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A Review of Input and Output Policies for Cereals Production in India

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ABBREVIATIONS AND ACRONYMS

AIBP	Accelerated Irrigation Benefit Program
APMC	Agricultural Produce Marketing Committee
Bt	Bacillus thuringiensis
CSO	Central Statistical Organization
CSISA	Cereal Systems Initiative for South Asia
CV	coefficient of variation
ECA	Essential Commodities Act
FAO	Food and Agriculture Organization of the United Nations
FCI	Food Corporation of India
GDP	gross domestic product
GoI	Government of India
Ha	hectare
HVC	high value commodities
ICAR	Indian Council for Agricultural Research
K	potassium
Kg	kilogram
MAHYCO	Maharashtra Hybrid Seeds Company Limited
MoA	Ministry of Agriculture
N	nitrogen
NADP	National Agriculture Development Policy
NAIP	National Agricultural Innovation Project
NBS	nutrient based subsidy
NDDB	National Dairy Development Board
NFSM	National Food Security Mission
NHB	National Horticulture Board
NHM	National Horticulture Mission
NSS	National Sample Survey
NSSO	National Sample Survey Organization
P	phosphorous
RKVY	Rashtriya Krishi Vikas Yojana
SAU	State Agricultural University
TE	triennium ending

ABSTRACT

This paper reviews the key policies with regard to agriculture inputs such as seed, fertilizer, water, agricultural equipment, research, extension, and agricultural credit. It also provides an overview of the policies and programs related to agricultural output markets that are crucial for improving cereal production in the country.

A review of the past performance and policies of India's foodgrain sector reveals that the main drivers of growth have been modern inputs and technology, institutions, and markets with the changing role of the public and private sectors. The present challenge facing Indian policymakers is to efficiently balance food security concerns and higher growth objectives. This will require not only pushing the production frontier to sustainably augment supply, but also ensuring strategic management of foodgrains including procurement and distribution.

The review of input policies highlights the pressure placed on foodgrain systems, in a business-as-usual scenario that extensively subsidizes input and promotes their intensive usage. Fallouts such as excessive groundwater withdrawals and distorted application of nitrogenous fertilizers have implications on the environmental sustainability of natural resources apart from being a considerable fiscal burden. The current policy of subsidizing agricultural power, irrigation, and fertilizers has outlived its relevance and is actually constraining agricultural investments in areas where the returns are higher. Although it is difficult to completely remove these subsidies, they still need to be gradually phased out and converted into investments in rural infrastructure (especially roads) and research and extension systems, which desperately need to be (re)vitalized. It is time the government started to actively partner with the private sector (in infrastructure creation and research) and civil society organizations (in extension), as they have played an increasingly important role in recent years.

The review of the output management policies show that the current policy paradigm consisting of public procurement of grains at a preannounced minimum support price, public storage, and public distribution has resulted in distortions across crops, especially rice and wheat, as well periodic buildup of large stockpiles and stock rundown of these grains at a high cost to the government. Moreover, public procurement and stocking, coupled with interventionist international trade policies, is often at variance with the trends in international markets, resulting in lost opportunities for Indian exporters of rice and wheat. The regional concentration of the system of public procurement in the northern states, aided by intra-country trade and movement restrictions, has also resulted in large spatial disparity in agricultural productivity and farm income as well as uneven development of output markets across states. As a result, producer and consumer welfare is often compromised, even though the government's objective is to maintain a balance between them. Major reforms on the output side would include linking of MSPs with market prices, allowing futures markets in cereals, liberalizing international trade and bring forth greater competition in domestic trade to ensure output markets are more uniformly developed across states and that the country has a truly integrated market for foodgrains.

Keywords: India, agriculture, input policies, output policies

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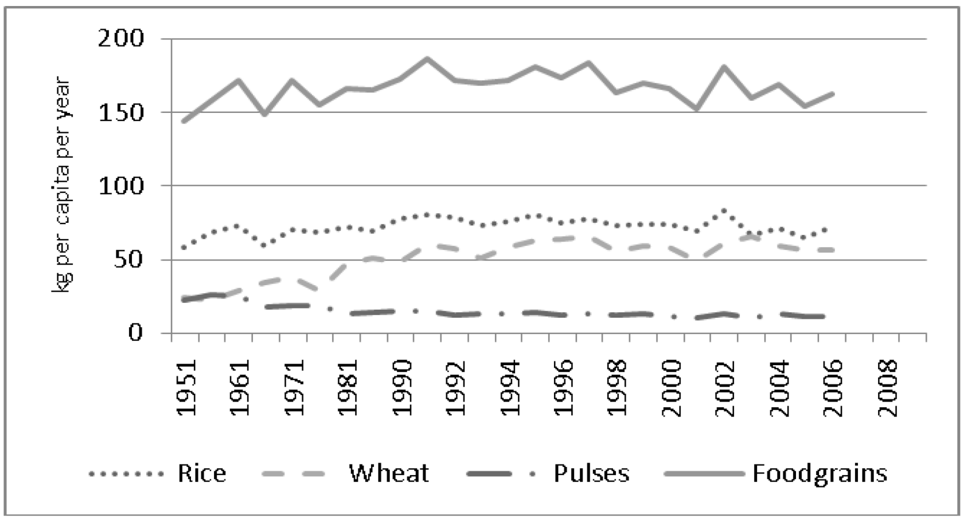
1. BACKGROUND

The experience of recurrent food shortages and famines during colonial times was instrumental in shaping India's food policies after Independence. The policies lay stress on achieving and sustaining self-sufficiency in foodgrain production as prerequisites for ensuring food security. The country has made considerable progress since the 1960s in securing foodgrain availability (Figure 1.1). India ranks second in world rice and wheat production, contributing to more than 21 percent and 11 percent of world rice and wheat output (India, Ministry of Agriculture [India, MoA] 2010). Foodgrain constitutes 64 percent of the gross cropped area (GCA), although it accounts for less than 25 percent of the total value of output of agriculture and allied activities (for Triennium TE 2005/06; India, MoA 2010d). From the demand side as well, consumer spending on foodgrains remains around 39 percent of total food expenditure (21 percent of total monthly expenditure) of rural households (National Sample Survey Organization [NSSO] 2006). Despite per capita cereal consumption has declined from 14 kgs to 11.5 kgs during 1983 to 2004/05, cereals still account for a significant share of total calorie and protein intake (68 percent and 66 percent of total calorie and protein intake is derived from cereals alone in rural India; see NSSO 2007).

