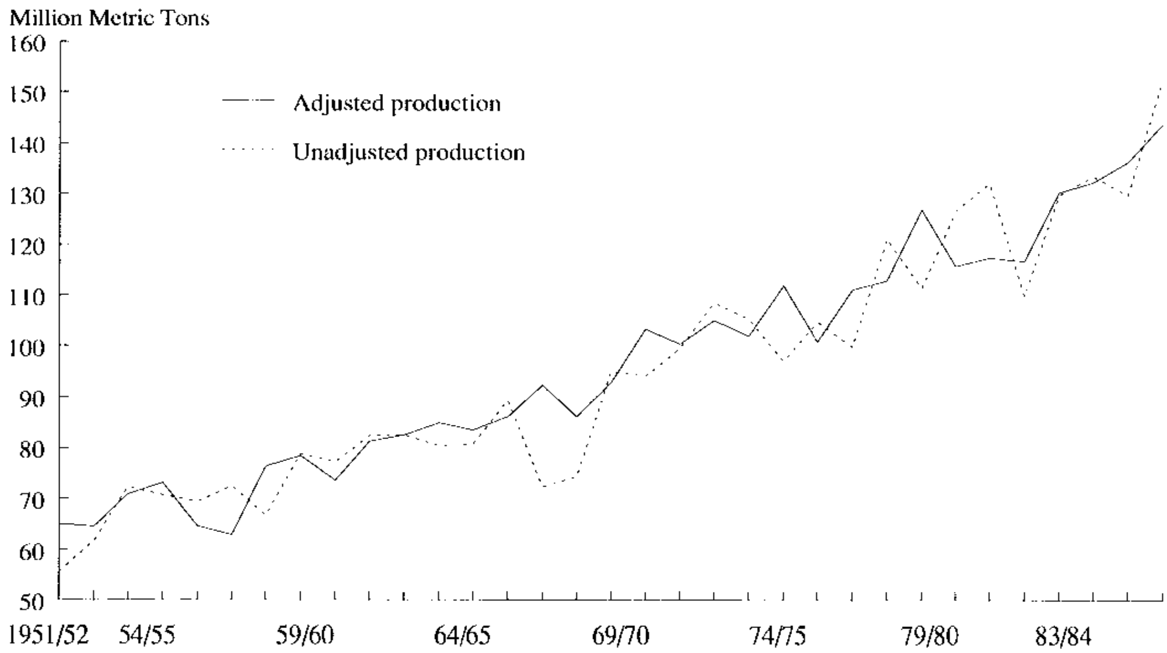
Sources: Production data are based on India, Ministry of Agriculture, Directorate of Economics and Statistics, *Area and Production of Principal Crops in India*, various issues (Delhi: Controller of Publications, various years); see Appendixes 2 and 4 for other sources and details.

foodgrain production. The tracking of fluctuations in production is somewhat better through the period 1973/74-1983/84 with the improved index calculated in this study. Prior to 1973/74, movement in the rainfall index does not agree with movement in production in 7 of the 22 years, but there is no disagreement in the movement after 1973/74.

An effort has also been made to simulate a time series on weather-adjusted foodgrain production. A Cobb-Douglas production function is estimated using the actual foodgrain production and the estimated rainfall index. This is then used to simulate the foodgrain production at rainfall index = 100 (normal rainfall). The resultant weather-adjusted production series and the actual foodgrain production are plotted in Figure 9. This indicates, for example, the great impact of bad weather on lowering foodgrain production in 1965/66 and 1966/67, and that of good weather on raising foodgrain production in 1977/78 and 1978/79. The plot also shows that the 1983/84 rise in foodgrain production goes beyond weather-related fluctuations.

Table 11 presents a comparison between some important parameters estimated on the basis of weather-adjusted production versus those estimated from unadjusted production. The long-term growth rate in production is about the same for both series, as should be expected. However, there are some differences between the two among the subperiods. In particular, the increase in growth rate between the first and second halves of the green-revolution period not only persists in the weather-adjusted series but is greater. This confirms, beyond the effects of weather, that there was an acceleration in foodgrain production in the second half of the green-revolution period. The unadjusted production series shows a doubling of the coefficient of variation between

Figure 9—Weather-adjusted foodgrain production, 1951/52-1983/84



Sources: Production data are based on India, Ministry of Agriculture, Directorate of Economics and Statistics, *Area and Production of Principal Crops in India*, various issues (Delhi: Controller of Publications, various years); see Appendixes 2 and 4 for other sources and details.

the pre-green-revolution and the green-revolution period when calculated after detrending, thus indicating a sharp rise in variability. However, the weather-adjusted series shows an increase of only 34 percent in the coefficient of variation, indicating a lesser rise in variability once weather effects are removed in both periods.

Table 11—Weather-adjusted and unadjusted foodgrain production: growth rates and coefficients of variation

Period	Actual Unadjusted Production	Weather-Adjusted Production
	Growth Rate (percent/year)	
1952/53-1983/84	2.47	2.46
1952/53-1964/65	2.33	2.42
1967/68-1975/76	1.91	1.79
1975/76-1983/84	2.48	2.61
	Coefficient of Variation (detrended production)	
1952/53-1964/65	6.17	5.85
1967/68-1983/84	12.07	7.82

Factor Analysis

Foodgrain production is affected by a multitude of variables. It is useful from the standpoint of analysis to sort these variables into groups, characterize the groups, and broadly assess their relative importance. One systematic method of achieving this is factor analysis.[10] Factor analysis was, therefore, carried out on several explanatory variables of foodgrain production, namely, area under foodgrains, area under rice and wheat, fertilizers, area under HYVs, irrigated area, and rainfall. The analysis may be useful in identifying important independent factors and also in showing those variables that are not independent in the data and therefore fall in the same factor. The summary results of factor analysis are shown in Table 12 (the complete results are given in Appendix 5). The eigenvalues show that among the six explanatory variables included, only three major factors can be identified. The first factor accounts for 78 percent of the variation (this is total variation and not variability around trend). The correlations with the explanatory variables in the rotated factor matrix show that because of its close relation to fertilizers, HYVs, and irrigation, this factor can be characterized as the technology/inputs factor. Since all three of these variables—fertilizers, HYVs, and irrigation—load on to the same factor, they seem to be moving closely together and may be highly correlated. This indicates that in production function analysis their

Table 12—Summary of factor analysis results for foodgrain production

Principal components on six variables	1	2	3	4	5	6
Cumulative percentage of eigenvalues	0.78397 78 percent	0.94596 16 percent	0.99250 5 percent	0.99753 . . .	0.99899 . . .	1.0000 . . .
Rotated factor matrix—(three factors)						
Factors	1	2	3			
Factor idenfitication	Technology/ Inputs	Rainfall	Area			
		(correlations)				
Variables						
afg (area)	0.50537	0.19469	*0.83767*			
arw (rice/wheat)	0.72269	0.10649	0.67787			
frfg (fertilizer)	*0.93102*	0.08348	0.33185			
hvfg (high-yielding varieties)	*0.91506*	0.08495	0.38171			
irfg (irrigation)	*0.81075*	0.01938	0.57895			
rain (rainfall)	0.06285	*0.99221*	0.10688			

Note: Detailed results are given in Appendix 5.

[10] In order to further understand the relationship between inputs and outputs, factor analysis and production function analysis are done. The former works only with explanatory variables or the inputs in this case. This analysis takes the entire variation in the block of explanatory variables and divides it into orthogonal components or factors that are "parallel" or similar within themselves but "perpendicular" or independent from one another. Two characteristics of these factors are then reported. One is their eigenvalues, which in percentage terms show how much of the total variation is explained by each factor. The second is their correlation with each of the explanatory variables, which shows the explanatory variables the factor is closely related to. The second helps to identify the factors that may be behind the explanatory variables when groups of them are closely related (Green 1978).

individual effects on output may become difficult to separate because of the problem of multicollinearity.

The second factor, which carries 16 percent of the variation, is very closely related to rainfall and may be called the rainfall factor. Its share of the variation is substantially lower than that of the technology/inputs factor. The third factor is most closely related to area and carries 5 percent of the total variation. The factor analysis also shows that area and technology inputs have a moderate and positive correlation, but area and rainfall have only a small positive correlation, and inputs and rainfall have almost no correlation. This is indicative of a relatively weak empirical relationship between rainfall and area, and between rainfall and inputs.

Production Function Analysis

Production function analysis was carried out using time-series data in an attempt to directly assess the relationship between inputs and output. This was done on an input-output basis without bringing in prices; price response was expected to be reflected through changes in input use. Further, area was eliminated from the relationship by taking yield per hectare as the dependent variable.[11] Area under rice/wheat was also dropped, since it accentuated multicollinearity, and because it was not found very useful, especially when fertilizers, HYVs, and irrigation were all included.

The functional forms tried (presented for a two-input case) are y_t = yield, x_{it} = inputs, e_t, u_t, and v_t are error terms, and the rest are parameters; t is the time subscript.

Linear:

$$y_t = a_0 + a_1 x_{1t} + a_{2t} x_{2t} + e_t. \qquad (1)$$

Cobb-Douglas:

$$y_t = b_0 x_{1t}^{b_1} x_{2t}^{b_2} u_t. \qquad (2)$$

This is linearized for estimation by taking the logarithm of both sides:

$$\log y_t = \log b_0 + b_1 \log x_{1t} + b_2 \log x_{2t} + \log u_t. \qquad (3)$$

Transcendental:

$$y_t = c_0 x_{1t}^{c_1} e^{d_1 x_{1t}} x_{2t}^{c_2} e^{d_2 x_{2t}} v_t. \qquad (4)$$

[11] Most researchers have found that the input-output relationships are estimated better with yield per hectare as the dependent variable rather than production.

For estimation of parameters, this is linearized by taking the logarithm:

$$\log y_t = \log c_0 + c_1 \log x_{1t} + d_1 x_{1t} + c_2 \log x_{2t} + d_2 x_{2t} + \log v_t. \qquad (5)$$

One criterion for selecting these functional forms is parsimony of parameters, that is, fewer parameters to be estimated, and this becomes important given the high multicollinearity and the limited degrees of freedom (see Fuss, McFadden, and Mundlak 1978). The linear form is the simplest but has the most restrictive production behavior assumptions, such as constant marginal productivities. With the same number of parameters, the Cobb-Douglas form has more acceptable assumptions but assumes constant elasticities and allows little flexibility to the shape of the production frontier. The transcendental form doubles the number of parameters to be estimated but is theoretically attractive, since it allows considerable flexibility in the shape of the input-output response frontier (see Halter, Carter, and Hocking 1957). It can accommodate increasing, decreasing, and classical production functional forms.

All of the above functional forms assume separability between inputs, which is a limitation. However, relaxing this assumption requires moving into other forms such as translog and quadratic (full), but these forms greatly add to the parameter load, and given the problem of multicollinearity and limited degrees of freedom, experimentation showed that their empirical results were poor, unstable, and unrealistic. A principal-components approach, as suggested by Mundlak (1981), was also attempted to get over the problem of multicollinearity. This, however, brought little improvement in the results with the given data. The reasons for such an outcome seem evident from the results of the factor analysis, which showed that fertilizer, HYVs, and irrigation all load very strongly on to one and the same factor, and only rainfall could be separated as a distinct factor. Thus the principal-components approach could not effectively overcome the problem of multicollinearity between fertilizer, HYVs, and irrigation. However, results of regressions between principal components and yield indicated that the component that represented fertilizers, HYVs, and irrigation explained 85 percent of the variation in the yield (total variation), whereas the component that represented rainfall explained about 5 percent.

This study does not address technical change as evaluated in general aggregate economic analyses, but only as reflected in the growth in use of modern inputs of irrigation, fertilizers, and HYVs. Irrigation is often considered a lead variable in technical change, but examination of past changes in India indicates that development of irrigation by itself might not have brought about growth in the other two inputs and therefore the rapid growth in yield. Each input, it appears, has required its own investment and efforts and has made its own contribution. Therefore, it would be incorrect to relate all technical change to irrigation. The framework leaves out some inputs such as labor, power, and machinery. One important reason for this omission is that it is extremely difficult to get accurate information on the actual use levels of these inputs. Besides, some of them, such as labor, may not be strongly constraining and may be surplus, so their quantities may not be instrumental in determining production changes. To the extent that this is not true, it may cause an excluded variable upward bias of the coefficients, some of which is frequently unavoidable. Further, this analysis does not use cross-state data. A cross-state production function analysis, though interesting, might not be accurate because of large differences in soils, agroclimatic conditions, cropping patterns (as indicated in Chapter 3), and more, most of which would be difficult to fully incorporate through measurable variables and available data. Incomplete incorporation could cause unknown biases, leading to difficulty in making inferences. Therefore, aggregate analysis was preferred here.

Apart from checking theoretical consistency, a major cross-check of the empirical results was done by computing input-output coefficients at the mean from the estimated production function parameters, and these were compared with estimates of response coefficients accepted in the research literature and used in Indian planning and projection work, as discussed above in connection with Sarma and Roy (1979). The empirical results are presented in Tables 13 and 14 (variable definitions are in Appendix 6). In terms of R^2 and F statistics, all the functional forms show good fits. In the linear case, all the parameters have the right signs, but the t-statistic significance of each coefficient—except that for rainfall—is weak, showing that partial response frontier fits of this functional form are not strong. There is substantial improvement of the significance in the Cobb-Douglas functional form, indicating the greater efficacy of this form. However, the HYV coefficient has an incorrect sign. The function also seems to exaggerate the input-output coefficient of irrigation and underestimate the coefficients of fertilizers and HYVs. The transcendental functional form, on the other hand, exaggerates the effect of fertilizers and HYVs but makes the input-output coefficient of irrigation negative. This "sharing of the cake" problem manifested in the instability of coefficients appears to be an outcome of the high multicollinearity between fertilizers, HYVs, and irrigation brought out in the factor analysis. These results also show how unreliable it could be to test only one functional form, especially without comparing it with prior values for coefficients.

One alternative under this multicollinearity problem was to force a prior value on the irrigation coefficient. Thus the transcendental function was reestimated, with the irrigation input-output coefficient being fixed at 0.5, a value frequently accepted for India (see Sarma and Roy 1979). This last restricted transcendental function gives the following input-output coefficients for each of the inputs: 5.50 for fertilizers (note that the HYV effect is segregated), 0.50 for HYVs, 0.50 (by restriction) for irrigation, and 0.34 for rainfall. The good tracking of actual yields by this function is shown in Figure 10.

The input-output coefficient of HYVs shows that for every million hectares of increase in the coverage of HYVs, there is a 0.5 million-ton increase in production of foodgrains. Further, an examination of the magnitude and significance of coefficients in different functional forms indicates that HYVs show a positive semilogarithmic nature of response. This indicates that the spread of HYVs may hold considerable potential for increasing foodgrain production.

Rainfall appears to be showing close to a classical production function response. The standard deviation of the rainfall index is about 10 points and gives a coefficient of variation of 10 percent, which is not as high as may have been expected. It probably shows that there is substantial regional compensation between good and bad rainfall areas in most years. Only in a rare year is the rainfall adverse for the country as a whole, and the statistical variability of the all-India foodgrain rainfall index does not appear very high when studied over the past 33 years. Further, the rainfall input-output coefficient is estimated to be 0.34, which implies that, on an average, a one-standard-deviation (10 points) drop in the rainfall index (one standard deviation covers 65 percent of a normal distribution) reduces foodgrain production, through yield change, by 3.4 million tons. This may not be considered large in percentage terms relative to the 1981/82-1983/84 average production level of about 140 million tons. Rainfall would also influence production through changes in the area. Preliminary analysis on this shows that detrended area is also highly correlated with the rainfall index. But the

Table 13—Production function estimation results, 1951/52-1983/84

Functional Form	Estimation (N = 33)
Linear	$\text{YIELD} = \underset{(0.19)}{40.60} + \underset{(1.48)}{3.50} \cdot \text{FERT} + \underset{(0.73)}{2.37} \cdot \text{HYV} + \underset{(1.77)}{15.02} \cdot \text{IRRG} + \underset{(4.30)}{3.39} \cdot \text{RAIN}$
	Adjusted $R^2 = 0.94$ F statistic = 118.4 Durbin-Watson = 1.38
Cobb-Doublas	$\text{LOG(YIELD)} = \underset{(2.51)}{1.89} + \underset{(2.06)}{0.039} \cdot \text{LOG(FERT)} - \underset{(-0.92)}{0.0090} \cdot \text{LOG(HYV)} + \underset{(3.73)}{0.74} \cdot \text{LOG(IRRG)} + \underset{(6.77)}{0.53} \cdot \text{LOG(RAIN)}$
	Adjusted $R^2 = 0.94$ F statistic = 127.5 Durbin-Watson = 1.61
Transcendental	$\text{LOG(YIELD)} = \underset{(-0.90)}{-5.65} + \underset{(1.05)}{0.0032} \cdot \text{FERT} + \underset{(2.67)}{0.072} \cdot \text{LOG (FERT)} + \underset{(3.40)}{0.012} \cdot \text{HYV} - \underset{(-0.75)}{0.0088} \cdot \text{LOG(HYV)} - \underset{(-1.30)}{0.095} \cdot \text{IRRG} + \underset{(0.85)}{1.60} \cdot \text{LOG(IRRG)} - \underset{(-2.45)}{0.023} \cdot \text{RAIN} + \underset{(2.73)}{2.50} \cdot \text{LOG(RAIN)}$
	Adjusted $R^2 = 0.97$ F statistic = 123.1 Durbin-Watson = 2.19
Transcendental (forcing irrigation I-O coefficient to 0.50)	$\text{LOG(YIELD)} = \underset{(-2.28)}{-12.21} + \underset{(1.24)}{0.0040} \cdot \text{FERT} + \underset{(1.90)}{0.034} \cdot \text{LOG(FERT)} + \underset{(2.74)}{0.0081} \cdot \text{HYV} - \underset{(-2.17)}{0.022} \cdot \text{LOG(HYV)} - \underset{(-2.07)}{0.15} \cdot \text{IRRG} + \underset{(2.16)}{3.54} \cdot \text{LOG(IRRG)} - \underset{(-2.78)}{0.026} \cdot \text{RAIN} + \underset{(3.23)}{2.97} \cdot \text{LOG(RAIN)}$
	Adjusted $R^2 = 0.97$ Durbin-Watson = 2.35

Notes: The numbers in parentheses below parameter estimates are t-statistics. Results are strongly affected by multicollinearity between irrigation, fertilizers, and high-yielding varieties. The implied input-output (I-O) coefficients from these regression estimates are given in Table 14. The transcendental production function gives the greatest flexibility to the shape of the production frontier vis-à-vis each input. Other functional forms such as translog and quadratic were also tried. These forms introduce interaction terms that greatly increase the variable load, and this coupled with the already great multicollinearity problem leads to poor and unstable results.

Definitions of variables:

YIELD = yield of foodgrains in kilograms per hectare,
FERT = fertilizer use in kilograms per hectare,
HYV = percent coverage of high-yielding varieties in foodgrain area,
IRRG = percent coverage of irrigation in foodgrain area, and
RAIN = all-India foodgrain rainfall index.

estimated impact on production through the area from a one-point change in the rainfall index is only about one-third in magnitude compared with the impact on production through the yield, at the mean.

The above analysis shows that though rainfall is a very important factor in determining India's foodgrain production, with a high statistical significance in all func-

Table 14—Implied input-output coefficients at mean from production function estimates

Functional Form	Fertilizer	High-Yielding Varieties	Irrigation	Rainfall
	(metric tons/ton)	(metric tons/hectare)		(million metric tons/ index point)
Linear	3.50	0.24	1.50	0.40
Cobb-Douglas	2.74	−0.06	2.51	0.50
Transcendental	7.57	0.86	−2.04	0.24
Transcendental (forcing irrigation I-O coefficient to 0.5)	5.49	0.50	0.50	0.34
Additional estimates				
Transcendental (forcing irrigation I-O coefficient to 0.4)	5.58	0.52	0.40	0.34
Transcendental (forcing irrigation I-O coefficient to 0.25)	5.70	0.54	0.25	0.33
Transcendental (excluding high-yielding varieties)	9.10	. . .	0.33	0.36
Transcendental (excluding high-yielding varieties and forcing irrigation I-O to 0.5)	8.64	. . .	0.50	0.36

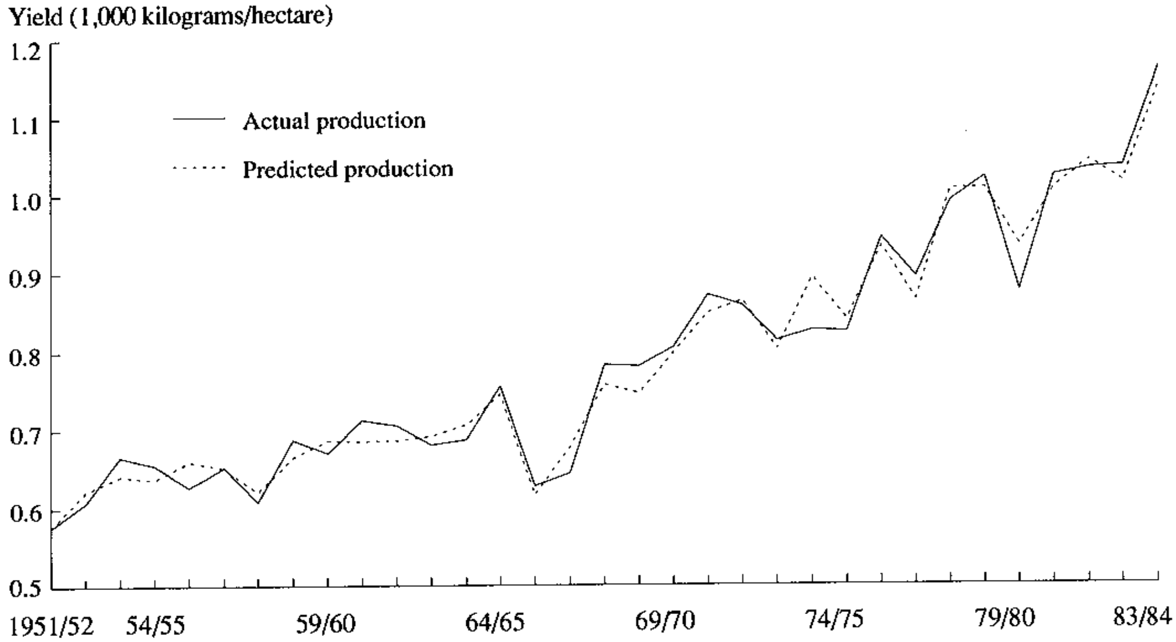
Notes: In the linear case the yield equation regression coefficient directly gives the marginal productivities. In order to obtain the input-output (I-O) coefficients in the units given above, the high-yielding varieties and irrigation coefficients need to be divided by 10, and for rainfall the coefficient needs to be multiplied by (118.71/1000). In the Cobb-Douglas case, the yield equation regression coefficients give the elasticities, which can be converted to derivatives at mean by multiplying with (mean yield/mean input level). These can be converted to input-output coefficients using the same methods as for linear. For the transcendental case, following Halter, Carter, and Hocking (1957), the derivatives at mean can be calculated as follows: $dy/dx = y(a/x + b)$, where y is mean yield, x is mean input level, a is coefficient of log input terms, and b is coefficient of linear input terms. The derivatives can be converted to input-output coefficients using the same methods as for linear.

tional forms, its average variability for the country as a whole is not extremely high when evaluated over the past 33 years. Further, when studied over many years, its effect on total foodgrain production in the country may not be as great as often assumed. An interesting area of further research could be to examine the impact of two or three consecutive bad rainfall years on foodgrain production.

Table 13 also shows several additional estimates obtained through alternative assumptions in the production function analysis. Since a prior value of 0.50 was forced for the irrigation input-output coefficient, it became important to check the sensitivity of the estimates to this assumption. The results show that varying the irrigation input-output coefficient to 0.40 and to 0.25 causes only a small change in the input-output coefficients of fertilizers, HYVs, and rainfall.

