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Changing Sources of Growth in Indian Agriculture

Implications for Regional Priorities for Accelerating Agricultural Growth

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ABSTRACT

Indian agriculture was transforming from a cereal-based production system toward high-value crops (HVC) during the 1990s. However, food security concerns resurfaced during the first decade of the 21st century, and the policy environment tilted in favor of cereal-based production systems, especially rice and wheat. This paper revisits an earlier study to evaluate how the policy shift influences the patterns and the sources of agricultural growth in India and assesses their implications for regional priorities for higher, more sustainable, and more inclusive agricultural growth. The study found that technology has remained the most important source of agricultural growth due to policy emphasis on cereal-based food security. Nevertheless, agricultural diversification toward HVCs, driven by a sustained rise in per capita income and urbanization, among other factors, emerged as the next most important source of agricultural growth. The growth in high-value agriculture has come largely from area reallocation from less profitable coarse cereals, mainly millets and sorghum. The contributions of area expansion and commodity prices to agricultural growth have been erratic and small, suggesting that these cannot be sustainable sources of agricultural growth.

The sources of agricultural growth, however, have varied widely across the regions; while the irrigated northern region followed a technology-led growth trajectory, the rainfed western and southern regions followed diversification toward HVCs as the main strategy to enhance and sustain agricultural growth. Agricultural diversification toward HVCs was found to exhibit a pro-poor bias and thus can serve as an important pathway for smallholders to move out of poverty.

In the long run, growth in agriculture must come from technological change and diversification toward HVCs. To sustain agricultural growth, investment in agricultural research must be increased, and the agricultural research agenda must be revisited in view of the emerging challenges and market opportunities in agriculture and the agrifood industry. Promoting high-value agriculture will require enabling policies, institutions, and infrastructure that facilitate farmers' access to remunerative markets.

Keywords: agriculture, growth sources, smallholders, policies, India

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ABBREVIATIONS AND ACRONYMS

AgGDP	agricultural gross domestic product
CGIAR	Consultative Group on International Agricultural Research
CSO	Central Statistical Organization
GDP	gross domestic product
ha	hectare
HVA	high-value agriculture
HVC	high-value crop
HYV	high yield variety
kg	kilogram
MPCE	monthly per capita expenditure
MSP	minimum support price
NCAP	National Centre for Agricultural Economics and Policy Research
NHB	National Horticulture Board
NSSO	National Sample Survey Organization (now Office)
Rs	Indian Rupees
sq km	square kilometer

1. INTRODUCTION

Over the past three decades, the Indian economy has undergone a significant structural transformation away from agriculture and toward nonagricultural sectors. The share of agriculture in the country's gross domestic product (GDP) has consistently declined, from an average 33 percent in the 1980s to 26 percent in the 1990s and further to 18 percent in the following decade. Despite this rapid decline, agriculture continues to be a key sector of the Indian economy because of its strategic importance to food security, employment generation, and poverty reduction. The sector engages more than half of the country's total workforce and has been important for poverty reduction, especially in rural areas (Ravallion and Datt 1996; Warr 2003; Kumar, Kumar, and Sharma 2011).

In the first three decades of the Green Revolution, the agricultural sector performed extremely well, culminating in an annual growth rate of 3.2 percent between 1980/1981 and 1995/1996. This growth was propelled by technological change, investment in infrastructure (irrigation, markets, and roads), development of institutions (credit and extension services), and enabling input and output price policies. However, the sector started showing signs of stress toward the late 1990s. Between 1996/1997 and 2004/2005, growth in the sector fell to 1.9 percent per year. This decline was attributable to several policy and nonpolicy factors. The technologies that had driven growth started showing signs of fatigue (Evenson, Pray, and Rosegrant 1999; Murgai, Ali, and Byerlee 2001; Sidhu 2002; Chand, Kumar, and Kumar 2010). The rate of growth in the yield of important crops and livestock species decelerated considerably during this period. Public investment in agriculture, which represented 5.7 percent of agricultural GDP in 1980/1981, dropped consistently to 2.9 percent in 2004/2005, causing stagnation in irrigation and private capital formation. The increased frequency of extreme climate events, such as droughts and floods, has also been responsible for sluggish and unstable growth in agriculture in recent years. However, to arrest the decline in agriculture, both central and state governments took corrective measures, such as increasing public investment, augmenting institutional credit, and raising minimum support prices (MSP) of food grains, and the growth recovered to 2.6 percent in the second half of the first decade of the 21st century. It may be mentioned that India's policymakers have been targeting 4 percent growth for the agricultural sector ever since the ninth five-year plan, beginning in 1995/1996; the target, however, has remained elusive.

Fostering rapid and sustainable growth in agriculture continues to be a major policy challenge. By 2030, India's population will exceed 1.5 billion—25 percent more than in 2011—and the need to produce more food remains as urgent as ever. The population growth will be accompanied by strong urbanization trends and a sustained rise in per capita income. These changes are likely to cause a significant transformation of the food basket, in quantity as well as quality (Joshi and Kumar 2011). Meeting the increasing demand through domestic production will not be as easy as in the Green Revolution period. Agricultural production systems will come under a confluence of biotic and abiotic pressures. Since the early 1970s, India's net cropped area has been stagnating at around 140 million hectares, implying little, if any, scope to expand the land frontiers. Intensification of the existing production systems is a possibility, but it will be limited by acute scarcity of water and energy. The competition for land, water, and energy will also intensify due to their increasing demand for urbanization and industrialization. Energy prices are expected to increase rapidly. India imports huge quantities of energy-intensive agro-inputs (fertilizer and diesel), and the rising prices mean a rise in the cost of agricultural production and a reduction in farm profits. In addition, coping with climate change will present a significant challenge to the sustainable development of the agricultural sector. Also, with the unfolding of globalization, the sector will come under the pressure of adjustment to global market forces. Addressing these challenges requires an understanding of the past sources of growth and their determinants.

This study revisits an earlier study[1] and analyzes changes in the patterns and sources of growth in the crop sector, which accounts for close to two-thirds of the total value of agricultural production in the

[1] See Joshi, Birthal, and Minot (2006).

country. A better understanding of the past sources of growth is necessary to provide empirical support to designing appropriate research and development strategies for sustainable intensification of agriculture. Specifically, the study (1) quantifies changes in the sources of growth in agriculture in the past three decades at national and subnational levels; (2) discusses the economic, institutional, and policy factors underlying these changes; (3) examines the implications of the changing sources of growth for small landholders; and finally (4) suggests strategies for higher, more sustainable, and more inclusive agricultural growth.

The paper is organized as follows. In the next section, we describe the data and the analytical approach used to decompose agricultural growth. Section 3 examines the anatomy of agricultural growth in terms of the share of different sources in growth at the national level, and this is followed by a discussion on the regional patterns of sources of growth in Section 4. Section 5 examines the implications of the changing patterns of sources of growth for small landholders. Conclusions and the policy implications of different growth sources are presented in Section 6.

2. ANALYTICAL APPROACH

The patterns and sources of agricultural growth are studied for the period 1980/1981 to 2009/2010. This period is further divided into three subperiods, 1980/1981 to 1989/1990 (the 1980s), 1990/1991 to 1999/2000 (the 1990s), and 2000/2001 to 2009/2010 (the 2000s), so as to compare the transformation and sources of growth in Indian agriculture in response to various technological, institutional, and policy measures implemented during the different periods. In the 1980s, Green Revolution technologies were spreading widely throughout the country; hence, this period can be considered the technological transformation phase of Indian agriculture. The decade of the 1990s can be labeled as a period of policy regime shift, when a number of economic reforms were undertaken focusing on macroeconomic policy, exchange rate and external trade, industrial licensing, and privatization. Though most of these reforms were not directly focused on agriculture, some important policy decisions that indirectly impinged on the agricultural sector included deregulation of the agrifood industry, liberalization of trade in agricultural commodities, and de-monopolization of external trade from state control.

The process of economic reforms continued beyond the 1990s, but with an emphasis on reforming domestic markets so as to align these with global markets. In the next decade, the market reforms were strengthened to allow private investment in agricultural markets, direct transactions in agricultural commodities outside the state-regulated markets, and contract farming. Futures trading was permitted, on and off, in agricultural commodities, including food grains. The list of agricultural commodities reserved for cottage and small-scale industries was pruned to allow private investment for the modernization of the food processing sector. The food industry was accorded the status of a priority sector for purposes of institutional financing. Restrictions on interstate movement of agricultural goods were removed so as to improve integration among spatially dispersed markets. This period was also characterized by extreme climatic events and saw some of the worst droughts, which caused agrarian distress in some parts of the country.

Data

To analyze the sources of agricultural growth, we have used data on area, yields, and prices of important crops from 20 major Indian states: Andhra Pradesh, Assam, Bihar, Chhattisgarh, Gujarat, Haryana, Himachal Pradesh, Jammu and Kashmir, Jharkhand, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Odisha, Punjab, Rajasthan, Tamil Nadu, Uttar Pradesh, Uttarakhand, and West Bengal. Data on area, production, and yield of crops (*cereals*: rice, wheat, maize, sorghum, pearl millet, finger millet, barley, and small millets; *pulses*: chickpeas, pigeon peas, and other pulses; *oilseeds*: groundnut, sesame, rapeseed and mustard, soybean, linseed, sunflower, safflower, castor, and niger seed; *fibers*: cotton, jute, and sun hemp; *spices*: betel nut, cardamom, chilies, pepper, turmeric, ginger, garlic, and coriander; *fruits*: bananas, cashew nuts, and other fruits; *vegetables*: potatoes, sweet potatoes, onions, tapioca, and other vegetables; *beverages*: tea and coffee; and coconut, sugarcane, tobacco, rubber, and cluster bean) were compiled from *Indian Agricultural Statistics* and *Agricultural Statistics at a Glance*, published by the Ministry of Agriculture (India, DAC various years a, b), and *the Indian Horticulture Database* (India, NHB various years). Wherever needed, data from these sources were supplemented with data from state-specific statistical abstracts published by the state governments. The selected crops account for more than 90 percent of both the total cropped area and the value of output of the crop sector.

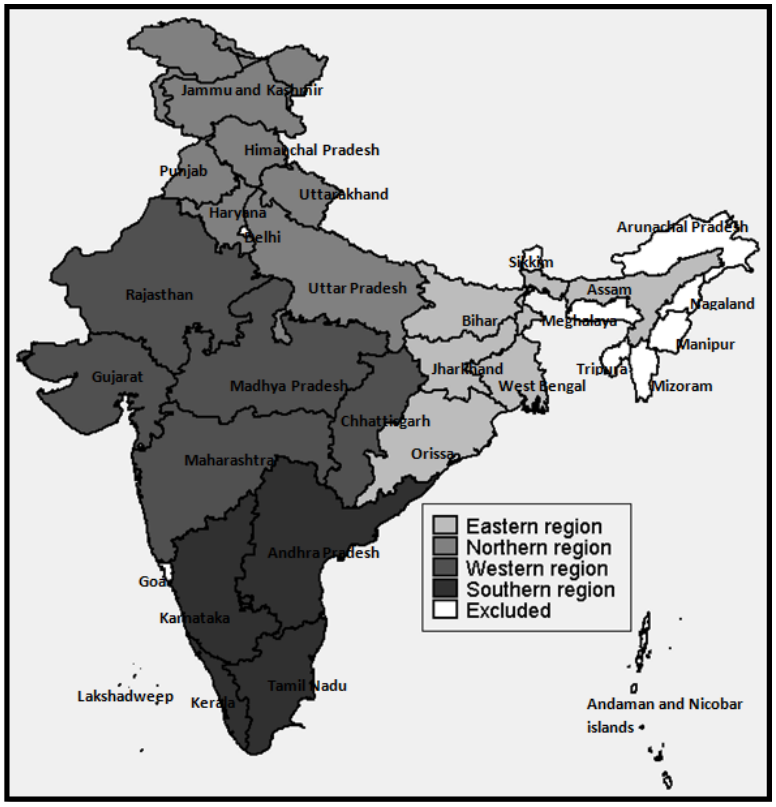
The state-level data on GDP were obtained from *National Accounts Statistics* and on the value of the main outputs of the selected crops (at their current prices) from *Value of Output of Crop Sector*, both published by the Ministry of Statistics and Program Implementation (India, CSO various years a, b). The value of output of different commodities was used to generate their implicit farm harvest prices. The farm harvest price of a commodity was estimated by dividing its value of output (at current prices) by its level of production.[2] The current prices of these commodities were then deflated by the general wholesale price

[2] The Central Statistical Organization (CSO) uses data on farm harvest prices and agricultural production supplied by the

index to convert them into real prices (at 1993/1994 base). The time series on area, production, and prices were smoothed by applying Hodrick-Prescott filter[3] with an adjustment factor of 6.25. The Hodrick-Prescott filtered data series were used for analyzing the patterns and sources of growth. The information on parameters related to technology (fertilizer consumption), infrastructure (roads, irrigation, and telecommunication), and socioeconomic variables were obtained from *India Statistics* (India, CSO 2012).

India has considerable heterogeneity in resource endowments, climate, infrastructure, and institutions, which may influence the crop composition, technology adoption, input usage, crop yields, and prices, which in turn are likely to influence the patterns and sources of growth across regions. We therefore studied the patterns and sources of growth at regional levels in addition to providing their scenario at the national level. The selected states were clustered into four broad regions[4]—northern, eastern, western, and southern—based on their geographical contiguity or proximity (see Figure 2.1). The eastern region comprises Assam, Bihar, Jharkhand, Orissa, and West Bengal; the northern region includes Haryana, Himachal Pradesh, Jammu and Kashmir, Punjab, Uttar Pradesh, and Uttarakhand; the western region includes Chhattisgarh, Gujarat, Madhya Pradesh, Maharashtra, and Rajasthan; and the southern region consists of Andhra Pradesh, Karnataka, Kerala, and Tamil Nadu.

Figure 2.1 Grouping of states into regions



Source: Authors' classification.

Directorates of Economics and Statistics and the Departments of Agriculture of different states to estimate their monetary values. Since information on the farm harvest prices of all the commodities at the state level was not readily available, we estimated these by dividing the value of output of different commodities by their respective levels of production.

[3] The Hodrick-Prescott filter is a data smoothing technique commonly applied to remove short-term fluctuations from time series data. It generates a smoothed nonlinear representation of a time series. The adjustment of the sensitivity of the trend to short-term fluctuations is performed by applying a suitable adjustment factor.

[4] The states of Arunachal Pradesh, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim, Tripura, and Goa were not included in this classification because of nonavailability of agricultural data on continuous basis.

The states within a region, to a large extent, are homogeneous in their agroclimatic conditions and crop composition. Table 2.1 presents salient characteristics of these regions. The northern region, excluding the hill states of Himachal Pradesh, Jammu and Kashmir, and Uttarakhand, has alluvial soils and a semiarid to humid climate. Agriculture contributes about one-fifth of the GDP in this region. In the plains, irrigation infrastructure is well developed, with more than 80 percent of the cropped area under irrigation. Landholdings are small but intensively cultivated, with wheat and rice the main crops in the plains, and maize, wheat, fruits, and vegetables in the hills. Fertilizer consumption per unit of cropped area is high in this region. Density is low for both roads and telephones.

The eastern region is characterized by relatively high rainfall and widespread cultivation of rice. Rice occupies 56 percent of the total cropped area. In value terms, however, fruits and vegetables outweigh the contribution of rice. The average size of landholding is smaller than in any other region. The levels of irrigation development and of technology adoption are also low here. This region is heavily populated but the least urbanized of the four. It has the lowest per capita income but good road infrastructure. Agriculture accounts for one-fifth of the GDP in this region.

The western region has low population density but high levels of both urbanization and per capita income. Economic dependence on agriculture is the lowest in this region (14 percent of GDP). This region receives less rainfall than others, and agriculture is highly diversified, with oilseeds (mainly groundnuts and rapeseed and mustard), wheat, pulses, fruits, and vegetables as important crops. Coarse cereals, such as millets and maize, are also widely grown. The average size of landholding in this region is larger than in any other region, but irrigation coverage and fertilizer use are poor.

Table 2.1 Selected indicators of development of different regions

Indicators	Northern region	Eastern region	Western region	Southern region	All India
Population, in millions, 2011[a]	282	301	340	251	1,210
Geographical area, '000 sq km[a]	667	497	1289	636	3,287
Population density, persons/sq km, 2011[a]	423	606	263	395	368
Urban population, in %, 2011[a]	25.1	20.0	35.2	40.9	31.2
Per capita GDP, in Rs (at 2004/2005 prices), 2008–2010[b]	26,587	21,749	38,787	43,006	35,722
Share of agriculture in GDP (%), 2004/2005 prices[b]					
1981–1983	43.2	38.0	33.1	33.6	35.1
1991–1993	36.1	34.5	25.6	28.3	29.0
1999–2001	31.1	28.2	18.8	22.7	24.0
2008–2010	22.0	20.8	13.7	15.3	15.7
Gross cropped area, in million ha, 2008–2010[a]	42.8	32.0	82.9	34.4	194.3
Gross irrigated area, in %, 2008–2010[a]	78.8	43.5	31.0	40.5	45.2
Fertilizer consumption, in kg/ha, 2008–2010[a]	173	108	89	180	136
Road density, in km per '000 sq km, 2008/2009[a]	689	1,601	548	1,552	966
Average size of landholding, in ha, 2005/2006[c]	0.89	0.69	2.02	1.02	1.23
Telephones/100 persons[a]					
Urban	86.0	123.9	112.6	151.9	162.1
Rural	23.0	30.1	40.6	46.8	37.9
Total	38.8	48.8	66.0	89.8	76.6

Source: Estimated by authors using data from: a. India, CSO (2012); b. India, CSO (various years a); c. India, DAC (various years).

Notes: sq km = square kilometers; kg/ha = kilograms per hectare; GDP = gross domestic product; Rs = rupees.