Figure 1.1—Per capita availability of foodgrains (kilograms (kg) per capita per year)



Source: India, Ministry of Agriculture 2010.

Given the centrality of cereals in the Indian food system, productivity enhancement via better input supply and better output management are essential to ensure food security. In the past, grain security has been approached by using a blend of policies and institutional arrangements. Some important policy interventions on the input side relate to seeds, water/irrigation, fertilizers, and extension. On the output side, the government intervenes in the grain markets in pricing and through its procurement-storage-distribution operations to ensure remunerative prices for the farmers and maintain an adequate supply of foodgrains. In overall terms, these interventions have been successful in turning the country from a net importer of grains to a net exporter of grains, suggesting that the goal of self-sufficiency has been achieved to a large extent.

Nevertheless, the country faces great challenges in ensuring food security for its citizens in the future. India still has a current population growth rate of 1.7 percent per year and is set to become the most populous country by 2030 with nearly 1.5 billion people. With increasing urbanization and economic growth, demand for foodgrains is set to grow; however, natural resources such as land and water remain limited. Against this, the declining per capita availability of grain in recent years has caused much concern, as have low growth rates of key staples like rice and wheat during the 1990s and post-

2000 period. More worryingly, past policies such as the provision of input subsidies have tended to support inefficient and environmentally unsustainable farm practices that now threaten the long-run prospects of agriculture in some of the net-food surplus regions. At the same time in other parts of the country, particularly in the east, past policies have had little impact in improving productivity levels and overall agriculture remains backward even though the regions endowed with natural resources, especially water.

The National Food Security Mission (NFSM) launched in 2007 is a testimony to the recognition of these concerns by the government and its efforts to boost the production of major foodgrain production, namely, rice, wheat, and pulses. The NFSM is a set of policy packages involving field demonstrations of best farming practices, incentives for adoption of modern technologies, and resource conservation and management practices. Recent times have seen initiatives by private and civil society organizations that aim to accelerate productivity improvements, especially of small farmers, though the use of modern science and technology.

To be fruitful, such initiatives require a clear understanding of the past policies, their successes, and their failures/limitations; this way, the lessons learned can help shape better interventions. In this context, this paper reviews the key policies with regard to agriculture inputs such as seed, fertilizer, water, agricultural equipment, research, extension, and agricultural credit. It also provides an overview of the policies and programs related to agricultural output markets that are crucial for improving cereal production in the country.[1]

The paper is organized as follows: Section 2 examines the trends in production and yield performance of the major cereals, rice, wheat, and maize. Section 3 provides an overview of the evolution of foodgrain policies in India. This is followed by detailed reviews of the input policies in Section 4 and output policies in Section 5. The final section summarizes the key findings, emerging policy challenges, and the way forward.

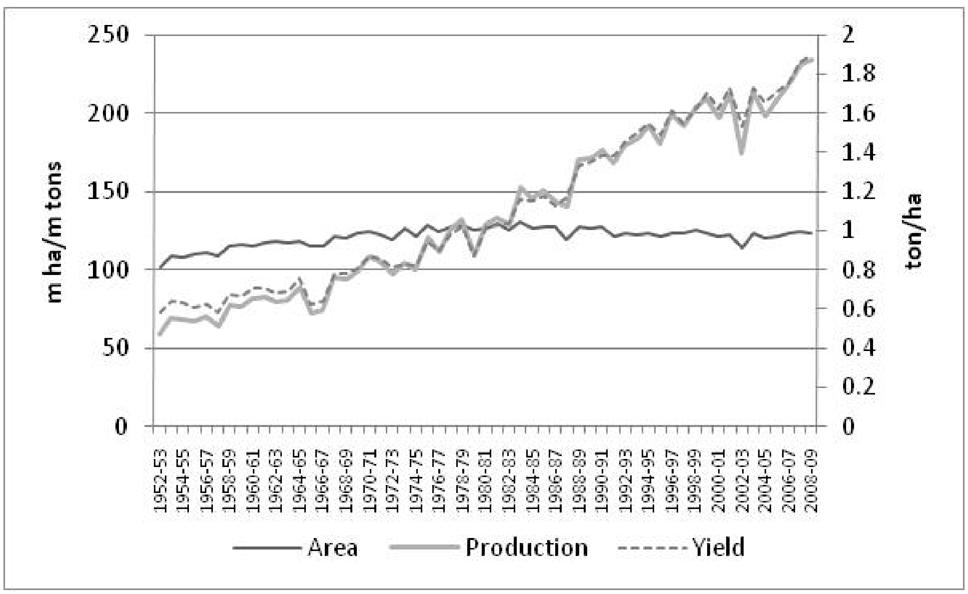
[1] This review paper is undertaken as part of the Cereal Systems Initiative for South Asia (CSISA) Project. The CSISA project has been started with the objective of providing an "overall strategy and a new umbrella for contributing new science and technologies to accelerating short- and long-term cereal production growth in South Asia's most important grain baskets" (CSISA 2010). India is one of the countries covered under the project.

2. TRENDS IN FOODGRAIN PRODUCTION AND PRODUCTIVITY

Immediately after Independence, India's foodgrain production growth was low and extremely unstable. Consequently, food aid and imports began to play an increasingly important role in meeting the growing domestic food demand. The turning point in India's food policy occurred in 1965/66 and 1966/67, when the country witnessed two consecutive droughts and foodgrain production plummeted to 72 and 74 million tons[2], respectively, from 82 million tons in 1960/61. This led to a shortage of foodgrains in the domestic market and rising food prices. India was forced to rely on wheat imports under Public Law 480 (signed with the United States in 1956), which compromised its political standing during the Cold War era and placed much stress on India's meager foreign reserves.