In the earlier approach of studying input response, the effect of HYVs was included under the fertilizer response, and no distinction was made between HYVs and fertilizers. To simulate this, the HYV variable was dropped from the equation, and the equation was reestimated. The results show that the fertilizer input-output coefficient under this assumption comes to 9.10 (at the mean), and for irrigation the coefficient comes to 0.33. To provide comparability with the earlier estimate, the irrigation input-output coefficient was forced to 0.50, and the results show that this causes a small reduction in the fertilizer input-output coefficient to 8.64. This result obtained through production function analysis supports those obtained earlier through the analysis using

Figure 10—Production function: actual and predicted values, 1951/52-1983/84



Source: Based on results of the second transcendental equation in Table 13.

response coefficients. The response coefficient analysis indicated a decline in the response for fertilizers, from a response of the order of 10 in the 1960s and early 1970s to a response of the order of 7 in more recent years. The production function analysis indicates a comparable response at the mean of 8.6. This supports the hypothesis that there has been a decline in the aggregate fertilizer response. Since fertilizers are expected to play a crucial role in the future growth of foodgrain production, this decline in the response is of major policy concern.

Yields under High-Yielding Varieties and Irrigation

This section provides some further facts on yields obtainable with HYVs and irrigation, since these could not be fully dealt with within the framework and methods above because of the multicollinearity problem.

In 1983/84 the area under HYVs reached a level of 54 million hectares, of which rice and wheat accounted for about 41 million. A shift to HYVs is expected to increase yields, and the available data on HYV yields in selected states indicates that the differentials between HYVs and local varieties are relatively high but have a wide variation from state to state. The HYV yields for wheat in 1983/84 were about 3.0 tons per hectare in Punjab, 2.7 tons in Gujarat, and 2.5 tons in Haryana, whereas in other states they ranged only from 1.0 to 2.0 tons per hectare. For rice the HYV yields were 3.0 tons per hectare in Punjab and West Bengal, followed by Haryana (2.7 tons) and summer rice in Karnataka (2.5 tons). The yields quoted above are state average HYV yields based on the results of crop-cutting experiments. The wide differences in state HYV yields can be attributed to variations in soil fertility, input use, and adoption of improved agricultural practices, including water management. In Punjab, HYV yields may be relatively high because of 91 percent irrigation of the foodgrain area and a high rate of fertilizer application (143 kilograms per hectare in 1983/84). On the other hand, in the Central region states of Madhya Pradesh and Rajasthan the average yields are low, possibly because of less irrigation and low per hectare use of fertilizers (Table 15). These yields indicate that the HYV yields are higher than average, and the yield differentials across states indicate that there may be scope for further improvement, even in HYV yields.

Irrigated area under foodgrains reached a level of 40 million hectares by 1983/84. Foodgrain yields under irrigation are generally known to be higher than those without irrigation. Aggregated data on average yield per hectare of irrigated and unirrigated foodgrains are not available. However, disaggregate data on irrigated yields in selected states based on crop-cutting experiments indicate that irrigated wheat yield in Punjab was 3.1 tons per hectare in 1983/84. In Gujarat and Haryana the irrigated yield averaged 2.7 and 2.5 tons, respectively, whereas in the remaining states it was about 2 tons per hectare or lower. In rice, again Punjab led with 3.1 tons per hectare, followed by West Bengal with 2.7 tons (winter crop). In West Bengal, however, irrigated summer rice yielded 3.9 tons per hectare. These yields actually represent the combined effects of irrigation, HYVs, chemical fertilizers, and associated improved practices. These yields also show that the yields under irrigation are higher than average, and the yield differentials across states indicate that there could be further scope for increasing irrigated yields.

Table 15—Irrigation, high-yielding variety, and fertilizer use, and crop yields in selected states, 1983/84

Item	Punjab	Madhya Pradesh	Rajasthan
Irrigated area under foodgrains to total cropped area (percent)	91.0	13.2	18.9
Yield of irrigated rice (metric tons/hectare)	3.1	1.5	1.8
Yield of irrigated wheat (metric tons/hectare)	3.1	1.8	1.7
Area under HYVs to total area under foodgrains (percent)	89.9	22.1	21.8
Yield of HYV rice (metric tons/hectare)	3.0	1.7	. . .
Yield of HYV wheat (metric tons/hectare)	3.0	1.9	1.9
Fertilizer use (kilograms/hectare)	143.1	14.5	11.3

Sources: Based on data from India, Ministry of Agriculture, Directorate of Economics and Statistics, *Area and Production of Principal Crops in India, 1985-86* (Delhi: Controller of Publications, 1987); and India, Ministry of Agriculture, Directorate of Economics and Statistics, *Indian Agriculture in Brief* (Delhi: Controller of Publications, 1986).

Note: HYV = high-yielding variety.

5

TRENDS AND CHANGES IN PER CAPITA CONSUMPTION OF FOODGRAINS

Statistics on per capita consumption of foodgrains in India are available from two separate sources that use entirely different methods. The Ministry of Agriculture annually computes and reports in its *Bulletin on Food Statistics* the per capita availability of foodgrains, using net production, net imports, changes in government stocks, and midyear population. These estimates are essentially based on supply-utilization accounts and use the disappearance concept. The second source is the National Sample Survey Organization (NSSO) of the Department of Statistics, which reports data on per capita consumption of foodgrains in quantity and value terms from household consumer surveys that are currently conducted every five years. The National Sample Survey (NSS) data are, therefore, based on direct estimation of consumption through the interview method. These permit a more disaggregate examination of the consumption levels and patterns. This chapter uses both of the above estimates to examine the trends, levels, and patterns of consumption, in rural and urban areas, by crop and by quartile group.

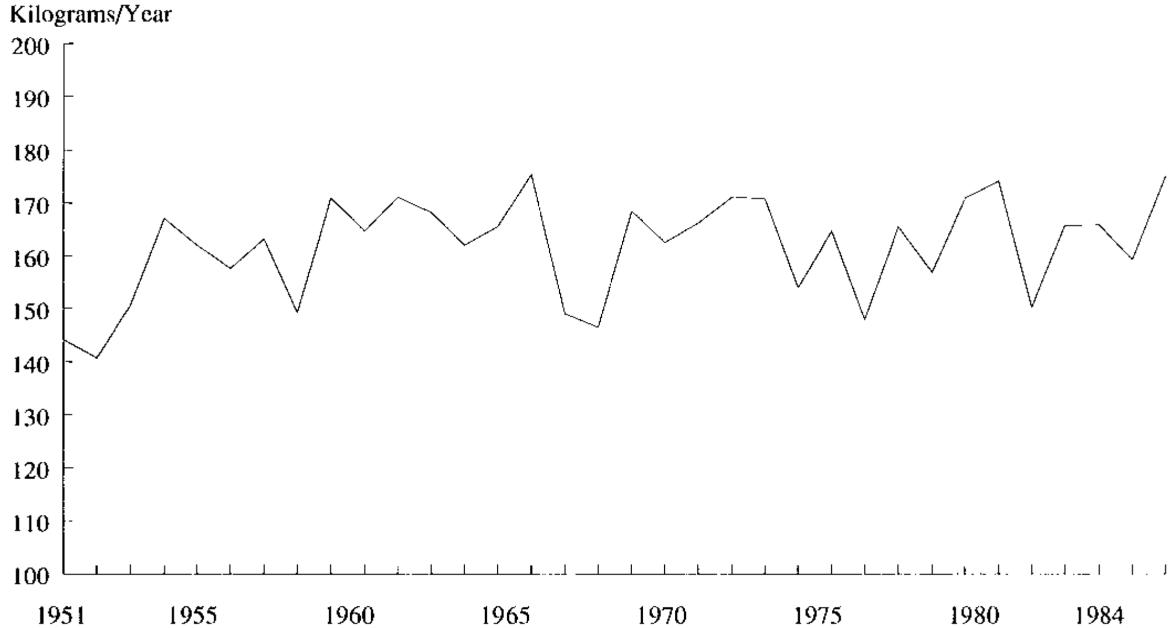
Per Capita Availability

The data on net availability of foodgrains do not account for changes in private stocks with trade, farmers, or consumers, as data on these are not readily available. The net production is obtained by subtracting from the gross production an overall predetermined allowance of 12.5 percent for seed, feed, and wastage.[12] Ideally, the seed use estimate should be based on seed rates and areas under different crops, and the rates relative to production would have changed considerably, especially after the introduction of HYVs. The feed use estimate should be based on the feeding ratios and measures of livestock output, and the wastage should be determined separately as a percentage of the foodgrain output. However, in the absence of any representative survey data giving alternative rates and ratios for these, there was no feasible way around these weaknesses in the data. Therefore, these weaknesses having been mentioned, the Ministry's figures on net production and per capita availability are used in the following analysis.

Figure 11 gives a plot of the annual national per capita availability of foodgrains from 1951 to 1984. It shows that availability has fluctuated considerably but without a

[12] Different percentages are applied to different foodgrains: for rice the allowance is 7.6 percent, for wheat, 12.1 percent, and for the aggregate of cereals and pulses, 12.5 percent.

Figure 11—Per capita availability of foodgrains, 1951-84



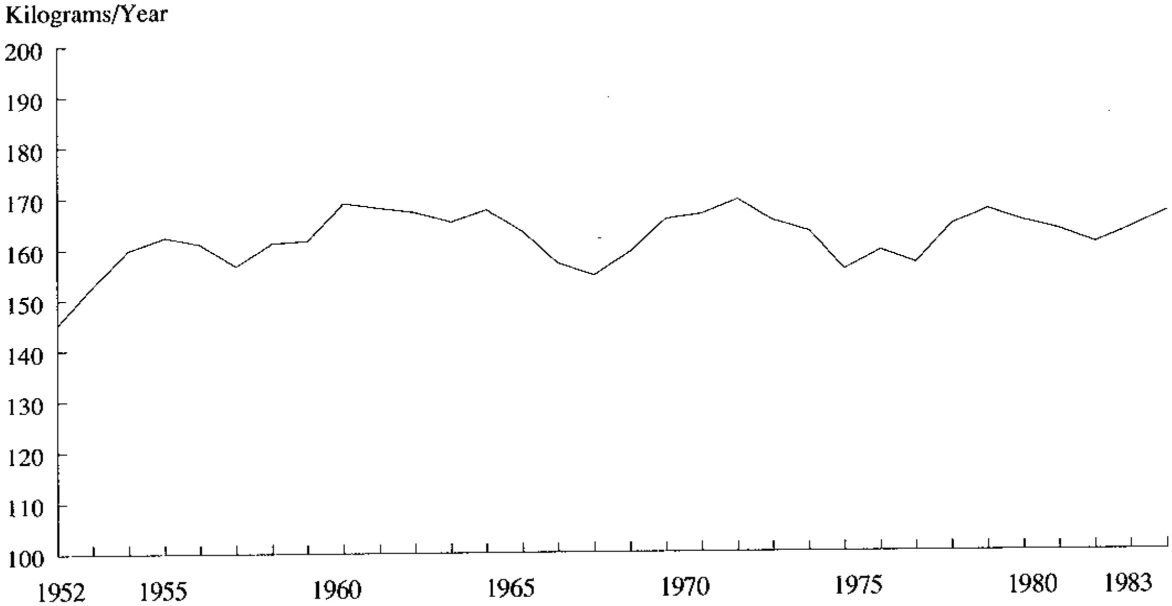
Sources: Based on data from India, Ministry of Agriculture, Directorate of Economics and Statistics, *Bulletin on Food Statistics*, various issues (Delhi: Controller of Publications, various years).

major trend. The following table gives estimated compound growth rates of per capita availability and their t-statistics for different periods.

Time Period	Growth Rate (percent/year)	t-Statistic
1951-84	0.19	1.85
1951-65	1.10	3.94
1968-84	negligible	0.03
1968-76	−0.79	−1.32
1976-84	0.27	0.39

The results show that the trend growth rate for the period 1951-84 as a whole is only 0.2 percent a year and is statistically insignificant. The first subperiod (1951-65), which is the pre-green-revolution part, shows an increase in per capita consumption of 1.1 percent a year. However, the green-revolution period (1968-84) shows no trend in either the first (1968-76) or second (1976-84) part. Thus, except in the pre-green-revolution period, the per capita availability figures show very little overall improvement or deterioration. Figure 12 gives a plot of a centered three-year moving average of per capita availability. This shows that the per capita average availability fluctuates in a band approximately between 150 kilograms and 170 kilograms a year for the period from 1952 to 1983.

Figure 12—Per capita availability of foodgrains: three-year moving average, 1952-83



Sources: Based on data from India, Ministry of Agriculture, Directorate of Economics and Statistics, *Bulletin on Food Statistics*, various issues (Delhi: Controller of Publications, various years).

Sarma and Roy (1979) reported a 6.2 percent decline in per capita availability of foodgrains in 1975-77 compared with the level in 1970-72.[13] Table 16 shows that the average per capita availability declined from 169.3 kilograms a year in 1970-72 to 156.7 kilograms a year in 1975-77. Subsequently, the per capita availability rose again to 166.6 kilograms a year in 1982-84. However, it remains to be seen why per capita availability fell substantially in 1975-77 compared with 1970-72. Related data in Table 16 show that there were increases in the net production of cereals, net imports, and per capita income, along with a decrease in the real price of foodgrains, and yet there was a decline in per capita availability. An increase in government stocks more or less absorbed the increase in cereal imports. To further analyze this implicit change in consumption behavior during 1970-84, the annual net production of foodgrains per capita and the real prices of foodgrains were calculated on a time-series basis, and these were plotted along with per capita availability (Figure 13). The following observations can be made from this analysis.

1. The per capita availability and the per capita net production series move closely together (the difference between the two can be accounted for by per capita imports and changes in stocks).

2. Especially in 1975 and to some extent in 1977, the per capita net production was much lower than in the early 1970s, and, coupled with the higher (total) net production

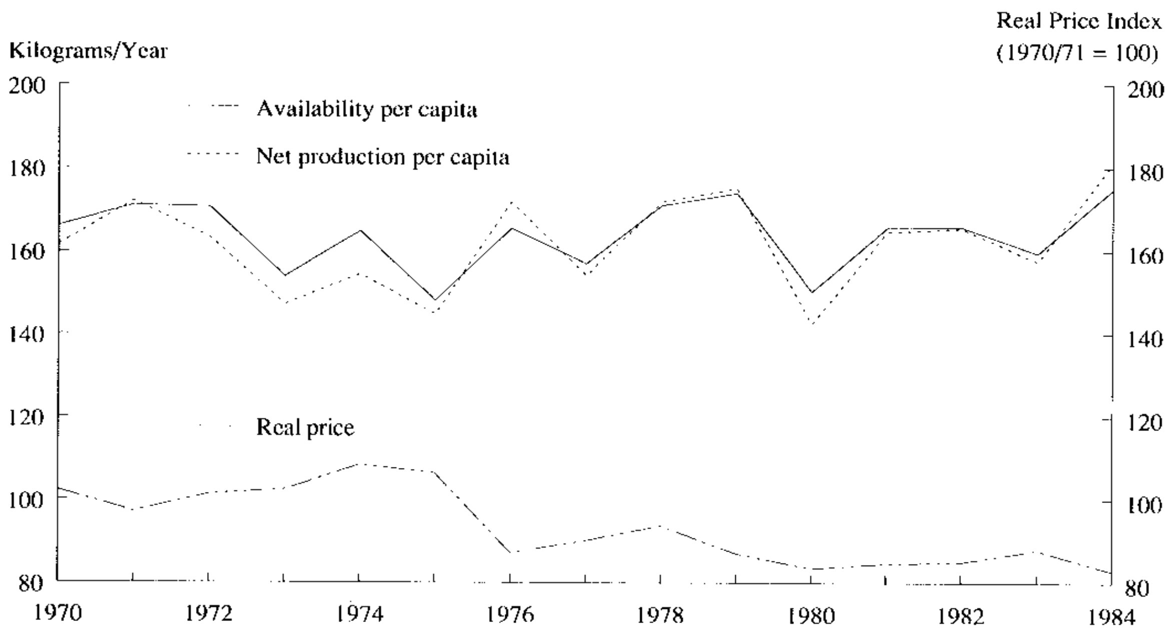
[13] The decline in availability in the mid-1970s was also a global phenomenon for developing countries; grain production declined in both developed and developing countries, causing a drawdown in stocks and reduction in grain trade.

Table 16—Changes in net availability of foodgrains across selected years, 1970-84

Item	1970-72 Average	1975-77 Average	1982-84 Average
Per capita availability of foodgrains (kilograms/year)	169.3	156.7	166.6
Net production of cereals (million metric tons)	81.2	86.8	110.5
Net import of cereals (million metric tons)	1.8	4.8	2.7
Net production of pulses (million metric tons)	10.1	10.0	10.6
Real price index of foodgrains (wholesale) (1970/71 = 100)	100.3	94.6	84.8
Per capita income (constant rupees/year)	624.0	644.0	734.0
Population (millions)	551.4	617.3	720.4
Change in government stocks of cereals (million metric tons)	−0.3	+ 4.9	+ 3.7
Net availability of foodgrains (million metric tons)	93.4	96.8	120.1

Sources: Based on data from India, Ministry of Agriculture, Directorate of Economics and Statistics, *Area and Production of Principal Crops in India*, various issues (Delhi: Controller of Publications, various years); and India, Ministry of Agriculture, Directorate of Economics and Statistics, *Bulletin on Food Statistics*, various issues (Delhi: Controller of Publications, various years).

Figure 13—Per capita availability, net production, and real prices of foodgrains, 1970-84



Sources: Based on data from India, Ministry of Agriculture, Directorate of Economics and Statistics, *Area and Production of Principal Crops in India*, various issues (Delhi: Controller of Publications, various years); and India, Ministry of Agriculture, Directorate of Economics and Statistics, *Bulletin on Food Statistics*, various issues (Delhi: Controller of Publications, various years).

of foodgrains in this period, this implies that though production increased, it could not keep pace with the increase in population. The 1.9 percent annual rate of growth in foodgrain production during 1967-76 was lower than the population growth rate of 2.3 percent.

3. In 1976, there was a sharp decline in the real prices of foodgrains. At least partly due to this decline, there was a large apparent transfer of foodgrain stock holdings from the unrecorded/unaccounted private sector to the recorded/accounted government sector. This was estimated by Sarma and Roy (1979) to be of the order of 2 million tons on an average during 1975-77. Such a shift in stocks would have an effect of relative underestimation of per capita human consumption since per capita availability does not take into account changes in private stocks. This would account for a difference of about 3.2 kilograms per capita. Thus the decline in per capita availability between 1970-72 and 1975-77 can be explained mainly in terms of production growth not keeping pace with population growth, and to some extent in terms of a relative underestimation of per capita availability in 1975-77 due to a shift of stocks from private to government hands.

Figure 13 also shows that the real prices of foodgrains fell significantly in the second half of the 1970s compared with their high levels in the first half, and these depressed real prices continued into the 1980s. Another observation is that government operations through stocks and imports appear to have been helpful in supplementing domestic procurement and in meeting requirements under the public distribution system. However, given that one of the objectives of the operation was stabilization of consumption, Figure 13 indicates that the government operations were unable to substantially dampen the instability in per capita availability arising from fluctuations in production. This, however, does not take into account the effects of private stocks. The above observations seem to indicate the indispensability of sustained growth in production for raising and stabilizing foodgrain consumption.

National Sample Survey Consumption Estimates

As mentioned earlier, the NSSO conducts all-India sample surveys that examine the levels and patterns of consumption of foodgrains and other items of consumption for both rural and urban consumers across income (total consumer expenditure) groups. Until 1973/74 the consumption surveys were conducted annually, but since then they have been conducted approximately every five years.[14] These surveys cover random samples of up to 150,000 households from all over the country and report consumption by major item, usually in per capita expenditures and quantities, but often and for many items, only in expenditure terms. For the 1977/78 and 1983 surveys, quantitative data on consumption of pulses are not available. The methodology followed for deriving quantity data from the expenditure data on pulses is described in Appendix 7.

Table 17 presents the average per capita consumption of cereals, pulses, and foodgrains at the rural, urban, and national levels from 1961/62 to 1983 based on NSS data. The figures show that about 94 percent of the foodgrains consumed are cereals and only 6 percent are pulses. The NSS data show a decline in the per capita consumption of foodgrains from the 1960s to the 1970s. For instance, between 1961/62 and

[14] Most of the NSSO's consumption surveys use the split-year basis of July to June. One exception was 1983, which was based on the calendar year.

Table 17—Per capita consumption of foodgrains, 1961/62-1983

Year	Grain	Monthly Consumption[a] Rural	Urban	National	Annual Consumption National[a]	Average per Capita Availability[b,c]
				(kilograms)		
1961/62	Cereals	17.55	12.49	16.63	...	...
	Pulses	1.50	1.53	1.51	...	...
	Total	19.05	14.02	18.14	220.7	167.1
1964/65	Cereals	16.19	11.65	15.32	...	...
	Pulses	1.66	1.18	1.56	...	...
	Total	17.85	12.83	16.88	205.4	163.2
1970/71	Cereals	15.35	11.36	14.56	...	...
	Pulses	0.96	1.01	0.97	...	...
	Total	16.31	12.37	15.53	188.9	169.3
1972/73	Cereals	15.29	11.27	14.45	...	...
	Pulses	0.85	0.93	0.87	...	...
	Total	16.14	12.20	15.32	186.4	165.2
1973/74	Cereals	15.09	11.32	14.30	...	...
	Pulses	0.88	0.82	0.87	...	...
	Total	15.97	12.14	15.17	184.6	155.5
1977/78	Cereals	15.25	11.62	14.44	...	...
	Pulses[d]	1.01	1.07	1.02	...	...
	Total	16.26	12.69	15.46	188.1	167.2
1983	Cereals	14.80	11.30	13.96	...	...
	Pulses[d]	1.02	1.13	1.04	...	...
	Total	15.82	12.43	15.00	182.5	166.6

Sources: Based on data from India, Department of Statistics, National Sample Survey Organization, *The National Sample Survey: Tables on Consumer Expenditure*, various rounds (New Delhi: NSSO, various years); and India, Ministry of Agriculture, Directorate of Economics and Statistics, *Bulletin on Food Statistics*, various issues (Delhi: Controller of Publications, various years).

Notes: The estimates of per capita availability derived from the Ministry of Agriculture's figures and those of per capita consumption obtained from the National Sample Survey are not strictly comparable for a number of reasons (see Appendix 7 for details). Parts may not add to totals because of rounding.

[a]Based on National Sample Survey consumption figures, which are on a July-June survey-year basis except for 1983, which is on a calendar-year basis.

[b]Based on Ministry of Agriculture per capita availability figures, which are provided on a calendar-year basis.

[c]The per capita availability shown against year 1961/62 (July-June) is the three-year average for calendar years 1961 to 1963, and so on for all years except 1983, when all figures are directly on a calendar-year basis.