The southern region, except the state of Kerala, has a semiarid climate; rainfall is nearly the same throughout the region. Agriculture is largely rain dependent, but irrigation coverage is fairly good. Rice is the dominant crop, followed by oilseeds, pulses, fruits, vegetables, and spices. The size of the average landholding is about 1 ha. The region has relatively low population density but is the most urbanized, with a higher income level than any other region. The region also has the best-developed road infrastructure and telecommunication system of all the regions.

Method of Decomposition of Growth

To decompose agricultural growth by source and crop, we followed the growth accounting approach as in Minot et al. (2006). According to this approach, the change in gross revenue from a single crop can be decomposed into (1) change in cropped area, (2) change in yield, (3) change in real price, and (4) a residual representing the interaction among the first three factors. The change in gross revenue from *n* crops can similarly be decomposed, except that there is one more source of change, the reallocation of area from lower-value to higher-value crops, based on comparative advantage.

These sources of change or growth in gross revenue are influenced by a number of economic and noneconomic factors. For instance, a change in the total cropped area could be due to changes in weather conditions, irrigation, industrialization, and urbanization, among other factors. Crop yields are influenced by the replacement of old varieties with new varieties, seed replacement rates, availability of water, input levels, and soil fertility. Farm prices are influenced by agricultural price policy, tariffs, world prices (in the case of tradable commodities), demand and supply imbalances, commodity substitution, and the like. Finally, land reallocation decisions are affected by changes in the relative prices of agricultural commodities, their costs of production or input prices, and the incentive structure, as well as the level of development of infrastructure and institutions.

Assuming that a farmer behaves rationally, he or she maximizes profit from his or her land by choosing a production mix, inputs, and technologies subject to his resource endowments and markets. If A_i is area under crop *i,* Y_i is its production per unit area, and P_i is the real price per unit of production, then the gross revenue R from n crops can be written as

$$R = \sum_{i=1}^{n} A_i Y_i P_i. \quad (1)$$

A_i can be further expressed as the share of crop *i* in the total cropped area, $a_i = \left(\frac{A_i}{\sum_i A_i}\right)$, and substituting this expression in equation (1) we get

$$R = \left(\sum_{i=1}^{n} a_i Y_i P_i\right) \sum_{i=1}^{n} A_i. \quad (2)$$

The total derivative of both sides of equation (2) provides the absolute contribution of changes in these components to the change in gross revenue

$$dR \cong \left(\sum_{i=1}^{n} a_i Y_i P_i\right) d\left(\sum_{i=1}^{n} A_i\right) + \left(\sum_{i=1}^{n} A_i\right) d\left(\sum_{i=1}^{n} a_i Y_i P_i\right). \quad (3)$$

Equation (3) is only an approximation, as it excludes the interaction term. The second term on the right-hand side of this equation can be further decomposed from a change in sums to the sum of changes, as follows

$$dR \cong \left(\sum_{i=1}^{n} a_i Y_i P_i\right) d\left(\sum_{i=1}^{n} A_i\right) + \sum_{i=1}^{n} A_i \sum_{i=1}^{n} d(a_i Y_i P_i). \quad (4)$$

Further expansion of the second term of equation (4) results in the following expression:

$$dR \cong \left(\sum_{i=1}^{n} a_i Y_i P_i\right) d\left(\sum_{i=1}^{n} A_i\right) + \sum_{i=1}^{n} A_i \sum_{i=1}^{n} (a_i Y_i dP_i) + \sum_{i=1}^{n} A_i \sum_{i=1}^{n} (a_i P_i dY_i) + \sum_{i=1}^{n} A_i \sum_{i=1}^{n} (Y_i P_i da_i). \quad (5)$$

Equation (5) decomposes change in gross revenue due to changes in (1) total cropped area, (2) crop yields or technology, (3) real prices, and (4) land reallocation or diversification. The first term on the right-hand

side of this equation represents the change in gross revenue due to a change in total cropped area. The second term on the right-hand side captures the change in gross revenue due to a change in the real prices of commodities. The third term measures the change in gross revenue due to a change in crop yields or technology. The fourth term represents the change in gross revenue associated with changes in crop composition. A positive fourth term indicates a reallocation of land from lower-value to higher-value crops. Dividing both sides of equation (5) by the overall change in gross revenue (dR) gives us the proportionate share of each source in the overall change in gross revenue or agricultural growth.

3. SOURCES OF GROWTH AT THE NATIONAL LEVEL

At the national level, cereals—mainly rice and wheat—dominate the cropping pattern, although their share in the gross cropped area as well as in the total value of output has been declining continuously (see Table 3.1). In the decade from 2000/2001 to 2009/2010, cereals accounted for 54 percent of the gross cropped area and 37 percent of the total value of output, down from 62 percent and 42 percent, respectively, in the 1980s. The decline, however, was confined to the coarse cereals, excluding maize. The second most important group of crops, in terms of value, comprises the horticultural crops (fruits, vegetables, plantation crops, and spices and condiments). These crops represented more than one-third of the gross value of output in the decade from 2000/2001 to 2009/2010, from an area share of less than 10 percent. Further, their share in the area as well as value of output has increased considerably over the past three decades. Oilseeds accounted for 12 percent of the gross value of output and 14 percent of the gross cropped area during that decade. Sugarcane, cotton, and pulses were other important crops.

The agriculture (crop) sector grew at an annual rate of 3.1 percent in the 1980s and then accelerated to 3.7 percent in the 1990s. The rate of growth, however, decelerated marginally in the following decade. Growth patterns are different for different crops. Horticultural crops, especially fruits and vegetables, experienced steady and relatively faster growth throughout the three decades. These crops grew at an annual rate of more than 6 percent in the 1990s, higher than the rate of growth in the 1980s and 2000s. Plantation crops and spices and condiments also experienced robust growth in their contribution. The contribution of oilseeds expanded at a rate of more than 6 percent a year in the 1980s. This momentum, however, could not be sustained, and the growth decelerated to less than 1 percent in the 1990s. Nevertheless, it was followed by a strong recovery in the following decade, with annual growth accelerating to 5.4 percent. The contribution of wheat grew at an accelerated rate of 5.5 percent a year in the 1990s, from 2.4 percent in the 1980s. But it decelerated significantly, to 1.2 percent, in the 2000s. Rice, which has a higher share of gross value of output than any other crop, experienced a strong decline in the same period (-0.2 percent), from more than 3 percent in the previous two decades. Likewise, there was no visible sign of growth in sugar crops in this period. However, maize, cotton, and pulses experienced strong growth in this period.

The last three columns of Table 3.1 present the contribution of each crop or crop group to the overall growth of agriculture. In the 1980s, with a share of more than 21 percent each, rice and oilseeds were the main contributors to agricultural growth, followed by fruits (11 percent), vegetables (11 percent), and wheat (10 percent). In the 1990s, wheat, sugarcane, fruits, and vegetables gained in their shares of growth; rice lost marginally, and oilseeds ceased to be a driver of growth. In the following decade, the growth share of rice and wheat declined considerably, leading to a drastic fall in the share of cereals in agricultural growth, from 43 percent in the 1990s to 7 percent from 2000/2001 to 2009/2010. In contrast, horticultural crops emerged as an important driver of growth. Their share in overall growth increased to 60 percent in the first decade of the 21st century. Area under fruits and vegetables grew at an annual rate of more than 3 percent in the 1990s and 4.5 percent in the next decade, doubling its share in gross cropped area to 6.5 percent. Oilseeds and cotton were other important crops driving agricultural growth during 2000/2001–2009/2010. However, the area under coarse cereals and pulses declined in the 1990s, while that under rice and oilseeds grew at less than 1 percent per year. These changes in the relative shares of crops in agricultural growth provide a clear indication of the growing importance of high-value crops (HVC) in Indian agriculture.

Table 3.1 Percent contribution of various crops to agricultural growth, national level, 1980/1981–2009/2010

Crop / crop group	Share in gross cropped area			Share in real value of output			Annual compound growth in real value of output			Share in overall growth		
	1980s	1990s	2000/2001-2009/2010	1980s	1990s	2000/2001–2009/2010	1980s	1990s	2000/2001–2009/2010	1980s	1990s	2000/2001–2009/2010
Rice	24.2	24.1	23.6	22.4	21.7	19.0	3.3	3.1	-0.2	23.1	20.5	-1.7
Wheat	14.2	14.6	15.1	12.0	12.7	12.6	2.4	5.5	1.2	10.2	20.7	4.6
Maize	3.5	3.4	4.1	2.1	1.9	2.1	0.5	3.1	5.0	0.7	1.9	3.2
Other cereals	20.0	14.6	11.6	5.8	4.1	3.2	-2.7	0.4	1.3	-3.2	-0.2	0.9
All cereals	*61.9*	*56.7*	*54.5*	*42.4*	*40.4*	*37.0*	*2.0*	*3.6*	*0.7*	*30.7*	*43.0*	*6.9*
Chickpeas	4.5	4.0	3.9	2.8	2.4	2.4	1.2	2.4	5.2	0.7	1.1	3.6
Pigeon peas	1.9	2.0	2.0	1.5	1.4	1.0	3.5	1.7	2.6	1.4	0.1	0.9
All pulses	*14.0*	*13.0*	*12.5*	*7.3*	*6.2*	*5.2*	*2.6*	*1.0*	*3.0*	*4.6*	*0.3*	*4.8*
Groundnut	4.5	4.4	3.5	5.2	4.4	3.0	3.2	-2.0	2.0	4.9	-4.2	1.1
Rapeseed and mustard	2.0	3.3	3.2	2.4	3.1	2.7	9.0	-1.5	6.1	6.9	-1.7	4.3
Soybean	0.7	2.8	4.3	0.5	2.0	2.4	30.0	8.7	9.1	4.2	3.7	6.6
Other oilseeds	4.3	6.6	7.4	4.3	4.8	4.1	8.7	-2.8	5.4	5.4	-0.5	1.0
All oilseeds	*10.8*	*14.2*	*14.0*	*12.4*	*14.1*	*12.1*	*6.9*	*-0.7*	*5.4*	*21.4*	*-2.6*	*13.0*
Cotton	4.5	4.8	4.9	3.9	5.0	5.0	1.4	2.8	10.7	4.0	1.7	14.5
Other fibers	0.7	0.6	0.6	0.7	0.5	0.4	3.7	1.1	1.4	0.8	0.1	0.2
All fibers	*5.2*	*5.4*	*5.5*	*4.7*	*5.5*	*5.4*	*1.7*	*2.6*	*9.9*	*4.8*	*1.8*	*14.7*
Plantation crops	1.3	1.6	1.8	1.7	1.8	1.6	5.6	2.7	5.0	6.8	0.0	1.1
Spices and condiments	1.1	1.3	1.3	2.8	3.8	3.9	8.5	6.8	3.8	4.8	5.1	5.4
Fruits	1.4	1.9	2.7	9.4	10.6	14.2	4.4	6.2	5.5	11.3	20.4	24.6
Vegetables	2.1	2.9	3.8	9.8	11.5	13.5	3.6	6.8	6.7	11.0	19.1	28.9
Sugarcane	1.9	2.3	2.5	8.1	8.6	8.8	1.2	5.0	0.0	3.8	13.1	-1.3
Other crops	1.6	1.5	1.9	1.0	0.9	0.9	0.9	1.0	6.8	0.8	-0.1	2.0
Total	100.0	100.0	100.0	100.0	100.0	100.0	3.1	3.7	3.3	100.0	100.0	100.0

Source: Estimated by authors.
Notes: Value of output does not include the value of crop by-products (straws and fodders). Subtotal of each group of crops is in italics.

A number of policy and non-policy factors were responsible for the variation in the observed patterns of growth of various crops and their contributions to growth. Demand-side factors played an important role. The observed changes in the production mix are consistent with changes in the consumption basket. Between 1983 and 2009, India's food basket underwent a significant transformation away from food grains and toward high-value commodities (see Table 3.2) due to sustained economic and income growth and a fast-growing urban population. India's per capita income grew at an accelerated rate of 2.8 percent in the 1980s, 4.0 percent in the 1990s, and 6.1 percent in the following decade. The corresponding rates of growth in the urban population during these decades were 3.2 percent, 2.9 percent, and 2.8 percent, respectively. As would be expected in accordance with Engel's law (as income increases, the food basket changes in favor of high-value commodities), the per capita consumption of food grains declined from 179 kilograms per year (kg/year) in 1983 to 141 kg/year in 2009/2010, while that of fruits and vegetables increased from 51 to 62 kg/year. Per capita consumption of edible oils also increased substantially during this period. These changes in the food basket were approximately the same for rural and urban consumers but were larger at the lower end of the income distribution (Joshi and Kumar 2011).

Table 3.2 Trend in per capita food consumption in India (kilogram/person/year), 1983/1984–2009/2010

Item	1983/1984	1993/1994	2004/2005	2009/2010
Cereals	167.9	133.4	141.2	132.8
Pulses	11.9	7.9	9.1	8.5
Edible oils	4.6	5.6	6.7	8.5
Vegetables	48.4	61.9	67.6	87.5
Fruits	3.4	10.0	11.0	15.8
Milk	45.8	59.5	61.1	64.2
Sugar	11.5	10.8	9.6	9.2
Meat, fish, and eggs	5.5	6.3	7.2	10.3

Source: Joshi and Kumar (2011).

Export demand for fruits and vegetables also acted as a catalyst in the growth of high-value agriculture (HVA). India's exports of fruits and vegetables increased from US$202 million[5] in 1980–1982 to $380 million in 1990–1992 and took a drastic jump to $2.068 billion in 2008–2010 (FAO: http://faostat.fao.org/site/535/default.aspx#ancor). Interestingly, there was also a significant increase in the imports of many exotic fresh as well as processed horticultural products. India's imports of fruits and vegetables increased from $545 million in 2000–2002 to $2.831 billion in 2008–2010.

The demand-driven growth in the horticultural sector was facilitated by improvements in roads, transportation, communication, and electricity (Joshi et al. 2004; Birthal et al. 2012) and the development of retail chains that could establish linkages with farmers for procurement of their crops through institutions such as contract farming and producers' organizations (Birthal, Joshi, and Gulati 2005; Roy and Thorat 2008; Reardon and Minten 2011). Further, to cater to the rising demand for horticultural products without importing as much, the government of India has been promoting the horticultural sector, first establishing the National Horticulture Board in 1985 and then launching the National Horticulture Mission in 2005.

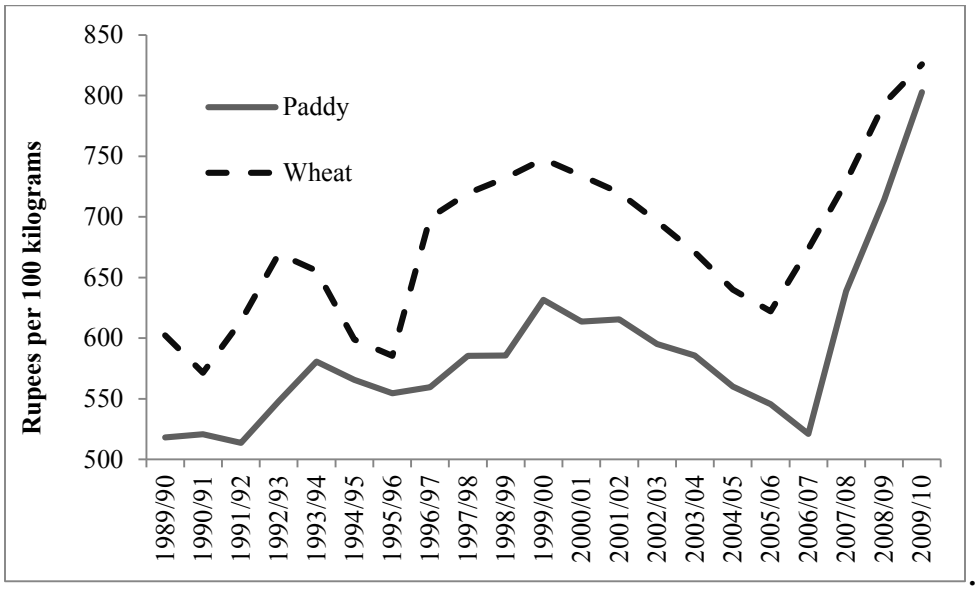
The factors underlying the changes in consumption patterns and demand have been quite robust in the recent past and are unlikely to subside in the near future, which means further increases in the demand for high-value food commodities. By 2030, per capita consumption of fruits and vegetables is expected to increase to 55 kg and 116 kg, respectively (Joshi and Kumar 2011). India's population is expected to exceed the 1.5 billion mark in 2030. To feed the growing population, the country will require

[5] All dollar amounts are in US dollars.

310 million tons of food grains, 103 million tons of fruits, and 192 million tons of vegetables (Joshi and Kumar 2011).

Two other notable dynamics of agricultural growth observed are (1) a decline in the share of rice and wheat and an increase in the share of maize in agricultural growth and (2) a strong recovery in the shares of oilseeds and cotton in agricultural growth. The increase in the share of wheat in the 1990s was due to a combination of factors, including expansion of its cropped area in nontraditional wheat-growing states (such as Madhya Pradesh), its assured offtake by the government for public distribution, and a substantial hike in its MSP (Figure 3.1).