In order to prevent a future crisis, the government prioritized augmenting domestic production of foodgrains. A new agricultural strategy was launched in the mid-1960s—a package of policies and institutional innovations for the input supply and output management side, commonly called the *Green Revolution*.[3] Figure 2.1 shows the steady improvement in the level of foodgrain output and yield. Although there has been limited expansion of cultivated area, overall foodgrain yields have more than doubled from the Green Revolution period, due to intensified use of improved agricultural inputs and technology.

Figure 2.1—Foodgrains in India: Area (million hectares (m ha)), production (million metric tons (m tons)), and yield (metric tons/hectare (ha)) performance, 1952/53 to 2008/09



Source: India, Ministry of Agriculture 2010.

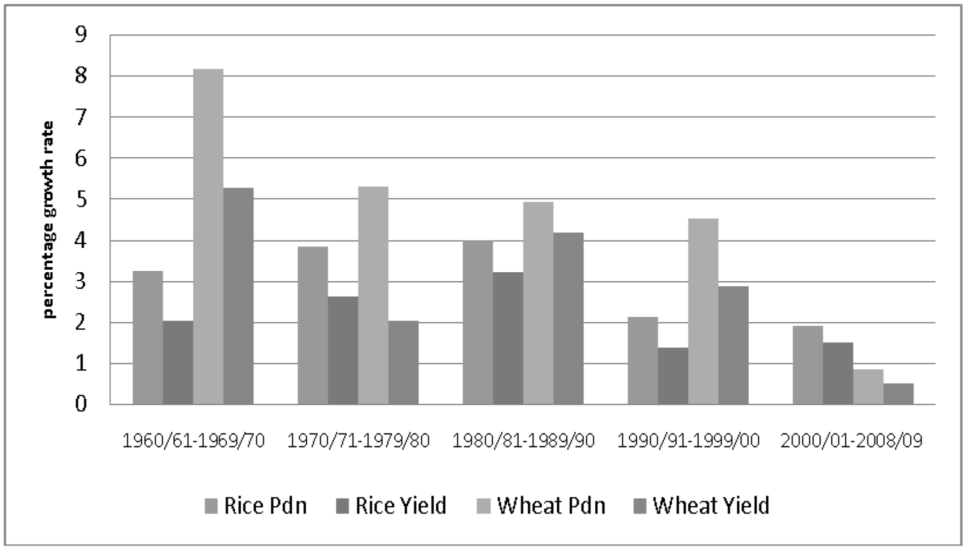
Self-Sufficiency in Rice and Wheat

The Green Revolution policy package aimed to boost foodgrain production to achieve self-sufficiency in a relatively short span of time. It focused primarily on rice and wheat, the two most important cereals in India. These two crops experienced the greatest production gains during the Green Revolution. Rice is the single largest cereal crop, constituting 40 percent of total foodgrain production and 36 percent of area under foodgrains. Since the 1970s, area under rice has increased by almost 6 million hectare, production

[2] Throughout this study "tons" refer to "metric tons".
[3] A detailed discussion of the Green Revolution policy framework follows later.

has increased by 47 million tons, and yield has doubled. Fastest production and yield growth was experienced in the 1980s when production grew at nearly 4 percent and yield growth was more than 3 percent per year (Figure 2.2).

Figure 2.2—Annual growth rate of production and yield: Rice and wheat

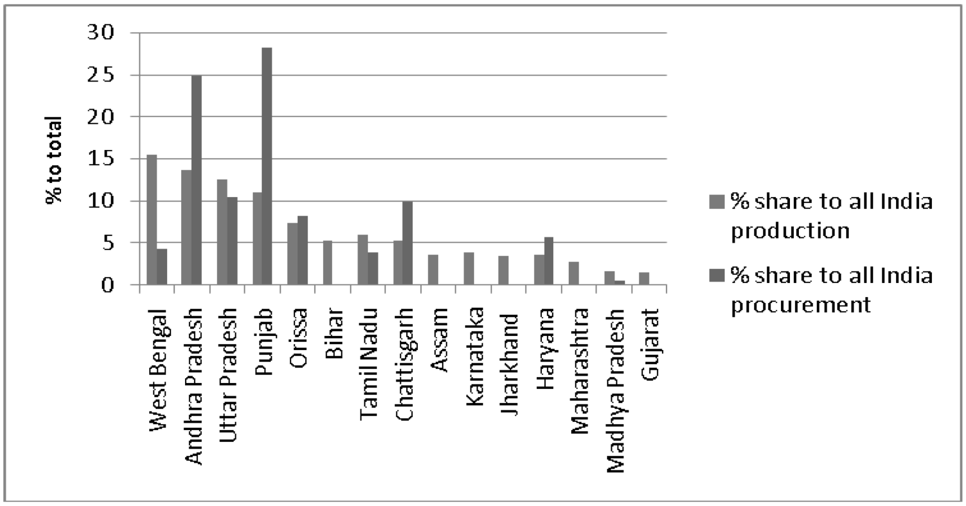


Source: India, Ministry of Agriculture 2010.
Note: Figures refer to growth rates of various crop years referred from the source.

Wheat is the second most important crop, constituting 34 percent of total foodgrain production and 22 percent of area under foodgrains. Wheat experienced the greatest boost during the Green Revolution, largely due to the success and spread of high-yielding variety (HYV) wheat seeds. Production growth during the 1960s was nearly 8 percent (when HYV seeds were introduced they pushed up wheat production by almost 45 percent in 1967/68 over the previous year) and slowly decreased in successive decades, finally dropping to less than 1 percent during 2000/01–2008/09. Yield tripled from less than 1 ton/hectare (TE 1960/1961) to 2.7 tons/hectare (TE 2007/08).