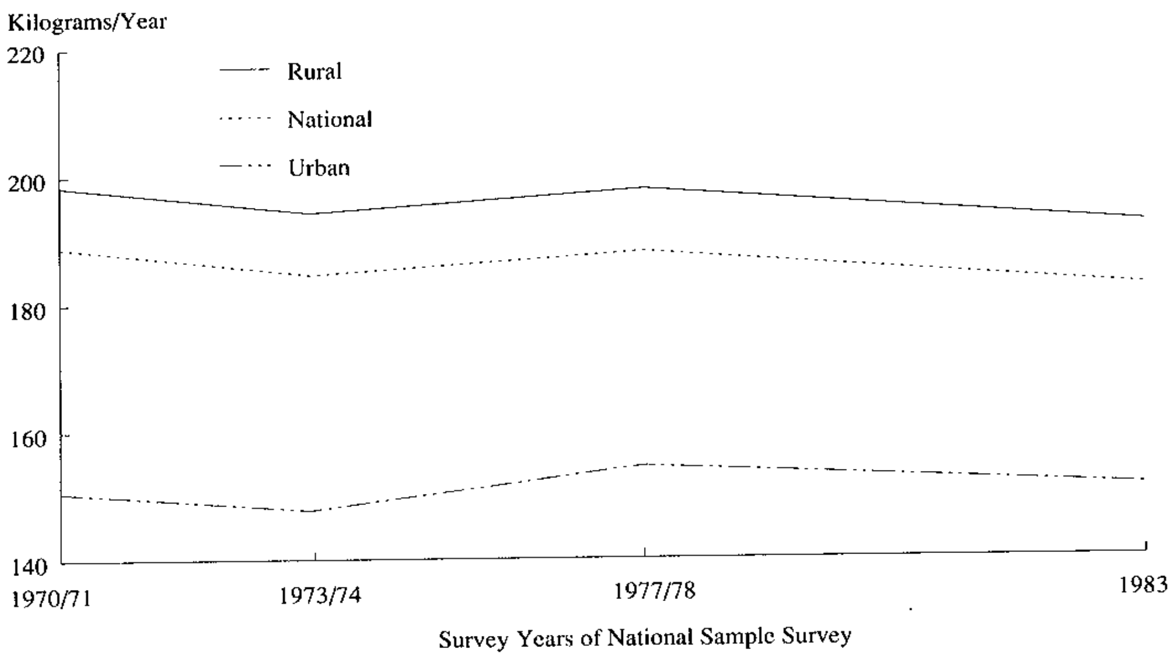
[d]Estimated.

1970/71 consumption declined from 220.7 kilograms a year to 188.9 kilograms, a reduction of 14.4 percent. In 1973/74 it declined further to 184.6 kilograms a year. It rose again to 188.1 kilograms in 1977/78, though in 1983 per capita consumption declined to 182.5 kilograms. Relative to the difference between the 1960s and 1970s, the changes in per capita consumption since 1970/71 have been small and have been in both directions, and since the per capita consumption is captured for only one year out of several years, they may reflect year-to-year fluctuations. Underlying price changes may also hold some explanation, and these will be discussed later.

In order to examine further the difference in the per capita consumption between the 1960s and 1970s, average per capita availability figures were calculated from the Ministry of Agriculture's data for comparison for the years corresponding to NSS surveys. Strictly speaking, the estimates of per capita availability, which are based on the disappearance concept, cannot be directly compared with the NSS estimates of consumption, which are obtained by the interview method, in part because the availability figures do not reflect changes in private stocks. The NSS data relate to household consumption only and do not include nonhousehold consumption such as that of hotels. However, broad comparisons are possible, and for this purpose, three-year-average per capita availabilities with the designated year as the midyear have been computed and are presented in Table 17. The availability figures indicate a much smaller change from the early 1960s to the early 1970s and show a 1.3 percent increase between 1961/62 and 1970/71 (compared with a 14.4 percent decrease shown by the NSS data). Several studies, including Vaidyanathan 1986, Suryanarayana and Iyengar 1986, Mukherjee 1986, and Minhas 1988, also indicate that the NSS estimates of per capita consumption in the early 1960s may be relative overestimates. Thus it seems that the NSS data may exaggerate the decline in consumption from the 1960s to the 1970s. There is a difference in magnitudes between the NSS consumption figures and the per capita availability figures, and this continues into the 1970s and 1980s to as much as 12-15 percent, but the gap is relatively stable in these years.

Figure 14 shows a large difference between the rural and urban consumption levels of foodgrains, based on the NSS data. This is of the order of 50 kilograms a year and could be a result of own-foodgrain production and consumption in the rural areas, rural-urban price difference due to market margins, different preferences due to higher incomes in the urban areas, and variety of foods available in the urban markets. Figure 14 also shows small changes in national per capita foodgrain consumption between 1970/71 and 1983. Consumption shows a small decline from 1970/71 to 1973/74, an increase from 1973/74 to 1977/78, and a decrease from 1977/78 to 1983. Given that NSS estimates consumption in only one year of several years, this may tend to reflect

Figure 14—Per capita consumption of foodgrains, 1970/71-1983



Sources: Based on data from India, Department of Statistics, National Sample Survey Organization, *The National Sample Survey: Tables on Consumer Expenditure*, various rounds (New Delhi: NSSO, various years).

the year-to-year fluctuations rather than trends. Rural and urban per capita consumptions show similar patterns over time. The difference between 1970/71 and 1983 may be partly due to changes in relative prices, which will be discussed later.

The overall consumption of pulses declined from 1.56 kilograms a month in 1964/65 to 0.87 kilograms by 1972/73 but subsequently increased to about 1.02 kilograms per capita by 1977/78 and remained more or less at that level in 1983. The difference between the rural and urban per capita consumption of pulses was very marginal in most years.

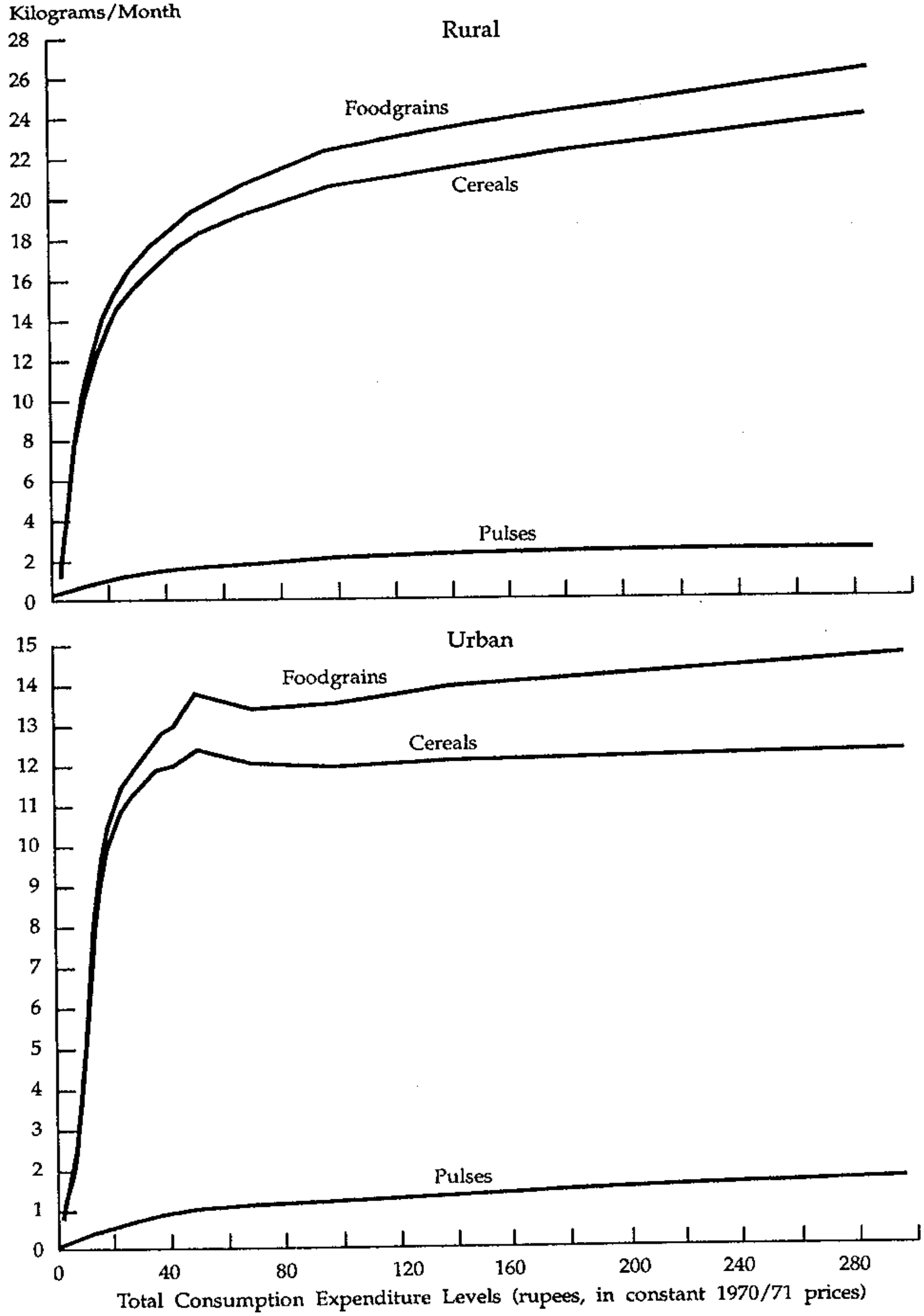
Figure 15 shows the 1977/78 per capita consumption of cereals, pulses, and foodgrains across income (total expenditure) groups in the rural areas in 1977/78. In the following discussion, income refers to its proxy: total expenditure in constant 1970/71 prices.[15] The consumption of foodgrains initially rises steeply with the rise in incomes but gradually levels off. The near-saturation level for the rural areas is about 27 kilograms a month, or 329 kilograms a year. Pulse consumption, which is nearly zero at the bottom income levels, rises to about 2.5 kilograms a month, or 30.0 kilograms a year, at the high income levels. In the urban areas, foodgrain consumption reaches near saturation at around 15.0 kilograms a month, or 183.0 kilograms a year, and pulse consumption reaches a level of about 2.0 kilograms a month, or 24.0 kilograms a year, at the highest income levels. These figures show the large difference between the levels of rural and urban direct consumption of foodgrains per capita. Given these food consumption patterns, it appears that income growth in rural areas can have a potentially greater total impact on direct foodgrain demand than similar changes in urban areas.

Table 18 shows the per capita monthly consumption of rice, wheat, and coarse grains in rural and urban areas, based on the NSS results. The data show declining consumption of coarse cereals in both rural and urban areas. The consumption of wheat in rural areas increased relatively faster than in urban areas. Consequently, the rural-urban disparity in wheat consumption narrowed considerably—perhaps partly because of the rapid expansion of fair-price shops distributing cheaper wheat in rural areas, particularly in the deficit states. Rapid expansion of area and production of wheat and its introduction into new areas also contributed to increased wheat consumption. Consumption of rice in rural areas grew steadily though slowly between 1970/71 and 1977/78. The per capita consumption of rice in urban areas in 1973/74 and 1977/78 was lower than in 1970/71.

In order to bring about comparability for the study of consumption levels across income groups at different time points, several adjustments were made in the data. The rural and urban income group means were deflated to 1970/71 prices by the agricultural-labor consumer price index and the working-class consumer price index, respectively. Nonavailable quantity data posed special problems in the case of pulses in 1977/78 and 1983 because past data showed that prices varied significantly across income groups—possibly because of differences in the composition and quality of foodgrains consumed. As a solution, the mean prices of pulses were moved forward using wholesale price indices for pulses, and the price distribution across income groups, estimated from 1970/71, was used to generate the prices at each income group level on the basis of its real relative value. (Details of this procedure are given in

[15] The use of total expenditure as a proxy for income has some limitations in the sense that it understates the income in the top quartile, which has a higher propensity to save, and may overstate the income in the bottom quartile, which may have a tendency to dissave.

Figure 16—Per capita consumption of foodgrains, rural and urban, 1977/78



Source: Based on data from India, Department of Statistics, National Sample Survey Organization, *The National Sample Survey: Tables on Consumer Expenditure*, Round 32 (1977/78) (New Delhi: NSSO, 1984).

Table 18—Per capita monthly consumption of cereals, 1970/71-1983

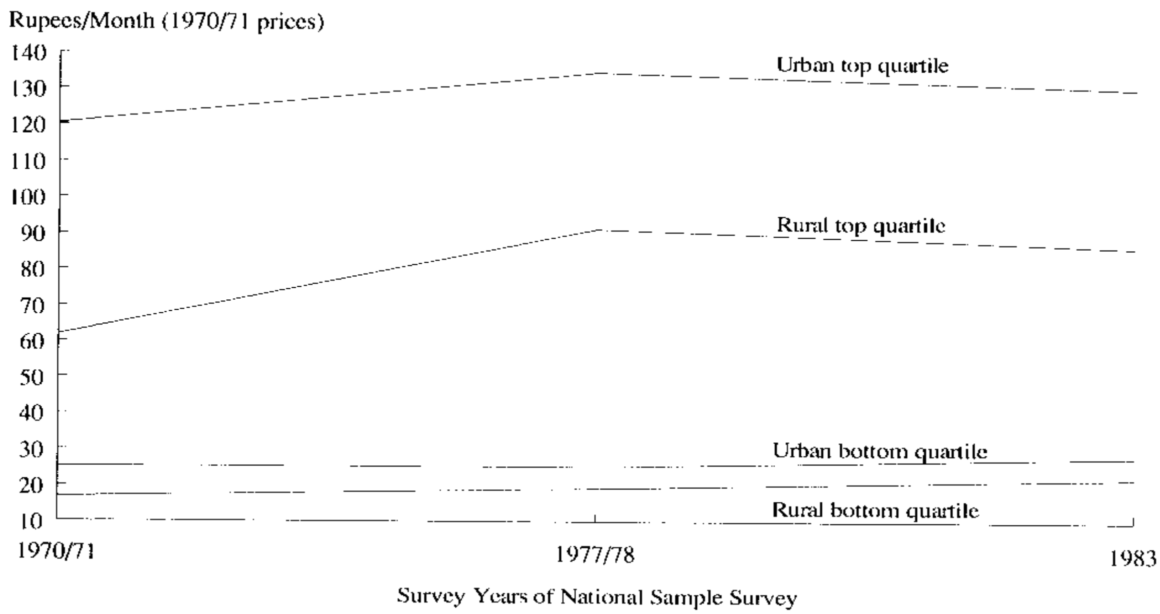
Cereal	Rural 1970/71	Rural 1973/74	Rural 1977/78	Rural 1983	Urban 1970/71	Urban 1973/74	Urban 1977/78	Urban 1983
	(kilograms)							
Rice	6.85	6.90	7.12	6.63	5.53	5.38	5.48	5.32
Wheat	2.78	3.52	4.05	4.46	4.12	4.32	4.87	4.82
Coarse grains	5.72	4.67	4.08	3.71	1.71	1.62	1.27	1.16
Total cereals	15.35	15.09	15.25	14.80	11.36	11.32	11.62	11.30

Sources: Based on data from India, Department of Statistics, National Sample Survey Organization, *The National Sample Survey: Tables on Consumer Expenditure,* various rounds (New Delhi: NSSO, various years); see Appendix 7 for details.

Appendix 7.) The computed comparable data were then used in a quartile analysis of consumption.

Figure 16 and Table 19 show total expenditure (total consumer expenditure) levels of the top and bottom, urban and rural, quartiles in constant 1970/71 prices. Considering total expenditure as a proxy for income, this figure shows that the income of the urban top quartile is substantially higher than that of the rural top quartile and that both the top quartiles are four to five times higher than the bottom quartiles. The total expenditure disparities in the urban as well as the rural areas appear to have increased

Figure 16—Total per capita consumer expenditure levels, by quartile, 1970/71-1983



Sources: Based on data from India, Department of Statistics, National Sample Survey Organization, *The National Sample Survey: Tables on Consumer Expenditure*, various rounds (New Delhi: NSSO, various years).

Table 19—Per capita foodgrain consumption and total consumer expenditures, rural and urban, top and bottom quartiles, 1970/71-1983

	Foodgrain Consumption				Total Expenditure[a]			
	Rural Quartiles		Urban Quartiles		Rural Quartiles		Urban Quartiles	
Year	Top	Bottom	Top	Bottom	Top	Bottom	Top	Bottom
	(kilograms/month)				(rupees/month)			
1970/71	20.56	11.90	12.83	11.02	61.95	16.77	120.39	25.20
1977/78	21.11	12.32	13.92	10.96	91.23	19.37	134.54	25.21
1983	20.29	12.67	13.90	11.00	86.19	22.12	130.03	27.90

Sources: Based on data from India, Department of Statistics, National Sample Survey Organization, *The National Sample Survey: Tables on Consumer Expenditure,* various rounds (New Delhi: NSSO, various years); see Appendix 7 for details.

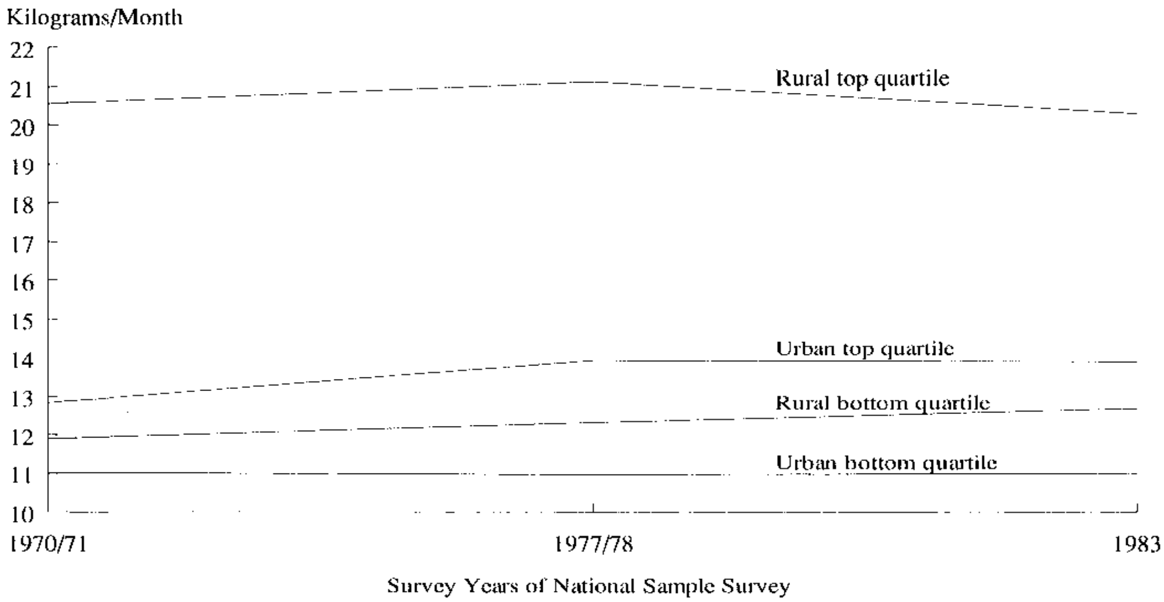
[a]At 1970/71 prices.

from 1970/71 to 1977/78 but decreased from 1977/78 to 1983. The rural-urban total expenditure disparities lessened over this entire period. The compound annual growth rates of total expenditure (income) of the different quartiles between 1970/71 and 1983 are rural top, 2.6 percent; rural bottom, 2.2 percent; urban top, 0.6 percent; and urban bottom, 0.7 percent. From this it appears that the rural total expenditures, though lower, may be improving faster at both the upper and lower income levels. Rural bottom quartile incomes show continuing growth from 1970/71 to 1983, which is encouraging, but the 2.2 percent rate of growth appears too small to raise this group rapidly from their low income levels. On the other hand, the income level of the urban bottom quartile shows an even smaller improvement, growing at a rate of only 0.7 percent.

Figure 17 and Table 19 give the per capita foodgrain consumption of different quartiles, showing the substantially higher level of foodgrain consumption of the rural top quartile. There was a small decline in this consumption level between 1970/71 and 1983, from 20.56 kilograms a month to 20.29 kilograms. However, foodgrain consumption of the urban top quartile increased from 12.83 kilograms a month in 1970/71 to 13.90 kilograms in 1983, and that of the rural bottom quartile also improved from 11.90 kilograms a month in 1970/71 to 12.67 kilograms in 1983. But the consumption of the urban bottom quartile was stagnant at about 11.00 kilograms a month. Thus, whereas the disparities in foodgrain consumption between income levels are decreasing in the rural areas, they are increasing in the urban areas. This is confirmed by the following compound growth rates of foodgrain consumption between 1970/71 and 1983: rural top, −0.10 percent; rural bottom, 0.50 percent; urban top, 0.60 percent; and urban bottom, −0.01 percent. The 0.50 percent growth rate of the rural bottom quartile, though positive, is itself not very encouraging, and the stagnation in consumption of the urban bottom quartile at the already low level is of great concern.

The growth in foodgrain consumption of the urban top quartile was about 8.3 percent, which is related to a growth of 8.0 percent in its total expenditure in the same period, but this 8.0 percent probably understates the growth in income of the top quartile, which generally has a high marginal propensity to save. This increase in consumption may also be partly because of the generally improved availability of foodgrains in the free market since the early 1970s and particularly after 1978. The decline in real prices of foodgrains may also have been sharper for urban areas than the average. This is supported by George (1979), who reported that the increase in nominal

Figure 17—Per capita foodgrain consumption levels, by quartile, 1970/71-1983



Sources: Based on data from India, Department of Statistics, National Sample Survey Organization, *The National Sample Survey: Tables on Consumer Expenditure*, various rounds (New Delhi: NSSO, various years).

prices of foodgrains has been less sharp in urban than in rural areas. This issue requires further investigation, since it has an important bearing on demand.

Mellor (1978) has shown that even though the poor have a smaller absolute expenditure on food, the impact of a food price increase falls most heavily on them because food has a large budget share in their total expenditure. Ezekiel (1990) has shown that because the poor tend to have relatively higher income and price elasticities of demand for food, in the event of a shortage and price increase the bulk of adjustment in demand takes place through a reduction in consumption of the poor. Given these observations, and given relatively slow growth in foodgrain consumption despite some rise in incomes, the underlying changes in the relative prices of foodgrains for different consumer groups merited further analysis. These changes were examined through the calculation of implicit prices paid by consumers in each quartile, in both urban and rural areas, on the basis of the NSS consumer expenditure and quantity data. The results, presented in the form of indices in Table 20, demonstrate that even though wholesale prices show a sizable decline in the real prices of cereals, consumer prices do not show as much decline in real terms. Whereas the real cereal wholesale price index declined from 100 to 85 between 1970/71 and 1983, the real urban consumer price index for cereals declined only from 100 to 93. The rural consumer cereal price index in fact increased from 100 to 103, and for the rural bottom quartile this index increased from 100 to 106.

The changes in these indices might be considered relatively small, but the differences between some of them seem to be rather large. They indicate divergences from the broad picture indicated by wholesale prices. The increase in the rural real consumer

Table 20—Implicit nominal and real price indices, by consumer group, 1970/71-1983

Group	Nominal Price 1970/71	Nominal Price 1977/78	Nominal Price 1983	Real Price 1970/71	Real Price 1977/78	Real Price 1983
Rural						
Consumer cereal prices, overall	100	163.4	270.5	100.0	97.1	103.4
Quartile 1 (bottom)	100	171.3	276.8	100.0	101.8	105.9
Quartile 2	100	166.4	277.2	100.0	98.9	106.0
Quartile 3	100	163.8	273.8	100.0	97.4	104.7
Quartile 4 (top)	100	160.6	269.9	100.0	95.5	103.2
Consumer price index, overall	100	168.2	261.5	...	...	...
Urban						
Consumer cereal prices, overall	100	158.6	265.1	100.0	91.3	93.2
Quartile 1 (bottom)	100	159.8	262.1	100.0	91.9	92.1
Quartile 2	100	158.4	266.0	100.0	91.1	93.5
Quartile 3	100	154.7	260.5	100.0	89.0	91.6
Quartile 4 (top)	100	155.1	264.3	100.0	89.2	92.9
Consumer price index, overall	100	173.8	284.5	...	...	...
Cereal prices						
National wholesale	100	157.9	256.4	100.0	86.9	85.1
All commodities						
National wholesale	100	181.6	301.4	...	...	...

Sources: Rural and urban overall consumer cereal prices are based on data from India, Department of Statistics, *The National Sample Survey: Tables on Consumer Expenditure*, various rounds (New Delhi: National Sample Survey Organization, various years); rural and urban overall consumer price indices and national wholesale cereal and commodity prices are based on indices from India, Ministry of Agriculture, Directorate of Economics and Statistics, *Bulletin on Food Statistics*, various issues (Delhi: Controller of Publications, various years).