Figure 3.1 Trends in minimum support prices (in real terms at 2004/2005 base) for paddy and wheat, 1989/1990–2009/2010

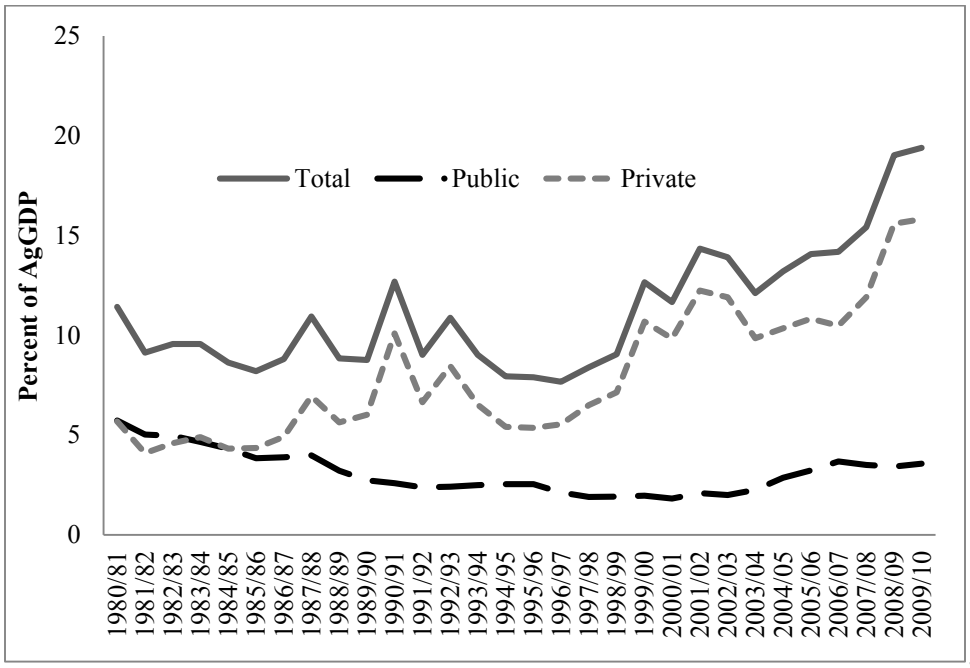


Source: India, Commission on Agricultural Costs and Prices (various years).

The decline in the contribution of wheat and rice to agricultural growth during 2000/2001 to 2009/2010 could be attributed to deceleration in their yield growths (due to saturation in the adoption of new varieties), increased weather uncertainty, and a continuous decline in their prices (in real terms) in the first half of this period. The government of India started some important programs such as Rashtriya Krishi Vikas Yojana [6] and the National Food Security Mission in the latter half of the decade to arrest the deceleration in agricultural growth. Moreover, public investment, which had plummeted to 1.8 percent of agricultural GDP in 2000/2001, rose considerably, to 3.6 percent in 2005/2006, and this level, by and large, was maintained afterward (Figure 3.2). These initiatives led to some recovery in growth; their full benefits, however, are yet to be realized. The increasing contribution of maize to agricultural growth is intrinsically linked to rising demand for maize as feed by the poultry industry, which has been growing fast. From 1991 to 2010, the production of poultry meat in the country grew at an annual rate of 8.2 percent, and the production of eggs grew at 5.8 percent.

[6] It literally means 'national agricultural development project'

Figure 3.2 Trends in public and private investment in India, 1980/1981–2009/2010



Source: National Accounts Statistics (various years).
Note: AgGDP = agricultural gross domestic product.

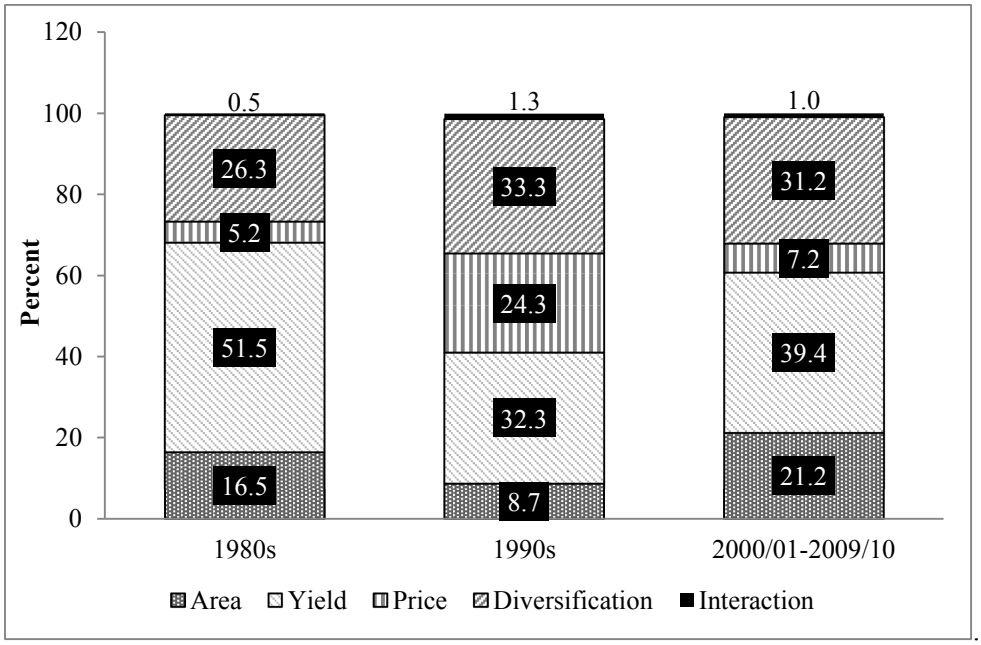
The large share of oilseeds in the overall growth of agriculture in the 1980s was due to favorable incentive and protection structures. The government launched the Technology Mission on Oilseeds in 1986 to stimulate their production in order to achieve self-sufficiency in edible oils. The mission provided a package of improved technology, high-quality inputs, and extension services to farmers to encourage cultivation of oilseed crops. These incentives were accompanied by higher tariff and nontariff barriers on imports. The TMO lasted until 1998 and succeeded in increasing production of oilseeds to the extent that by the time it was dismantled the country's dependence on imported edible oils had almost disappeared (Birthal et al. 2011). However, with implementation of the World Trade Organization Agreement on Agriculture in 1994, quantitative restrictions on imports were lifted and tariffs were reduced gradually, which again caused a surge in imports of edible oils. This in turn had a depressing effect on the producer prices of oilseeds, and consequently their production stagnated. This falling trend in oilseed production was reversed to some extent in the first decade of the 21st century, due in part to technology and policy initiatives. In 2004, the government of India launched a special program called the Integrated Scheme of Oilseeds, Pulses, Oil Palm and Maize to promote their production.

Cotton production increased impressively during 2000/2001–2009/2010, mainly due to the introduction of Bt cotton in 2002/2003, and since then its area has increased considerably, reaching 90 percent of the total cotton area in 2009/2010. Between 2002/2003 and 2009/010, cotton production increased at an annual rate of 12 percent, which turned the country from a net importer to a net exporter of cotton. In 2009/2010, India exported 1.4 million tons of cotton, valued at $2 billion.

Another way to decompose agricultural growth is by its source, that is, area expansion, price increases, yield improvements or technological change, and area reallocation. Figure 3.3 shows changes in the contributions of these sources to the growth of agriculture over the past three decades. Yield improvements were the main source of growth in the 1980s, accounting for more than half of the growth during this period. More than one-fourth of the growth in agriculture during this period was associated with land reallocation from lower- to higher-value crops. Area expansion accounted for about 17 percent of overall growth, and prices did not have any significant effect during this period. Sources of growth

changed drastically in the 1990s. Technology became a relatively less important source of growth, its share in growth falling to one-third, while diversification consolidated its share of growth, making it equal to that of technology. There was a drastic increase in the contribution of price, from 5.2 percent in the 1980s to 24.3 percent in the 1990s, which was mainly due to a significant rise in the prices of rice and wheat (see Table A.1 in the appendix). In the next decade, the contribution of technology improved marginally, reaching 39.4 percent, while that of price declined drastically, to 7.2 percent. During this period, the price effect on growth was driven by horticultural crops. Diversification maintained its share of around 30 percent of overall growth. Surprisingly, area expansion also turned out to be an important source of growth during this period.

Figure 3.3 Percent contribution of various sources to growth in the crop sector in India, 1980/1981–2009/2010

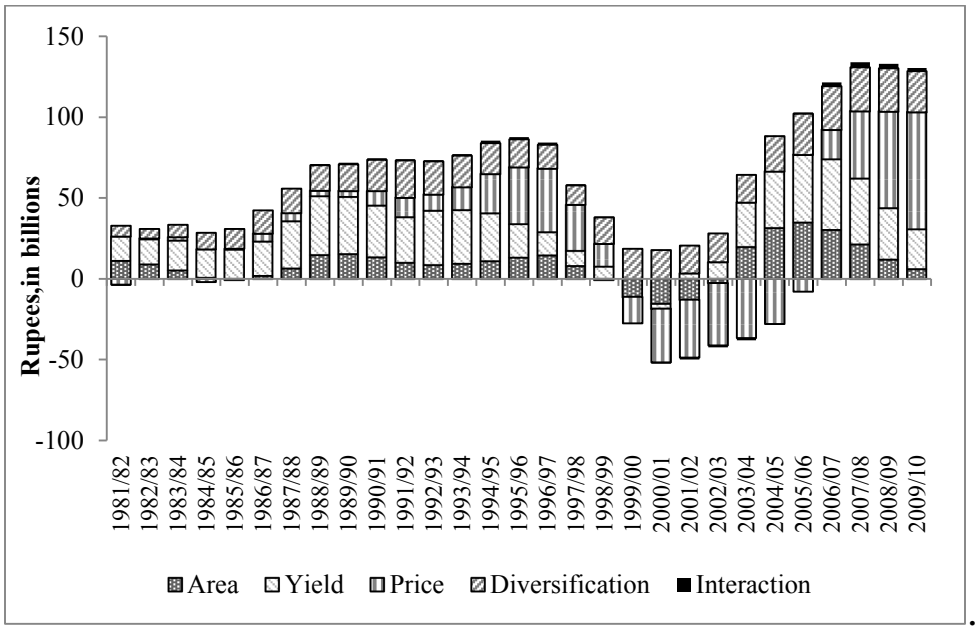


Source: Estimated by authors.

For deeper insight into the dynamics of the growth sources, we now look at the year-over-year changes in their contribution to overall growth (Figure 3.4). In the past three decades, agricultural growth behaved in a cyclical manner, accelerating from 1980/1981 to 1996/1997, falling until 2001/2002, and rising thereafter. By source, technology, as expected, was the main source of growth until the mid-1990s. In the latter half of the 1990s, growth became driven by prices, and the effect of technology started fading, having almost a negligible contribution between 1999/2000 and 2002/2003. Later, however, technology started regaining its lost position, which could be due to significant improvements in the availability and distribution of high-quality seeds in the latter half of the first decade of the 21st century. The distribution of certified, high-quality seeds increased from 0.86 million tons in 2000/2001 to 1.27 million tons in 2005/2006, and further to 2.57 million tons in 2009/2010 (India, DAC 2012a).

Real prices of agricultural commodities declined in the first half of the decade 2000/2001–2009/2010, to the extent that these turned out to be a detractor of growth. However, in the second half of that decade, the prices of agricultural commodities started rising, which led to an improvement in their contribution to growth. Interestingly, despite the erratic behavior of agricultural growth, diversification more or less maintained its share of growth throughout the past three decades, which leads us to conclude that diversification is a steady source of agricultural growth.

Figure 3.4 Annual changes in sources of agricultural growth in India, 1980/1981–2009/2010



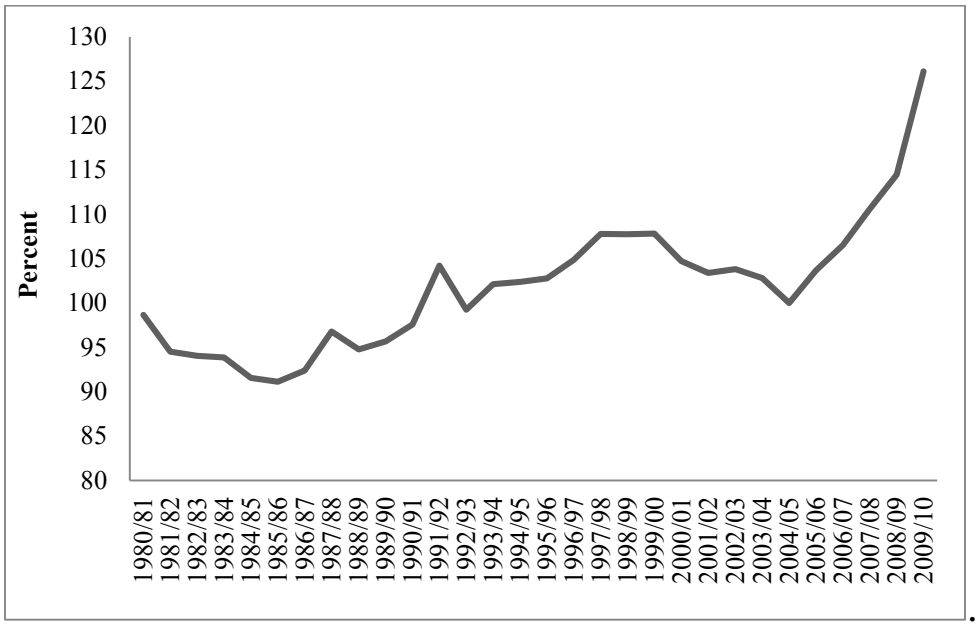
Source: Estimated by authors.

These changes in growth sources can be explained by a number of policy and nonpolicy factors. The improvement in the growth share of area expansion in the most recent decade was an outcome of increased weather uncertainty, which led to considerable contraction as well as expansion of the cropped area in some years, depending on the quantity and distribution of rainfall. Nevertheless, the scope to enhance agricultural growth through area expansion is limited by the fixed supply of land; India's net cropped area has almost stabilized around 140 million ha and has hardly ever exceeded 143 million ha.

In the 1990s, the terms of trade turned in favor of agriculture (Figure 3.5), which led to an increase in the contribution of prices to agricultural growth. With the exception of oilseeds, cotton, and beverages, the real prices of most agricultural commodities grew faster in the 1990s than in the 1980s. It may be noted that as a matter of policy most food grain crops in India are covered under MSPs. The MSP serves twin purposes: (1) an incentive to farmers to produce more and (2) protection of poor consumers against price volatility. The central government procures huge quantities of rice and wheat for public distribution, welfare programs, and buffer stocks. In the 1990s, the MSPs of rice and wheat were raised to minimize the adverse effect of decelerating yield growth on farmers' welfare (see Figure 3.1). In real terms, the wholesale prices of rice and wheat increased, respectively, at an annual rate of 1.3 percent and 2.4 percent in the 1990s, as compared with -0.3 percent and -1.3 percent in the 1980s. Prices of fruits and vegetables also increased owing to their growing demand.

During the 2000s, the behavior of prices was much different than before. It was prices of wheat and rice that turned out to be the leading cause of erratic behavior of agricultural growth during this period. Starting in 2000/2001, the MSP of wheat (in real terms) declined continuously until 2005/2006, and that of rice until 2006/2007. The MSPs of both wheat and rice, however, were raised afterward, when their international prices were on an upward trajectory. But this could not compensate for the loss in their share of growth that occurred in the first half of the decade. India's agricultural price policy aims at providing safeguards to both producers and consumers from changes in international prices, and the MSPs of these commodities have rarely been aligned with their international prices. It is worth mentioning that in the 1990s price increases were fueled by a rise in the prices of rice and wheat, and in the 1980s and 2000/2001–2009/2010 by the rise in the prices of fruits and vegetables (see Table A.1 in the appendix).

Figure 3.5 Terms of trade for Indian agriculture, 1980/1981–2009/2010



Source: Estimated by authors using data from India, CSO (various years a).

The declining contribution of technology to overall agricultural growth was due to the slowing of growth in the yields of most of crops in the 1990s and thereafter (see Table A.2 in the appendix). The yield of rice and wheat, which had been growing at an annual rate of more than 3 percent in the 1980s, decelerated to less than 2 percent during 2000/2001–2009/2010. The high-yielding seeds had, by and large, spread throughout the country by the mid-1990s. It may be noted that high-yielding seeds are not high-yielding by themselves. They require irrigation and fertilizers for better response, but there was a significant deceleration in growth of these inputs in recent years.[7] Another reason for the decline in yield growth was the increased uncertainty in the weather.

Diversification has been an important source of growth throughout the past three decades, but more so in the 1990s and the subsequent decade. Land reallocation took place from less profitable food grain crops, such as millets, sorghum, and pulses, toward vegetables, fruits, and spices (see Table A.1 in the appendix). Note that there has been little, if any, diversion of area from wheat and rice. Fruits and vegetables together accounted for more than three-fourths of the diversification-induced growth in agriculture. The diversification was driven by demand and facilitated by appropriate policies, infrastructure, and institutions, as indicated earlier in this section.

These sources of growth differ across crops (see Table A.1 in the appendix). Growth in cereals and fiber crops, mainly cotton, was largely due to yield improvements and also area expansion throughout the past three decades. For pulses and oilseeds, price increases and yield improvements were the main sources of growth. In contrast, growth in horticultural crops arose from land reallocation and price increases, with little from yield improvements.

The changing patterns of growth sources suggest that (1) area expansion and price increases cannot be sustainable sources of growth and (2) in the long run, growth must come from improvements in yields, that is, technological change and sustainable diversification of the agricultural production portfolio based on comparative advantage.

[7] Growth in gross irrigated area and fertilizer use per hectare during the period 1996/1997 to 2004/2005 was 0.4 percent and 1.9 percent, respectively, as against 2.5 percent and 5.9 percent from 1980/1981 to 1995/1996.

4. REGIONAL PATTERNS OF SOURCES OF GROWTH

This section compares the patterns and sources of growth across four different regions: northern, eastern, western, and southern.