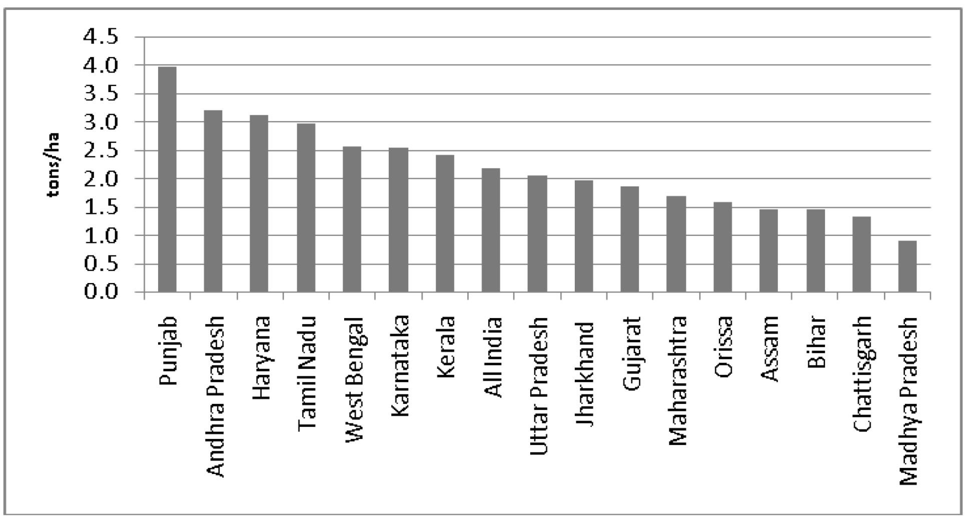
Although self-sufficiency in rice and wheat has been achieved at the national level, there is considerable regional variation in production and yield performance. Though rice is grown in almost all states, a few rice-intensive states—southern states of Andhra Pradesh, Tamil Nadu, and Karnataka; northern states of Punjab, Uttar Pradesh, and Haryana—drive much of the production growth. Along with the eastern states of West Bengal, Bihar, Orissa, and Assam, they contribute to more than 80 percent of the total rice production (Figure 2.3). West Bengal is the largest producer, contributing 16.5 percent of total production, followed by Andhra Pradesh, Uttar Pradesh, and Punjab, which contribute around 12 percent and 11 percent each (TE 2008/09). Over the past two decades, there has been no major regional shift in production patterns; the top three states have maintained their position. It is significant to note that although West Bengal is the largest producer, in terms of yields Punjab and Haryana top the list (Figure 2.4). High yields in these regions have been supported by the intensive input usage, with almost 100 percent irrigated rice and significant adoption of high-value and high-quality *basmati rice*. Apart from the relatively higher use of modern inputs, rice production has also been supported by assured procurement by the government from these particular states (Figure 2.3).

Figure 2.3—Top rice-producing states: Shares in total output and total procurement (percent, TE 2008/09)



Source: India, Ministry of Agriculture 2010.
Note: States arranged in descending order of share to total production.

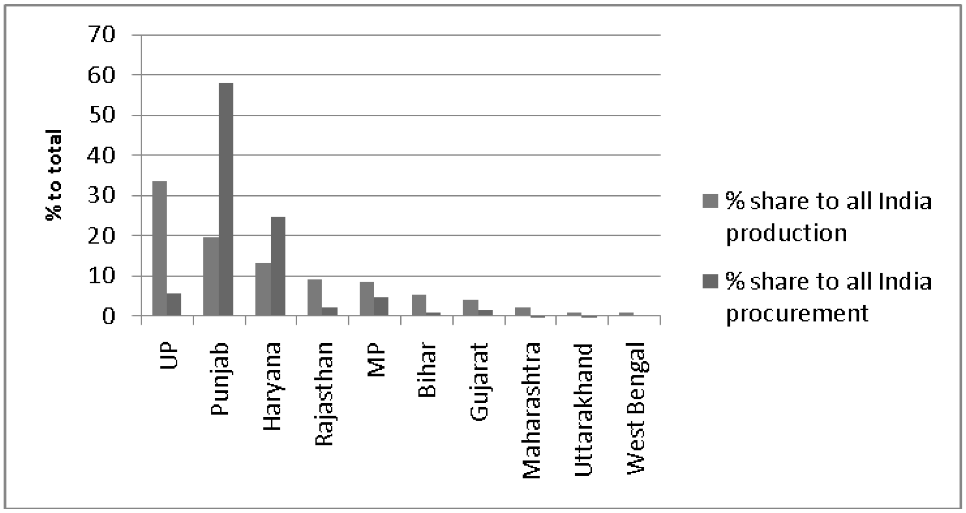
Figure 2.4—Rice yields across states (tons/hectare, TE 2008/09)



Source: India, Ministry of Agriculture 2010.
Note: States arranged in descending order of yield.

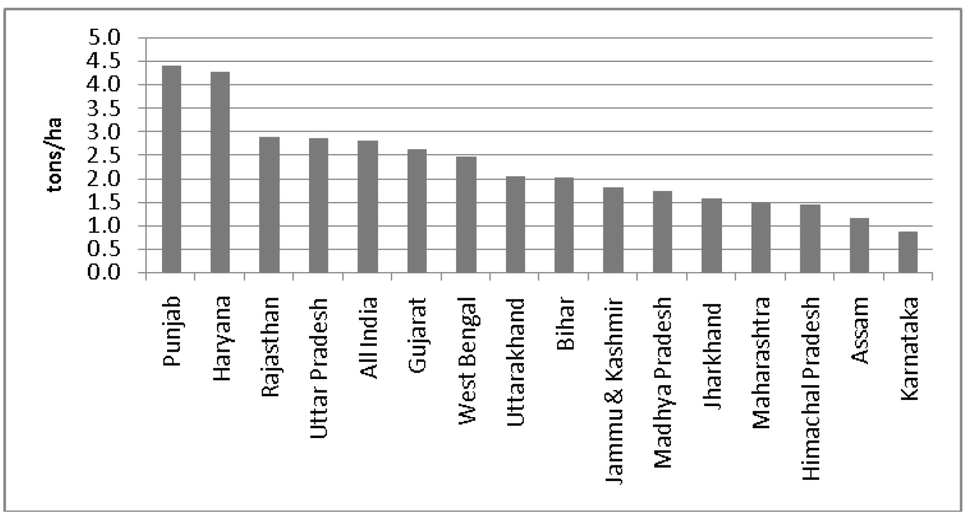
Wheat is primarily a *rabi* (winter) crop, and production is highly concentrated in the northern belt of Uttar Pradesh, Punjab, and Haryana, contributing 67 percent of total production (Figure 2.5) and 55 percent of area. Over the past two decades there has been no change in the ranking of the states based on their production. Uttar Pradesh, which contributes 33.5 percent of the country's output, ranks number one both in terms of wheat output and area (23.9 million tons from 9 million hectare). Madhya Pradesh, Rajasthan, and Bihar are the other significant wheat producers. In terms of yields, the northern belt tops the chart with Punjab and Haryana standing at the front well above all India average (Figure 2.6). With nearly 100 percent of wheat under irrigation, yield levels in Punjab and Haryana are almost one and a half times higher than in Uttar Pradesh. As with rice, these states also enjoy maximum support through high procurement (Figure 2.5).