Note: The base year for all price indices in this table is 1970/71.

prices for cereals may be due to increasing market coverage and integration, which brings more grains on the market and brings rural prices closer to urban prices. The relatively faster increase in prices for the rural bottom quartile may be due to the increased dependence of these consumers on the market. These changes may also be associated with a shift in the composition of cereal consumption from coarse grains to fine grains, particularly to rice, the price of which has risen somewhat faster than that of other grains. The calculations indicate that despite production breakthroughs the real prices of cereals for rural consumers, particularly those in the bottom quartile, have not declined and in fact seem to show an increase. This could have contributed to a slower growth in the food consumption of the poor and the overall demand, and also indicates that part of the benefits of development to the rural bottom quartile may have been nullified by increases in real food prices.

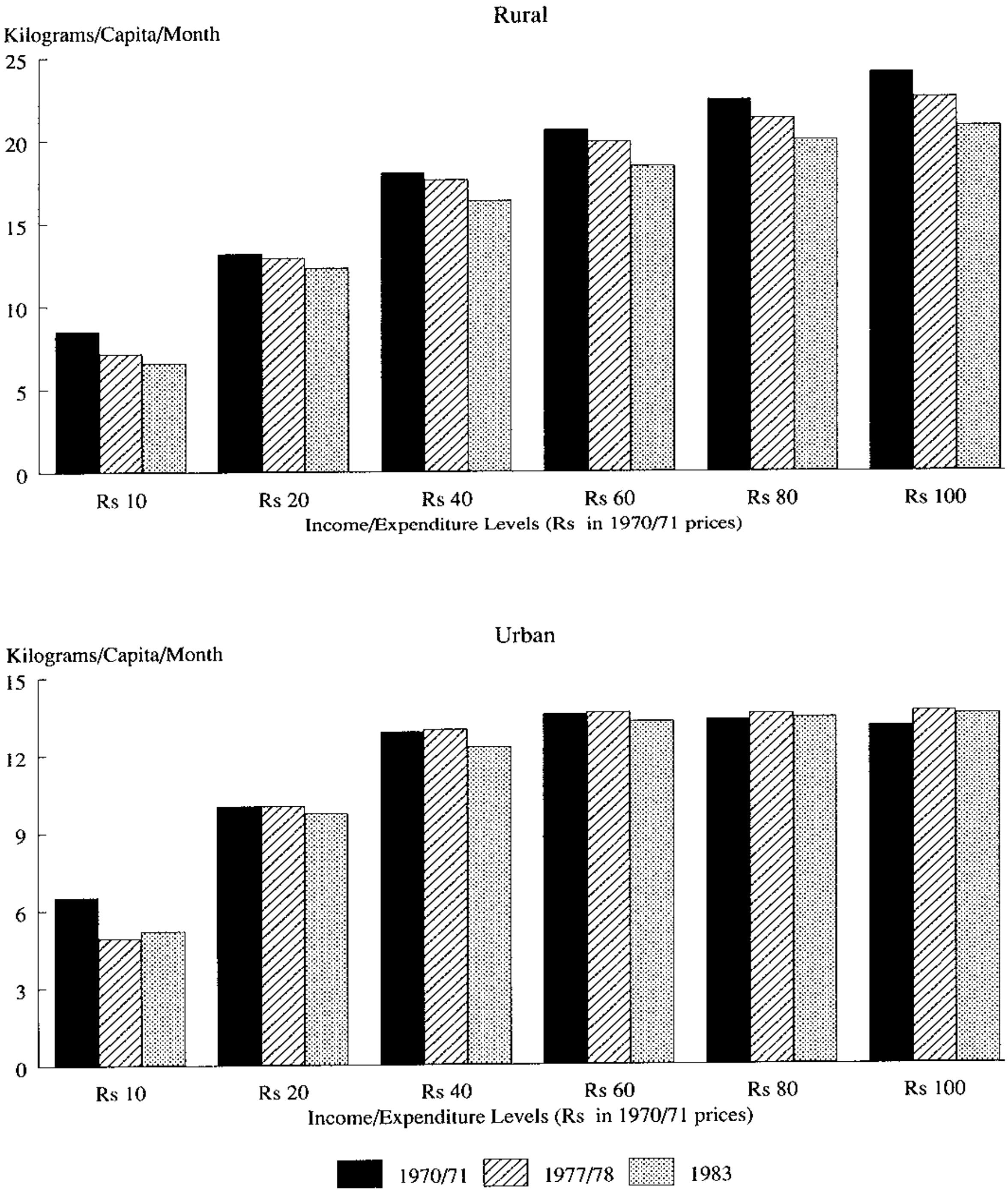
The quartile analysis aggregates foodgrain consumption over the income range of the quartile, which itself may change, and therefore does not give an idea of what the consumption of foodgrains is at specific levels of income, how much this consumption changes from level to level, and how people at specific income levels have moved over time between levels. As mentioned earlier, a common axis of income for comparing the different surveys (at different points in time) has been derived by deflating to the 1970/71 prices with the aid of the relevant consumer price indices. Using linear interpolation with the consumption functions of the type plotted in Figure 15, the levels of foodgrain consumption are calculated at the following interior levels of income (total expenditure) per month: Rs 10, 20, 40, 60, 80, and 100. This calculation is done for each of the surveys, that is, for 1970/71, 1977/78, and 1983.

The results for rural and urban areas are shown in Figure 18. These charts show, surprisingly, that in the rural areas there was a reduction in per capita consumption of foodgrains from 1970/71 to 1983 at each income level. This may be, particularly for upper income levels, partly because of the phenomenon of urbanization of rural consumption patterns, which is caused mainly by improvement in rural infrastructure. The reduction is least at the income level of Rs 20 a month and largest at the high income level of Rs 100 a month. The data show that among the people at the lower income levels (Rs 10-20 a month), foodgrain consumption deteriorated for those who stayed at the same income level. This, coupled with the earlier analysis, shows that the increased foodgrain consumption of the bottom quartile came about primarily because of an increase in incomes in this quartile. It can be seen that an increase in a poor rural individual's income from Rs 10 to Rs 20 raises that person's foodgrain consumption from 6.6 kilograms a month to 12.3 kilograms, or by 5.7 kilograms a month (87 percent). However, an increase in an upper or middle class individual's income from Rs 80 to Rs 100 raises foodgrain consumption by only 0.8 kilograms a month (about 4 percent). This underscores the tremendous impact that poverty alleviation can have on foodgrain demand. It also indicates that skewed or unequal growth can result in slow growth of foodgrain demand. The decline in the rural consumption of foodgrains at the upper income levels between 1970/71 and 1983 adds to the direct demand problem and can probably be explained by substitution, away from an already very high level of foodgrain consumption to other foods and other consumption.

The urban areas show a more skewed pattern than the rural areas. The consumption of the lowest urban income level shows a decline from 6.51 kilograms a month in 1970/71 to 5.20 kilograms in 1983, whereas consumption at the upper income levels of Rs 80 and Rs 100 a month shows a marginal increase between 1970/71 and 1983. Unlike those in the rural areas, the low-income groups in the urban areas show very little growth in income levels to counterbalance this decline in consumption at the low income levels, and therefore foodgrain consumption for the urban bottom quartile shows little change. This decrease at given low real income levels may also be a manifestation of the greater and greater pressure on urban resources and rising living costs due to continuing rural-urban migration. The data show that an increase in a poor urban individual's income from Rs 10 to Rs 20 raises that person's consumption of foodgrains from 5.20 kilograms a month to 9.75 kilograms, that is, by 4.55 kilograms or 88 percent. However, an increase in an upper or middle class individual's income from Rs 80 to Rs 100 raises foodgrain consumption by only 0.10 kilogram or 0.7 percent. This indicates the great impact that poverty alleviation (for instance, through an employment strategy of growth) can have on raising foodgrain demand rapidly. It also shows that growth that is unequal or biased toward upper-income groups can result in slow growth in foodgrain demand.

It can be inferred from the above analysis that a major reason why direct foodgrain demand (or consumption) is not accelerating as fast as might be expected is slow progress in raising the incomes of the poor section of the population, that is, in alleviating poverty, especially in the urban areas. Some (but small) positive progress is seen in this direction in the rural areas, where incomes and foodgrain consumption in the bottom rural quartile are increasing. The results indicate that programs to help development that can generate more employment and incomes for the poor are of great importance and could significantly raise foodgrain demand.

Figure 18—Per capita rural and urban foodgrain consumption at different income levels, 1970/71-1983



Sources: Based on data from India, Department of Statistics, National Sample Survey Organization, *The National Sample Survey: Tables on Consumer Expenditure*, various rounds (New Delhi: NSSO, various years).

6

SCENARIOS FOR THE YEAR 2000

The previous chapters have examined the dynamics and behavior of some major components and elements in the past growth of foodgrain production and consumption in India. Given the results of this analysis, the present chapter examines possible future scenarios in the evolution of the foodgrain situation in India to the year 2000. On the production side, provided that there is continued strong government emphasis on raising food production and its efficiency, it is anticipated that the past performance in raising overall foodgrain production could continue into the future. In seeking to estimate the broad outcome of this growth by 2000, the past regional area and yield growth rates by crop are used under some limiting assumptions. The response coefficients from the previous production analysis are then used to calculate the physical requirements of this growth in terms of the needs for the different major inputs. These requirements help to present for policy purposes the overall magnitude and various dimensions of the task of raising foodgrain production to the estimated levels.

The processes on the demand and consumption sides of foodgrains are somewhat different, particularly because they depend on the nature and pace of economic growth and the changing patterns of foodgrain demand. In this context, the Indian national plans have set for the future the twin objectives of acceleration of economic growth and elimination of poverty by 2000. What the implications of the achievement of these objectives would be for foodgrain demand has never been carefully analyzed. Considering the obvious importance of such an analysis, this study has examined and estimated the demand for foodgrains under several scenarios, including the continuation of past per capita income growth rates and several alternative scenarios of accelerated growth. Some of these also simulate a small change in income distribution and indicate the implications for foodgrain demand of further progress toward poverty alleviation. Implications of increases in income can also occur in terms of an acceleration in the demand for feedgrain through increased consumption of livestock products. Feedgrain demand is found to be a relatively dynamic component of the total foodgrain demand in a large number of Asian developing countries, especially when income growth rates accelerate. The effect of this is also estimated here and is built into the total demand estimates.

Production

Most production projections for foodgrains in India are done on an aggregate all-India basis, and implicit in such projections is uniform application of average all-India growth parameters. Given the wide diversity in agroclimatic conditions, cropping patterns, and technological change in India, this may not be an appropriate assumption. This study attempts to work on a regional basis. Earlier in the study the country was subdivided into six regions—Northern, Uttar Pradesh, Central, Western, Eastern, and Southern—on the basis of geographical location and agroclimatic and cropping pattern characteristics. This division is applied here to obtain regional projections for production, thereby developing national projections that better reflect India's diverse agriculture.

Production projections are made separately within each region for rice, wheat, coarse cereals, and pulses. Area and yield are also projected separately for each region (more details are provided in Appendix 8). Given the important differences between the pre-green-revolution period (1949/50-1964/65) and the green-revolution period (1967/68-1983/84), particularly in the acceleration of yield and deceleration of area growth differing from crop to crop, it was decided to base the projections on the growth rates over the 16 years of the green-revolution period. Though foodgrain production growth accelerated in the later part of this period, the entire period was used as the base, since the second half of the period was considered too short a time to base long-term projections on, given the possible instability of short-period growth rates, particularly at the disaggregated levels of regions and crops.

With regard to area, the trend projections to the year 2000, when done on the basis of area under individual foodgrain crops in each region, were, when aggregated, found to differ from the trend projected for the total foodgrain area in the region. As the latter trend was believed to better reflect the overall land constraint, a normalization procedure was used in which the individual projected crop areas were proportionally adjusted to conform to the projected total foodgrain area in the region. Apart from this, the Northern region's foodgrain area growth rate was constrained to 0.5 percent (compared with 1.3 percent in the past), in consideration of the limits to further area growth in this region.

Concerning yield projections, analysis of past trends indicated that in some regions the yield growth rates have been very high, particularly for wheat, often exceeding 3 percent a year. Continuation of such growth rates to the year 2000 appears difficult; therefore, a limiting assumption restricting the yield growth rate to less than or equal to 3 percent a year is made. This affects yield growth rates in rice in the Northern region, wheat in the Uttar Pradesh, Central, Western, and Southern regions, and coarse grains in the Western region. However, where yields have declined, the declines are not projected to continue, and this assumption becomes relevant for crops such as pulses in some regions.

It was shown in Chapter 3 that the growth rate of foodgrain production in the Eastern region has been very poor. For rice, the major foodgrain crop of the region, the yield growth rate (Table 6) has been very low (0.28 percent during 1967/68-1983/84) and yield levels are currently lower than those in several other regions. With the expected emphasis on development of this region, it is assumed that the rice yield growth rate will accelerate to 2.50 percent a year. Such an acceleration will require substantial development effort, and in this context the constraints to agricultural growth and development in the Eastern region have been examined by the Reserve Bank of India Committee on Agricultural Productivity in Eastern India (India, Reserve Bank 1984), headed by S. R. Sen.

The committee considered the region to have a high potential but found the development constrained by institutional, technological, and economic factors resulting substantially from deficiencies in infrastructure, administration, and management. To accelerate the spread of new technology the committee recommended a massive effort from the government toward investment in infrastructure and in bringing inputs within easy reach of the cultivators. To raise agricultural growth in the region the committee recommended well-organized and coordinated implementation of plans that would create incentive-oriented conditions for small farmers, raising the physical production potential through better irrigation and drainage; improvement in the delivery systems for inputs, services, and credit; identification and promotion of a few lead technologies for homogeneous groups of farmers through "tapering" subsidies; research, extension, and education systems that recognize diversity and choice; and strengthening of the marketing systems through evenly spread growth centers in the rural areas. Acceleration of agricultural growth in the Eastern region could also make a significant dent in national poverty alleviation, given the relative concentration of poverty there.

The projected yield levels for the year 2000, based on the above assumptions, are presented in Table 21. Projected wheat and rice yields are highest in the Northern region, reaching 4 tons per hectare. Coarse cereals yields are projected to be highest in the Southern and Western regions, whereas pulse yields are expected to be highest in the Uttar Pradesh region. The interregional yield disparities show a slight reduction, but foodgrain yields in the Northern, Uttar Pradesh, and Southern regions continue to be above the national average, whereas in the Central, Western, and Eastern regions the yields remain below the national average.

The projections of production for 2000 (Table 22) indicate that wheat production will rise to 87 million tons, surpassing rice production of 85 million tons. The production levels of coarse cereals and pulses are projected to rise modestly to 35 and 14 million tons, respectively. These projections put the overall production of foodgrains in India at about 219 million tons by 2000. Rapid foodgrain production growth is projected in the Northern, Uttar Pradesh, and Western regions. Considering the growth rates from the second part of the green-revolution period (1975/76-1983/84) discussed earlier, foodgrain production in the Uttar Pradesh and Central regions may be somewhat higher than these projections, whereas that in the Western region may be lower.

A sizable contribution to production growth is expected to come from rice production in the Northern region and wheat production in the Uttar Pradesh region. Of the incremental production of 79.4 million tons, wheat accounts for 52.0 percent, rice for

Table 21—Projections of foodgrain yields to year 2000

Region	Rice	Wheat	Coarse Grains	Pulses	Total Foodgrains
			(kilograms/hectare)		
Northern	4,680	3,961	1,207	540	3,828
	(2,916)	(2,663)	(1,100)	(540)	(2,163)
Uttar Pradesh	1,690	2,860	907	781	2,221
	(1,076)	(1,783)	(828)	(781)	(1,290)
Central	703	1,849	527	495	839
	(693)	(1,152)	(477)	(445)	(628)
Western	2,267	2,325	1,234	524	1,300
	(1,605)	(1,449)	(769)	(411)	(857)
Eastern	1,516	2,199	946	499	1,443
	(1,021)	(1,670)	(800)	(499)	(999)
Southern	2,646	1,176	1,256	586	1,831
	(1,943)	(733)	(832)	(373)	(1,282)
All India	2,023	2,675	978	532	1,627
	(1,294)	(1,779)	(718)	(486)	(1,059)

Source: Calculated by the authors; see Appendix 8 for details.
Note: Figures in parentheses are 1983/84 trend values.

Table 22—Projections of foodgrain production to year 2000

Region	Rice	Wheat	Coarse Cereals	Pulses	Total Foodgrains
			(million metric tons)		
Northern					
Projection for 2000	21.2	22.7	1.4	0.2	45.5
1983/84 trend production	6.6	14.4	2.6	0.6	24.2
Increment in production	14.6	8.3	−1.2	−0.4	21.3
Contribution to all-India increment (percent)	(18.4)	(10.5)	(−1.5)	(−0.5)	(26.8)
Uttar Pradesh					
Projection for 2000	8.4	33.1	1.8	1.2	44.4
1983/84 trend production	5.8	16.5	3.4	2.3	28.1
Increment in production	2.6	16.6	−1.6	−1.1	16.3
Contribution to all-India increment (percent)	(3.3)	(20.9)	(−2.0)	(−1.4)	(20.5)
Central					
Projection for 2000	4.2	14.2	5.8	5.0	29.2
1983/84 trend production	3.6	6.8	5.9	3.9	20.2
Increment in production	0.6	7.4	−0.1	1.1	9.0
Contribution to all-India increment (percent)	(0.8)	(9.3)	(−0.1)	(1.4)	(11.3)
Western					
Projection for 2000	7.3	7.3	17.7	3.6	35.9
1983/84 trend production	4.9	3.3	11.7	2.1	22.0
Increment in production	2.4	4.0	6.0	1.5	13.9
Contribution to all-India increment (percent)	(3.0)	(5.0)	(7.5)	(1.9)	(17.5)
Eastern					
Projection for 2000	23.8	9.4	2.0	1.8	37.0
1983/84 trend production	18.0	4.6	1.9	1.8	26.4
Increment in production	5.8	4.8	0.1	0.0	10.6
Contribution to all-India increment (percent)	(7.3)	(6.0)	(0.1)	(0.0)	(13.4)
Southern					
Projection for 2000	19.9	0.0	5.7	1.7	27.2
1983/84 trend production	13.6	0.0	4.6	0.9	19.1
Increment in production	6.3	0.0	1.1	0.8	8.1
Contribution to all-India increment (percent)	(7.9)	(0.0)	(1.4)	(1.0)	(10.2)
All India					
Projection for 2000	84.7	86.7	34.5	13.5	219.4
1983/84 trend production	52.6	45.7	30.2	11.6	140.0
Increment in production	32.1	41.0	4.3	1.9	79.4
Contribution to all-India increment (percent)	(40.4)	(51.6)	(5.4)	(2.4)	(100.0)

Source: Calculated by the authors; see the following note and Appendix 8 for details.

Notes: Projections are based on 1967/68-1983/84 regional area and yield growth rates. Yield growth rates are constrained to be nonnegative and to be not more than 3.0 percent across all crops and regions. Area growth by crop is constrained in each region and adjusted for the region's past growth rate in total foodgrain area. The Northern region's total foodgrain area growth rate is further constrained to 0.5 percent. In expectation of special efforts in the Eastern region, this region's rice yield growth rate is assumed to accelerate to 2.5 percent. Parts may not add to totals because of rounding.

40.0 percent, coarse cereals for 5.0 percent, and pulses for 2.0 percent. However, the projections by commodity need to be viewed with caution. The continuation of past negative area growth rates to 2000 for coarse grains and pulses, and the normalization procedure adopted to adjust individual projected crop areas to be consistent with the projected foodgrain area result in relatively lower output projections for these crops. The overall output projection of 219.4 million tons in 2000 compared with the base level output of 140 million tons in 1983/84 implies an average compound growth rate of 2.8 percent. This represents acceleration over the past 2.6 percent growth rate in all-India foodgrain production.

Of the 79.4-million-ton increment in production, about one-half is expected to come from the Northern and Uttar Pradesh regions, whereas the Eastern and Southern regions will together contribute less than one-fourth. This is despite the fact that under the yield and area growth caps applied, the Northern region's production growth rate is projected to be 4.0 percent compared with 5.1 percent in the past, and the growth rate of Uttar Pradesh would be 3.0 percent compared with 4.8 percent in the past. At the same time, the Eastern region's production growth rate is assumed to accelerate from −0.22 percent to 2.2 percent. For the Southern region the yield growth rate is high, but since the region has a −1.0 percent area growth rate, showing diversion of area to nonfoodgrain crops (as total cropped area is not declining), it does not make a large contribution to production. The interregional differences in production growth have major implications for interregional trade, income growth, and poverty alleviation. Faster growth in the current surplus areas and slower growth in the others implies a considerable increase in dependence on an efficient foodgrain marketing system. Interregional distribution of rural incomes could become more skewed and this might increase labor migration. However, relatively faster growth in the Eastern region might help reduce the substantial poverty in that region.

Instead of projecting, as above, with the area and yield of each crop or crop group by region, if a projection is done on the basis of area and yield of the aggregate of all foodgrains in each region, the resulting all-India production of foodgrains works out to 211 million tons in 2000 (production scenario 2). An additional assumption made in this scenario is that foodgrain yield in the Eastern region will grow at 2.00 percent a year compared with 0.43 percent a year in the past. In production scenario 3 the projection is made on the basis of the area and yield of foodgrains at the all-India level using all-India area and yield growth rates. The total projected output in this scenario comes to 215 million tons. These results are presented in Table 23.

Table 23—Alternative projections of area, yield, and production of foodgrains for year 2000

Scenario	Projection	Area	Yield	Production
		(million hectares)	(kilograms/ metric ton)	(million metric tons)
1	Based on each crop area and yield projected separately in each region (same as in Table 22)	134.9	1,627	219.4
2	Based on foodgrain area and yield projected separately in each region	134.9	1,563	210.7
3	Based on total foodgrain area and yield projected at the all-India level	130.2	1,654	215.2

Source: Calculated by the authors; see the following note and Appendix 8 for details.

Notes: The projections are based on 1967/68-1983/84 area and yield growth rates. Yield growth rates are constrained to be nonnegative and subject to a ceiling limit of 3.0 percent across all crops and regions. Area growth by crop is constrained in each region and adjusted for the region's past growth rate in total foodgrain area. The Northern region's total foodgrain area growth rate is constrained to 0.5 percent. The growth rate of rice yield in the Eastern region is assumed to accelerate to 2.5 percent. The growth rate of foodgrain yield in the Eastern region is assumed to accelerate to 2.0 percent in scenario 2.

The projected output of 219-220 million tons of foodgrains in 2000 represents a huge increase of about 80 million tons over the base level trend output of about 140 million tons in 1983/84. Achievement of a production increase of this order will require substantial increases in irrigated area, fertilizer use, and use of HYV seeds, possibly with increases in the area under wheat and rice. Even the maintenance of the past trends in productivity growth will call for continued high priority for a first-rate agricultural research system stressing development of new technology, and emphasis on technology transfer through a strong extension system to farmers' fields in both irrigated and rainfed areas.

To provide a broad assessment of the order of magnitude of the efforts involved, the input requirements for achieving the additional production of 80 million tons have been worked out using estimates of input response from the production analysis in Chapter 4. Table 24 gives the results of the estimation of input requirements. It indicates that a gross irrigated area of 100 million hectares will be required, of which about 60 percent is expected to be under foodgrains. Achieving the 220-million-ton production level will also require a fertilizer consumption level of about 20 million tons of nutrients (NPK) of which 70 percent is expected to be applied to foodgrains. Given that about 80 percent of the increment in production depends on the increase in fertilizer use, it may be stressed that not only is the achievement of 20 million tons of nutrient use important, but maintenance of the fertilizer response coefficient at a level of 7 or above is crucial. Given the decline in the fertilizer response coefficient from 10 to 7, as shown in Chapter 4, it appears that research, extension, and input diffusion efforts to raise this response would be crucial and would give excellent returns.