Northern Region

The cropping pattern in the northern region is dominated by wheat and rice. These two crops together occupy close to two-thirds of the gross cropped area and contribute about half the value of output of the crop sector (see Table 4.1). Over time, however, their share in the gross cropped area as well as value of output has increased. This region is considered the *food basket* of India. The region experienced significant technological transformation in the wheat/rice system, which made the country self-sufficient in cereals. Horticultural crops, mainly fruits and vegetables, make up the next most important crop group in this region, with concentration in the hill states of Himachal Pradesh, Jammu and Kashmir, and Uttarakhand. Fruits and vegetables together accounted for 5.8 percent of the gross cropped area and represented about one-fifth of the gross value of the output of crops in the most recent decade. Both their area and value shares have increased significantly over time.

Agriculture in this region grew at an annual rate of 3 percent in the 1980s and accelerated to 3.5 percent in the 1990s (Table 4.1). The sector came under stress in the subsequent decade, however, with growth falling to 1.8 percent per year. The deceleration in overall growth was caused by deceleration in the growth of the main crops, wheat and rice. These crops together accounted for about two-thirds of growth in the 1980s and 1990s. These patterns, however, reversed in the first decade of the 21st century. Annual growth in both rice and wheat output decelerated to less than 1 percent, with a concomitant decline in their share of growth to less than one-fifth. The share of fruits and vegetables in overall growth was around one-fifth in the 1980s and 1990s. However, these crops grew at an accelerated rate and consolidated their share in overall growth to more than 70 percent in the first decade of the 21st century. Oilseeds and cotton regained their lost position in this time period—their shares in growth improved to 7 percent and 10 percent, respectively.

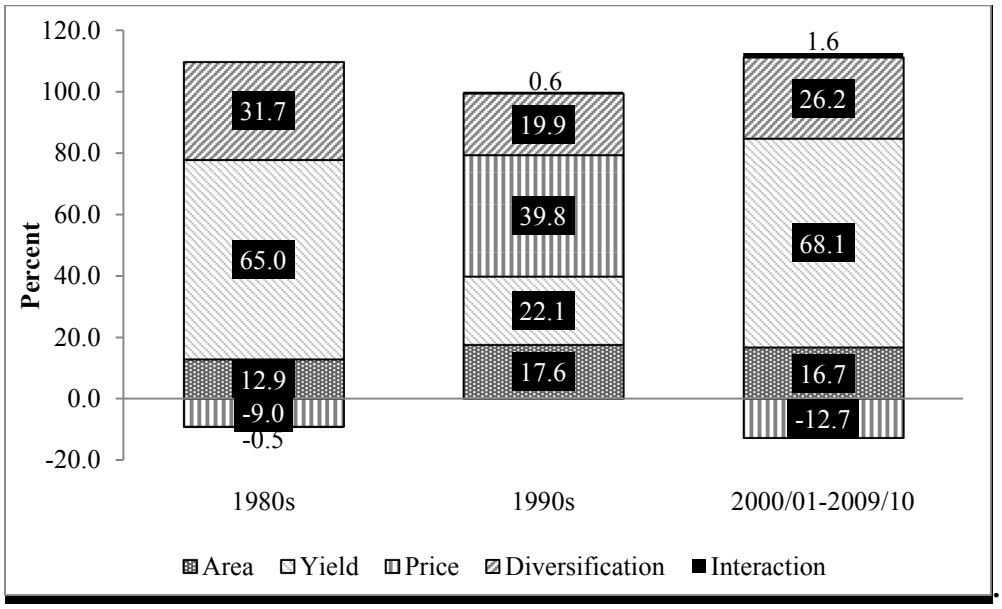
Table 4.1 Percent contribution of various crops to agricultural growth, northern region, 1980/1981–2009/2010

Crop / crop group	Share in gross cropped area			Share in real value of output			Annual growth in real value of output			Share in overall growth		
	1980s	1990s	2000/2001–2009/2010	1980s	1990s	2000/2001–2009/2010	1980s	1990s	2000/2001–2009/2010	1980s	1990s	2000/2001–2009/2010
Rice	20.9	22.8	24.2	19.5	20.9	20.0	5.2	4.3	0.4	32.2	25.4	5.8
Wheat	36.8	37.8	39.2	29.8	30.5	30.9	3.1	5.0	0.6	30.6	44.3	12.6
Maize	5.6	4.8	4.1	3.2	2.4	1.8	-0.4	0.5	-0.1	-0.1	0.3	-0.4
Other cereals	9.9	7.4	6.0	3.1	2.4	1.9	-2.3	1.8	1.2	-1.8	0.7	1.0
All cereals	*73.2*	*72.8*	*73.3*	*55.7*	*56.1*	*54.5*	*3.2*	*4.4*	*0.5*	*60.9*	*70.7*	*19.1*
Chickpeas	5.9	3.5	2.0	3.6	2.0	1.0	-0.4	-4.7	-5.4	-1.9	-2.8	-2.8
Pigeon peas	1.5	1.4	1.0	1.7	1.2	0.6	0.6	-0.4	-5.3	0.0	-0.7	-2.0
All pulses	*11.4*	*8.9*	*7.1*	*8.0*	*5.3*	*3.4*	*0.2*	*-1.6*	*-1.8*	*-1.5*	*-3.4*	*-3.0*
Groundnut	0.7	0.4	0.3	0.7	0.3	0.2	-7.6	-4.3	-1.5	-1.5	-0.5	-0.2
Rapeseed and mustard	2.7	3.7	3.5	3.2	3.7	3.1	6.4	-2.0	4.9	7.5	-1.7	7.2
Soybean	0.3	0.1	0.1	0.2	0.1	0.0	-9.8	-2.2	4.3	-0.4	-0.1	0.1
Other oilseeds	0.9	1.1	0.9	3.6	4.3	3.4	6.5	-2.1	4.7	1.6	-0.5	0.3
All oilseeds	*4.2*	*5.1*	*4.6*	*7.7*	*8.3*	*6.7*	*4.8*	*-2.2*	*4.7*	*7.2*	*-2.8*	*7.3*
Cotton	2.8	3.1	2.6	3.7	4.1	3.2	6.5	-4.4	6.9	8.4	-4.3	9.8
Other fibers	0.1	0.0	0.0	0.0	0.0	0.0	-6.4	2.2	-20.9	-0.1	0.0	-0.1
All fibers	*2.9*	*3.1*	*2.6*	*3.8*	*4.1*	*3.2*	*6.4*	*-4.4*	*6.8*	*8.3*	*-4.3*	*9.7*
Plantation crops	0.0	0.0	0.0	0.0	0.0	0.0	3.7	0.6	0.2	0.0	0.0	0.0
Spices and condiments	0.1	0.1	0.1	0.5	0.5	0.9	2.7	4.5	7.2	0.3	0.9	3.2
Fruits	1.1	2.2	2.2	7.6	7.6	9.0	3.9	4.4	5.4	8.3	8.3	27.7
Vegetables	1.7	2.5	3.5	5.3	7.2	10.2	6.8	6.5	8.6	11.2	12.4	47.7
Sugarcane	5.1	5.5	6.0	14.4	14.3	14.7	1.1	4.1	-1.9	4.8	17.6	-14.0
Other crops	0.9	0.5	0.8	0.4	0.4	0.6	3.3	5.1	8.3	0.5	0.5	2.3
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**3.0**	**3.5**	**1.8**	**100.0**	**100.0**	**100.0**

Source: Estimated by authors.
Notes: Value of output does not include the value of crop by-products (straws and fodders). Subtotal of each group of crops is in italics.

Decomposition of agricultural growth by source shows that in the 1980s farmers in the rice- and wheat-dominated northern region were net taxed, as the real prices of agricultural commodities, particularly of wheat and rice, were on a declining trend, pulling down overall growth by 9 percent (Figure 4.1). The negative effect of prices, however, was well compensated for by a phenomenal rise in the yields of important crops (rice and wheat) and also by the diversification of the production portfolio (Figure 4.1) toward fruits, vegetables, rice, wheat, and sugarcane. The situation changed drastically in the 1990s. The terms of trade turned favorable to agriculture and the price effect dominated growth. As discussed in the previous section, MSPs of rice and wheat were raised substantially during this period, and in fact it was the prices of these two commodities that contributed two-thirds to the total price effect (see Table A.3 in the appendix). It is to be noted that this region has been making a substantial contribution to national rice and wheat supplies for public distribution and other welfare programs; hence agricultural growth in the region is greatly influenced by changes in the prices of these two commodities.

Figure 4.1 Percent contribution of various sources to growth in the crop sector, northern region, 1980/1981–2009/2010

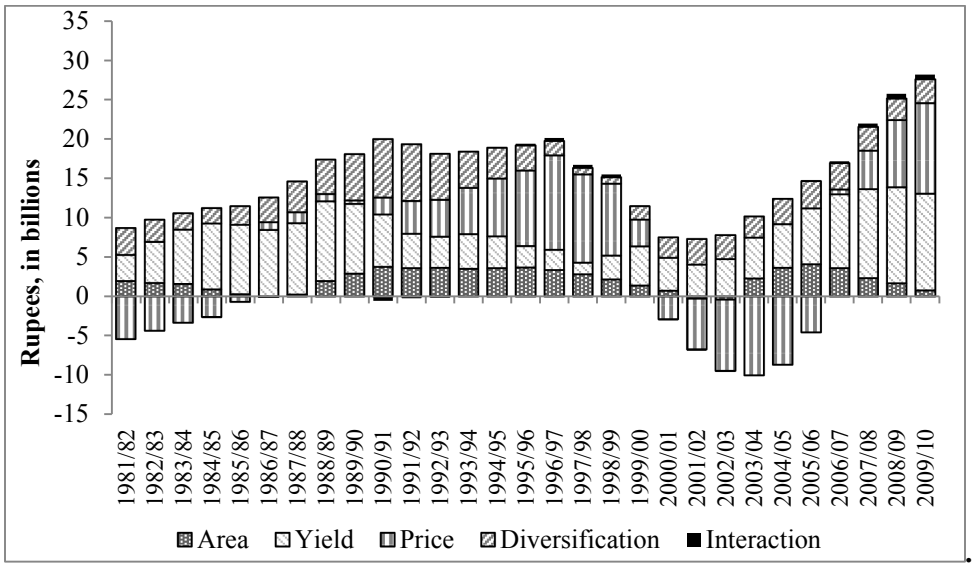


Source: Estimated by authors.

Land reallocation toward rice, wheat, fruits, vegetables, and sugarcane continued in the 1990s, but at a slowing pace. This led to a decrease in the share of growth due to reallocation, to 20 percent from 32 percent in the previous decade. More than two-thirds of the diversification-induced growth in agriculture in this period was due to diversification toward horticultural crops (see Table A.3 in the appendix). Technology regained its lost prominence in the most recent decade and turned out to be the main driver of agricultural growth. The growth share of diversification also improved during this period. It is worth noting that throughout the past three decades diversification in favor of HVCs occurred, replacing pulses, millets, and occasionally sugarcane (see Table A.3 in the appendix). Area expansion continued but mainly under wheat and rice. In each of the past three decades, more than half of the additional area brought under cultivation was accounted for by rice and wheat. The price effect faded during 2000/2001–2009/2010 because of unfavorable terms of trade for agriculture in the first half of that decade.

Figure 4.2 shows annual changes in the sources of agricultural growth in the northern region. The crop sector grew at an accelerated rate between 1980/1981 and 1996/1997 but showed a decline thereafter, which continued for about five years. Yield improvements and diversification were the main sources of growth in the 1980s. In the 1990s, while diversification continued to gain in its share of growth, the effects of technology started fading. The price effect started becoming stronger, and in the latter half of the 1990s prices emerged as one of the most important sources of growth. Real prices of agricultural commodities declined thereafter, resulting in their negative contribution to growth until 2006/2007. From then onward, the contribution of prices increased vigorously, primarily due to a substantial rise in the MSPs of wheat and rice. The contribution of technology also improved during this period. Crop diversification remained a steady source of growth throughout the three decades despite a cyclical pattern of agricultural growth.

Figure 4.2 Annual changes in sources of agricultural growth, northern region, 1980/1981–2009/2010



Source: Estimated by authors.

Wheat and rice will remain dominant crops in the plains of the northern region as long as the policies of price support and input subsidies are favorable to these crops. The prospects of further growth in these crops in this region are relatively small, however. Though significant increases in rice and wheat production in this part of the country have made a substantial contribution toward achieving national food security, these crops have also been held responsible for the degradation of land and water resources in the region (Kumar et al. 1998; Chauhan et al. 2012). The sustainability of agricultural growth in this region will depend on a breakthrough in yield-augmenting technologies for rice and wheat, conservation and management of soil and water resources, and land reallocation toward crops with a comparative advantage. Evidence shows that diversification in favor of fruits and vegetables cushions agricultural growth and provides a hedge against the price volatility of food grains.

Eastern Region

Rice has been the most important crop in the eastern region, accounting for more than 55 percent of the gross cropped area in each of the past three decades. Surprisingly, in value terms, the contribution of rice, which was very close to that of horticultural crops in the first two decades of the study period, was outweighed by the latter in the 2000s. Fruits and vegetables, with an area share of 13 percent, accounted for 43 percent of the value of the crop sector's output in that decade, compared with 35 percent for rice (Table 4.2).

Table 4.2 Percent contribution of various crops to agricultural growth, eastern region, 1980/1981–2009/2010

Crop / crop group	Share in gross cropped area			Share in real value of output			Annual compound growth in real value of output			Share in overall growth		
	1980s	1990s	2000/2001–2009/2010	1980s	1990s	2000/2001–2009/2010	1980s	1990s	2000/2001–2009/2010	1980s	1990s	2000/2001–2009/2010
Rice	56.2	58.3	56.8	35.9	37.5	34.7	4.4	3.0	-0.9	42.1	39.3	-14.7
Wheat	7.7	8.3	8.6	5.1	5.3	4.9	2.8	5.3	-0.6	4.1	8.7	-1.5
Maize	3.2	2.7	3.1	1.8	1.7	1.9	1.4	2.1	3.8	0.9	1.4	3.6
Other cereals	2.8	1.4	0.8	0.7	0.3	0.1	-6.0	-3.6	-5.3	-1.2	-0.5	-0.5
All cereals	*69.9*	*70.7*	*69.3*	*43.5*	*44.7*	*41.6*	*3.9*	*3.2*	*-0.7*	*45.9*	*48.9*	*-13.0*
Chickpeas	1.0	0.7	0.7	0.6	0.4	0.4	-0.2	-2.6	1.3	-0.2	-0.2	0.3
Pigeon peas	0.8	0.8	0.8	0.6	0.5	0.4	4.5	-2.6	5.5	0.7	-0.5	1.3
All pulses	*11.4*	*7.8*	*6.6*	*6.0*	*3.4*	*2.6*	*2.7*	*-5.9*	*3.4*	*2.3*	*-7.7*	*4.9*
Groundnut	1.1	0.6	0.4	1.2	0.4	0.3	9.4	-18.1	9.3	1.9	-3.2	0.9
Rapeseed and mustard	2.5	2.6	2.7	2.6	1.6	1.2	5.8	-7.5	3.9	2.9	-4.5	2.8
Soybean	0.0	0.0	0.0	0.0	0.0	0.0	-0.2	10.4	-1.1	0.0	0.0	0.0
Other oilseeds	2.6	2.1	1.7	4.1	2.6	2.0	5.1	-6.6	4.3	3.7	-1.2	-0.6
All oilseeds	*6.2*	*5.3*	*4.8*	*7.9*	*4.6*	*3.5*	*5.9*	*-8.0*	*4.5*	*8.5*	*-8.9*	*3.2*
Cotton	0.0	0.1	0.2	0.0	0.0	0.1	2.1	32.8	9.5	0.0	0.3	0.5
Other fibers	3.0	2.9	2.9	2.9	2.4	2.2	4.1	1.1	1.6	3.7	0.6	2.1
All fibers	*3.0*	*3.0*	*3.0*	*2.9*	*2.4*	*2.3*	*4.1*	*1.5*	*2.0*	*3.7*	*0.8*	*2.6*
Plantation crops	1.2	1.4	1.8	4.5	4.2	3.3	6.0	1.4	0.7	7.5	0.2	1.2
Spices and condiments	1.0	1.2	1.1	2.6	3.1	2.6	7.1	3.4	1.0	2.7	1.4	3.6
Fruits	1.9	2.3	2.8	11.4	11.8	13.8	2.9	4.5	2.8	8.9	18.4	21.3
Vegetables	5.4	8.0	10.2	21.0	25.4	29.9	2.7	6.7	4.8	19.6	47.8	76.8
Sugarcane	0.8	0.7	0.6	2.1	1.6	1.3	1.1	-0.3	-1.6	0.7	-0.6	-1.2
Other crops	0.2	0.1	0.1	0.7	0.4	0.4	2.6	-1.3	3.8	0.3	-0.4	0.7
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**3.7**	**3.3**	**1.8**	**100.0**	**100.0**	**100.0**

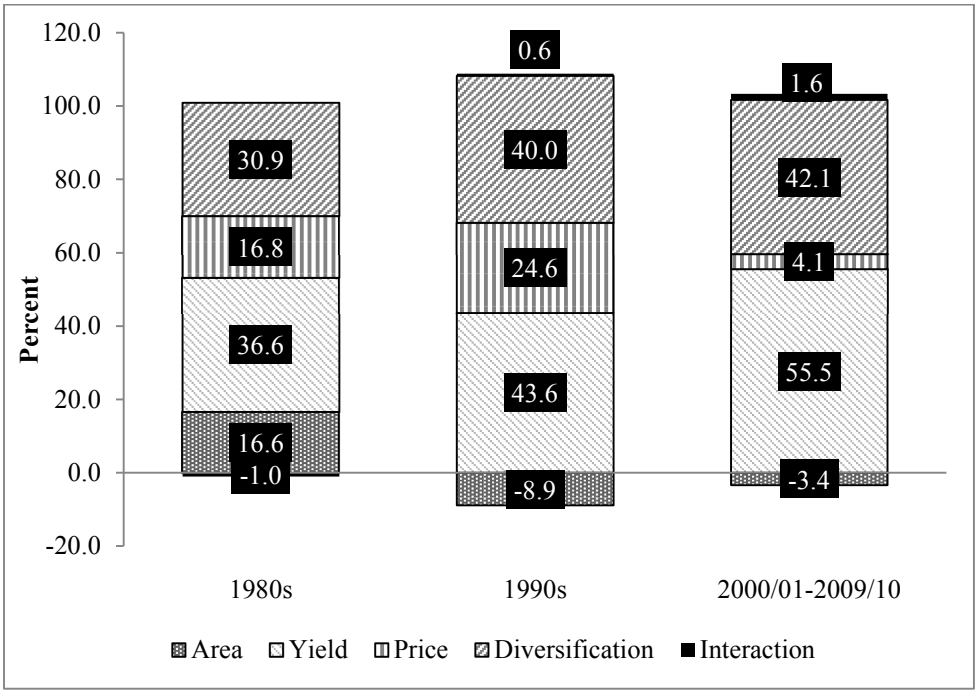
Source: Estimated by authors.