Figure 2.5—Top wheat-producing states: Shares in total output and total procurement (percent, TE 2008/09)



Source: India, Ministry of Agriculture 2010.
Note: States arranged in descending order of share to total production. MP refers to Madhya Pradesh, UP refers to Uttar Pradesh.

Figure 2.6—Wheat yields across states (tons/hectare, TE 2008/09)

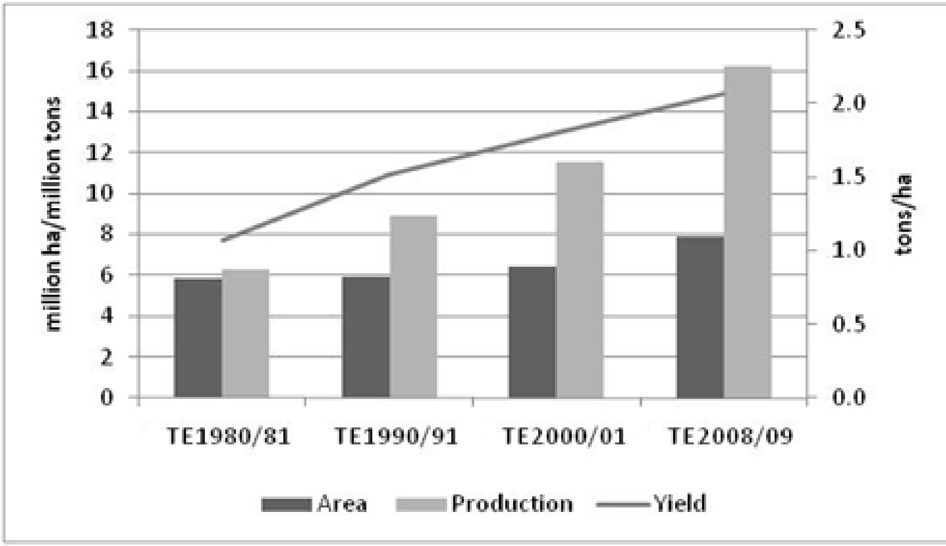


Source: India, Ministry of Agriculture 2010.
Note: States arranged in descending order of yield.

Rapidly Rising Maize Production

India currently ranks sixth in world maize production, contributing around 2.3 percent of production from 5.2 percent of cultivated area. This is a gradual rise from the 10th rank in the 1980s and 8th rank in the 1990s (Food and Agricultural Organization 2010). Yields are somewhat lower than the international average at around 2 tons/hectare, but have still doubled since the early 1970s (TE 1970/71). Within the Indian grains segment, however, maize performance has been dramatic. It has emerged as the third major foodgrain crop and the most important coarse cereal—it has risen from around only 5 percent of total foodgrain production in the 1980s and early 1990s to 7.4 percent (TE 2007/08) (Figure 2.7).

Figure 2.7—Growth in maize production and yields: All India



Source: India, Ministry of Agriculture 2010.

Maize is cultivated primarily in the *kharif* season and as a *rabi* crop in parts of southern and eastern India[4]. As a share of land under coarse cereals, the maize area has doubled from around 14 percent (TE 1980/81) to 27.5 percent (TE 2007/08). It contributed around 13 percent in production of coarse cereals in the early 1950s, increased to 21 percent by the 1980s and 1990s, and increased to 45 percent at present (TE 2007/08). The latest period (2000/01–2008/09) has seen high growth in the maize-cultivated area (above 3 percent per year) and more or less stable yield growth since the 1980s. This growth has largely been driven by rising adoption of hybrid seed from the private sector (refer to the following section), demand for feedstock (due to rapid growth in the poultry sector), and other indirect effects from economic liberalization in the 1990s (Narayanan, Dalafi, and Gulati 2008).

The expansion in area and production has been accompanied by a regional shift in cultivation since the late 1990s, to the southern states from the traditional *Maize Be*lt (Bihar, Madhya Pradesh, Rajasthan, and Uttar Pradesh) in the north (Narayanan, Dalafi, and Gulati 2008). Andhra Pradesh and Karnataka contribute 34 percent to total production, up from 14 percent (TE 1990/91)—against 37 percent from the Maize Belt in TE 2008/09 and 57 percent in TE 1990/91 (Figure 2.8). This is significantly at odds with what has been experienced in the rice and wheat sectors, which have experienced little regional shift in production. Andhra Pradesh and Karnataka also have higher yields (2.9 and 3.5 tons/hectare) compared to the Maize Belt states. However, Bihar's yields are the highest among the traditional maize-grower states, with around 2.3 tons/hectare, partly because 57 percent of the maize is irrigated with winter maize, which has emerged as an important *rabi* crop in the state (Figure 2.9). In contrast, maize yields in Madhya Pradesh, Uttar Pradesh, and Rajasthan are only a little above 1 ton/hectare.