Table 24—Estimated input requirements for projected foodgrain production in year 2000

Input	Assumed Production Response Coefficient[a]	Input Level, 1981/82-1983/84 Average	Projected Input Level, 1999/2000	Projected Input Increment	Projected Contribution to Production Increment
	(metric tons of foodgrains/ hectare)	(million hectares)	(million hectares)	(million hectares)	(million metric tons of foodgrains)
Area	0.45	128.46	134.85	6.39	2.88
Irrigation	0.50	38.69	60.00[b]	21.31	10.65
Shift to wheat and rice	0.33[c]	63.37	74.30	10.93	3.61
	(metric tons of foodgrains/ ton)	(million metric tons)	(million metric tons)	(million metric tons)	
Fertilizer	7.00	5.00	14.00[d]	9.00	63.00
Total increment	...	...	...	...	80.14

[a]The response coefficients are based on Table 10. The derivation of these response coefficients is discussed in Chapter 4.
[b]Projected irrigated area in 1999/2000 is 100 million hectares, of which 60 percent would be under foodgrains.
[c]This response coefficient is based on the difference in yield levels after excluding the effect of irrigation and fertilizer and is likely to be conservative.
[d]Projected fertilizer use in 1999/2000 is 20 million metric tons, of which 70 percent would be applied to foodgrains.

Arrangements will also be needed for production and distribution of an annual supply of about 5.5 million tons of seeds of both HYVs and other improved varieties.[16] Institutional arrangements for the supply of credit and for marketing and storage of both inputs and outputs to support the increased scale of activity will need to be considerably strengthened. These findings indicate that reaching a foodgrain production of 220 million tons by the year 2000 will without doubt be a formidable task.

Consumption

The estimation of future foodgrain consumption has been done under several alternative assumptions of income growth and income distribution. The estimation works separately with rural and urban consumption and different commodities, namely, rice, wheat, coarse cereals, and pulses, and with different quartiles. As observed earlier, an average annual gap of as much as 25 kilograms per capita exists between the foodgrain consumption estimates of the NSSO and the per capita availability estimates worked out through supply accounting by the Ministry of Agriculture. Since it was necessary to maintain consistency with the estimation on the supply side (the NSSO does not provide output estimates), it was decided to work with the basic magnitudes of per capita availability estimates, but ratios, rates, and elasticities derived from the 1977/78 NSS data were used in many parts of the estimation procedure. (See Appendix 8 for details.)

The starting point for each estimate was the national three-year average per capita availability of foodgrains (for human consumption) during 1982-1984, and this was disaggregated into rice, wheat, coarse cereals, and pulses. This was further broken down into rural and urban consumption levels. The procedure used rural-urban population ratios and differences between rural and urban per capita consumption of each grain represented by ratios obtained from the 1977/78 NSS results. Further, since consumption projections are based on disaggregated data by quartile, quartile shares are computed from the 1977/78 NSS survey data, and these are used to arrive at the per capita consumption level in each quartile for each major foodgrain in rural and urban areas. These starting levels are presented in Table 25.

The direct demand for foodgrains is considered to be driven primarily by population growth, income growth, and changes in income distribution. Estimates of past population growth are available from the population census conducted every 10 years, and projections for the year 2000 (which assume a slow decline in the population growth rate) are available in the Perspective Plan (India, Planning Commission 1985, vol. 1, chap. 2). Growth rates implicit in the Perspective Plan for rural and urban populations have been utilized in the projections. The rural and urban average per capita income (total expenditure) levels are available for 1970/71 from the 1970/71 NSS survey; similar figures are also available for 1983 from the 1983 NSS survey and were deflated to 1970/71 prices. However, the 1970/71-1983 growth rate in overall per capita incomes obtained from the above NSS figures were found to be too high (especially for the rural areas) relative to comparable figures obtained from national income data (India, Central Statistical Organization 1985) and the population census. Thus it was decided to use only the quartile per capita income shares from the 1983

[16] The 5.5 million tons includes paddy seed expressed as paddy.

Table 25—Per capita consumption of foodgrains: initial levels and shares

	1982-84 per Capita Average	Quartile (Q) Share, 1977/78 National Sample Survey				1982-84 Quartile Mean Consumption Level			
		Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
	(kilograms/year)								
Rural									
Rice	72.1	0.1729	0.2487	0.2824	0.2961	49.86	71.73	81.44	85.40
Wheat	47.8	0.1346	0.2070	0.2594	0.3991	25.74	39.58	49.60	76.31
Coarse cereals	40.3	0.2702	0.2512	0.2404	0.2382	43.56	40.49	38.75	38.40
Pulses	11.4	0.1210	0.2024	0.2672	0.4093	5.52	9.23	12.18	18.66
Foodgrains	171.7	0.1841	0.2359	0.2652	0.3147	124.67	161.03	181.98	218.77
Urban									
Rice	55.5	0.2050	0.2566	0.2729	0.2655	45.51	56.97	60.58	58.94
Wheat	57.6	0.1875	0.2443	0.2732	0.2949	43.20	56.29	62.95	67.94
Coarse cereals	12.6	0.3891	0.2714	0.2087	0.1307	19.61	13.68	10.52	6.59
Pulses	12.2	0.1429	0.2169	0.2802	0.3600	6.97	10.52	13.67	17.57
Foodgrains	137.8	0.2115	0.2501	0.2672	0.2712	115.29	137.52	147.72	151.04

Sources: Based on data from India, Department of Statistics, National Sample Survey Organization, *The National Sample Survey: Tables on Consumer Expenditure,* various rounds (New Delhi: NSSO, various years); and India, Ministry of Agriculture, Directorate of Economics and Statistics, *Bulletin on Food Statistics,* various issues (Delhi: Controller of Publications, various years).

NSS survey. The mean per capita income levels of the 1970/71 survey were moved to 1983 using per capita income growth rates based on national accounts (India, Central Statistical Organization 1985) and population figures. These were then distributed into quartile per capita income levels using shares obtained from the 1983 NSS survey.

Consumption scenario 1 assumed the continuation of past per capita income growth rates. Per capita income growth rates from 1970/71 to 1983 based on national accounts and population figures were used as the past per capita income growth rates. These were 0.49 percent a year for rural and 1.03 percent a year for urban areas (Table 26). Scenario 2 assumed the income growth rates of the perspective to 2000 in the Seventh Five-Year Plan of the Government of India. The plan projects an agricultural (assumed equivalent to rural income) growth rate of 2.50 percent, and an income growth rate for the total economy of 5.00 percent from the mid-1980s to 2000. Using midperiod sectoral weights, one can infer a nonagricultural (assumed equivalent to urban income) growth rate of 6.20 percent. The rural and urban populations are expected to grow at 1.15 and 3.63 percent, respectively (the rural, urban, and total populations are expected to reach 657, 319, and 976 million, respectively, by year 2000). This gives rural and urban per capita income growth rates of 1.33 and 2.48 percent. Scenario 3 assumes an increase in the income growth rates with the rural income growth rate rising to 3.00 percent and the urban to 7.00 percent, giving an overall income growth rate of 5.68 percent. Scenario 4 assumes a further acceleration of income growth rates to 3.50 percent for rural and 8.00 percent for urban areas. The latter is based on the observation that the industrial growth rate was close to 9.00 percent for three consecutive years prior to the 1987/88 drought and is expected to exceed 9.00 percent in 1988/89. In scenarios 3 and 4 it is assumed that nonfoodgrain agriculture in the rural areas, particularly the more labor-intensive and less land-using commodities, will grow at a faster rate than foodgrain agriculture. Scenario 4 implies a growth rate of 7.00 percent for the whole economy.

Alternative scenarios were also developed with regard to income distribution. The quartile income distribution from the 1983 NSS survey works out to 12, 18, 25, and 44

Table 26—Alternative growth rate assumptions used in the simulations

Scenario/Group	Income[a]	Population[b]	Per Capita Income
		(percent)	
Base period			
Rural	2.31	1.81	0.49
Urban	4.95	3.88	1.03
Total	3.86	2.26	1.56
1. Continuation of past per capita income growth rates			
Rural	1.65	1.15	0.49
Urban	4.70	3.63	1.03
Total	3.43	1.84	1.56
2. Growth rates envisaged in the Perspective Plan[c]			
Rural	2.50	1.15	1.33
Urban	6.20	3.63	2.48
Total	5.00	1.84	3.10
3. First accelerated growth rate scenario			
Rural	3.00	1.15	1.86
Urban	7.00	3.63	3.25
Total	5.68	1.84	3.77
4. Second accelerated growth rate scenario			
Rural	3.50	1.15	2.32
Urban	8.00	3.63	4.22
Total	7.00	1.84	5.07

Sources: Based on authors' calculations; see Appendix 8 for details and sources of data.
[a]The income growth rates are for gross domestic product at factor cost.
[b]The past population growth rate is the rate between the 1971 and 1981 census figures. The future population growth rate is between the 1981 census figure and the Perspective Plan projected figure for March 2001 adjusted to midyear 2000.
[c]In Chapter 2 of the Seventh Five-Year Plan of the Government of India.

percent, respectively, for the 1st, 2nd, 3rd, and 4th quartiles in the rural areas, and to 11, 17, 24, and 48 percent for those quartiles in the urban areas. If between 1983 and 2000 the income distribution does not change, then these shares will stay the same in 2000. It is implicit in this assumption that per capita income levels in each quartile will grow at the same rate, that is, at one overall income growth rate. Under an alternative assumption it is considered that there is a small improvement in the income distribution in the economy: the quartile shares change to 15, 20, 25, and 40 percent by the year 2000 in both the rural and urban areas. This implies that the per capita incomes of different quartiles grow at different rates—in particular, the incomes in the lower quartiles grow at a somewhat faster rate than the incomes in the higher quartiles. The initial and final quartile income levels and the required income growth rates for the different assumptions of income growth with change in income distribution are shown in Table 27. Given that the income elasticities of demand for foodgrains are higher in the lower quartiles, these differences lead to a higher overall demand for foodgrains—the effect of the change in income distribution. The gains from a change in income distribution are, however, dampened as elasticities fall with a rise in incomes. This aspect will be discussed later.

IFPRI has stressed that a major objective of global development should be the alleviation of the bulk of world poverty and hunger by the year 2000 (see Mellor 1989). The elimination of poverty by 2000 is also an objective set by the Planning Commis-

Table 27—Per capita income growth rates and income levels under change in income distribution from 1983 to 2000, by quartile

Item	Rural Income Quartile				Urban Income Quartile			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Initial income distribution (percent)	12.00	18.00	25.00	44.00	11.00	17.00	24.00	48.00
Initial income level (Rs/month)	17.00	25.71	35.10	62.77	27.85	42.71	59.70	118.21
Final income distribution (percent)	15.00	20.00	25.00	40.00	15.00	20.00	25.00	40.00
Under past per capita growth rates								
Growth rate (percent)	1.77	1.02	0.50	−0.16	2.78	1.93	1.27	0.00
Income (Rs/month)	22.91	30.55	38.19	61.11	44.36	59.15	73.93	118.29
Under Seventh Plan growth rates[a]								
Growth rate (percent)	2.62	1.86	1.34	0.68	4.25	3.40	2.72	1.44
Income (Rs/month)	26.40	35.20	44.00	70.39	56.52	75.36	94.20	150.72
Under first accelerated growth rate scenario[b]								
Growth rate (percent)	3.16	2.40	1.87	1.20	5.03	4.17	3.49	2.20
Income (Rs/month)	28.85	38.46	48.08	76.92	64.19	85.59	106.98	171.17
Under second accelerated growth rate scenario[b]								
Growth rate (percent)	3.63	2.86	2.33	1.66	6.02	5.15	4.46	3.16
Income (Rs/month)	31.14	41.52	51.90	83.05	75.25	100.33	125.41	200.66

Sources: Based on data from India, Department of Statistics, National Sample Survey Organization, *The National Sample Survey: Tables on Consumer Expenditure,* various rounds (New Delhi: NSSO, various years); and India, Ministry of Agriculture, Directorate of Economics and Statistics, *Bulletin on Food Statistics,* various issues (Delhi: Controller of Publications, various years).

Notes: No change in the distribution implies that all quartiles will grow at the same rate namely, the rate of growth of per capita income. All incomes are in constant 1970/71 prices. The initial income levels are for 1983 and the final figures are for year 2000.

[a]Refers to the Seventh Five-Year Plan of the Government of India.

[b]Growth rate assumptions are given in Table 26.

sion of India. It was of interest, therefore, to examine whether poverty would be substantially eliminated by 2000 under any of these scenarios. The most commonly accepted definition of the poverty line for India has been given by Dandekar and Rath (1971); this amounts to an income (consumer expenditure) level of Rs 15.00 a month in rural areas and Rs 22.50 a month in urban areas in 1960/61 prices. These levels are based on a daily minimum calorie intake level of 2,250 calories a person. Rural people obtain comparatively more calories from foodgrains than urban people, but urban people pay more per calorie. Most later studies, including those of Ahluwalia (1978, 3-41) and Mellor and Desai (1985), use the consumer-expenditure-based standards of the poverty line set by Dandekar and Rath. On moving consumer expenditures to 1970/71 prices (the base used in this study), using the agricultural laborers' consumer price index for rural and the industrial workers' consumer price index for urban expenditures, the poverty line works out to an income (total expenditure) level of Rs 28.80 a month for rural and Rs 41.25 for urban in 1970/71 prices (the former figure has been confirmed by Ahluwalia [1978]). Therefore, one way to examine whether poverty has been nearly eliminated would be to see whether the income level of each quartile has crossed the above-mentioned poverty line levels. This will be examined and discussed with the projection results. (There may be bottom-end poverty left in the bottom quartile even when its average income crosses the poverty line. The Perspective Plan aims for elimination of poverty but actually targets reduction in poverty to 5 percent.)

With respect to the income elasticities of demand, it was found that the log-log inverse function, which is frequently used for estimating elasticities from consumer survey data, provided in general a poor fit for the foodgrain consumption data of the 1977/78 NSS survey. Further, when quartile elasticities were computed from the function, they tended to be too low for the bottom quartile and too high for the top quartile. This is due to the shape restrictions of the curve and because a single curve was fitted to the entire data. The NSS data, however, permit the estimation of elasticities (by log-log function) for each quartile (Table 28), and these estimates appeared to be, in general, more reasonable.

The estimates show that the elasticities are greater than 1 for the bottom quartile, and close to zero for the top quartile. The elasticity estimate of 3.25 for wheat for the urban bottom quartile is probably a result of some specific data problems for wheat in this survey (this estimate is not used directly, as explained below). The elasticity for coarse cereals is shown to be high (of the order of 1.5) for the bottom quartile, whereas the elasticity for pulses was found to be still quite high in the top quartile. Given the long period of 17 years across which projections were to be made, it was inappropriate to assume that these elasticities would hold constant. As incomes rise, the elasticities would fall. This is evident from the interquartile differences in the elasticities. Therefore, the above figures were not used directly. It was assumed that the elasticities would fall along a log-log function path, and the path was estimated by using the quartile elasticities. Elasticities were stepped down in four steps for each of the periods 1983-85, 1985-90, 1990-95, and 1995-2000, and these elasticity matrices were used for the projection work. Each set of growth rates and income distribution assumptions

Table 28—Income elasticities of demand, by foodgrain and quartile

					Sample of Step Elasticity Matrix (1990-95) Used for Simulation							
	Estimated within Each Quartile by Log-Log, Using National Sample Survey 1977/78 Data				Under Past per Capita Income Growth Rates and No Change in Distribution				Under Second Accelerated Growth Rate Scenario with Change in Income Distribution			
Foodgrain	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Rural												
Rice	1.02	0.59	0.28	0.09	0.93	0.58	0.36	0.03	0.68	0.42	0.26	−0.02
Wheat	1.37	0.74	0.81	0.41	1.23	0.92	0.71	0.39	1.01	0.77	0.61	0.33
Coarse cereals	1.46	−0.09	−0.16	0.00	0.68	0.30	0.08	−0.24	0.41	0.14	−0.03	−0.29
Pulses	1.27	1.05	0.90	0.38	1.34	1.00	0.78	0.42	1.09	0.84	0.66	0.36
All foodgrains	1.24	0.47	0.35	0.20	0.98	0.64	0.44	0.10	0.74	0.49	0.32	0.05
Urban												
Rice	0.95	0.28	−0.04	0.00	0.52	0.26	0.08	−0.20	0.24	0.06	−0.06	−0.27
Wheat	3.25	0.28	0.26	0.10	1.39	0.69	0.28	−0.27	0.64	0.24	−0.01	−0.38
Coarse cereals	1.61	−0.65	−0.95	−0.11	−0.38	−0.54	−0.64	−0.78	−0.55	−0.65	−0.71	−0.81
Pulses	1.53	0.80	0.58	0.20	1.14	0.73	0.47	0.04	0.71	0.43	0.25	−0.06
All foodgrains	1.35	0.22	0.07	0.06	0.68	0.36	0.15	−0.18	0.34	0.12	−0.02	−0.26

Sources: Based on data from India, Department of Statistics, National Sample Survey Organization, *The National Sample Survey: Tables on Consumer Expenditure*, Round 32 (1977/78) (New Delhi: NSSO, 1984); and India, Ministry of Agriculture, Directorate of Economics and Statistics, *Bulletin on Food Statistics*, various issues (Delhi: Controller of Publications, various years).

therefore gave a different set of elasticity matrices for projection. A sample of two such matrices is presented in Table 28 for rural and urban areas.

Bouis and Haddad (1989), on the basis of consumption survey data from Bukidnon Province of the Philippines, have indicated that the elasticity estimates obtained vary with the kind of data used for estimation, and there would be a tendency for them to be somewhat higher when estimated on the basis of consumer expenditure survey data. This could not be tested in the case of the Indian data, but high elasticity estimates for the bottom quartile seem reasonable given the extreme hunger and poverty in India, and the elasticity estimates for the top quartile are in any case very low. The projection procedure also steps down the elasticities as incomes increase over time.

Apart from the foodgrain demand for direct human consumption, an increasingly important component is the indirect demand for feedgrains through livestock consumption. Unfortunately, an elaborate projection of this demand cannot be made because of inadequate and poor data; in particular, income distribution effects cannot be worked out. For details of the procedure followed, see "Projections of Requirements for Seed, Feed, Industrial Use, and Wastage" in Appendix 8. The procedure works with livestock output units that equal the weight of meat plus the weight of eggs plus one-tenth the weight of milk. Even in these terms, milk dominates the livestock output/demand in India with a share of 70 percent, followed by meat and then eggs. It is assumed that the demand for livestock products is driven by income growth, through an income elasticity of demand of 0.9. This is an output weighted average across different livestock products for India and is derived from Sarma (1986); it is close to a broad FAO estimate provided by Paulino (1986). The relationship between livestock demand and feedgrain demand expressed in terms of the average feeding ratio (kilograms of feedgrain to kilograms of livestock output measured in livestock output units) was estimated to be 2.0 for India in 1984/85. This level reflects a largely rural livestock sector feeding large amounts of crop residues. Mellor and Ponteves (1964) have shown that the ratio is likely to rise substantially with increasing demand for livestock products, particularly as crop residues become inadequate and more productive livestock require better feeding. It is assumed that the average feeding ratio would rise at a rate of 1.2 percent a year to reach about 2.4 by the year 2000, which is equal to the current developing-country average and compares with 3.2 for the world and 2.6 for Asian developing countries. Based on these ratios, the feedgrain demand in the year 2000 is estimated to be about 22 million tons under continuation of past per capita income growth rates, 27 million tons under Perspective Plan income growth rates, 29 million tons under the first accelerated growth rate scenario, and 35 million tons under the second accelerated growth rate scenario. The range between the feedgrain demand outcomes of 22 million tons and 35 million tons is large and can make a significant difference in the foodgrain situation of the country. Such scenarios would be likely to come about sooner or later with the acceleration of economic growth, and they have been observed in several other developing countries. Apart from feed, the seed demand works out to about 5 million tons and other uses and wastage to about 12 million tons. (See Appendix 8 for details.)

The results of total estimated foodgrain demand under the different scenarios—continuation of past per capita income growth rates, Seventh Plan/Perspective Plan income growth rates, first accelerated growth rate scenario, and second accelerated growth rate scenario, with and without income distribution change, are summarized in Table 29. The results show that substantially different outcomes of demand can emerge under these different future scenarios. The direct foodgrain demand can vary from 167 million tons to as much as 189 million tons. The total foodgrain demand (incorporating

Table 29—Projected total demand for foodgrains in India in year 2000

Consumption Scenario for Alternative Income Growth Rate Assumptions	Alternative Income Distribution Assumptions			
	Without Change in Income Distribution (1983-2000)[a]		With Change in Income Distribution (by 2000)[b]	
	Human Demand	Total Demand[c]	Human Demand	Total Demand[c]
	(million metric tons)			
1. Continuation of past per capita income growth rates				
Rural	121.06	...	126.53	...
Urban	46.02	...	49.01	...
Total	167.08	206.35	175.54	214.81
2. Growth rates envisaged in the Perspective Plan				
Rural	127.82	...	133.13	...
Urban	47.68	...	49.99	...
Total	175.51	219.70	183.11	227.30
3. First accelerated growth rate scenario				
Rural	131.69	...	136.83	...
Urban	47.97	...	49.82	...
Total	179.66	226.30	186.65	233.29
4. Second accelerated growth rate scenario				
Rural	134.78	...	139.73	...
Urban	47.76	...	49.01	...
Total	182.54	234.54	188.74	240.74

Notes: Foodgrains include cereals and pulses; rice is expressed in terms of milled rice. Parts may not add to totals because of rounding.
[a]Shares in percentages ($Q_1/Q_2/Q_3/Q_4$); rural—12/18/25/45, urban—11/17/24/48. Q_1, Q_2, Q_3, and Q_4 represent quartile shares of income based on the National Sample Survey consumer expenditure data for 1983.
[b]Shares in percentages ($Q_1/Q_2/Q_3/Q_4$); both rural and urban—15/20/25/40.
[c]Includes allowance for seed, feed, other uses, and wastage. The estimated feed demand takes into account the effect of income growth only, not of changes in its distribution.

feed, seed, industrial use, and wastage) can vary from 206 million tons to as much as 240 million tons. Acceleration of income growth rates adds up to 28 million tons for the demand, and the assumed change in income distribution totals 6 million tons.

With regard to poverty alleviation, it is found that consumer expenditure (income) levels cross the poverty line for all the quartiles only under the first and second accelerated growth rate scenarios, and in both cases only when accompanied by a change in income distribution. In none of the other scenarios is poverty alleviated (see also Table 27). This shows that a combination of acceleration in growth rates and at least a moderate change in income distribution will be required to alleviate poverty by the year 2000—neither of these alone may be sufficient. And further, this will have substantial implications for foodgrain demand. In this context, given the above observations relating the scenarios to poverty alleviation, and with the national objectives of acceleration of economic growth and alleviation of poverty, it may be stressed that *a foodgrain consumption level of about 233 million tons by the year 2000 might be considered a target.*

The demand estimates, when compared with the foodgrain production projections given earlier, show outcomes ranging from the emergence of a marginal self-sufficiency or a surplus of 13 million tons to a deficit of 20-30 million tons. These outcomes have profound implications for various scenarios for India's development (see Table 30). They show that if the twin objectives of acceleration in economic growth and alleviation of poverty set by the Indian planners are to be realized, there will be tremendous pressure on foodgrain supplies. This will call first for unrelenting efforts to raise foodgrain production. Moreover, this will need to be done with increased efficiency if it is to be economical, generate growth in real farm incomes, and avoid large government subsidies. However, the estimates show that even impressive performance on production may prove inadequate to meet the demand. This may call for political courage to import foodgrains on a sizable scale and would require a development strategy that can pay for the foodgrain imports by generating export surpluses in other goods. Therefore, faster economic growth and eradication of poverty might not be feasible without sizable imports, notwithstanding even an impressive growth in foodgrain production from current levels to 220 million tons by the year 2000.