Notes: Value of output does not include the value of crop by-products (straws and fodders). Subtotal of each group of crops is in italics.

The performance of agriculture in this region in the 1990s was as good as in the 1980s. The sector grew at an annual rate of around 3.5 percent in these two decades (Table 4.2). There was, however, a sharp deceleration in growth in the 2000s, but with highly variable performance by various crops. The rate of growth in rice output, which was 4.4 percent in the 1980s, dropped to 3 percent in the 1990s and turned negative in the following decade. Fruits and vegetables, in contrast, experienced faster growth and remained important to overall growth. Their share in overall growth almost doubled, to 56 percent, in the 1990s and grew even larger in the following decade. Pulses, oilseeds, and fiber crops also performed better in the most recent decade, but because of their small area their contribution to growth was very small.

Higher growth in agriculture in the 1980s came from technological change in rice production. Rice yield during this period increased at an annual rate of 3.8 percent (see Table A.4 in the appendix). Decomposition analysis shows that yield increases alone accounted for about 37 percent of the overall growth (Figure 4.3). Area expansion and diversification were also important sources of growth in the 1980s, contributing 17 percent and 31 percent, respectively. In the 1990s, the region witnessed a contraction in cropped area, which resulted in its negative contribution to growth. It may be noted that most crops experienced a decline in area during this period. Yield improvements and diversification remained important sources of growth in the 1990s, each contributing more than 40 percent of growth. Diversification occurred toward vegetables and fruits, which replaced millets and sorghum.

Figure 4.3 Percent contribution of various sources to growth in the crop sector, eastern region, 1980/1981–2009/2010

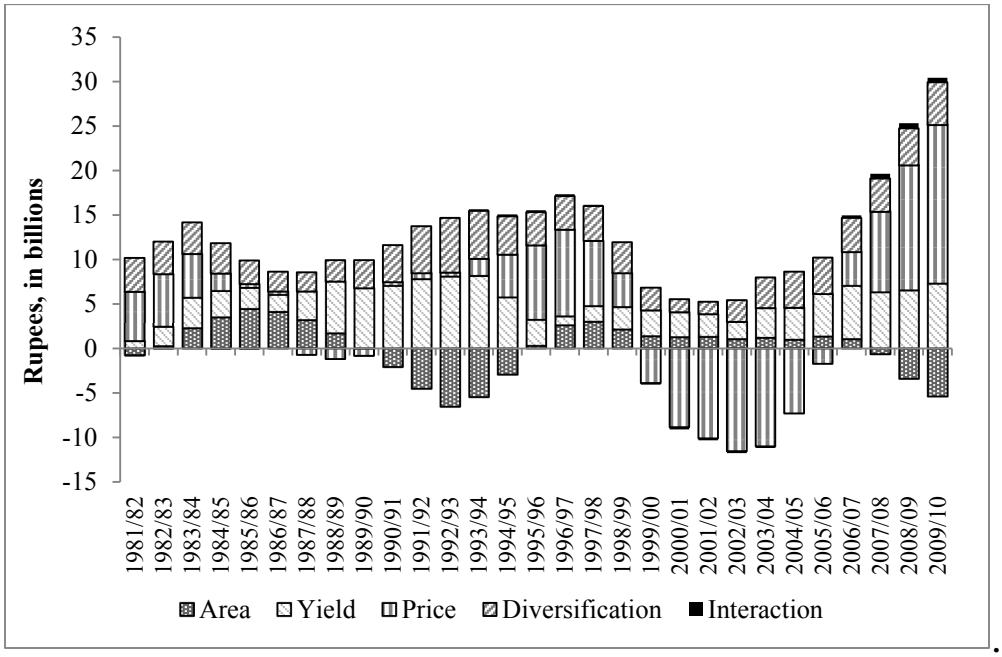


Source: Estimated by authors.

Prices emerged as an important source of growth in the 1990s and represented about one-fourth of the overall growth. In the following decade, the declining contribution of area continued; nonetheless, yield improvements and diversification consolidated their share of growth to 56 and 42 percent, respectively. It is interesting to note that during 2000/2001–2009/2010, agricultural growth was driven by land reallocation in favor of fruits and vegetables, accompanied by improvements in their yields. The price effect, however, remained weak in this period, primarily due to a significant decline in the real price of rice.

The dynamics of growth are better captured by the year-over-year changes in its components (Figure 4.4). Until the mid-1990s, yield improvements or technology continued to be the main source of growth, while the contribution of price was small and declining. These trends, however, reversed thereafter and continued until the middle of the next decade. Afterward, the effects of both technology and price became even stronger. Crop diversification remained a steady source of growth throughout the three decades.

Figure 4.4 Annual changes in sources of agricultural growth, eastern region, 1980/1981–2009/2010



Source: Estimated by authors.

The eastern region is heavily populated, and diversion of agricultural land for nonagricultural purposes is expected, causing a further decline in the area share in growth. Yields of most crops in this region are low but improving slowly. It may be recalled that the region is endowed with sufficient water resources, good-quality soils, and plenty of labor, and hence has considerable potential for agricultural growth. Harnessing this potential will require investment in agricultural research and extension to generate and disseminate improved technologies, as well as the development of markets and institutions for HVCs.

Western Region

The western region has a relatively diversified cropping pattern, with coarse cereals and oilseeds dominating (Table 4.3). However, there has been a considerable decline in the area share of coarse cereals. Area share of rice and wheat has remained almost stagnant at around 10–11 percent each. Interestingly, there has been a substantial increase in the area under fruits, vegetables, and spices, from about 2 percent in the 1980s to 2.7 percent in the 1990s and to 4.6 percent in the next decade. Their share in the value of crop-sector output increased from 15 percent in the 1980s to 19 percent in the 1990s and further to 27 percent in the following decade. Oilseeds accounted for about one-fourth of the total value of output.

Table 4.3 Percent contribution of various crops to agricultural growth, western region, 1980/1981–2009/2010

Crop / crop group	Share in gross cropped area			Share in real value of output			Annual compound growth in real value of output			Share in overall growth		
	1980s	1990s	2000/2001–2009/2010	1980s	1990s	2000/2001–2009/2010	1980s	1990s	2000/2001–2009/2010	1980s	1990s	2000/2001–2009/2010
Rice	11.0	10.7	10.3	10.9	8.7	6.7	0.9	1.6	0.5	5.6	3.7	0.3
Wheat	10.7	10.9	10.8	11.3	11.4	10.5	0.6	7.0	3.0	6.4	18.8	5.2
Maize	3.3	3.4	4.0	2.3	1.9	1.9	1.1	2.6	2.9	1.4	1.9	1.2
Other cereals	30.8	23.1	18.6	12.5	8.8	6.4	-2.1	0.2	1.8	-4.2	-0.6	1.7
All cereals	*55.8*	*48.2*	*43.6*	*37.0*	*30.7*	*25.6*	*-0.2*	*3.2*	*2.1*	*9.1*	*23.8*	*8.4*
Chickpeas	7.2	6.8	6.6	6.3	5.9	5.3	2.1	4.5	5.5	4.3	4.7	5.0
Pigeon peas	2.5	2.6	2.4	2.7	2.5	1.8	5.0	2.3	3.6	3.7	0.4	1.4
All pulses	*17.8*	*17.7*	*17.2*	*11.9*	*11.3*	*9.1*	*3.6*	*3.1*	*3.7*	*13.0*	*5.9*	*6.0*
Groundnut	4.9	4.3	3.8	8.6	6.1	5.2	0.0	0.2	3.3	0.2	-2.2	2.7
Rapeseed and mustard	2.3	4.8	4.8	4.3	5.7	5.2	13.1	0.2	7.1	16.7	-1.2	5.4
Soybean	1.7	6.6	10.0	1.8	6.6	7.5	39.7	8.7	9.0	16.2	12.3	12.2
Other oilseeds	6.7	11.1	13.3	8.1	8.8	7.2	9.3	-0.6	6.2	6.4	-2.4	1.6
All oilseeds	*14.0*	*20.2*	*21.9*	*22.8*	*27.2*	*25.1*	*7.5*	*1.8*	*6.6*	*39.5*	*6.6*	*21.9*
Cotton	7.5	7.5	8.1	7.5	9.0	10.1	-1.8	5.9	13.2	1.5	7.8	20.6
Other fibers	0.1	0.1	0.0	0.0	0.0	0.0	-3.3	-2.7	3.4	0.0	0.0	0.0
All fibers	*7.6*	*7.5*	*8.1*	*7.5*	*9.0*	*10.1*	*-1.8*	*5.9*	*13.2*	*1.5*	*7.8*	*20.6*
Plantation crops	0.0	0.0	0.0	0.1	0.2	0.1	7.8	5.2	-10.0	0.3	0.2	-0.2
Spices and condiments	0.8	1.0	1.0	1.8	2.3	2.2	7.2	6.4	6.7	3.5	2.7	2.9
Fruits	0.5	0.8	2.0	6.8	9.7	15.5	10.9	9.4	6.1	18.5	30.4	17.7
Vegetables	0.7	1.0	1.6	7.7	7.2	9.1	4.9	8.2	8.6	9.4	12.5	14.7
Sugarcane	0.8	1.0	1.3	7.4	7.1	7.6	0.6	5.9	5.6	3.8	10.4	6.0
Other crops	3.2	3.1	3.7	1.7	1.5	1.2	0.7	0.9	7.4	1.4	-0.1	1.9
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**2.6**	**4.4**	**5.7**	**100.0**	**100.0**	**100.0**

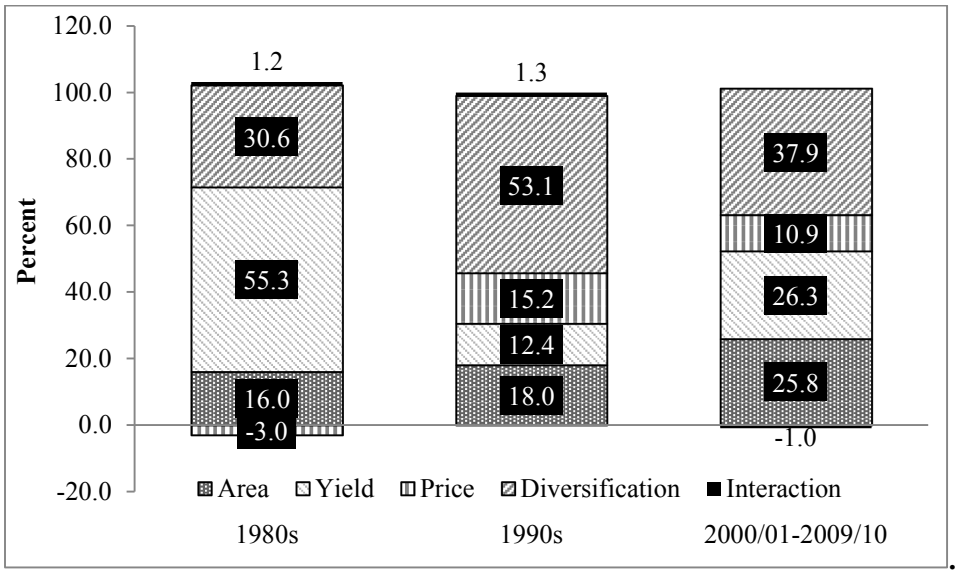
Source: Estimated by authors.
Notes: Value of output does not include the value of crop by-products (straws and fodders). Subtotal of each group of crops is in italics.

Unlike in other regions, agriculture in the western region has grown at an accelerated rate, from 2.6 percent in the 1980s to 4.4 percent in the 1990s and 5.7 percent in the following decade (Table 4.3). Important reasons for this are (1) increased availability of water for irrigation and of micro-irrigation technologies, leading to an increase in cropping intensity, and (2) increased fertilizer use. The proportion of the gross cropped area under irrigation in the region increased from 16 percent in 1980/1981 to 27 percent in 2000/2001 and further to 31 percent in 2009/2010. Microirrigation has played an important role in improving irrigation coverage in the states of Maharashtra and Rajasthan, where 16 percent and 10 percent, respectively, of the gross irrigated area is estimated to be covered under drip and sprinkler irrigation systems (Palanisami et al. 2011). This coverage has resulted in an increase in cropping intensity from 114 percent in 1990/1991 to 129 percent in 2009/2010. Fertilizer consumption per ha of gross cropped area increased substantially, from 18 kg/ha in 1980/1981 to 53 kg/ha in 2000/2001 and further to 86 kg/ha in 2009/2010.

Oilseeds, pulses, fruits, and vegetables have remained important to agricultural growth in this region. Together, these crops represented about 80 percent of overall growth in the 1980s (Table 4.3). In the 1990s, the region's production portfolio became more diversified toward wheat, pulses, oilseeds, cotton, sugarcane, fruits, and vegetables, which together contributed more than 90 percent of overall growth. The contribution of fruits, vegetables, wheat, and cotton increased, while that of pulses and oilseeds decreased in this period. In the next decade, oilseeds and cotton again emerged as important contributors to agriculture growth. Among oilseeds, soybean remained a major contributor to growth throughout the past three decades, mainly due to area expansion. Soybean cultivation, which had initially remained largely confined to Madhya Pradesh, spread rapidly to the adjoining states of Maharashtra and Rajasthan. Fruits and vegetables, although experienced a decline in share, they have remained important drivers of growth.

Diversification remained the dominant source of growth in this region, and more so in the 1990s, when its share in growth peaked at 53 percent, up from 28 percent in the 1980s (see Figure 4.5). In the 2000s, the share of diversification in growth declined to 38 percent. In the 1990s, the region's production portfolio shifted toward oilseeds, fiber crops, fruits, vegetables, and sugarcane, substituting these for millets and other coarse cereals. Land reallocation away from coarse cereals continued in the following decade, but the shift was more in favor of fruits and vegetables. The area under fruits and vegetables grew at a rate of 8.8 percent during this period. In fact, most of the diversification-led growth in that decade was due to land reallocation toward fruits and vegetables (see Table A.5 in the appendix). Agriculture in the region is dependent on rain, while rainfall is low and uncertain, and to manage production risks farmers grow diverse crops that are more water efficient, more remunerative, or both.

Figure 4.5 Percent contribution of various sources to growth in the crop sector, western region, 1980/1981–2009/2010



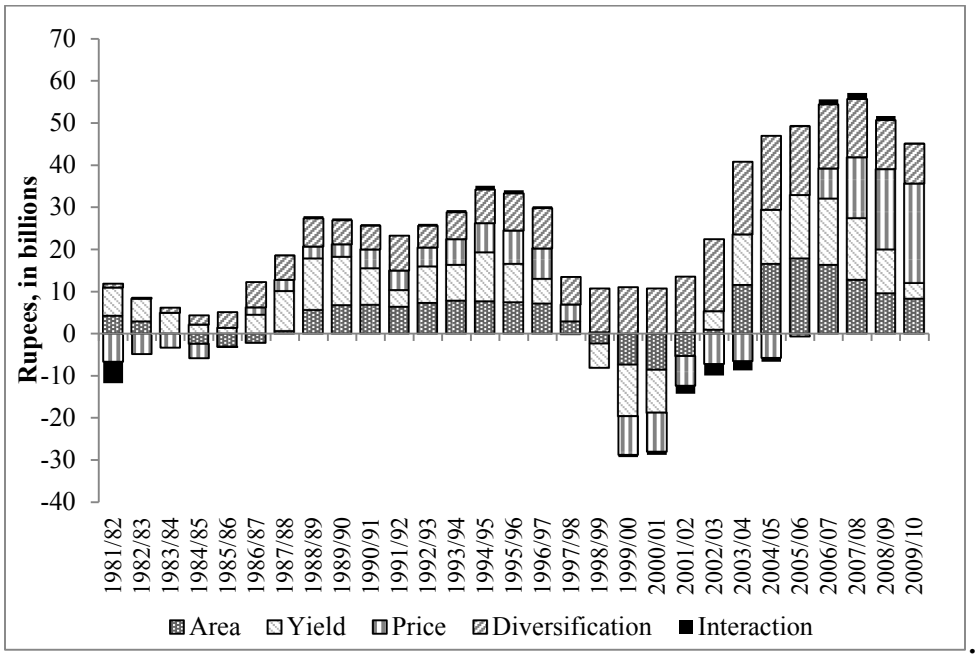
Source: Estimated by authors.

Improvements in the yield of crops such as wheat, rice, millet, and soybeans also contributed to agricultural growth in the 1980s. The contribution of yield increases to agricultural growth, however, declined drastically in the 1990s, but it recovered to some extent in the following decade, primarily on account of substantial improvements in the yields of cotton, wheat, sugarcane, and oilseeds. Cotton, however, dominated the yield effect because of the higher yield of its Bt strains. The western region shares 70 percent of the country's total cotton area, and Bt cotton now occupies about 90 percent of the total cotton area in the country. The average cotton yield in this region almost doubled between 2002/2003 and 2009/2010. Area expansion continued to be an important source of growth, with an increasing contribution. It may be noted that landholding size in this region is higher than in any other region.