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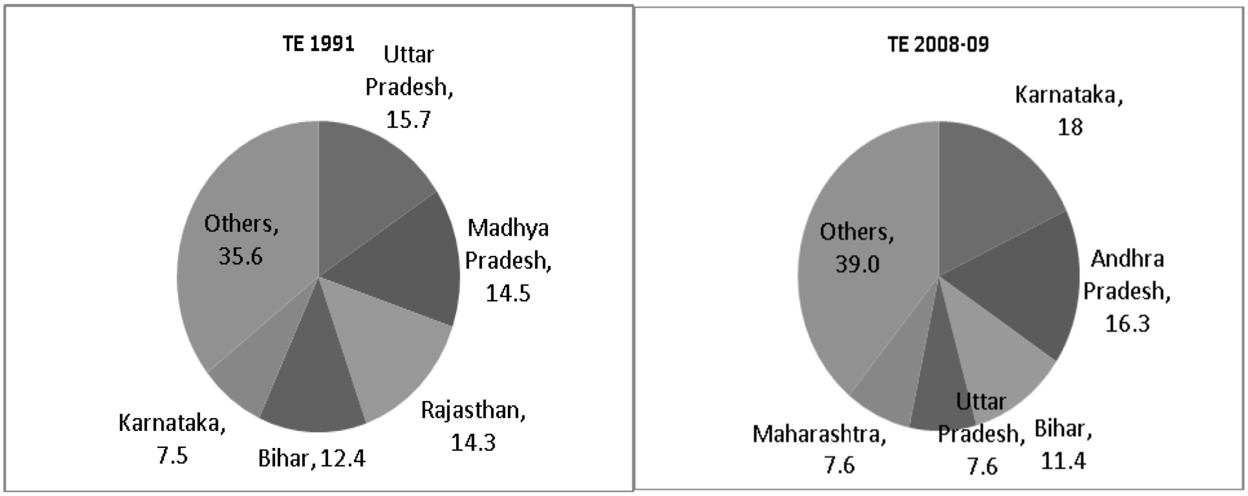
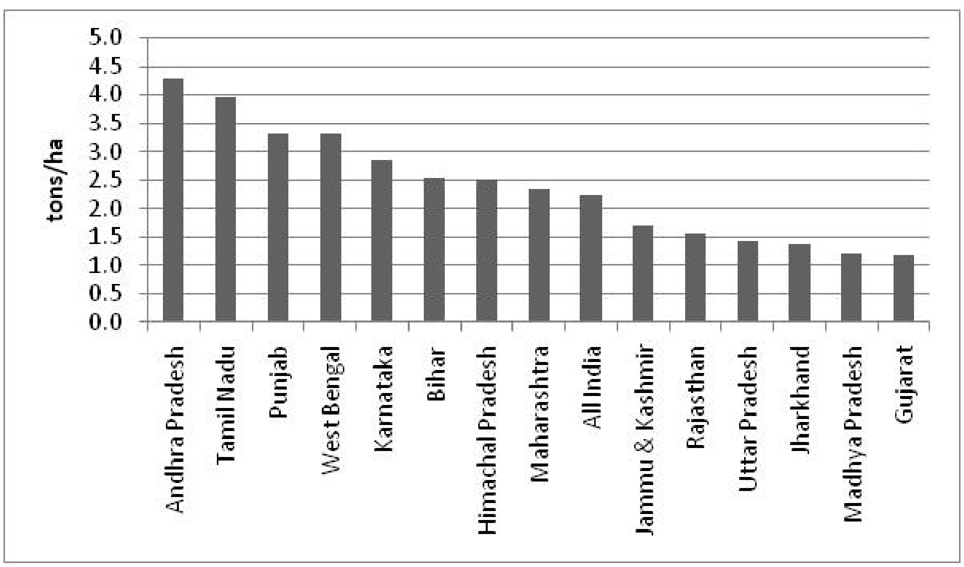
[4] The two main crop harvesting seasons in India are the Rabi (spring harvest) and Kharif (autumn harvest).

Figure 2.8—Regional shift in share of maize production (percent)



Source: India, Ministry of Agriculture 2010.

Figure 2.9—Maize yields across states (tons/hectare, TE 2008/09)



Source: India, Ministry of Agriculture 2010.

3. EVOLUTION OF FOODGRAIN POLICIES IN INDIA[5]

Green Revolution

As mentioned earlier, in the mid-1960s the government embarked on a new agricultural strategy—popularly called the Green Revolution—involving a set of policies and institutional innovations, including in the agricultural research system, to augment the supply and use of modern farm inputs in order to boost production. The strategy was also meant to manage output price and markets in a way that balanced the needs of consumer and producer welfare. Initially the focus of the Green Revolution policy package was on the two main cereals, rice and wheat. Maize and other coarse cereals received active government support only after the 1980s. Roughly, three phases can be identified during the course of the Green Revolution policies (Fan, Gulati and Dalafi 2008).

In the first phase (1966–1972) the policy focus was on modernizing and intensifying agriculture to raise yields through the use of improved seeds, multicropping methods, modern fertilizer and pesticides, and so on. In 1966, India imported 18,000 tons of high-yielding varieties (HYVs) of wheat seeds developed by Centro Internacional de Mejoramiento de Maiz y Trigo (CIMMYT) to be first sown in the irrigated parts of Punjab, Haryana, and Uttar Pradesh. Since agricultural research and development (R&D) was central to this strategy, the Indian Council of Agricultural Research (ICAR) was reorganized in 1965/66 to coordinate research of various state-level and commodity-based research institutes as well as other research centers that were under the Agriculture (MoA). Extension services and demonstrations were also carried out under the umbrella of famers' training activities. Other institutional innovations included the setting up of parastatals like National Seeds Corporation Limited for producing, processing, and marketing seeds on the input side; Agricultural Prices Commission for monitoring and controlling prices; and Central Warehousing Corporation and Food Corporation of India (FCI) for managing foodgrain produce and output. Initially, the main program for technology diffusion was the Intensive Agricultural District Program, which focused on around 13 high-potential districts mostly in the northern belt—Punjab, Haryana, and western Uttar Pradesh. Later this program was modified and extended to several other better endowed regions of the country as the Intensive Agricultural Area Program.