Mellor (1978) and Ezekiel (1990) have shown that if demand is allowed to outstrip supply and food prices rise, the burden of adjustment falls mainly on the poor, since they have relatively high income elasticities of demand and high budget shares of income spent on food. This may be undesirable. In the context of the appropriate development strategy, Desai and Schluter (1974) have shown that even marginal changes in the cropping pattern can help generate more employment in the rural areas. Further, Islam (1990) has shown that nontraditional agricultural exports could play an important role in generating the necessary export surpluses while also helping rural income and employment growth. Model simulations by Mellor and Mudahar (1974) have shown that the nonfoodgrain agriculture sector appears to have a large potential for employment and that the importance of this employment may increase as industrialization takes place. Changes in the cropping pattern and an acceleration in the

Table 30—Projected foodgrain supply-demand balances under alternative scenarios of production and consumption projections in year 2000

Consumption Scenario	Total Demand	Production Scenario (1) 219.4 Million Metric Tons[a]	(2) 210.7 Million Metric Tons[b]	(3) 215.2 Million Metric Tons[c]
		(million metric tons)		
1. Continuation of past per capita income growth rate	206.4[d] 214.8[e]	+13.0 +4.6	+4.3 −4.1	+8.8 +0.4
2. Growth rates envisaged in the Perspective Plan[f]	219.7[d] 227.3[e]	−0.3 −7.9	−9.0 −16.6	−4.5 −12.1
3. First accelerated growth rate scenario	226.3[d] 233.3[e]	−6.9 −13.9	−15.6 −22.6	−11.1 −18.1
4. Second accelerated growth rate scenario	234.5[d] 240.7[e]	−15.1 −21.3	−23.8 −30.0	−19.3 −25.5

Sources: Based on Tables 23 and 29.
[a]Production scenario 1 is based on each crop area and yield projected separately for each region.
[b]Production scenario 2 is based on total foodgrain area and yield projected in each region.
[c]Production scenario 3 is based on total foodgrain area and yield projected at the all-India level.
[d]Consumption scenario without change in income distribution (1983-2000), given the following existing percent income shares for the different quartiles: $Q_1/Q_2/Q_3/Q_4$; rural—12/18/25/45, urban—11/17/24/48.
[e]Consumption scenario with change in income distribution (by 2000) to the following percent income shares for the different quartiles: $Q_1/Q_2/Q_3/Q_4$; both rural and urban—15/20/25/40.
[f]From the Seventh Five-Year Plan of the Government of India.

nonfoodgrain rural sector through activities such as production of livestock and nontraditional agricultural goods would be crucial for accelerating rural income growth, particularly beyond the limits of growth in foodgrain production. This may become critical for meeting the twin overall objectives of acceleration in economic growth and alleviation of poverty.

The breakup by commodity of the demand-supply balances is given in Table 31 for the demand scenario of the Perspective Plan (India, Planning Commission 1985, vol. 1, chap. 2) growth rates without change in income distribution. Attention was drawn earlier to the caution necessary in interpreting the breakup by commodity of projected foodgrain production in 2000. Subject to these cautions, Table 31 shows that, whereas rice demand is almost squarely met by production, a significant surplus of 11 million tons emerges for wheat under the assumptions of this scenario. A substantial deficit of 11 million tons emerges for coarse cereals. This deficit appears mainly because of the projected rise in feedgrain demand as well as the projected decline in the coarse cereals area due to downward regional trend lines and the area normalization procedure. Therefore, such a deficit may or may not emerge, but if it does it would tend to bid up the relative prices of coarse cereals. This may affect the food consumption of the poor, especially the rural poor, who depend on coarse cereals to a larger extent. At the same time, high coarse cereal prices may tend to suppress the growth of the livestock industry, which may be otherwise beneficial from the point of view of employment and income growth. This may raise complex questions about the comparative advantage of producing coarse cereals for livestock feed in India versus importing it at a possibly lower relative price to help the livestock industry and perhaps generate more employment.

Pulses show a deficit of 3 million tons, which may be met by diversion of more area to pulses or by import of substitutes, as sometimes seen in past imports of Australian chickpeas. In general, these imbalances in individual commodities may be expected to be resolved through market mechanisms, either in a closed or an open economy framework. These mechanisms may lead either to a change in production and consumption patterns or to the export of one commodity and the import of another. Wheat may partly substitute for coarse grains, both in food and feed; pulses may rebound in production because of high market prices.

Table 32 provides a comparison between the scenario results in this study and the projections of other studies. It shows that the production projections of this study are lower than those of the Seventh Five-Year Plan but higher than those of the World

Table 31—Comparison of foodgrain production and demand projections for year 2000

Foodgrain	Production	Demand	Difference
		(million metric tons)	
Rice	84.7	82.0	2.7
Wheat	86.7	75.0	11.7
Coarse grains	34.5	46.2	−11.7
Pulses	13.5	16.5	−3.0
Total foodgrains	219.4[a]	219.7[b]	−0.3

[a]From production scenario 1 (see Table 30).
[b]From consumption scenario 2 (see Table 30) with no change in income distribution.

Table 32—Comparison with foodgrain production and consumption projections to year 2000 by other studies

Study	Production	Consumption
	(million metric tons)	
National Commission on Agriculture, India, 1976	230.0	225.0 (high) 205.0 (low)
World Bank, 1981	213.0 (high) 197.0 (low)	205.0 (high) 191.0 (low)
Seventh Five-Year Plan, 1985-90, Planning Commission	235.0-240.0	240.0
Present study	219.4 (high)[a] 210.7 (low)[c]	240.74 (high)[b] 206.35 (low)[d]
IFPRI study (for the Asian Development Bank), 1984	220.74	210.23

[a]Based on production scenario 1 (see Table 30).
[b]Based on the second accelerated growth rate consumption scenario with change in income distribution.
[c]Based on production scenario 2 (see Table 30).
[d]Based on continuation of past per capita income growth rate consumption scenario with no change in income distribution.

Bank. The Seventh Plan consumption target of 240 million tons in 2000 matches closely the estimates of this study under accelerated economic growth with a small change in income distribution. As stated earlier, this scenario would result in the alleviation of poverty. However, the Seventh Plan's production projections appear high, since they imply a production growth rate of up to 3.4 percent compared with 2.6 percent in the past, and, as was analyzed earlier, even the achievement of 220 million tons appears to be a difficult task. Achievement of the necessary rural income growth rates to reach poverty alleviation and the target consumption would also require rapid growth in nonfoodgrain agriculture.

The foodgrain production in 2000 estimated by the National Commission on Agriculture at 230 million tons is higher than the present study's estimate of 219 million tons in production scenario 1. However, since the two projections started with different base periods, the implicit growth rates actually work out to be the same. The commission assumed a higher fertilizer response coefficient (10 tons/ton), so despite a higher production projection, the commission estimated lower fertilizer requirements of 14-16 million tons by 2000. Analysis in this study has, however, shown that the response coefficient has declined to about 7, indicating that apart from the need for more fertilizers (estimated at 20 million tons), there would be increased difficulty in reaching even 220 million tons of foodgrain production.

IFPRI (1984) also attempted to project the supply-demand balances of foodgrains for member countries of the Asian Development Bank. The production estimates obtained in it for India are similar to those under the present study, but the high consumption estimates of this study are considerably higher. In particular, the other studies do not bring out the markedly different demand-supply scenarios that are likely to emerge for foodgrains in India under alternative scenarios of development, particularly when the twin objectives of acceleration in economic growth and eradication of poverty are pursued. These differences stem substantially from an increased demand for food as incomes grow and poverty is alleviated, and from an increased demand for feedgrains as the demand for livestock products increases.

7

CONCLUSIONS AND POLICY IMPLICATIONS

India has accomplished an impressive transformation in its agricultural sector, particularly in foodgrains, over the past 25 years. Study of the country's foodgrain production and consumption shows substantial growth in production and considerable change in various factors underlying that growth. However, the levels and patterns of consumption on a per capita basis show relatively less improvement. In the coming decades the foodgrain situation may still change significantly, and growth in consumption may play a very important role. Future development will, however, depend substantially on the objectives, priorities, and strategy of government policies. The results and discussions in this study provide a number of findings that may be of considerable importance for these decisions and policies.

Sustaining Growth in National Foodgrain Production

In the late 1970s and early 1980s, a number of studies raised concerns about a possible deceleration in the growth of foodgrain production, indicating a decline in the momentum of the green revolution and possible exhaustion of the potential of available technology. Analyzing a longer national time series, the present study finds that there was, in fact, some deceleration from the pre-green-revolution period (1949/50-1964/65) to the first half of the green-revolution period (1967/68-1975/76), coming substantially from a decline in the area growth rate. But the study also finds evidence of an acceleration of the growth rate, from 1.9 to 2.4 percent a year, from the first to the second half (1975/76-1983/84) of the green-revolution period. This appears to have been driven, in particular, by a geographic spread in the yield growth that led to a more broad-based growth in foodgrain production. This has, however, still left out several potential growth regions such as the Eastern region.

This acceleration raises the hope of sustaining the national growth in foodgrain production. Other evidence, however, indicates that as much as 90 percent of the growth in the second half of the green-revolution period came from yield growth and that this growth was almost entirely technology-based, involving substantial increases in the adoption and use of modern inputs by the farmers. This shows that future growth in foodgrain production is likely to be critically dependent on a rapid pace of technological change. In this process, increasing the use of modern inputs and maintaining their productivities would be crucial. Thus, even though there has been acceleration in the recent past, the study indicates that any future growth in foodgrain production would be extremely demanding, and a substantial government commitment to technology-based growth in agriculture would be exceedingly important.

Regional Patterns in Production Growth

Analysis of regional patterns of growth indicated that in past decades, growth in foodgrain production had been relatively concentrated, particularly in the Northern region. This was partly related to natural endowments, preexisting infrastructure, suitability of seed-fertilizer technology breakthroughs, and concentration of government efforts in this region to raise food production rapidly. All these factors led to a predominance of the Northern region in growth, and also to concerns about the country's substantial dependence on it and doubts about whether other regions could generate such growth. This predominance may also have contributed to difficulties in sustaining and accelerating the growth adequately and in improving the cost-efficiency of the growth.

The analysis in this study shows that the growth in 1975/76-1983/84 had better geographic distribution, with the Uttar Pradesh and Central regions in particular joining in more rapid growth. This change in pattern helped to reduce the concentration of growth and dispel doubts about the potential for growth in other regions. It showed that more broad-based growth was possible and, given its many benefits, should be planned for. Further progress in this direction would imply, in particular, the inclusion of the Eastern and Western regions in growth through the diffusion and adoption of better technologies.

Inclusion of the Eastern region would be critical to making a significant dent in elimination of national poverty, because of the concentration of poverty and potential for growth there. Rapid growth in the Eastern region would require concerted efforts to tackle its special problems of development. The Committee on Agricultural Productivity in Eastern India (Sen Committee) has indicated that this would require large-scale investment in infrastructure as well as emphasis on improving the administration and management of development programs. Accelerating growth in the Western region would call for special efforts to improve the productivity and stability of dryland crops through new varieties, better water management, and tackling of the specific soil fertility constraints there. Declining production growth in the Southern region is also of concern but is found to be mainly due to the declining area allocated to foodgrains. The nature, causes, and relative benefits of this diversion may require further investigation.

Inputs: Growth in Use and Decline in Productivities

Observations on growth rates indicates the large and increasing importance of yield growth in raising production in the green-revolution period. Further, decomposition of the yield increase into components of cropping pattern change and pure yield effects shows that the bulk of the increase in overall yields on an all-India basis came from the pure increases in crop yields. This implies the substantial importance of technological change associated with large increases in input use. A study of the input use data shows that there is a large growth in modern input use in the recent past, particularly of HYV area and fertilizer use. The use of these continues to be concentrated but seems to have extended beyond the relatively slow-growing irrigated area.

A major problem indicated by the analysis, however, is a decline in aggregate input productivities. This is shown for fertilizers but in every likelihood involves the other inputs as well (the decomposition is difficult because of problems in separating effects and because of multicollinearity). The decline in productivities implies that large increases in input use will be required to generate the necessary growth in production. The reasons behind this decline urgently require further investigation and research. The decline could be partly a result of diminishing returns due to persistent concentration of input use in certain areas. Overcoming this will require policy changes toward the diffusion of input use to other areas where the gains obtainable in additional production may be higher. In areas of current concentration, efforts may be required to break out of the diminishing returns, possibly through more balanced application of nutrients, application of organic manures, and more careful management of soil fertility and other factors of production including water management. Another reason for the decline in productivities may be the spread of fertilizer use to rainfed and dryland areas and to coarse grains where productivities may currently be low. This will require further work in developing productive and resilient varieties for these areas, better water management, and a clearer understanding of the soil fertility and nutrient constraints in these locations.

Growth and Patterns in per Capita Consumption

An examination of trends in the levels of per capita availability of foodgrains showed no statistically significant long-term improvement or decline. This was puzzling, particularly because the long-term growth in foodgrain production was fairly impressive at 2.6 percent a year and was higher than the population growth rate of 2.2 percent. It seems that the difference was utilized primarily to reduce foodgrain imports and build up stocks. There was little growth in the per capita consumption of foodgrains, despite national income growth on the one hand and persistent hunger on the other. Among the reasons for the slow growth in demand appear to be the weak linkage effects from the growth in foodgrain production, and the failure of the development strategy to significantly improve the incomes of the poor. Since the incomes of those in the bottom quartile, who have relatively high elasticities of foodgrain demand, have not grown rapidly, this has affected the growth in foodgrain demand. This calls for an enhanced focus on poverty alleviation through improving growth linkages of the existing productive activities (through better infrastructure and services), encouraging growth in potential areas where the poor are concentrated (for example, the Eastern region), and fostering labor-intensive productive activities (including forms of livestock and horticulture production).

The National Sample Survey data on per capita total consumer expenditure (in real terms, used as a proxy for real income per capita) confirm the above-mentioned patterns in income distribution. The data further indicate that between 1977/78 and 1983 the total expenditure disparity between the top and bottom quartiles in the rural areas lessened somewhat, and the disparity between rural and urban areas also appears to have been reduced. This may indicate slight movement toward an improved income distribution that may continue into the future. Between 1970/71 and 1983 the income in the rural bottom quartile shows a small increase, but the urban bottom quartile income shows very little change, perhaps reflecting relatively good agricultural performance but inadequate nonagricultural growth. This situation draws attention to the urgent need to address persistent urban poverty, but there is an equally urgent need to tackle poverty in rural areas, where the numbers are much larger and the income levels still extremely low.

The National Sample Survey per capita foodgrain consumption data show a small decline of 6.4 kilograms or 3.4 percent in annual per capita foodgrain consumption between the 1970/71 and 1983 surveys. An equivalent trend is, however, not shown by the per capita availability data. Given that the consumption survey covers one year in several years, this decline might be a reflection of year-to-year fluctuations. The decline is shown by both the urban and rural data and is intriguing because the real per capita incomes, particularly in the rural areas, show a small rise between these years. One answer may lie in the relative price movements. On examination of these movements for cereals the results show that the real prices of cereals, when based on the national wholesale price indices, declined between 1970/71 and 1983, but when based on implicit consumer prices, the real prices did not decline as much. And particularly in the rural areas the real consumer prices increased, and increased relatively more for the bottom quartile. This indicates that part of the benefits of income growth, especially to the poor in the rural areas, were neutralized by adverse movement of prices. The above finding indicates that under development with inflation, in order to maintain and improve the nutritional status of the poor, their incomes may need to grow faster than usually assumed so as to counteract adverse price effects. It also shows that past growth in foodgrain demand may have been constrained not only because of slow growth in the incomes of the poor but also to some extent because of adverse movement of prices for the rural poor.

Future Growth in Production

Even though doubts about a deceleration might be put aside for the time being, it is evident from the study that sustaining future growth in production is likely to be an extremely difficult task. This is apparent from, among other things, the sharp increase in the importance of yield growth, little recent change in the absolute potential of basic biochemical technology, the decline in input productivities, and the relative geographic concentration of growth. Future production growth will require continued substantial emphasis by the government on technology-based growth in agriculture along all these fronts.

The future scenario with the level of production projected for the year 2000 at 219 million tons (base) envisages a growth of 2.8 percent a year in the total output, and of this, 96 percent needs to come from increases in yield—from an average of 1,060 kilograms per hectare in 1983/84 to 1,627 kilograms in 2000. The other two production scenarios imply growth rates of 2.7 percent and 2.6 percent over the trend base of 140 million tons in 1983/84. The input requirements for achieving the base scenario level of production indicate an annual increase of about 6.0 percent in fertilizer consumption and 3.9 percent in gross irrigated area under all crops. For fertilizers this involves, on average, an increment of 750,000 tons of fertilizer (NPK) every year, which is almost double the past annual increases between 1967/68 and 1983/84. This increment will require, among other things, wider geographic distribution of fertilizer use and its more intensive and balanced use in some areas. This may call for tremendous efforts in several directions such as development of knowledge on the appropriate fertilizer use on different locations and crops and dissemination of that information; institutional arrangements and services for the supply of fertilizers on time in the required quantities and type; provision of credit for fertilizer purchase; and favorable input/output pricing policies.

The level of irrigated area assumed in the base scenario (100 million hectares) calls for an annual increase of 2.9 million hectares between 1983/84 and 2000 in the actual utilization of irrigation. This is nearly double the annual increase achieved between 1967/68 and 1983/84. The Seventh Five-Year Plan assumes an addition of 2.2 million hectares under irrigation each year, and this needs to be stepped up in subsequent plans, particularly because the potential created is frequently not fully utilized. Data given in Chapter 4 indicate that average yields of at least 3 tons per hectare of wheat and rice can be realized on irrigated areas if HYVs, fertilizers, and improved agricultural practices are adopted simultaneously.

The production growth envisaged in this study also requires an acceleration of growth in the Eastern region, which will require substantial emphasis on the development of this region. The Committee on Agricultural Productivity in Eastern India has indicated that this will require large investments in infrastructure and improvement of rural services as well as location-specific research to better exploit the potential of this region.

Future Growth in Direct Human Consumption Demand

The study finds that the low-income groups have relatively low levels of foodgrain consumption as well as high income elasticities of foodgrain demand. Improvement in their incomes, through growth and better income distribution, is extremely important for alleviation of poverty and hunger but will lead to faster growth in the demand for foodgrains.

Under a consumption scenario that assumes Perspective Plan (India, Planning Commission 1985, vol. 1, chap. 2) income growth rates and no change in income distribution, direct human consumption in 2000 is expected to reach about 176 million tons, which amounts to about 180.0 kilograms per capita per year compared with 166.6 kilograms in 1982-84, assuming unchanged relative prices. Two-thirds of this increase may be attributed to population growth and one-third to income growth. Under an accelerated growth rate scenario that assumes an acceleration in income growth rates (to 3 percent rural and 7 percent urban, amounting to 5.7 percent national), with a small change in income distribution, direct human consumption is expected to reach 187 million tons in 2000. This amounts to about 191 kilograms per capita per year. This latter scenario would result in poverty alleviation by raising even the average income of the bottom quartile above the poverty line. Achieving this scenario, which may be considered a target, would require substantial efforts in raising growth in foodgrains, nonfoodgrains, and the nonagricultural sector in ways that generate more employment and incomes for the poor.

Future Growth of Feed Demand

More rapid economic growth will also lead to faster growth in the demand for livestock products, particularly from the upper- and middle-income groups. This in turn is likely to lead to a rise in the demand for feedgrains. The feedgrain demand usually rises rapidly with economic growth in most developing countries, and its past growth rate in India has been relatively high. Future economic growth is likely to lead to a more buoyant demand for livestock products in India. This would result in a larger demand for livestock feed and would gradually lead to the exhaustion of by-products currently available for feeding animals, which would necessitate feeding more grains to the animals. The shift to rearing more productive animals would also create a need for better animal nutrition, thereby increasing the need to feed grains. All these factors may lead to an increase in the average feeding ratios of feedgrain input to livestock output, thus further accelerating feedgrain demand. Since livestock production can be substantially labor-intensive in developing countries, an expansion of the livestock sector could also contribute to generating employment and incomes for the poor.

Production-Consumption Balances

Although the scenarios for production and consumption of foodgrains in 2000 may appear to have been worked out separately, they are in fact linked through the assumptions. The output levels of 211-219 million tons in 2000 imply growth rates of 2.6-2.8 percent over the trend output of 140 million tons in 1983/84. The rural income growth rates envisaged in the different consumption scenarios, however, range from 2.3 to 3.5 percent. The growth rates in use of inputs required to sustain a growth of 2.8 percent in foodgrain production are by themselves very large, and when further given the constraints to area growth, it becomes obvious that rapid growth in rural incomes may need to come significantly from outside the foodgrain sector. To achieve a rural income growth rate of 3.5 percent, nonfoodgrain agriculture would need to grow at a rate of over 4.0 percent. There appears to be potential for faster growth in nonfoodgrain activities in the rural areas, and the development strategy should focus on these activities, particularly those that are labor-intensive. Such a strategy may also improve the employment and income opportunities for the lower-income groups. Cultivation of high-value export-oriented crops, livestock production including the poultry and dairy sectors, and small-scale industries are possible labor-intensive activities with potential for rapid growth.

The regional pattern of growth within the foodgrain production projections also has important linkages with the consumption scenarios. An explicit assumption in the production projection is acceleration in production growth in the Eastern region. Given the relative concentration of poverty in this region, this acceleration of growth would be crucial for raising the incomes in the rural bottom quartile, thereby alleviating poverty as well as bringing growth in foodgrain demand. Similarly, achievement of the expected production growth performance in the Southern and Western regions would be important for raising the incomes of the poor. Such accomplishments would require specific policy emphasis toward the problems of agricultural growth in these regions.

The achievement of expected yield growth rates in wheat and rice in the Northern, Uttar Pradesh, and Central regions would also be required to bring about overall growth in production and rural incomes. This would demand continued government emphasis, particularly on research and extension in these regions.

Implications of Faster Economic Growth and Poverty Alleviation

India's Perspective Plan (India, Planning Commission 1985, vol. 1, chap. 2) aims to accelerate economic growth and eliminate poverty by 2000. Alleviation of poverty will require raising the incomes of the poor, particularly the bottom quartiles in both the rural and urban areas. This will require economic growth as well as better distribution of income. Growth in foodgrain production, given its importance, will need to be an important cornerstone of the development strategy. But meeting the government's objectives will also require accelerated growth in nonfoodgrain rural activities including nonfoodgrain crops, livestock, fisheries, social forestry, and rural industries. It will require greater emphasis and investment in an employment-oriented strategy of growth that can raise the incomes of the poor more rapidly. This analysis shows that a successful implementation of such a strategy, leading to acceleration of income growth rates and improvement in income distribution, could also lead to food demand growth that might make India deficit in foodgrains. This would create a need to import despite an impressive agricultural performance. On the other hand, a failure of the strategy might leave India marginally surplus in foodgrains.

Therefore, achieving the twin objectives of acceleration of economic growth and elimination of poverty will call for the adoption of an appropriate development strategy, a major food production effort, and the political courage to import on a sizable scale if required, in order to sustain the necessary growth and development in the Indian economy.

Statistical Improvements

This section highlights some issues concerning data limitations for policy research that were encountered in this study. Attention has already been drawn to the large impact that poverty alleviation can have on growth of foodgrain demand. However, the effect of higher incomes in the upper- and middle-income groups on demand is not clear. While on the one hand their per capita demand for foodgrains for direct consumption may not increase rapidly, or may even decline somewhat, their demand for livestock products may increase, resulting in increased derived demand for foodgrains for feed. In the absence of reliable data on feedgrain use and quantities of livestock products consumed, this aspect could not be examined in detail here. The issue calls for collection and provision of such statistics on a national basis.