The price effect was negative at the margin in the 1980s, mainly due to the declining prices of cereals (see Table A.5 in the appendix). The contribution of prices to growth improved to 15 percent in the 1990s thanks to a rise in the real prices of wheat and fruits. The real prices of cereals declined early in the first decade of the 2000s, weakening the share of price in overall growth.

The annual changes in sources of growth depicted in Figure 4.6 reveal that agriculture in the region was virtually stagnant until the mid-1980s but started picking up afterward, and the momentum continued until 1996/1997. During this period, growth sources were diversified. From 1996/1997 onward, there was a sharp deceleration in agricultural growth until 2002/2003, but the growth rose quickly afterward and was driven by diversification, area expansion, and yield improvements until 2005/2006. Later, the price effect became more prominent.

Figure 4.6 Annual changes in sources of agricultural growth, western region, 1980/1981–2009/2010



Source: Estimated by authors.

Southern Region

As in the western region, agriculture in the southern region is quite diversified. Rice occupies more than 22 percent of the gross cropped area, with oilseeds and pulses the next most significant crops. Maize is becoming an important crop in this region. The area share of millets and sorghum has declined by almost half, from 26 percent in the 1980s to 13 percent in the third decade of the study. Oilseeds and pulses each occupy around 15 percent of the total cropped area. HVCs (fruits, vegetables, spices, and plantation crops) also occupy a sizable share of the gross cropped area and are becoming important. During 2000/2001–2009/2010, these crops together accounted for about one-fifth of the gross cropped area and contributed 47 percent of the gross value of crops.

Despite low and erratic rainfall, agriculture in this region has grown consistently at an annual rate of more than 3 percent in the past three decades, though with marginal deceleration (see Table 4.4). This region has been at the forefront in the development of watersheds and also in the adoption of micro-irrigation technologies. Andhra Pradesh and Karnataka each have about 10 percent of their gross irrigated area under micro-irrigation (Palanisami et al. 2011).

Oilseeds, plantation crops, and rice were the main contributors to agricultural growth in the 1980s in this region (Table 4.4). In the 1990s, rice continued to maintain its share of growth, while oilseeds and plantation crops became less important and were replaced by fruits (25 percent), sugarcane (22 percent), spices (13 percent), and vegetables (13 percent). In the following decade, fruits consolidated their share of growth to 42 percent and vegetables to 23 percent, while sugarcane and spices lost importance. Among cereals, maize emerged an important crop in the most recent decade, with a share of 12 percent in the value of output and 11 percent in overall growth. The growing importance of maize is due to its increasing demand as feed in the poultry industry. Note that the organized poultry industry is stronger in the southern region than anywhere else in the country.

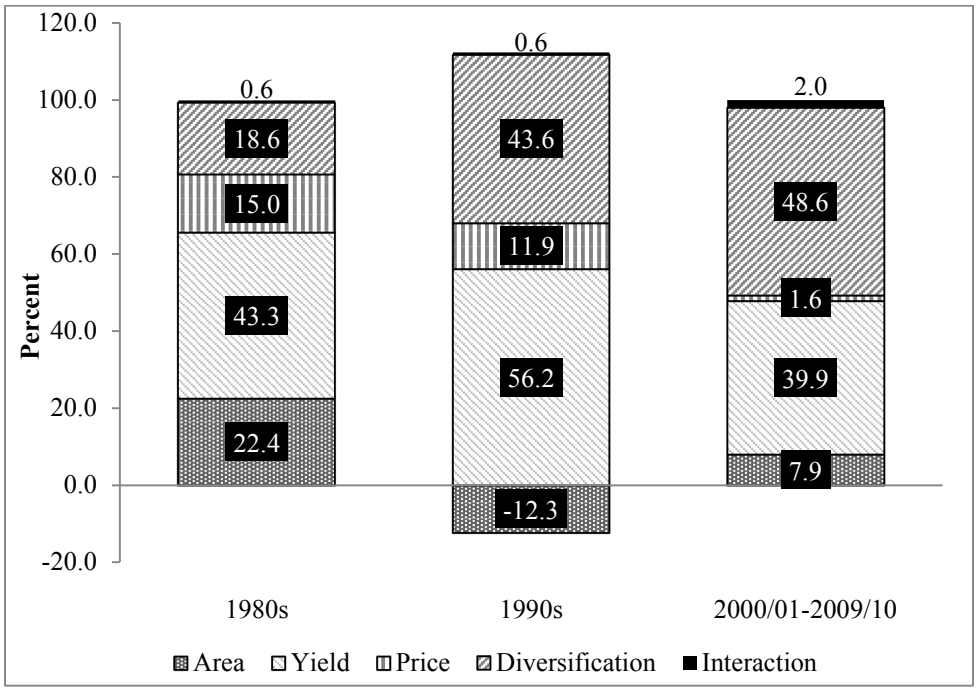
Table 4.4 Percent contribution of various crops to agricultural growth, southern region, 1980/1981–2009/2010

Crop / crop group	Share in gross cropped area			Share in real value of output			Annual compound growth in real value of output			Share in overall growth		
	1980s	1990s	2000/2001–2009/2010	1980s	1990s	2000/2001–2009/2010	1980s	1990s	2000/2001–2009/2010	1980s	1990s	2000/2001–2009/2010
Rice	24.1	23.3	22.1	26.8	23.2	20.2	1.8	2.8	-0.1	16.4	20.4	-5.6
Wheat	0.9	0.7	0.8	0.3	0.2	0.2	-6.2	6.5	3.4	-0.3	0.5	0.2
Maize	1.7	2.4	5.3	1.1	1.4	2.9	0.2	9.4	11.7	0.5	4.9	10.9
Other cereals	26.2	17.3	12.7	6.2	3.7	2.8	-3.9	0.2	-0.1	-5.2	-0.4	-0.7
All cereals	*52.9*	*43.8*	*41.0*	*34.3*	*28.6*	*26.2*	*0.6*	*2.8*	*1.1*	*11.3*	*25.3*	*4.9*
Chickpeas	0.8	1.3	3.1	0.2	0.4	1.5	4.0	11.9	14.0	0.3	2.8	7.1
Pigeon peas	2.5	2.6	3.3	0.8	0.8	0.9	5.0	5.5	5.3	0.9	1.2	1.6
All pulses	*11.9*	*12.1*	*14.3*	*3.1*	*3.1*	*4.1*	*5.5*	*3.6*	*5.4*	*4.0*	*4.7*	*7.6*
Groundnut	11.2	12.7	9.6	10.2	9.6	5.6	6.6	-2.9	0.4	17.9	-13.0	-2.1
Rapeseed and mustard	0.0	0.0	0.0	0.0	0.0	0.0	7.0	-1.7	8.2	0.0	0.0	0.0
Soybean	0.0	0.2	0.6	0.0	0.1	0.2		15.0	16.2	0.1	0.3	1.0
Other oilseeds	5.3	7.1	7.2	1.9	2.2	2.2	12.1	-4.3	4.1	9.4	2.8	0.8
All oilseeds	*16.4*	*19.8*	*16.8*	*12.1*	*11.9*	*8.0*	*7.4*	*-3.1*	*1.6*	*27.4*	*-9.9*	*-0.3*
Cotton	4.7	5.3	5.1	3.8	4.9	4.3	3.0	3.0	6.8	5.7	2.8	10.2
Other fibers	0.4	0.3	0.2	0.1	0.1	0.0	-1.0	0.7	-4.2	0.0	0.0	-0.1
All fibers	*5.1*	*5.5*	*5.3*	*3.9*	*4.9*	*4.3*	*2.9*	*2.9*	*6.6*	*5.7*	*2.8*	*10.1*
Plantation crops	5.6	7.0	8.3	10.6	10.7	9.2	6.8	0.3	1.9	18.9	-0.6	5.3
Spices and condiments	3.1	3.4	3.6	6.5	9.3	10.7	10.1	8.0	3.3	12.0	17.4	14.7
Fruits	3.2	3.5	4.7	12.7	13.2	18.0	2.7	6.1	6.9	8.8	25.3	42.2
Vegetables	2.3	2.8	3.3	8.2	8.2	9.2	2.4	6.2	6.8	5.7	12.8	23.1
Sugarcane	1.7	2.4	2.6	7.8	9.1	9.4	2.1	6.7	-2.4	5.3	22.7	-10.1
Other crops	0.7	0.7	0.7	1.4	1.2	1.0	-0.3	0.2	5.8	0.8	-0.5	2.4
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**3.4**	**3.3**	**3.1**	**100.0**	**100.0**	**100.0**

Source: Estimated by authors.
Notes: Value of output does not include the value of crop by-products (straws and fodders). Subtotal of each group of crops is in italics.

Technology remained an important source of agricultural growth in this region, especially in the 1990s, when it accounted for 56 percent of growth (see Figure 4.7). In the 1990s, there was a substantial improvement in the yields of rice, oilseeds, and HVCs. The share of yield improvements in growth was nearly the same (close to 40 percent) in the 1980s and in the third decade of the study. The decline in the contribution of yield to growth from the 1990s to the following decade was mainly due to deceleration in the yield growth of rice and oilseeds (see Table A.6 in the appendix). Cotton, vegetables, and spices, in contrast, enhanced the yield effect in this period.

Figure 4.7 Percent contribution of various sources to growth in the crop sector, southern region, 1980/1981–2009/2010



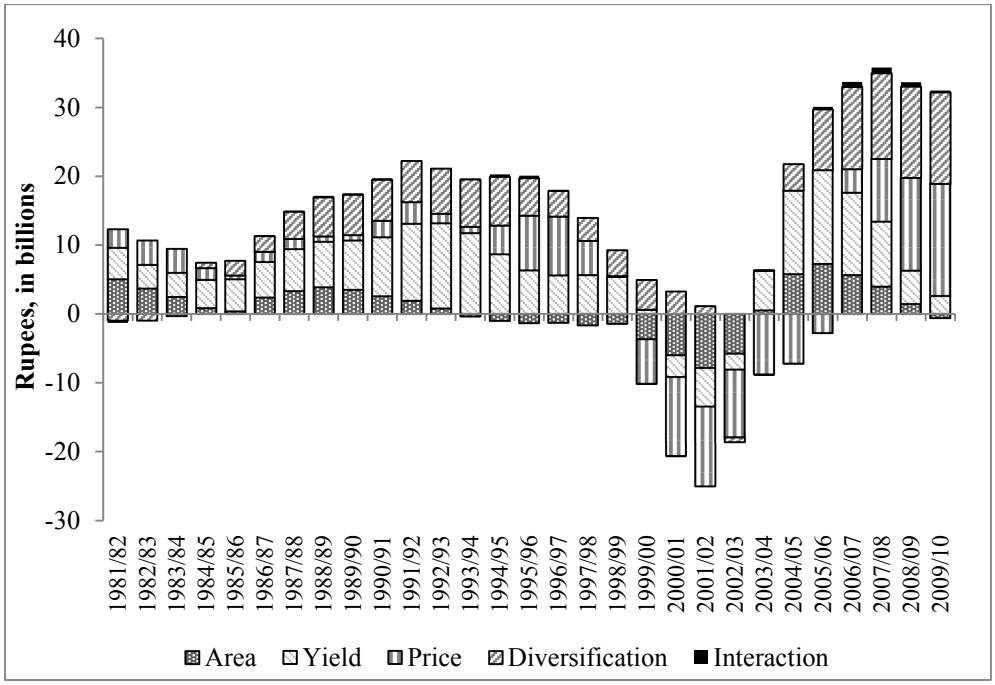
Source: Estimated by authors.

There was a drastic increase in the contribution of diversification to overall growth in the 1990s, when its share rose to 44 percent, from 19 percent in the 1980s. During 2000/2001–2009/2010, diversification alone accounted for close to half of agricultural growth. In the 1990s, fruits, vegetables, spices, and plantation crops gained land, reallocated from oilseeds, cotton, coarse cereals, and pulses. Land reallocation in the following decade was more toward fruits, vegetables, and maize, away from rice, sugarcane, and millets. It is interesting to note that land reallocation in the 1980s was more toward oilseeds (perhaps because of the government policy of achieving self-sufficiency), plantation crops, and sugarcane, and away from millets, sorghum, and rice. Institutional developments such as contract farming and producers' organizations in the region facilitated diversification toward HVCs. Note that the southern region has a monopoly in the production and export of gherkins, which by and large are cultivated under contract farming.

The contribution of price to agricultural growth declined to less than 2 percent during 2000/2001–2009/2010, from more than 12 percent in the earlier decades. The price effect in the 1980s was dominated by the prices of oilseeds and HVCs. Note that there was a considerable decline in the prices of plantation crops in the 1990s, but the aggregate price effect of HVCs remained important. The modest price effect on growth in the following decade was due to a decline in the price of rice.

Figure 4.8 shows the dynamics of growth sources on an annual basis in this region. Yield improvements have been a sustainable source of growth in this region, except for a short period from 1999/2000 to 2002/2003. The contribution of yield to growth, as expected, was higher in the first half of the 1990s. Likewise, diversification was also a sustainable source of growth, especially after the mid-1980s. The price effect, in contrast, was quite erratic throughout. It was strongly negative in the first half of the third decade under study and strongly positive in the second half of that decade.

Figure 4.8 Annual changes in sources of agricultural growth, southern region, 1980/1981–2009/2010



Source: Estimated by authors.

How do these patterns of sources of growth compare across regions? There are considerable regional differences in the patterns of agricultural growth and their sources. Agricultural growth decelerated significantly in the rice and wheat dominated Indo-Gangetic plains, spreading from north to east. It also decelerated in the southern region, but not much. In contrast, agriculture grew at an accelerated rate in the western region.

Technology was an important source of growth in all the regions, but the irrigated northern region followed a technology-led growth trajectory. The focus of technology, however, has largely remained on rice and wheat. The price effect was stronger in the rice and wheat-dominated northern region because of assured offtake of these grains at MSPs by the government for public distribution, welfare programs, and buffer stocks. As a result of intensive cultivation of these crops, the region is facing severe degradation of natural resources (land and water), which if not controlled at the earliest will adversely affect the prospects of growth through rice and wheat. There is a need to reexamine the policies of MSPs and input subsidies so as to induce farmers away from rice and wheat. Diversification toward HVCs was a more important source of growth in the rainfed western and southern regions than elsewhere, due to higher urbanization, higher per capita income, and more extensive infrastructure. In general, to sustain diversification-led growth it is important to focus on improving farmers' access to remunerative markets.

5. CHANGING SOURCES OF GROWTH AND SMALLHOLDERS

Indian agriculture is predominantly small-farm agriculture; about two-thirds of the landholdings are 1 ha or less (considered marginal holdings) and another one-fifth range from 1 to 2 ha (considered smallholdings) (Table 5.1). Together, these make up 84 percent of the total holdings and account for 42 percent of the land area. The average size of the marginal holdings is 0.38 ha and of the smallholdings 1.38 ha. From a livelihood perspective, the viability of such tiny holdings is often questioned. Chand, Prasanna, and Singh (2011) reported that if crop production were the sole source of livelihood, a majority of the households owning such tiny landholdings would be poor and food insecure.

Table 5.1 Selected farm characteristics by landholding size, 2006/2007

Characteristic	Marginal (≤ 1 ha)	Small (1–2 ha)	Medium (2–4 ha)	Large (>4 ha)	All
Share in holdings (%)	65	19	11	6	83
Share in operational area (%)	21	21	24	34	100
Average farm size (ha)	0.38	1.38	2.68	7.33	1.21
Irrigated area (%)	58	47	45	42	47
Cropping intensity (%)	142	130	126	126	130
Area HYV (%)	75	70	67	60	67
Fertilizer use (kg/ha)	198	167	137	109	147
Households availing institutional credit (%)	20	33	35	39	25

Source: India, DAC (2012b).
Note: ha = hectare; HYV = high-yielding varieties.

How are small farmers impacted by the changing patterns of growth sources? These changes offer opportunities and pose challenges to small landholders. For instance, the demand-driven growth in HVA is an opportunity for smallholders to enhance their income and utilize their resources, particularly family labor, efficiently by diversifying their production portfolio toward market-oriented HVCs, but this strategy also involves greater production and market risks, which may also adversely affect their household food grain security.

To obtain a decent livelihood from tiny pieces of land, marginal and small farmers practice intensive agriculture. The cropping intensity on marginal holdings and smallholdings is relatively higher (see Table 5.1), but a higher cropping intensity also implies limited scope to bring more area under cultivation on marginal and small farms. Smallholders are also less likely to benefit from price-led growth, as the benefits of higher prices accrue in proportion to farmers' marketable surplus, which is less on smaller holdings.

Smallholders are likely to benefit more from technological change and diversification toward higher-value crops than from other drivers of growth. Let us look at the role of technology first. Smallholders have a larger proportion of their cultivated land under irrigation and under high-yielding crop varieties than do those with larger farms. They also apply more fertilizers and pesticides per unit area, compared with others (Table 5.1). Smallholders, however, have chronically faced acute institutional credit and market constraints. Despite these limitations, they have been reported to be more efficient in production, mainly due to the labor advantage they have over larger farmers (Bharadwaj 1974; Bhalla 1979; Bagi 1981; Rao and Chotigeat 1981; Chand, Prasanna, and Singh 2011). Most of these studies, however, conclude this based on the size–productivity relationship in one or another important crop.

Using household-level data from a large-scale survey conducted by the National Sample Survey Organization of the government of India (India, NSSO 2005), we examine the relationship between farm size and productivity at the aggregate level and in the case of important crops in Table 5.2. As an aggregate of all crops, the net revenue per unit of land is about 35 percent more on marginal landholdings than on large landholdings, and 11–13 percent more than on other types of holdings. This confirms the existence of an inverse size–productivity relationship in Indian agriculture.