In the second phase (1973–1980), more investment went into developing new seed varieties, including efforts at developing hybrid rice, and Green Revolution technology spread to more areas. To encourage farmers to access inputs to augment production, extensive input subsidies were introduced, which only kept ballooning over time. By the mid-1980s, input subsidies in Indian agriculture were around 4 percent of agricultural gross domestic product (GDP) (TE 1985/86). This increased to around 8.7 percent by the end of the 1990s (TE 1999/00; Gulati and Narayanan 2003). Foodgrain production grew at more than 3 percent from 1972/73 to 1980/81.

The last phase is from 1980s onward, when India became food secure and successfully managed the 1987 drought. During this phase the government started paying more attention to the growing regional divide in foodgrain systems. In 1988, the Agro-Climatic Regional Planning Approach (ACRP) was initiated by the Planning Commission to formulate a macro-level strategy for the 15 broad agroclimatic zones. This *regionally differentiated strategy* continued to be emphasized in the Ninth and Tenth Plans. The government started providing support to coarse cereal crops such as maize, *bajra*, and *jowar* that were cultivated in the rainfed regions. For example, transport subsidy for movement of seeds was extended to maize in 1986/87. In 1995/96, the Technology Mission on Maize (TMM) was launched. Other schemes that affected maize production include Integrated Cereals Development Program in Coarse Cereals Based Cropping Systems Areas (ICDP-Coarse Cereals); Minikit Demonstration Program of Wheat, Rice, and Maize; and the UNDP-sponsored program for hybrid maize development (1997–2002). In 2004/05 a centrally sponsored Integrated Scheme on Oilseeds, Pulses, Oil Palm, and Maize (ISOPOM) was initiated under which Maize Development Program is being implemented in 15 states.

[5] This section describes the different phases in the evolution of foodgrain policies in India to set the stage for a more detailed review of specific policies covering different farm input and output management in later sections.

The large spatial variation in production and yield performance seen earlier was partly molded by past Green Revolution policies that favored the relatively well-endowed regions in terms of water resources. These regions benefited from the initial boom in investments, infrastructure, and inputs as the marginal returns to investment were higher. Although this strategy met food security needs rapidly, it left behind many of what are presently rainfed areas (Fan and Hazell 2000). Over the decades, however, several problems have arisen in the Green Revolution states as well.

The Challenges

The high growth witnessed earlier in these high-potential regions has finally begun to plateau as the effects of the Green Revolution technologies wear down. There is growing concern that input subsidies for fertilizers, irrigation, and electricity for water pumps have promoted unsustainable farm practices that are putting enormous stress on soil and water resources. The long-run sustainability of the production systems in these states and the rationale behind depending on them almost entirely for food security are questionable. For instance, Punjab contributes 31 percent of the rice procured and 66 percent of the wheat procured in the country (TE 2007/08). It is also the largest user of fertilizer per unit of land, and subsidies for water and electricity have enabled intensive rice cultivation, resulting in rapid depletion of groundwater reserves. About 75 percent of the districts are overexploited, that is, the groundwater use is more than 100 percent and the stage of groundwater development is 145 percent, highest among rice-growing states.[6] Water-intensive crops like rice may no longer be feasible in the region (Johl and Ray 2002). Policies need to be brought into place to overcome these environmental problems, reduce stress on natural resources, and better balance food security concerns across regions. The way forward for the Green Revolution states will be to develop a high-value segment such as horticulture, dairying, and poultry. This can be instrumental in revitalizing agricultural growth in these states and simultaneously addressing a different aspect of food security (Gulati, Cummings, and Ganguly 2009).

The eastern region (composed of the eastern Himalayan region; Assam and northeastern region; lower and middle Gangetic plains of eastern Uttar Pradesh; West Bengal, Bihar, and eastern plateau and hills Orissa, Jharkhand, and Chhattisgarh), which lags behind in yield indicators, is mostly rainfed, but has abundant water and natural resources. At present, the resources of this region are neglected or underused with poor access to markets, technology, and basic infrastructure (Planning Commission 2008). Unlike the rice-producing states in the north, the eastern states have much lower yield, which can be increased through adequate infusion of technology, water, and other agricultural inputs. If the eastern belt becomes the next high-growth belt for foodgrains, the burden of food security can also be shifted away from the northern belt. At present, although West Bengal is the highest rice-producing state, it contributes only 3.4 percent to the total rice procured (TE 2007/08). Economic growth seems to be already picking up in other states, especially Bihar, which has showed signs of faster agricultural growth (3 percent–5 percent per year during 2000/09, though still volatile) as well as overall economic growth (see Sharma et al. 2010; *Economist* 2010; Aiyar 2010).

The National Food Security Mission and Second Green Revolution

Recognizing the looming threats and opportunities facing the foodgrain sector, the Indian government has launched a set of policy initiatives under the National Food Security Mission (NFSM) to stimulate growth of rice, wheat, and pulses. The NFSM has three components (1) NFSM-Rice (2) NFSM-Wheat, and (3) NFSM-Pulses, which aim to increase the production of rice by 10 million tons, wheat by 8 million tons, and pulses by 2 million tons, respectively, by the end of the Eleventh Plan (2011/12).

Demonstrations in best farming practices, incentives/subsidies for distribution/replacement of (hybrid) seeds/farming implements/machinery, incentives for soil micronutrients, and incentivizing local farming initiatives are some of the activities under NFSM. It is presently being implemented in 312

[6] The stage of groundwater development (percent) is defined as [annual groundwater draft/net annual groundwater availability] * 100.

districts in 17 states across India. Though it is a centrally sponsored scheme, implementation is decentralized; the state and district agencies are responsible for management of funds and implementation, and the village *panchayats* are actively involved in identification of beneficiaries and priority areas for Mission interventions and implementation of local initiatives in the identified districts (Ministry of Agriculture [MoA] 2010d).