The allowances for seed, feed, and wastage now being applied by the Ministry of Agriculture in calculating the net availability of foodgrains for human consumption from the production estimates have not been changed since the early 1950s. The proportion of seed to yield per hectare is likely to have declined after the adoption of HYVs and the allowance needed to account for losses in storage and handling also could have declined. On the other hand, the requirements for feed would have increased with the increase in demand for livestock products and the current programs for development of livestock activities including dairying and poultry. It is important that the Government of India take measures to correct and update these estimates. Studies such as Bansil 1989 could be done on a national basis.

Consumption data from the NSSO consumption surveys are often available only after a considerable time lag. No quantitative data on nonfoodgrain consumption are available from these surveys. These data deficiencies need early attention. Beyond the national analysis in this study, a disaggregated analysis of consumption could be done at a regional level and should include items of food consumption besides cereals and pulses. This study also shows that foodgrain rainfall indices are very useful, and it is suggested that the Government of India should compute and publish such index numbers on a regular basis, adopting an appropriate standard methodology.

Some work on the determination of response coefficients for different inputs and crops is being done at the Indian Agricultural Research Statistics Institute. It would be useful if the institute would help undertake the regular revision of the input response yardsticks for foodgrains as a whole. Whereas this would be adequate for planning, for policy research—particularly in studying productivity—it would also be valuable to have measures of response for different states, regions, crops, and nutrients under different associated conditions.

APPENDIX 1

DECOMPOSITION OF YIELD INCREASE INTO PURE YIELD EFFECT AND CROPPING PATTERN EFFECT

$$Y = W_f Y_f + W_c Y_c ,$$

$$\Delta Y = \Delta Y_f W_f + \Delta W_f Y_f + \Delta W_f \Delta Y_f$$

$$+ \Delta Y_c W_c + \Delta W_c Y_c + \Delta W_c \Delta Y_c , \text{ and therefore}$$

$$\Delta Y = \Delta Y_f W_f + \Delta Y_c W_c \quad \text{(pure yield effect)}$$

$$+ \Delta W_f Y_f + \Delta W_c Y_c \text{ (cropping pattern effect)}$$

$$+ \Delta W_f \Delta Y_f + \Delta W_c \Delta Y_c \text{ (interaction),}$$

where

$$W_f = \frac{A_f}{A} ,$$

$$W_c = \frac{A_c}{A} ,$$

$$A = A_f + A_c ,$$

Y = total foodgrain yield,

Y_f = yield of fine grains (rice and wheat),

Y_c = yield of coarse grains (coarse cereals and pulses),

A = total foodgrain area,

A_f = area under fine grains (rice and wheat), and

A_c = area under coarse grains (coarse cereals and pulses).

APPENDIX 2

SOURCES AND METHODS FOR REGIONAL FOODGRAIN PRODUCTION DATA

A significant effort has been made in this study to put together consistent regional data on foodgrain area, production, and yield in India by crop, exhaustively covering the entire country from the early 1950s to the latest available year of firm estimates at the time of the analysis. An effort has been made to make each of these time series consistent and comparable over time so as to permit as accurate an analysis of these variables as possible. Foodgrain production data for India are reported under the 31 different states and union territories, which are listed below.

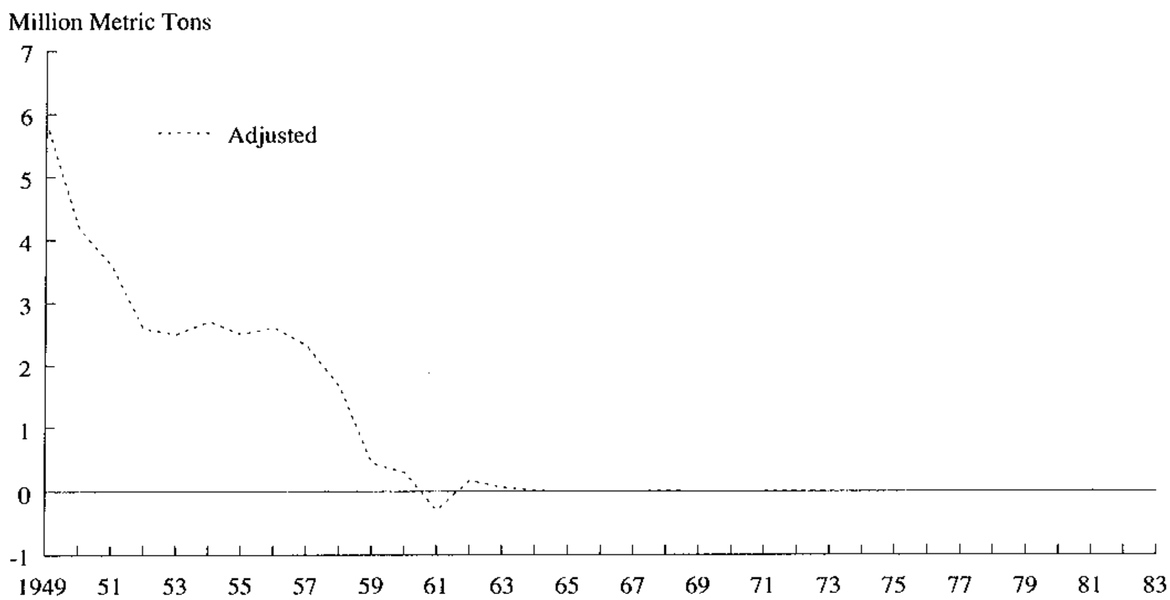
1. Andhra Pradesh
2. Assam
3. Bihar
4. Gujarat
5. Haryana
6. Himachal Pradesh
7. Jammu and Kashmir
8. Karnataka
9. Kerala
10. Madhya Pradesh
11. Maharashtra
12. Manipur
13. Meghalaya
14. Nagaland
15. Orissa
16. Punjab
17. Rajasthan
18. Sikkim
19. Tamil Nadu
20. Tripura
21. Uttar Pradesh
22. West Bengal
23. Andaman and Nicobar Islands
24. Arunachal Pradesh
25. Dadra and Nagar Haveli
26. Delhi
27. Goa, Daman, and Diu
28. Mizoram
29. Pondicherry
30. Chandigarh
31. Lakshadweep

For the early years, most of the data are reported in acres, long tons, and pounds and require conversion. The geographical coverage of the area reporting the crop estimates has expanded over time and the methods of yield estimation have also undergone a change in many of the states and union territories. Traditional methods of yield assessment based on eye estimates have been replaced by systematic crop-cutting surveys. All these changes cause noncomparability in the published time-series estimates, which then do not necessarily reflect real growth or changes. To add to the difficulty, these changes have taken place at different times in different states, and state boundaries too have sometimes changed because of reorganization of states.

In an effort to overcome these problems, which are very serious for time-series studies, the Directorate of Economics and Statistics, Ministry of Agriculture, has worked out and published a special set of adjusted estimates of foodgrain production for the period 1949/50-1964/65. In addition, index numbers of area, production, and yields of foodgrain crops, which reflect time series adjusted for the above-mentioned methodological and coverage changes, were also published. However, these are commonly available only for the aggregate all-India level. The Directorate at one point published similar adjusted index numbers for area, production, and yield for 15 major states, and these are available in a publication (India, Ministry of Agriculture 1968) that gives index numbers by crop for these states from 1952/53 to 1964/65. No major changes in methods of reporting or coverage of the crop estimates have taken place since 1964/65. The difference between "adjusted" and "unadjusted" estimates of all-India production of foodgrains for 1949/50 was as high as 6 million tons (Figure 19). This fluctuated from year to year and was gradually reduced to nil only by 1964/65, by which time most of the changes were completed.

For these 15 states, rather than using published unadjusted data from *Area and Production of Principal Crops in India* (India, Ministry of Agriculture), adjusted area and production data have been generated for 1952/53-1963/64 using the above-mentioned index numbers, with the 1964/65 index numbers and corresponding final estimates of area and production serving as the equating base. From the year 1964/65 onward, figures of area and production are directly adopted from *Area and Production of Principal Crops in India*. For the remaining states and union territories, figures for area and production were directly adopted from this publication for the entire period. The contribution of these remaining states and union territories to total foodgrain area and production is small. The area and production figures for each state and union territory were aggregated into regional figures for the Northern, Uttar Pradesh, Central, Western, Eastern, and Southern regions, based on the composition of each region given in Chapter 3.

Figure 19—Difference between adjusted and unadjusted production estimates of foodgrains in India, 1949-83



Sources: Based on data from India, Ministry of Agriculture, Directorate of Economics and Statistics, *Area and Production of Principal Crops in India*, various issues (Delhi: Controller of Publications, various years).

APPENDIX 3

REGIONAL GROWTH RATES AND THEIR t-STATISTICS

Table 33—Regional growth rates of foodgrain area, production, and yield

Region/Period	Rice Area	Rice Production	Rice Yield	Wheat Area	Wheat Production	Wheat Yield	Coarse Cereals Area	Coarse Cereals Production	Coarse Cereals Yield	Total Cereals Area	Total Cereals Production	Total Cereals Yield	Total Pulses Area	Total Pulses Production	Total Pulses Yield	Total Foodgrains Area	Total Foodgrains Production	Total Foodgrains Yield
	(percent/year)																	
Northern																		
1952/53-1964/65	4.64	5.99	1.29	3.30	5.25	1.89	−0.17	2.45	2.62	1.84	4.39	2.52	1.37	1.23	−0.14	1.64	3.58	1.91
t-statistic	11.90	10.90	4.30	11.70	13.20	3.40	−0.51	3.50	5.38	10.27	11.20	7.05	1.13	0.75	−0.12	4.42	8.32	4.40
1967/68-1975/76	4.54	10.24	5.45	2.75	4.49	1.69	0.21	0.85	0.65	1.98	4.38	2.36	−1.98	−5.77	−3.85	1.26	3.30	2.02
t-statistic	24.26	9.85	6.00	3.60	3.08	2.00	0.32	0.86	0.63	8.04	4.08	2.60	−1.05	−1.53	−1.65	2.65	3.25	2.57
1975/76-1983/84	8.38	11.36	2.75	3.20	6.36	3.07	−3.69	−2.03	1.73	2.16	6.19	3.95	−7.55	−14.42	−7.43	0.89	5.13	4.21
t-statistic	7.90	7.75	2.90	14.70	15.60	10.90	−5.62	−1.40	1.95	13.80	15.35	9.95	−3.20	−5.02	−2.95	2.90	10.55	10.50
Uttar Pradesh																		
1952/53-1964/65	1.83	4.29	2.42	0.84	1.54	0.70	−0.93	−0.61	0.33	0.38	1.46	1.08	0.53	−1.20	−1.72	0.42	0.79	0.37
t-statistic	18.30	6.06	3.50	2.75	1.55	0.73	−5.40	−1.00	0.58	2.78	2.65	2.10	3.38	−1.37	−1.80	3.50	1.38	0.67
1967/68-1975/76	0.22	2.90	2.66	2.86	3.14	0.27	−1.87	−1.74	0.13	0.44	1.69	1.25	−3.51	−5.36	−1.92	−0.32	0.52	0.84
t-statistic	0.70	2.60	2.70	6.10	2.05	0.21	−6.30	−1.15	0.09	2.80	1.60	1.35	−11.60	−2.90	−0.99	−2.50	0.49	0.83
1975/76-1983/84	1.81	4.83	2.97	3.83	8.34	4.33	−3.23	−1.97	1.30	1.36	5.51	4.09	−0.95	−0.70	0.24	1.01	4.81	3.77
t-statistic	4.40	1.30	0.83	10.50	8.20	4.60	−8.65	−0.96	0.70	5.75	3.30	2.50	−2.80	−0.31	0.10	5.60	2.80	2.25
Central																		
1952/53-1964/65	1.30	2.17	0.86	3.49	2.74	−0.73	1.30	2.27	0.95	1.72	2.34	0.60	2.08	2.62	0.53	1.82	2.38	0.56
t-statistic	17.97	1.80	0.73	4.30	2.50	−1.23	4.74	2.50	1.40	11.50	4.20	1.30	4.16	2.30	0.68	8.70	3.80	1.17
1967/68-1975/76	1.12	0.57	−0.54	2.08	5.02	2.88	−1.34	−0.72	0.63	−0.08	1.26	1.34	2.61	4.09	1.43	0.66	1.84	1.17
t-statistic	4.80	0.27	−0.26	1.86	3.04	3.10	−2.00	−0.31	0.28	−0.16	0.73	0.85	3.50	2.15	1.08	1.55	1.06	0.80
1975/76-1983/84	0.73	1.85	1.11	1.24	5.62	4.34	1.94	3.16	1.20	1.49	3.74	2.21	−0.77	−0.48	0.30	0.83	2.87	2.02
t-statistic	4.20	0.47	0.30	1.50	3.50	4.30	4.17	1.06	0.40	6.30	1.60	0.99	−1.05	−0.18	0.14	3.80	1.20	0.94
Western																		
1952/53-1964/65	1.87	4.29	2.38	1.19	3.48	2.28	0.01	2.41	2.41	0.34	2.98	2.63	−0.34	−0.27	0.07	0.22	2.59	2.37
t-statistic	12.30	8.40	4.90	1.70	3.80	2.70	0.07	3.90	3.90	5.90	5.40	5.40	−0.84	−0.35	0.11	1.60	4.90	4.80
1967/68-1975/76	−0.43	1.38	1.82	1.75	8.24	6.39	−1.20	1.57	2.82	−0.84	2.22	3.09	1.86	3.56	1.68	−0.39	2.36	2.76
t-statistic	−0.82	0.58	0.95	0.97	2.40	3.80	−1.20	0.60	1.70	−0.87	0.87	1.90	1.37	1.07	0.86	−0.38	0.90	1.72
1975/76-1983/84	0.78	1.42	0.63	−1.02	1.13	2.17	0.04	1.19	1.15	0.04	1.23	1.19	1.59	2.87	1.26	0.32	1.38	1.05
t-statistic	2.70	1.09	0.60	−1.95	1.02	2.50	0.12	1.07	1.24	0.12	1.25	1.60	3.05	1.70	0.97	0.96	1.38	1.47

Eastern																		
1952/53-1964/65	0.69	2.19	1.49	0.71	2.23	1.51	0.72	2.21	1.48	0.70	2.20	1.49	0.57	1.10	0.52	0.68	2.07	1.38
t-statistic	5.40	2.90	2.26	0.83	1.20	0.73	1.47	2.50	3.10	4.82	3.12	2.47	0.96	1.05	0.66	3.30	2.90	2.40
1967/68-1975/76	0.72	0.64	−0.08	9.61	15.11	5.01	−0.11	−2.26	−2.16	1.33	1.73	0.41	0.60	−2.66	−3.24	1.23	1.39	0.15
t-statistic	2.90	0.84	−0.11	3.60	3.90	2.25	−0.15	−0.64	−0.73	7.55	2.32	0.63	1.20	−2.20	−4.20	7.04	1.98	0.25
1975/76-1983/84	−0.73	−0.58	0.15	−1.87	−0.89	1.02	−1.32	0.99	2.35	−0.91	−0.48	0.43	0.42	3.19	2.75	−0.74	−0.22	0.52
t-statistic	−1.83	−0.30	0.09	−2.40	−0.50	0.85	−1.90	0.75	2.30	−2.40	−0.27	0.30	0.60	2.60	2.45	−2.03	−0.13	0.40
Southern																		
1952/53-1964/65	2.62	4.64	1.96	1.61	1.15	−0.46	−0.60	2.12	2.74	0.87	3.82	2.92	0.28	−0.18	−0.46	0.79	3.67	2.84
t-statistic	11.60	12.70	9.60	1.06	0.60	−0.57	−2.70	5.16	7.80	5.40	11.60	11.30	1.20	−0.38	−1.40	5.10	11.20	11.30
1967/68-1975/76	0.46	2.88	2.40	9.24	28.94	18.02	−0.58	1.62	2.21	−0.03	2.56	2.58	1.79	6.07	4.21	0.20	2.66	2.46
t-statistic	0.96	3.40	3.80	9.30	8.50	6.20	−1.60	1.98	3.30	−0.06	3.70	5.45	2.85	3.45	3.20	0.55	3.80	5.35
1975/76-1983/84	−0.68	1.93	2.63	−4.90	−4.64	0.27	−2.98	−1.28	1.76	−1.72	1.12	2.89	1.55	5.24	3.63	−1.28	1.27	2.58
t-statistic	−0.90	1.50	3.60	−3.20	−1.15	0.09	−5.50	−1.15	2.25	−2.80	0.95	4.20	4.09	3.90	3.10	−2.25	1.10	3.70
All India																		
1952/53-1964/65	1.57	3.34	1.74	2.29	3.32	1.02	0.21	1.38	1.16	0.99	2.63	1.62	1.36	0.62	−0.73	1.07	2.33	1.25
t-statistic	20.80	7.02	3.94	4.90	5.20	1.65	1.30	3.30	3.80	9.60	7.20	5.60	4.50	0.90	−1.30	8.40	6.10	4.00
1967/68-1975/76	0.67	1.89	1.21	3.20	5.47	2.18	−1.07	0.27	1.35	0.31	2.22	1.90	0.77	−0.51	−1.27	0.40	1.91	1.50
t-statistic	3.50	2.00	1.40	5.55	3.89	2.65	−3.40	0.19	1.29	1.40	3.30	3.80	1.50	−0.20	−1.17	1.50	2.80	3.05
1975/76-1983/84	0.22	1.97	1.75	1.94	5.72	3.72	−0.46	0.68	1.14	0.31	2.77	2.45	−0.32	−0.22	0.11	0.19	2.48	2.28
t-statistic	0.48	1.33	1.50	4.50	7.90	6.70	−1.15	0.79	1.58	1.50	2.65	2.80	0.15	0.51	0.57	1.25	2.40	2.60

Sources: Based on data from India, Ministry of Agriculture, Directorate of Economics and Statistics, *Area and Production of Principal Crops in India*, various issues (Delhi: Controller of Publications, various years); see Appendix 2 for modifications to this data.

APPENDIX 4

SOURCES AND METHODS FOR INPUT DATA AND RESPONSE COEFFICIENTS

Input Data

Fertilizers

The basic source of fertilizer data is *Fertilizer Statistics*, published annually by the Fertilizer Association of India in New Delhi. The data on fertilizer consumption relate to nitrogenous, phosphatic, and potassic fertilizers and are based on dispatches to the retail trade. Therefore they do not include stock changes at the retail and farmer levels. The data are indicative of the total fertilizer use on all crops but do not give the amount or percentage that is applied to foodgrains each year. An IFPRI research report (Desai 1982) provides a rigorous study of the pattern of fertilizer use in India as well as several benchmark estimates on this issue. The report estimates, on the basis of NSS survey data, that 45 percent of the fertilizer used in 1955/56 went to foodgrains and that by 1970/71 this share had risen to 56 percent. Further, on the basis of a survey by the National Council of Applied Economic Research, the report estimates that by 1976/77 this figure had risen to 70 percent. It is assumed in this study that the share of fertilizers going to foodgrains rose more slowly to 75 percent by 1983/84.

Between these benchmarks, linear (steady) rate increases have been assumed in the percentage share between 1976/77 and 1983/84, and between 1970/71 and 1976/77. The annual rate of increase between 1970/71 and 1976/77 was adopted for the period between 1967/68 and 1970/71 also, under the assumption that a certain acceleration for foodgrains began from the first year of the green revolution, namely 1967/68. Again, a linear rate of increase is assumed between the benchmark of 1955/56 and the year 1967/68, and the annual rate of increase between these two years has been extended back to 1949/50. Estimating annual utilization of fertilizers using linear rates of increase and relating the production potential created to fluctuating foodgrain production is open to objection. It can at best give approximate relationships, and caution is required in reaching conclusions from these data. Table 34 shows the relevant data along with the implied average per hectare rate of application of fertilizers to foodgrains and nonfoodgrains. It may be noted that the average per hectare rate for nonfoodgrains is higher than that for foodgrains during most of the period until the early 1980s, when it is surpassed by the rate for foodgrains. This is consistent with the more rapid increase in the foodgrain yield index compared with the nonfoodgrain yield index around this period. For 1967/68 the fertilizer consumption figure given in Table 34 is 1,539,900 tons, whereas that given in Table 7 is 1,166,000 tons. This difference between the aggregate and the disaggregate data exists in the Indian fertilizer statistics and cannot be currently resolved without further information.

High-Yielding Varieties

High-yielding varieties (HYVs) started entering Indian agriculture in a significant way in 1967/68. The data for this are obtained from *Area and Production of Principal*

Table 34—Fertilizer use in India, 1949/50-1983/84

Year	Total Fertilizer Consumption	Share of Fertilizer for Foodgrains	Total Amount of Fertilizer for Foodgrains	Fertilizer for Foodgrains per Hectare	Fertilizer for Nonfoodgrains per Hectare
	(1,000 metric tons)	(percent)	(1,000 metric tons)	(kilograms)	(kilograms)
1949/50	22.8	43.00	9.80	0.10	0.39
1950/51	36.4	43.33	15.77	0.16	0.58
1951/52	65.6	43.67	28.65	0.30	1.01
1952/53	65.7	44.00	28.91	0.28	1.02
1953/54	105.1	44.33	46.59	0.43	1.73
1954/55	120.9	44.67	54.00	0.50	1.85
1955/56	130.8	45.00	58.86	0.53	1.96
1956/57	153.8	45.33	69.72	0.63	2.19
1957/58	183.7	45.67	83.89	0.77	2.74
1958/59	223.8	46.00	102.95	0.90	3.27
1959/60	304.6	46.33	141.13	1.23	4.34
1960/61	293.8	46.67	137.11	1.19	4.20
1961/62	338.3	47.00	159.00	1.36	4.55
1962/63	452.2	47.33	214.04	1.81	6.14
1963/64	543.9	47.67	259.26	2.21	7.19
1964/65	773.2	48.00	371.14	3.14	9.79
1965/66	784.6	48.33	379.22	3.29	10.09
1966/67	1,100.6	48.67	535.63	4.65	13.44
1967/68	1,539.9	49.00	754.55	6.21	18.56
1968/69	1,760.7	51.33	903.83	7.50	21.91
1969/70	1,982.4	53.67	1,063.89	8.61	23.74
1970/71	2,256.0	56.00	1,263.36	10.16	23.93
1971/72	2,656.9	58.33	1,549.86	12.64	26.01
1972/73	2,767.9	60.67	1,679.19	14.08	25.40
1973/74	2,838.6	63.00	1,788.32	14.13	24.24
1974/75	2,573.3	65.33	1,681.22	13.89	20.69
1975/76	2,893.8	67.67	1,958.14	15.28	21.70
1976/77	3,411.0	70.00	2,387.70	19.20	23.80
1977/78	4,285.8	70.71	3,030.67	23.77	28.05
1978/79	5,116.9	71.43	3,654.93	28.33	31.96
1979/80	5,255.4	72.14	3,791.40	30.28	32.94
1980/81	5,515.6	72.86	4,018.51	31.72	32.24
1981/82	6,064.0	73.57	4,461.37	34.55	33.45
1982/83	6,388.0	74.29	4,745.37	37.94	34.55
1983/84	7,710.0	75.00	5,782.50	44.09	40.09

Sources: Authors' calculations based on data from Fertilizer Association of India, *Fertilizer Statistics* (New Delhi: FAI, various years).

Crops in India (India, Ministry of Agriculture) for the number of hectares of gross cropped area and cover HYVs of rice, wheat, maize, *jowar*, and *bajra*. These data are obtained from the state governments, who base their estimates on data furnished by the primary reporting agencies after periodic crop inspection. In some states the data are based on the reports of agricultural extension and other staff of the agricultural department.