Table 5.2 Net revenue per hectare from various crops by farm size, 2002/2003 (rupees/ha)

Crops / crop groups	Marginal (≤1.0 ha)	Small (1.0–2.0 ha)	Medium (2.0–4.0 ha)	Large (>4.0 ha)	All
Rice	8,594	8,394	8,919	9,313	8,734
Wheat	9,497	9,108	10,614	9,736	9,711
Maize	4,781	4,769	4,604	5,140	4,807
Other cereals	3,375	3,287	2,415	2,039	2,611
Total cereals	**7,903**	**7,298**	**7,444**	**6,611**	**7,349**
Pulses	5,248	4,393	5,031	4,187	4,579
Oilseeds	8,738	6,759	6,395	6,150	6,694
Fiber crops	7,639	6,999	7,784	5,731	6,697
Sugar crops	22,627	17,780	23,139	21,279	21,186
Fruits	32,687	21,004	19,243	14,881	21,715
Vegetables	14,182	12,686	11,752	12,592	13,103
Spices	21,288	19,340	18,035	13,061	17,557
Plantation crops	23,355	19,678	18,665	11,449	19,049
Flowers	20,667	9,508	10,896	11,585	13,925
Medicinal and narcotic plants	13,684	16,822	14,303	12,351	14,386
High-value crops	**19,220**	**16,250**	**15,699**	**13,159**	**16,444**
Other crops	12,421	10,363	8,622	4,230	7,350
All crops	**9,018**	**7,944**	**8,120**	**6,668**	**7,877**

Source: India, NSSO (2005).
Note: ha = hectare.

The efficiency advantage, however, differs across crops. Horticultural crops generate more net revenue per unit of land than do most other crops, almost twice the mean revenue from other crops. Interestingly, the size–productivity relationship is also stronger in the case of horticultural crops, except floriculture. For other crops, especially rice and wheat, there is no definite relationship between farm size and productivity. An important reason for this is the increasing mechanization of field operations in these crops, and more so on larger farms, which has helped improve their production efficiency. However, there has been little, if any, mechanization of field operations in horticultural crops because many of the activities cannot be accomplished by machines and require human and animal labor. Most HVCs are highly responsive to constant and careful monitoring of plant health; careful weeding, pruning, and irrigation; harvesting based on assessments of when individual pieces of fruit and vegetables are ripe; and careful, efficient handling (Collins 1995). These findings indicate that although small farmers might have lost their earlier comparative advantage in the cultivation of rice and wheat, they remain efficient in the production of HVCs, which are labor-intensive, and, relative to others, small farmers have a larger endowment of labor per unit of land.

Although horticultural crops are more remunerative, the capability of small farmers to grow them is often limited, for several reasons. First, such farmers' average size of landholding is too small to permit them to divert more land from staples toward HVCs at the cost of their household food grain security. Second, cultivation of HVCs is capital- and information-intensive,[8] which may prevent them from

[8] We estimated the costs of cultivation for horticultural crops as an aggregate, and these were higher on smaller farms. The

growing such crops. Third, most HVCs are perishable and are prone to greater production and market risks, while small farmers are risk averse. Fourth, the marketable surplus of such crops may be too small to be remuneratively traded in the urban markets due to high transportation and transaction costs. Fifth, the emerging marketing systems, characterized by vertical coordination, are expected to benefit farmers, but there is an apprehension that small farmers may be excluded from these systems because of their low volume and inability to comply with food safety standards imposed by the buying firms. Notwithstanding these arguments, a large body of literature suggests that diversification of agriculture from lower- to higher- value crops offers significant opportunities to farmers to enhance their income and employment (Barghouti et al. 2005; Joshi et al. 2004; Weinberger and Lumpkin 2007). Most HVCs have short gestation periods, require low start-up capital, and generate a stream of outputs that can be easily liquidated for cash (Weinberger and Lumpkin 2007; Joshi, Joshi, and Birthal 2006).

Do small farmers participate in HVA? Table 5.3 compares area allocated to various crops by farm size. Three important observations stand out prominently from this comparison. First, as compared with large farmers, smaller farmers allocate a larger proportion of their land to HVCs. Horticultural crops occupy 7.5 percent and 6.3 percent of the total cropped area on marginal and small farms, respectively, as against 5.7 percent on medium and 4.1 percent on large farms. Birthal et al. (2008) found an increasing tendency to diversify toward HVCs on smaller farms.

Table 5.3 Percent area share of various crops by farm size, 2002/2003

Crops / crop groups	Marginal	Small	Medium	Large	Total
Rice	38.09	31.14	24.76	15.13	26.67
Wheat	20.90	17.21	15.83	14.16	16.92
Maize	5.66	5.45	4.38	2.89	4.50
Other cereals	9.26	12.85	14.76	17.69	13.82
Total cereals	**73.90**	**66.64**	**59.73**	**49.87**	**61.90**
Pulses	6.58	9.53	10.96	16.01	11.04
Oilseeds	6.20	8.31	12.13	15.44	10.78
Fiber crops	2.01	3.64	5.05	6.87	4.51
Sugar crops	2.20	3.30	3.47	2.88	2.93
Fruits	1.12	1.20	1.37	1.06	1.18
Vegetables	4.03	3.08	2.06	1.24	2.54
Spices	1.05	1.00	1.24	1.13	1.11
Plantation crops	0.98	0.70	0.52	0.49	0.67
Flowers	0.09	0.05	0.13	0.03	0.07
Medicinal and narcotic plants	0.20	0.27	0.39	0.16	0.25
High-value crops	**7.46**	**6.29**	**5.71**	**4.11**	**5.81**
Other crops	1.65	2.28	2.96	4.82	3.03

Source: India, NSSO (2005).

Second, smaller farms have a comparative advantage in the production of vegetables over fruits and spices. This is expected, as vegetables generate quick and regular returns and require more labor and less capital, which matches smallholders' resource endowments (Birthal et al. 2012). Further, most fruit crops and certain spices (betel nut and cardamom, for example) require more start-up capital and have longer gestation periods, which discourage small farmers from growing these crops. Third, compared with others, though small farmers allocate a larger share of their area to HVCs, they also allocate a larger

unit cost of production, measured as paid out cost (excluding the imputed cost of family labor) to produce one unit of output in monetary terms, was similar (Rs 37–41 to produce output worth Rs 100) across farm types. The gross revenue per ha on smaller farms, however, was enough higher to offset the cost disadvantage. Higher gross revenue on smaller farms could be attributed to the higher endowments of family labor on smaller farms per unit of arable land.

proportion of their land to rice and wheat. This suggests that smallholders do take care of their household cereal requirements even while diversifying toward market-oriented HVCs.

With a higher share of HVCs in the cropped area on small farms and a negative size–productivity relationship, smallholders do not seem to be at a disadvantage in the process of agricultural diversification toward HVCs, as their labor and supervision cost advantages could compensate for the disadvantages of higher marketing and transaction costs and limited access to credit and information. Hence, diversification-led growth is expected to benefit more small farmers and help them escape poverty. Table 5.4 compares monthly per capita consumption expenditures and poverty rates among growers and nongrowers of HVCs by farm size. In general, the incidence of poverty is higher among farm households toward the bottom of the land distribution: 29.4 percent among marginal farmers and 19.4 percent among small farmers, as compared to 9.8 percent among large farm households. However, on average, the incidence of poverty is less among the growers of HVCs (19.6 percent) as compared to the nongrowers (25.4 percent). By farm size as well, the incidence of poverty is less among growers of all sizes than among nongrowers.

Table 5.4 Monthly per capita consumption expenditure (MPCE), in rupees, and poverty status of farm households, 2002/2003

Farm class	Mean MPCE	Head-count ratio	Poverty gap	Squared poverty gap
Growers of high-value crops				
Marginal	526	0.241	0.044	0.012
Small	559	0.169	0.025	0.007
Medium	617	0.109	0.016	0.004
Large	718	0.072	0.015	0.005
All	558	0.196	0.034	0.010
Nongrowers of high-value crops				
Marginal	455	0.302	0.056	0.016
Small	511	0.203	0.035	0.009
Medium	543	0.174	0.031	0.008
Large	624	0.105	0.017	0.005
All	488	0.254	0.046	0.013
All farmers				
Marginal	467	0.294	0.054	0.015
Small	522	0.194	0.032	0.008
Medium	558	0.160	0.028	0.008
Large	645	0.098	0.016	0.004
All	504	0.242	0.044	0.012

Source: India, NSSO (2005).

In addition to the head-count ratio, Table 5.4 also presents the poverty gap, which measures depth of poverty (how far households are from the poverty line), and squared poverty gap, which measures severity of poverty (in addition to the poverty gap it takes into account the inequality among the poor). Both the poverty gap and squared poverty gap are smaller for growers of HVCs at all scales. Consumption expenditures of growers of HVCs are about 15 percent higher than those of nongrowers. The incidence of poverty as well as the depth and severity of poverty are also lower among farmers growing HVCs.

Further, multiplier effects of diversification-led growth are realized beyond the farmgate. Labor will be in demand for the postharvest activities, such as transportation, packing, sorting, grading, and cleaning, which are all labor-intensive (Weinberger and Genova 2005). In addition, expansion of the agroprocessing and agri-input industries will cause an increase in the demand for labor and agriservices (Dolan and Sorby 2003). Many studies, however, have indicated that the potential of HVA may not be

fully realized due to lack of infrastructure, such as cold storage facilities and refrigerated transportation; bias in allocation of institutional credit against small farmers; higher taxes and excise duties on processed foods; multiple laws governing the food industry; and poor implementation of the new marketing act (the Model Act of 2003) that allows transactions in agricultural commodities outside the state-regulated markets (Birthal, Joshi, and Gulati 2005; Landes 2008; Reardon and Gulati 2008).

These findings indicate that diversification toward HVCs is more pro-poor. In the short run it may not help all the poor to come out of poverty, but it may mitigate its severity and reduce the poverty gap. In the long run, given enabling policies, infrastructure, and support services, HVCs will definitely have a large positive impact on the welfare of farm households.

6. CONCLUSIONS AND POLICY IMPLICATIONS

Owing to technological change, and enabling policies, the landscape of Indian agriculture has changed considerably in the past three decades. During this period, agriculture grew at an annual rate of more than 3 percent, though with considerable year-to-year variation. Technology was the main source of growth in the 1980s, followed by crop diversification, which gained momentum in the 1990s and contributed as much to agricultural growth as did technology. The price effect was also stronger in the 1990s, but it faded in the following decade. Technology reemerged as an important source of growth in the third decade of this study, especially toward the latter half.

Most issues related to agriculture in India are handled by the states, and owing to the differences in policy environments and resource endowments there are notable differences in the patterns and sources of agricultural growth across states. In the past three decades, agriculture grew at an accelerated rate or maintained its growth momentum in the western and southern regions, which are largely rainfed and relatively more diversified than elsewhere. In the rice- and wheat-dominated northern and eastern regions, agriculture grew at a decelerating rate. Pathways of growth, however, were different in different regions. The northern region, excluding the hilly and mountainous areas, followed a technology-led growth path, while the western and southern regions relied more on diversification in their growth strategy. Price effects were stronger in the rice- and wheat-dominated regions in both the rising and declining phases of agricultural prices.

Four important implications emerge from this study. First, prospects for growth through area expansion are limited due to land constraints at the national as well as the regional level. India's net cropped area has stagnated at around 140 million ha. Competition for land is likely to intensify due to the increasing demand for land for residential and industrial purposes. The only possibility for enhancing the contribution of area expansion to growth is intensifying the cultivation of existing cropped land through extending irrigation facilities.

Second, output prices play an important role in stimulating agricultural growth. But price-led growth may not be sustainable in the long run. In India, the government sets a floor price (MSP) for many crops, excluding HVCs. Hence, part of the price effect is due to changes in the administered prices, mainly of rice and wheat, which the government procures in large quantities for public distribution and buffer stocks. For instance, in the 1990s it was a significant rise in the MSPs of rice and wheat that made the price effect prominent in agricultural growth. In the 1980s and 2000/2001–2009/2010 the price effect on average was not so strong because of the smaller increases in the prices of these commodities. But during the second half of the latter decade, driven by the rise in international prices of agricultural commodities, the price effect on growth was quite strong, leading some to infer that in the future the supply of agricultural commodities will be driven by price (Chand and Shinoj 2012). In these periods, the price effect was driven by the prices of fruits and vegetables, which are determined by the market. The administered price–led growth may distort cropping patterns, degrade natural resources, and widen interpersonal and regional disparities, as the benefits of price increases accrue in proportion to the marketable surplus, which obviously is less for poor farmers and in poorer states (Joshi, Birthal, and Minot 2006). The need is to enhance competition in the marketplace and improve market and transportation infrastructure to reduce marketing and transaction costs.

Third, decline or fluctuation in the relative contribution of yields to agricultural growth should be a matter of concern. It might happen due to an amalgamation of factors, such as lack of investment in agriculture in general and agricultural research in particular, inefficiency in research, poor linkages between research and extension, weather uncertainty, and so on. All these factors have implications for agricultural research and development. One implication is the need to improve and sustain the level of public investment in agriculture, as it also induces private investment. Another is that investment in agricultural research and extension is far from adequate. India spends only about 0.6 percent of its agricultural GDP on agricultural research and extension, which is less than the average of 2–3 percent for developed countries (Beintema, Adhiguru, and Birthal 2008).

There is sufficient evidence to show that the payoff on investment in agricultural research is very attractive (Fan, Gulati, and Thorat 2007). Higher investment in agricultural research is required to keep yields up or to reduce the costs of production. A third implication is that the agricultural research agenda needs to be revisited and reprioritized to tackle the emerging challenges of climate change, rising prices of agricultural commodities and energy inputs, increasing costs of production, labor shortages, and degradation of natural resources, and also changing food preferences. While the focus of research is likely to remain on breeding for higher yields, the significance of research for management of biotic and abiotic stresses cannot be overemphasized. Research on horticultural crops merits special attention, as there have been limited yield gains in most horticultural crops. Because small farmers proportionally devote more area to horticultural crops and are more efficient in their production than are those with larger landholdings, investment in horticultural research would have a larger effect on small farmers' income. Finally, in the early stages of the Green Revolution, the public extension system played an important role in the delivery of technologies and services to farmers. The efficiency and outreach of the public extension system, however, appears to have diminished: barely 6 percent of farmers are reported to have access to public extension for their information needs (Adhiguru, Birthal, and Kumar 2009). Production systems are becoming diverse and market oriented, and therefore the need to reform technology, information, and service delivery systems cannot be overstressed.

Fourth, diversification toward high-value commodities is a sustainable source of growth and provides a cushion to agricultural growth. It also provides an opportunity for smallholders to enhance their income and escape poverty, as the demand for high-value food crops is expected to accelerate. In the last few years, there has been some progress in dismantling policy and institutional barriers to the HVA and food industry, yet harnessing its potential for inclusive growth will require (1) increased investment in public infrastructure (roads, electricity, and communication) that reduces transportation and transaction costs and induces the private sector to invest in agroprocessing, cold storage facilities, refrigerated transportation, and retail chains to enhance the efficiency of value chains and minimize postharvest losses; (2) enhanced access by farmers to technology, credit, inputs, information, and services; and (3) appropriate policies that facilitate institutional arrangements such as contract farming, producers' organizations, and cooperatives that provide farmers easy access to markets, distribute price risks, and reduce marketing and transaction costs.

APPENDIX: SUPPLEMENTARY TABLES

Table A.1 Average annual change in the sources of agricultural growth, national level (in million rupees), 1980/1981–2009/2010

Crop / crop	1980s						1990s						2000/2001–2009/2010					
group	A	Y	P	D	I	T	A	Y	P	D	I	T	A	Y	P	D	I	T
Rice	1,714	9,205	-171	-81	30	1,0697	995	4,714	4,354	799	104	10,965	2,863	5,280	-5,097	-4,198	-109	-1,260
Wheat	919	5,285	-1,511	51	-29	4,715	518	4,012	4,235	2,134	194	11,093	1,896	2,179	-852	45	92	3,361
Maize	163	741	-345	-240	-10	308	85	809	-185	329	0	1,039	327	997	0	974	31	2,328
Other cereals	437	1,408	-1,349	-1,954	-46	-1,505	221	855	1,229	-2,331	-58	-85	491	1,121	1,022	-1,933	-67	635
All cereals	*3,233*	*16,639*	*-3,377*	*-2,224*	*-55*	*14,216*	*1,818*	*10,390*	*9,633*	*931*	*241*	*23,012*	*5,578*	*9,577*	*-4,927*	*-5,112*	*-53*	*5,063*
Chickpeas	215	704	228	-777	-54	316	120	568	207	-309	-2	585	361	751	226	1,249	49	2,636
Pigeon peas	114	-64	258	337	-10	634	67	-32	130	-123	-3	39	146	131	513	-154	-6	630
All pulses	*568*	*1,417*	*801*	*-587*	*-68*	*2,131*	*318*	*-110*	*799*	*-826*	*-23*	*158*	*792*	*479*	*1,486*	*723*	*3*	*3,483*
Groundnut	413	1,017	23	772	50	2,275	257	688	-1,192	-1,993	16	-2,225	479	851	1,049	-1,565	-27	788
Rapeseed and	208	895	-555	2,627	32	3,208	171	406	-1,491	25	-26	-915	445	1,379	1,092	220	21	3,157
Soybean	46	347	204	1,223	119	1,939	81	268	-1,134	2,756	17	1,988	368	510	1,371	2,464	123	4,836
Other oilseeds	196	727	751	810	24	2,507	144	277	-451	-248	14	-264	327	639	-310	71	-31	695
All oilseeds	*863*	*2,987*	*424*	*5,431*	*225*	*9,929*	*653*	*1,639*	*-4,268*	*539*	*21*	*-1,415*	*1,619*	*3,379*	*3,202*	*1,189*	*86*	*9,475*
Cotton	303	2,228	-67	-628	37	1,873	265	-1,507	728	1,242	158	886	766	8,797	-283	1,293	-2	10,571
Other fibers	45	251	256	-199	6	360	26	130	-178	82	-5	56	68	168	108	-173	-7	163
All fibers	*349*	*2,479*	*189*	*-827*	*43*	*2,233*	*291*	*-1,377*	*550*	*1,324*	*153*	*942*	*833*	*8,965*	*-175*	*1,119*	*-9*	*10,734*
Plantation	278	1,114	691	1,027	40	3,150	192	857	-2,241	1,225	-59	-25	434	23	141	180	27	804
Spices and	170	872	848	297	40	2,226	115	1,503	706	356	23	2,703	468	2,084	1,303	76	-7	3,923
Fruits	716	-1,264	2,141	3,627	2	5,223	429	2,522	2,871	4,943	155	10,919	2,229	-2,096	392	17,369	59	17,954
Vegetables	753	-959	1,240	4,136	-53	5,117	444	1,451	1,133	7,110	103	10,240	1,995	4,908	6,283	7,267	635	21,088
Sugarcane	639	260	-747	1,564	40	1,756	365	405	3,907	2,274	79	7,029	1,412	819	-2,724	-376	-51	-921
Other crops	80	333	205	-251	6	372	47	23	-71	-36	-6	-43	125	611	276	361	57	1,429
Total	**7,648**	**23,878**	**2,417**	**1,2192**	**219**	**46,353**	**4,672**	**17,302**	**13,017**	**17,841**	**687**	**53,519**	**15,48**	**28,748**	**5,257**	**22,797**	**747**	**73,033**

Source: Estimated by authors.