Irrigation

Data for irrigated area for foodgrains are obtained from *Indian Agriculture in Brief* (India, Ministry of Agriculture) for the number of hectares of gross irrigated area. These data are also based on the reports furnished by the primary reporting agencies of the Revenue/Land Records departments after periodic crop inspection. In some states, the data are furnished by the staff of the irrigation departments. There is also another source of data on irrigation, namely, the progress reports on major, medium, and minor irrigation schemes submitted by the respective departments. There are wide differences between the data from these two sources. For the present study the former source has been adopted.

Basis of Response Coefficients

Sarma and Roy (1979) adopted the following response coefficients (yardsticks) for assessing input response in foodgrain production: 0.50 tons per hectare for irrigation, 10.00 tons per ton of nutrient (NPK) for fertilizers, 0.45 tons per hectare for additional area under foodgrains, and 0.33 tons per hectare for the shift in area to rice and wheat from coarse cereals and pulses. It is assumed that these response coefficients are additive though the inputs are applied in combination. Fertilizer response is assumed to include the HYV response.

The response coefficients for irrigation and fertilizers were the same as those that have been used in national planning in India for determining food production targets fixed, in part, on the basis of production potential. To arrive at the other coefficients, the estimated contribution of irrigation and fertilizers was subtracted from the average foodgrain output in 1959/60-1961/62, that is, 80.62 million tons. The balance (67.81 million tons) was subdivided into two parts representing the outputs of (1) rice and wheat and (2) coarse cereals and pulses. The latter was estimated using the average yield of coarse cereals and pulses (0.45 tons per hectare). The average yield of rice and wheat (excluding the contribution of irrigation and fertilizers) was then derived as 0.78 tons per hectare. Thus the yardstick of additional production for shift of area from other foodgrains to rice and wheat was estimated as 0.78 − 0.45 = 0.33 tons per hectare. No separate response coefficient for labor was adopted.

Considerable work was done on the yardsticks or response coefficients by the Indian Agricultural Statistics Research Institute (IASRI) in the 1960s, based on the data on field trials. The National Commission on Agriculture (India, Ministry of Agriculture 1976) also reviewed the available data and arrived at the response coefficients of fertilizers at 8 for traditional varieties and 10 for an average of traditional and high-yielding varieties. But these have not been reviewed since then. Although IASRI is continuing its work on yardsticks, no updated composite yardsticks in a form suitable for application in the computation of production potential have been evolved.[17]

Calculation of the Rainfall Index

Rainfall data are reported by the India Meteorological Department on a compiled basis for 32 different rainfall zones (Table 35). *Agricultural Situation in India* (India, Ministry of Agriculture) reports rainfall received in each of the 32 zones in the four seasons of each year: monsoon, June-September; postmonsoon, October-December; winter, January-February; and premonsoon, March-May. Actual rainfall received and normal rainfall in each season is reported for each zone.

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[17] IASRI recently brought out a monograph on yardsticks for irrigation, but these are given in output per centimeter of water for selected individual crops at different centers.

Table 35—Rainfall reporting zones in India

State/Zone	Share in Gross Sown Area, 1973/74
	(percent)
Andhra Pradesh	
Coastal	2.7
Telangana	3.3
Rayalaseema	1.8
Assam and Meghalaya	1.9
Bihar	
Plateau	1.6
Plains	4.7
Gujarat	
Gujarat region	3.5
Saurashtra, Kutch, and Diu	2.7
Haryana	3.0
Himachal Pradesh	0.5
Jammu and Kashmir	0.5
Karnataka	
Coastal	0.2
Interior north	3.6
Interior south	2.6
Kerala	1.8
Madhya Pradesh	
East	5.3
West	7.3
Maharashtra	
Konkan and Goa	0.5
Madhya Maharashtra	4.7
Marathwada	3.1
Vidarbha	3.2
Nagaland, Manipur, Mizoram, and Tripura	0.5
Orissa	4.3
Punjab	3.6
Rajasthan	
East	4.9
West	5.7
Tamil Nadu	4.5
Uttar Pradesh	
East	8.0
West (Plains)	5.0
West (Hills)	0.7
West Bengal	
Sub-Himalayan and Sikkim	1.2
Gangetic	3.1
All India	100.0

Source: Based on data from Center for Monitoring Indian Economy, *Basic Statistics Relating to the Indian Economy*, vols. 1 and 2 (Bombay: CMIE, 1984).

In this study, for the *kharif* crops, the monsoon and postmonsoon rainfall are considered the most relevant. Therefore, for each zone the rainfall received in these two seasons is added and expressed as an index or percentage in relation to the normal rainfall. This is called the *kharif* rainfall index for the zone. For the *rabi* crops, the postmonsoon and winter rainfall are considered the most relevant and these are similarly computed into a *rabi* rainfall index for the zone.

State (a state may have several zones) *kharif* and *rabi* rainfall indices are computed from the zonal indices by using the gross sown area in the reference year of 1973/74 in each zone as the weights (Table 35). A state rainfall index is then computed for each crop year by using the state *kharif* and *rabi* average foodgrain production in the reference period 1972/73-1974/75 as weights. This is an improvement over the Cummings and Ray (1969) methodology (also adopted by Sanderson and Roy [1979]), which makes a prior classification of states into groups and applies only the *kharif* index to one group of states.

The state rainfall indices are then converted into an all-India rainfall index for each year by using the average foodgrain production in each state in the reference period 1972/73-1974/75 as weights. In this manner, the gross sown area and the foodgrain production are allowed to do all the weighting for aggregations across zones and states, and no other prior classifications are applied.

Given the limitations of time and data, indices were computed in this manner for the years 1973/74-1983/84. For the years 1951/52-1968/69 the Cummings and Ray indices (for cereals) were adopted, and for the years 1969/70-1972/73 the Sanderson and Roy extension of the indices was adopted. The overlapping period of the two indices (1973/74-1977/78) showed that both were highly correlated and close; therefore, there was little problem in merging them.

APPENDIX 5

RESULTS OF FACTOR ANALYSIS ON FOODGRAIN PRODUCTION DETERMINANTS

A. Principal components on six variables; three factors retained.

1	2	3	4	5	6
Eigenvalues:					
4.7038	0.97192	0.27927	0.03018	0.008727	0.006070
Sum of eigenvalues = 6.0000					
Cumulative percentage of eigenvalues:					
0.78397 78%	0.94596 16%	0.99250 5%	0.99753	0.99899	1.0000
Eigenvectors:					
Vector 1					
0.42409	0.45532	0.43816	0.44569	0.45518	0.12261
Vector 2					
0.10725	−0.02947	−0.10401	−0.09805	−0.13665	0.97392
Vector 3					
0.70253	0.24764	−0.50183	−0.40833	0.02405	−0.16120
Factor matrix (three factors):					
Variable afg					
0.91977	0.10573	0.37126			
Variable arw					
0.98750	−0.02905	0.13087			

Variable frfg

0.95029	–0.10254	–0.26520

Variable hvfg

0.96662	–0.09666	–0.21579

Variable irfg

0.98721	–0.13472	0.01270

Variable rain

0.26591	0.96015	–0.08518

Iteration Cycle	Variances
0	0 .223537
1	0 .282626
2	0 .285571
3	0 .285575
4	0 .285575
5	0 .285575
6	0 .285575
7	0 .285575

B. Results of factor analysis on foodgrain production determinants.

Rotated factor matrix (three factors):

Factor	1	2	3
Factor identification	Technology/ Inputs	Rainfall	Area
Variable			
afg (area)	0.50537	0.19469	*0.83767*
arw (rice/wheat)	0.72269	0.10649	0.67787
frfg (fertilizers)	*0.93102*	0.08348	0.33185
hvfg (HYV)	*0.91506*	0.08495	0.38171
irfg (irrigation)	*0.81075*	0.01938	0.57895
rain (rainfall)	0.06285	*0.99221*	0.10688

Check on communalities:

Variable	Original	Final	Difference
1	0.99499	0.99499	0.47367E-06
2	0.99313	0.99313	0.49816E-06
3	0.98389	0.98389	0.50197E-06
4	0.99027	0.99027	0.50461E-06
5	0.99289	0.99288	0.50796E-06
6	0.99986	0.99986	0.81344E-08

APPENDIX 6

VARIABLE NAMES AND DEFINITIONS IN PRODUCTION FUNCTION ANALYSIS

YIELD = Yield of foodgrains in kilograms per hectare. This is an average yield obtained by dividing the foodgrain production by the gross cropped area under foodgrains. Both production and area figures are adjusted for changes in coverage and methodology over the years.

FERT = Fertilizer use in kilograms per hectare. This is obtained by dividing the quantity of fertilizers applied to foodgrains (see Appendix 4) by the gross cropped area under foodgrains. The fertilizer data are for an April-March year, but given the cropping practices in India, this requires no adjustment for the July-June crop-year basis of the rest of the data.

HYV = Percent coverage of high-yielding varieties. This is obtained by dividing the gross cropped foodgrain area under HYVs by the total gross cropped area under foodgrains. In an input-output context, assuming a constant HYV seed rate, this represents the per unit average HYV seed use.

IRRIG = Percent coverage of irrigation. This is obtained by dividing the gross irrigated foodgrain area by the gross cropped area under foodgrains. In an input-output context, assuming a constant rate of irrigation, this represents the average irrigation application per unit of area.

RAIN = Foodgrain rainfall index. This is the all-India foodgrain rainfall index and represents an index of the weighted average rainfall actually received for foodgrain crops per unit of area (see Appendix 4).

APPENDIX 7

METHODS ADOPTED IN USING NATIONAL SAMPLE SURVEY CONSUMPTION DATA

The National Sample Survey (NSS) consumer expenditure data on foodgrains (India, Department of Statistics) are available annually up to 1973/74; subsequently, they are available for 1977/78 and 1983. The principal focus of this study is on the 1977/78 and 1983 data. As a convenient past reference point, main use has been made of the year 1970/71, in part because a more detailed breakdown is available from the 1970/71 survey on food items through a special report made on this by the National Sample Survey Organization (NSSO) to the National Commission on Agriculture (India, Department of Statistics 1975).

For cereals and pulses, quantity as well as value data are available by income (total expenditure) group in the 1970/71 survey. From the mean values and quantities, implicit consumer prices for cereals and pulses are computed for the year 1970/71 for the rural and urban areas. In lieu of any alternative information, wholesale price indices for cereals and pulses are used to shift these mean consumer prices to 1977/78 and 1983. In this way, the wholesale-consumer and the rural-urban price differentials are maintained. The 1977/78 and 1983 survey data provide the quantity data for cereals, but the pulse data are only in value terms; therefore, mean values are converted to quantity by applying the estimated 1977/78 and 1983 prices for pulses. The rural and urban mean per capita consumption levels for cereals, pulses, and foodgrains thus obtained for 1977/78 and 1983 are converted to national estimates by applying rural-urban population ratios computed from census estimates.

The nonavailability of quantity data for pulses in 1977/78 and 1983 survey publications poses more difficult problems for analysis of the data by income group and quartile. Quantity as well as value data are available for the 1970/71 survey, and implicit prices calculated from this show that the prices vary considerably and broadly over income groups, being low for low-income groups and high for high-income groups. Part of the price differentials may be due to the quality composition of the pulses consumed by different income groups. Given such a distribution of prices, it would be incorrect to apply a uniform price across income groups for estimation of quantities. Another problem is that the nominal income groups vary from survey to survey, and even if they are the same, the real value they reflect is not equal, because of the substantial inflation taking place over time.

From the 1970/71 survey data, implicit prices can be calculated for cereals and pulses for each of the income groups and these are divided by the mean price of cereals and pulses for this year, giving the distribution of the prices around the mean. It is found that a log-log function between this price ratio and the mean income (total expenditure) levels of each group provides a good fit for the price distribution. It is assumed, therefore, that a relationship of this form exists between the real income (real total expenditure) levels and the implicit prices (expressed as a ratio of the price to the mean price), and this could be used for other years. The mean income levels of the different income (total expenditure) groups for the 1977/78 survey are deflated to the (real) 1970/71 price level by applying the agricultural-labor consumer price index for the rural areas and the working-class consumer price index for the urban areas. No quantity data are available for pulses from the 1977/78 survey. Therefore the real income levels for 1977/78 are applied to the 1970/71 estimated log-log price distribution function for pulses to give a distribution of pulse prices around the mean for 1977/78. The mean pulse price for 1977/78 is computed by moving the 1970/71 mean pulse price to 1977/78 by using the wholesale price index of pulses. Applying this mean price to the computed distribution, a pulse price is generated for each income group. Applying these prices to the already available values, quantities of pulse consumption are generated for each income group.

Quantity data are also unavailable from the 1983 survey for pulses, so the above method is repeated to estimate the quantity data by income group for 1983. The 1970/71 estimated price distribution function is used for pulses, applying the appropriate deflated real income data. An observation of the plots of actual and fitted data for 1970/71 showed that this method works well but may have a very slight tendency to overestimate the low-income group consumption and underestimate the high-income group consumption.

Quartiles are based on the sample frequency distribution of numbers of households and use the per capita income (total expenditure) group means provided by the survey data as well as the available or otherwise computed per capita consumption quantities. The consumption at specific income levels is read off from a discrete function plot between income and consumption, assuming straight-line changes between the points of observation reported with respect to each income group.

It may be added that the estimates of per capita availability derived from the Ministry of Agriculture's figures and those of per capita consumption obtained from the NSSO are not strictly comparable for a number of reasons. First, the ministry figures are based as supply-utilization balances and represent the disappearance concept. The NSS data represent direct estimates of per capita household consumption obtained by the interview method. Second, to the extent that the ministry takes into account changes in government stocks only, and not those with private trade and farmers and consumers, the per capita availability figures are approximate. They do not represent annual fluctuations correctly. To avoid this difficulty, three-year moving averages are sometimes considered. Third, the NSS per capita consumption figures relate to household consumption only and do not include nonhousehold consumption such as hotels; thus they may underestimate the consumption.

APPENDIX 8

METHODOLOGY FOR PROJECTIONS

Assumptions in Projections of Foodgrain Production and Consumption to Year 2000

Production Projection

The projections are worked out separately for rice, wheat, coarse cereals, and pulses disaggregated over the six regions of the country—Northern, Uttar Pradesh, Central, Western, Eastern, and Southern—and are based on adjusted state data from national sources. This is the base scenario.

Area and yield are projected separately using their trend growth rates (modified if necessary as explained below) and are finally multiplied to give the production projections. Growth rates are applied to 1983/84 trend values.

Post-green-revolution (1967/68-1983/84) semilogarithmic trend growth rates are used for both area and yield.

Area projections require some adjustment to make them realistic. Within each region, area under each crop/crop-group as well as that of total foodgrains is projected using their growth rates. Then, considering the projected total foodgrain area as a ceiling, the individual crop/crop-group areas are adjusted proportionately to give their projected areas.

The Northern region foodgrain area growth rate is constrained to 0.5 percent. Yield growth rates are constrained to be nonnegative, and a ceiling of 3.0 percent is also applied on the growth rate. This procedure affects yield growth rates in rice in the Northern region, wheat in the Uttar Pradesh, Central, Western, and Southern regions, and coarse grains in the Western region.

For the Eastern region, the yield growth rate is assumed to accelerate to 2.5 percent for rice and 2.0 percent for foodgrains.

The rice yield and production figures are in terms of milled rice.

Alternative projections for production were generated by two different methods. First, the projection for production is done by aggregating all foodgrains in each region on the basis of area and yield (scenario 2). The second method projects production based on area and yield of foodgrains at the all-India level using the all-India area and yield growth rates (scenario 3).

Consumption Projection

Given the continuing differences between the Ministry of Agriculture's per capita availability data and the National Sample Survey Organization's per capita consumption data, and the need for maintaining comparability with the production data, the projections use the ministry's availability data for the absolute quantities. But the ratios and elasticities computed from the NSS data for 1977/78 are applied for some of the disaggregations and responses.

The starting points for the projections are the 1982-84 average per capita availability levels for wheat, rice, coarse cereals, and pulses. These national-level figures are decomposed into rural and urban per capita availability/consumption levels by applying proportions calculated from the 1977/78 NSS data and proportions of rural and urban populations.

The projected income growth rate of 5.0 percent for the country for the Perspective Plan given in the Seventh Five-Year Plan (India, Planning Commission 1985, vol. 1, chap. 2) is used and is decomposed into 2.5 percent for rural (agriculture) and 6.0 percent for urban (nonagriculture) on the basis of the midpoint sectoral income shares of agriculture and nonagriculture sectors projected to the year 2000 in the Seventh Five-Year Plan.

The first future scenario assumes the continuation of past per capita income growth rates. The second future scenario assumes the income growth rates indicated in the previous paragraph. The third scenario assumes an increase in income growth rates, with the rural income growth rate rising to 3.0 percent and the urban income growth rate to 7.0 percent, giving an overall income growth rate of 5.7 percent. The fourth scenario assumes a further acceleration of income growth rates to 3.5 percent for rural and 8.0 percent for urban, implying a growth rate of 7.0 percent for the economy.

Alternative scenarios were also generated in relation to change in the income distribution as follows (in percentages):

	Base (1983)	Projected (2000)
Rural	12/18/25/44	15/20/25/40
Urban	11/17/24/48	15/20/25/40

Projections of Requirements for Seed, Feed, Industrial Use, and Wastage

In deriving the estimates of net availability for human consumption from the estimates of gross production of foodgrains, the Indian Ministry of Agriculture deducts for seed, feed, and wastage an overall allowance of 12.5 percent from the gross production. This consists of approximately 5.0 percent for seed, 5.0 percent for feed, and 2.5 percent for wastage. By crop, the overall allowances are about 7.6 percent for rice, 8.2 percent for wheat, and 12.5 percent each for the totals of cereals and of pulses. These allowances have not been revised since the early 1950s. With the introduction of HYVs of cereals, the seed requirements as a proportion of production may have declined. On the other hand, the use of foodgrains in livestock feed may have increased. No separate allowance is made for industrial uses of foodgrains. With some analysis based on these considerations, the National Commission on Agriculture arrived at an overall allowance of 19.0 percent for seed, feed, industrial use, and wastage for the year 2000 (India, Ministry of Agriculture 1976).

In spite of various recommendations by the National Commission on Agriculture and other committees, these data have not been updated. However, a recent survey in Punjab, Haryana, and western Uttar Pradesh (Bansil 1989) concluded that in this region the overall allowance for seed, feed, and wastage works out to about 10.0 percent. In a recent study, Tyagi (1990) showed that as the seed rate is now much lower than before and the allowance for feed and wastage remains unchanged, the actual per capita availability in recent years may have been larger than is shown by the ministry's figures. There is, however, reason to believe that the requirements for feed, particularly in the poultry and dairy sectors, have increased, though the exact magnitude of the increase on an all-India basis is not known. Therefore the ministry's figures on net production and per capita availability have been directly utilized in the analysis of past trends in this report. The following procedure has been adopted for future projections.

Seed

In the present study, the requirements of seeds have been estimated on the basis of the projected area under each crop, and the expected seed rates have been derived from the National Commission on Agriculture report (India, Ministry of Agriculture 1976). These work out as shown in Table 36, with a total seed requirement of 5 million tons.

Feed

Between 1970/71 and 1984/85 the output of livestock products increased at an average rate of 4.33 percent a year from 3.10 million tons to 5.61 million tons, as expressed in livestock output units (Table 37). During this period, population increased

Table 36—Projected crop area and seed requirements for year 2000

Crop	Projected Area	Seed Requirement per Hectare	Total Seed Requirement
	(million hectares)	(kilograms)	(million metric tons)
Paddy	41.88	30	0.84[a]
Wheat	32.42	75	2.43
Coarse grains	35.25	15	0.53
Pulses	25.30	50	1.27
Total	134.85	...	5.07

Source: Based on data from India, Ministry of Agriculture, Directorate of Economics and Statistics, *Report of the National Commission on Agriculture,* part 3 (Delhi: Controller of Publications, 1976).
[a]In terms of rice.

Table 37—Output of livestock products, 1970/71 and 1984/85

Product	1970/71		1984/85	
	Actual	In Terms of LOU[a]	Actual	In Terms of LOU[a]
	(million metric tons)			
Meat	0.69	0.69	1.19	1.19
Milk	21.71	2.17	38.80	3.88
Eggs	0.24	0.24	0.54	0.54
Total	...	3.10	...	5.61

Source: Based on data from India, Planning Commission, *The Seventh Five-Year Plan: 1985-90* (Delhi: Controller of Publications, 1985).
[a]LOU = livestock output units, obtained by adding output of meat, one-tenth of milk output, and the weight of eggs estimated at 40 grams per egg.

at a rate of 2.26 percent, the per capita income increased at 1.56 percent, and the per capita output of livestock products increased at 2.02 percent. The 1984/85 base-level feed use of foodgrains is estimated at 11.22 million tons based on a feeding ratio of 2:1; this amounts to 7.70 percent of the foodgrain production.

The feeding ratio (that is, the quantity of feed [foodgrains] required to produce one unit of livestock products) is projected to increase from 2.00 in 1984/85 to 2.40 in 2000 (the current developing-country average), an annual increase of 1.21 percent given the increasing demand, increased modernization of livestock production, and near exhaustion of available crop residues. The income elasticity of livestock demand has been assumed to be 0.9 based on Sarma (1986) and Paulino (1986). On the basis of the above assumptions, feed requirements are expected to increase at 5.95 percent a year on the assumption that the entire demand for livestock products will be met from domestic production. The relevant parameters are given below:

Growth in per capita income assumed in the Perspective Plan, 1985-2000	= 3.10 percent/year;
Income elasticity of demand for livestock products	= 0.9;
Rate of growth in per capita demand for livestock products	= 2.79 percent/year;
Rate of growth in feeding ratio	= 1.21 percent/year;
Population growth rate	= 1.84 percent/year; and
Rate of growth of feed use	= 5.95 percent/year.

On this basis the estimated demand for feed in 2000 works out to 26.69 million tons under the Perspective Plan income growth rates. One advantage of this method is the possibility of estimating feed use under alternative income growth assumptions. The demand for feed works out to 21.77 million tons under continuation of past income growth, 29.14 million tons under the first accelerated growth rate scenario, and 34.50 million tons under the second accelerated growth rate scenario.[18] Due to data limitations, it was not possible to work out the effect of changes in income distribution on the feed requirements.

Wastage and Industrial Use

A combined allowance of 12.5 million tons is made for wastage (7.5 million tons) and industrial use (5.0 million tons) in 2000. This is close to the 8-9 million tons for

[18]The last two estimates assume rapid growth in livestock output to meet the increased demand under the first and second accelerated growth rate scenarios. If livestock production falls short of demand, the gap may need to be met through import of these livestock products instead of feedgrains.

wastage and 5 million tons for industrial use assumed by the National Commission on Agriculture.

Overall Allowance

The overall requirements for seed, feed, industrial use, and wastage allowance work out to 44.2 million tons or roughly 20.1 percent of gross production under the scenario of Perspective Plan income growth rates. A breakdown of these requirements by crop is given in Table 38. These estimates are comparable to the estimates of the National Commission on Agriculture.

The projections reflect a substantial increase in the derived demand for feed, assuming the rapid increase in the demand for livestock products if per capita income growth accelerates. A word of caution is, however, in order. In the absence of reliable base level data, the projections are rough estimates, and several of the allowances are not based on as firm a foundation as desirable. There is an urgent need for more studies of what these requirements are and how they are likely to change over time.

Table 38—Requirements for seed, feed, industrial use, and wastage allowance for year 2000, by crop

Crop	Seed	Feed	Industrial Use and Wastage	Total Requirements	Gross Production	Total Requirements as Share of Gross Production
				(million metric tons)		
Rice	0.84	6.09	5.00	11.93	84.72	14.09
Wheat	2.43	8.19	5.00	15.62	86.74	18.01
Coarse grains	0.53	11.79	1.62	13.94	34.47	40.44
Pulses	1.27	0.62	0.81	2.70	13.45	20.07
Total foodgrains	5.07	26.69	12.43	44.19	219.38	20.14

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