Notes: A = area; Y = yield; P = price; D = diversification; I = interaction; T = technology. Subtotal of each group of commodities is in italics.

Table A.2 Percent annual growth in yield of important crops in India, 1980/81–2009/10

Crop / crop group	1980s	1990s	2000/2001–2009/2010
Rice	3.15	1.21	1.42
Wheat	3.24	1.82	0.73
Maize	2.04	2.22	2.27
Gram	2.48	1.53	1.16
Pigeon peas	0.07	0.13	0.94
Groundnut	1.74	1.34	1.76
Rapeseed and mustard	3.00	0.38	2.13
Soybean	5.27	1.91	1.71
Cotton	4.21	-1.40	10.29
Sugarcane	0.21	0.79	0.59
Fruits	-2.21	1.81	-1.48
Vegetables	-2.46	0.38	1.31

Source: Estimated by authors.

Table A.3 Average annual change in sources of agricultural growth, northern region (in million rupees), 1980/1981–2009/2010

Crop / crop group	1980s						1990s						2000/2001–2009/2010					
	A	Y	P	D	I	T	A	Y	P	D	I	T	A	Y	P	D	I	T
Rice	290	2,798	-121	746	46	3,758	588	1,187	1,154	1,131	61	4,121	384	1,539	-1,296	55	-2	679
Wheat	444	3,348	-890	676	-5	3,574	851	2,841	2,757	624	108	7,181	595	1,030	-787	599	41	1,477
Maize	47	311	-158	-200	-11	-12	69	196	-14	-205	-3	43	35	87	37	-198	-3	-41
Other cereals	46	356	-130	-474	-12	-214	68	209	123	-284	-3	113	35	234	73	-229	5	118
All cereals	*827*	*6,813*	*-1,300*	*748*	*18*	*7,106*	*1,577*	*4,433*	*4,020*	*1,266*	*163*	*11,458*	*1,049*	*2,890*	*-1,973*	*227*	*41*	*2,233*
Chickpeas	54	253	38	-555	-15	-225	62	102	17	-629	-11	-458	20	-33	0	-310	0	-324
Pigeon peas	26	-80	55	10	-6	4	37	12	39	-204	-3	-120	11	-167	26	-102	-3	-235
All pulses	*119*	*110*	*168*	*-554*	*-22*	*-178*	*161*	*-65*	*209*	*-833*	*-17*	*-545*	*65*	*-178*	*200*	*-429*	*-7*	*-348*
Groundnut	10	16	-3	-190	-4	-172	10	-17	-28	-41	1	-75	3	-14	13	-24	0	-22
Rapeseed and mustard	52	428	-132	511	17	876	112	180	-454	-112	0	-275	63	483	393	-97	-5	837
Soybean	2	36	5	-77	-12	-45	2	-17	-5	11	-2	-11	0	12	3	-7	0	7
Other oilseeds	6	33	-26	221	-47	187	19	-49	-76	14	5	-86	5	-19	53	4	-11	31
All oilseeds	*69*	*513*	*-156*	*465*	*-45*	*846*	*142*	*97*	*-563*	*-128*	*5*	*-447*	*71*	*462*	*462*	*-125*	*-17*	*854*
Cotton	60	632	79	181	26	978	127	-797	206	-226	-6	-696	64	1,491	-114	-248	-47	1,145
Other fibers	0	2	6	-15	-1	-7	0	0	4	-5	0	-1	0	-2	-1	-4	0	-6
All fibers	*61*	*634*	*85*	*166*	*26*	*972*	*127*	*-798*	*210*	*-230*	*-6*	*-697*	*64*	*1,489*	*-115*	*-252*	*-47*	*1,139*
Plantation crops	0	1	0	-1	0	0	0	1	0	-1	0	0	0	0	0	0	0	0
Spices and condiments	8	20	56	-52	0	31	13	16	57	55	9	149	18	38	2	318	0	376
Fruits	112	-1,146	316	1,773	-84	971	216	-413	644	967	-63	1,351	176	1,988	-128	1,177	22	3,236
Vegetables	80	541	161	500	25	1,307	199	216	149	1,472	-22	2,013	193	1,249	1,412	2,590	139	5,582
Sugarcane	222	27	-405	700	18	562	404	55	1,730	630	25	2,843	310	-32	-1,396	-569	44	-1,643
Other crops	7	77	18	-43	1	59	12	42	-8	32	2	79	11	67	54	130	13	274
Total	**1,505**	**7,590**	**-1,057**	**3,703**	**-64**	**11,677**	**2,850**	**3,584**	**6,448**	**3,229**	**93**	**16,205**	**1,956**	**7,973**	**-1,481**	**3,069**	**187**	**11,705**

Source: Estimated by authors.

Notes: A = area; Y = yield; P = price; D = diversification; I = interaction; T = technology. Subtotal of each group of commodities is in italics.

Table A.4 Average annual change in sources of agricultural growth, eastern region (in million rupees), 1980/1981–2009/2010

Crop / crop group	1980s						1990s						2000/2001–2009/2010					
	A	Y	P	D	I	T	A	Y	P	D	I	T	A	Y	P	D	I	T
Rice	578	3,600	67	-40	9	4,213	-344	2,252	1,516	484	15	3,923	-53	1,985	-1,904	-1,216	-53	-1,241
Wheat	87	363	-115	75	-1	408	-37	252	368	274	11	867	-9	6	-105	-30	11	-127
Maize	29	237	-36	-130	-7	94	-17	195	-2	-30	-2	143	-7	96	28	190	1	307
Other cereals	12	31	-33	-131	-2	-123	-4	-9	22	-61	0	-52	0	2	-4	-36	0	-38
All cereals	*705*	*4,231*	*-117*	*-226*	*-1*	*4,592*	*-403*	*2,690*	*1,904*	*667*	*24*	*4,881*	*-70*	*2,089*	*-1,986*	*-1,092*	*-40*	*-1,099*
Chickpeas	10	38	4	-68	-3	-19	-6	6	6	-25	0	-19	-1	13	0	9	0	21
Pigeon peas	9	32	20	7	-1	67	-6	-45	12	-7	-2	-48	-2	39	47	22	0	106
All pulses	*96*	*225*	*143*	*-222*	*-13*	*229*	*-62*	*-67*	*52*	*-695*	*7*	*-765*	*-10*	*73*	*219*	*128*	*4*	*414*
Groundnut	21	-3	26	139	3	185	-14	-44	-32	-241	16	-316	-2	16	27	36	2	79
Rapeseed and	38	216	-248	295	-9	293	-33	14	-336	-106	13	-447	-5	73	108	56	4	237
Soybean	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other oilseeds	42	63	183	77	4	369	-28	32	42	-159	-10	-123	-3	32	-157	90	-9	-47
All oilseeds	*101*	*276*	*-39*	*511*	*-2*	*848*	*-75*	*2*	*-326*	*-506*	*19*	*-885*	*-9*	*121*	*-22*	*182*	*-3*	*269*
Cotton	0	0	0	0	0	0	0	4	-3	25	0	27	-1	19	-1	23	0	40
Other fibers	57	248	237	-184	8	366	-23	116	-174	144	-5	58	-6	173	84	-72	-1	178
All fibers	*57*	*249*	*237*	*-185*	*8*	*366*	*-23*	*120*	*-177*	*169*	*-5*	*84*	*-6*	*192*	*83*	*-49*	*-1*	*218*
Plantation crops	77	194	318	142	20	752	-45	-8	-284	373	-13	23	-8	-16	-68	202	-12	97
Spices and condiments	26	22	101	114	3	267	-15	65	50	40	2	142	-7	154	133	17	9	306
Fruits	191	-200	309	605	-14	890	-92	628	591	720	-11	1,838	-43	221	-14	1,596	35	1,795
Vegetables	356	-1,498	718	2,470	-92	1,955	-148	978	488	3,413	43	4,773	-128	1,790	2,096	2,578	149	6,486
Sugarcane	34	140	-35	-71	-3	65	-19	-38	143	-143	-2	-59	-1	-22	-81	9	-2	-98
Other crops	12	22	48	-46	-1	34	-6	-10	17	-42	0	-41	-1	87	-9	-14	-2	60
Total	**1,656**	**3,662**	**1,684**	**3,092**	**-96**	**9,997**	**-888**	**4,361**	**2,457**	**3,997**	**65**	**9,990**	**-284**	**4,690**	**350**	**3,557**	**135**	**8,448**

Source: Estimated by authors.

Notes: A = area; Y = yield; P = price; D = diversification; I = interaction; T = technology. Subtotal of each group of commodities is in italics.

Table A.5 Average annual change in sources of agricultural growth, western region (in million rupees), 1980/1981–2009/2010

Crop / crop	1980s						1990s						2000/2001–2009/2010					
	A	Y	P	D	I	T	A	Y	P	D	I	T	A	Y	P	D	I	T
Rice	195	526	-16	-21	1	686	285	-212	537	-13	-5	592	674	824	-560	-766	-60	112
Wheat	201	1,292	-414	-296	-7	775	276	967	1,074	589	86	2,992	999	1,200	-80	-197	53	1,976
Maize	44	186	-99	39	-1	170	54	179	-38	102	-2	296	190	100	15	162	2	469
Other cereals	234	890	-757	-862	-21	-516	305	387	753	-1,502	-44	-102	640	590	602	-1,123	-55	653
All cereals	*675*	*2,894*	*-1,287*	*-1,141*	*-27*	*1,115*	*921*	*1,321*	*2,326*	*-825*	*35*	*3,778*	*2,503*	*2,715*	*-23*	*-1,925*	*-59*	*3,211*
Chickpeas	120	518	172	-245	-46	518	170	480	138	-61	19	745	514	610	197	539	42	1,902
Pigeon peas	55	69	147	181	2	455	78	19	78	-106	0	68	160	216	306	-172	10	520
All pulses	*236*	*980*	*471*	*-68*	*-38*	*1,580*	*346*	*179*	*494*	*-96*	*13*	*936*	*883*	*458*	*721*	*225*	*22*	*2,309*
Groundnut	173	204	-12	-353	18	30	210	521	-516	-553	-16	-353	545	720	576	-785	-25	1,031
Rapeseed and mustard	105	189	-66	1,785	24	2,037	203	188	-649	84	-18	-192	543	835	619	65	18	2,080
Soybean	56	346	191	1,237	142	1,972	164	268	-1,115	2,614	31	1,962	728	546	1,342	1,928	134	4,679
Other oilseeds	77	346	97	251	6	777	120	96	-251	-350	10	-374	200	170	298	-86	16	600
All oilseeds	*412*	*1,085*	*209*	*2,920*	*190*	*4,816*	*697*	*1,073*	*-2,531*	*1,795*	*8*	*1,042*	*2,017*	*2,272*	*2,835*	*1,123*	*144*	*8,390*
Cotton	139	580	-118	-452	34	183	265	-219	242	792	154	1,234	987	6,475	-106	520	20	7,897
Other fibers	0	-1	2	-2	0	-1	0	0	0	-1	0	-1	0	0	1	-1	0	0
All fibers	*139*	*580*	*-116*	*-454*	*34*	*183*	*265*	*-219*	*242*	*790*	*154*	*1,233*	*987*	*6,475*	*-104*	*519*	*20*	*7,897*
Plantation	2	49	6	-20	-1	36	4	-15	-32	71	-4	24	10	-58	-21	10	0	-60
Spices and condiments	38	132	216	37	7	430	57	148	171	36	16	428	205	213	321	320	34	1,094
Fruits	141	350	489	1,225	56	2,262	185	568	772	3,316	-5	4,836	1,571	-4,260	-273	10,505	-772	6,771
Vegetables	141	459	-269	891	-80	1,141	145	-542	8	2,395	-19	1,987	840	724	1,553	2,320	208	5,644
Sugarcane	132	60	-170	448	-5	465	185	-438	946	949	15	1,657	756	1,105	-1,005	1,443	-5	2,293
Other crops	33	154	84	-102	6	175	50	-101	17	18	-5	-21	115	437	179	-25	33	738
Total	**1,94**	**6,744**	**-367**	**3,736**	**142**	**12,20**	**2,855**	**1,974**	**2,413**	**8,450**	**208**	**15,900**	**9,886**	**10,080**	**4,182**	**14,515**	**-375**	**38,28**

Source: Estimated by authors.
Notes: A = area; Y = yield; P = price; D = diversification; I = interaction; T = technology. Subtotal of each group of commodities is in italics.

Table A.6 Average annual change in sources of agricultural growth, southern region (in million rupees), 1980/1981–2009/2010

Crop / crop group	1980s						1990s						2000/2001–2009/2010					
	A	**Y**	**P**	**D**	**I**	**T**	**A**	**Y**	**P**	**D**	**I**	**T**	**A**	**Y**	**P**	**D**	**I**	**T**
Rice	749	2,293	1	-988	-16	2,040	-323	1,367	1,235	24	26	2,329	177	600	-1,279	-371	63	-810
Wheat	8	-2	-8	-39	0	-41	-3	20	17	18	1	53	2	27	-5	8	2	35
Maize	31	19	-36	39	3	56	-24	67	-29	544	-1	557	47	337	113	1,054	41	1,592
Other cereals	178	201	-487	-526	-18	-651	-47	243	277	-503	-13	-44	26	368	182	-653	-21	-99
All cereals	*965*	*2,512*	*-529*	*-1,513*	*-31*	*1,403*	*-397*	*1,696*	*1,500*	*83*	*12*	*2,895*	*252*	*1,333*	*-988*	*38*	*84*	*719*
Chickpeas	7	3	7	25	0	41	-8	122	23	166	14	318	26	181	-20	829	20	1,037
Pigeon peas	21	-18	40	67	-3	107	-11	81	0	72	-3	139	13	74	136	25	-8	240
All pulses	*86*	*193*	*149*	*72*	*0*	*500*	*-44*	*151*	*157*	*259*	*9*	*532*	*53*	*220*	*222*	*606*	*7*	*1,108*
Groundnut	285	635	144	1,116	51	2,232	-106	331	-752	-988	34	-1,481	54	80	409	-852	10	-300
Rapeseed and mustard	0	0	0	2	0	2	0	0	-1	0	0	0	0	3	1	0	0	3
Soybean	0	1	0	6	4	12	-1	14	-9	33	0	37	5	-38	29	157	-3	150
Other oilseeds	92	155	470	447	11	1,174	-57	95	-169	458	-7	319	65	291	-496	286	-35	110
All oilseeds	*377*	*791*	*614*	*1,571*	*66*	*3,419*	*-164*	*440*	*-930*	*-498*	*27*	*-1,125*	*124*	*335*	*-59*	*-409*	*-28*	*-37*
Cotton	104	774	21	-182	-6	711	-67	-113	110	356	35	321	45	1,124	-164	445	39	1,489
Other fibers	2	0	11	-11	-1	2	-1	8	-3	-3	0	0	0	1	13	-22	-2	-10
All fibers	*107*	*774*	*32*	*-193*	*-7*	*713*	*-68*	*-105*	*107*	*353*	*35*	*321*	*45*	*1,125*	*-151*	*422*	*36*	*1,479*
Plantation crops	289	872	361	815	24	2,361	-134	855	-1,941	1,203	-55	-73	121	54	253	307	32	767
Spices and condiments	134	586	522	226	30	1,498	-117	1,063	421	611	7	1,984	89	1,508	915	-302	-62	2,147
Fruits	351	-7	356	398	2	1,099	-201	1,046	603	1,410	36	2,895	263	-8	93	5,725	80	6,152
Vegetables	226	-249	446	311	-19	714	-126	783	364	490	-43	1,467	100	1,307	746	1,082	141	3,376
Sugarcane	222	-137	-156	727	9	665	-144	514	1,089	1,084	45	2,588	91	-160	-793	-603	-8	-1,474
Other crops	39	73	83	-94	3	103	-15	-19	-17	-11	1	-60	11	108	-1	223	15	357
Total	**2,796**	**5,408**	**1,877**	**2,319**	**76**	**12,476**	**-1,410**	**6,424**	**1,354**	**4,983**	**74**	**11,425**	**1,149**	**5,820**	**237**	**7,089**	**297**	**14,593**

Source: Estimated by authors.
Notes: A = area; Y = yield; P = price; D = diversification; I = interaction; T = technology. Subtotal of each group of commodities is in italics.

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