Fifty-two percent of the target districts for NFSM-Rice fall in the eastern region (if Uttar Pradesh is added to the eastern belt, the figure rises to 71 percent). For NFSM-Wheat, the majority of the target districts are spread more or less evenly over the eastern (49 percent, including Uttar Pradesh) and northwestern region (51 percent, including Madhya Pradesh). It is heartening to note that the eastern region, especially Bihar, has received the attention of policymakers, with the largest number of districts in NFSM-Rice and second highest number of districts under NSFM-Wheat.

Since agriculture is primarily a state subject under the Indian Constitution (that is, the responsibility of state governments), an additional central assistance scheme called the Rashtriya Krishi Vikas Yojna (RKVY) was also launched in August 2007. The RKVY scheme is expected to play a major role in promoting state-level agricultural growth as well as incentivizing state plan investments in agriculture and allied sectors via additional resources from the center. Following this, allocation as a percentage of total state plan expenditure has gone up marginally to 5.8 percent in 2008/09 from 5.1 percent in 2006/07 (Ministry of Finance 2010). Some broad focus areas include integrated development of foodcrops (coarse cereals, minor millets, and pulses); mechanization; soil health and productivity; development of rainfed farming systems; horticulture; marketing; and so on.

In order to usher in a second Green Revolution in the rainfed areas and eastern regions, a concerted strategy fueled by adequate resources is a mandatory first step. The Budget 2010/11 has allocated Rs 67.2 billion for the RKVY scheme, which amounts to 32.2 percent of the total budget provision for the MoA. The NFSM has received Rs 12.2 billion or 5.8 percent of the budget provision. The two new subcomponents of the RKVY to be introduced in the coming year include a special initiative for pulses and oilseeds development in selected villages in rainfed areas and a scheme to bridge the yield gap in the eastern region (Ministry of Finance 2010). In the first subcomponent of RKVY, each of the target 60,000 pulses/oilseeds villages will get only Rs 50 thousand, going by the current budget allocation. Rs 4 billion may also be insufficient to significantly boost productivity and revolutionize foodgrain cropping systems in the six eastern states. Efforts must be scaled up.

The impact and reach of these initiatives have yet to be fully evaluated. At the all India level, both NSFM-Rice and NSFM-Wheat seem to have made more progress in 2008/09 than 2007/08, although actual performance is below the target rates in many activities. At the state level, there have been reports of improvements in productivity/production and input usage after NSFM. According to the Government of Uttar Pradesh (2010), non-NFSM districts seem to have registered slower production and productivity growth compared to NFSM districts in 2007/08 and 2008/09 over the previous year. According to the Government of Bihar (2010), although production and productivity response has been mixed in NFSM districts (mainly due to severe floods in some rice and pulse districts), the coverage of Boro rice in 2008/09 still showed a 94 percent increase over the previous year. In Maharashtra, the state government reports steady increases in seed replacement rate and better productivity growth in NSFM districts for rice and wheat in 2008/09 (Government of Maharashtra 2010).

The NFSM and the efforts to usher in a second Green Revolution reflect the government's commitment to ensure national-level food security. At its core, the strategy involves bringing the benefits of modern technology to the eastern parts of the country that the Green Revolution bypassed. A set of supportive input and output policies is critical to this effort. The following sections review these policies in detail, starting with the input policies in the next section.

4. INPUT POLICIES

As seen earlier, ensuring adequate supply of quality seeds, irrigation, fertilizer, and farm equipment has been a key element in the relative success of the Green Revolution. The government has maintained elaborate policies with regard to not just these farm inputs, but also to providing agricultural support services such as research, extension, and credit. This section reviews the current status with regard to each of these inputs and support services, and also the evolution of the policies pertaining to them.

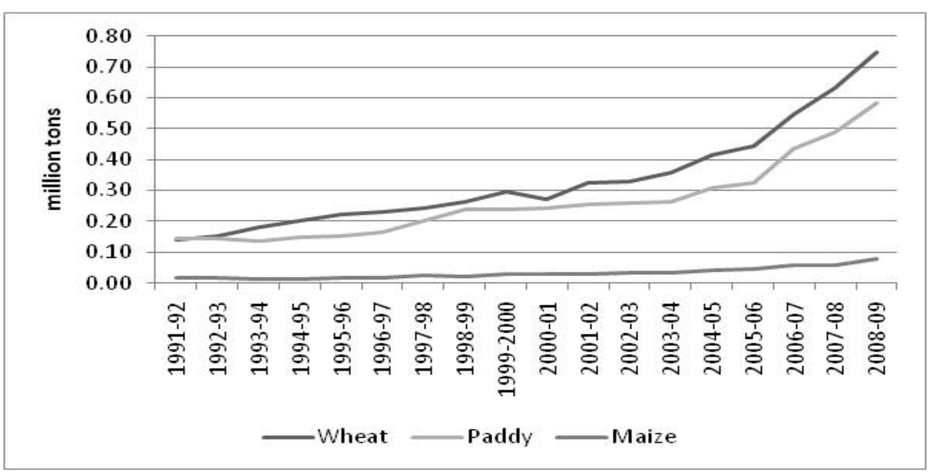
Seed-Sector Review

Current Status

There has been a manifold increase in the area under high-yielding variety (HYV) (as a percentage of total cropped area of the crop) from 1966/67 to 1998/99. From being almost negligible (in 1966/67) the area under HYV (in 1998/99) was 90 percent, 75 percent, and 60 percent for wheat, rice, and maize, respectively. Most of the cereal seed production, especially rice and wheat, still comes from the public sector. In contrast, the private sector so far has largely been concentrating on high-value and low-volume crops such as cotton, vegetables, and so on, hybrid maize, and in recent years, hybrid rice. The public sector is composed of the National Seeds Corporation and State Farms Corporation of India (both at the national level) and 15 State Seed Corporation, which carry out and coordinate research, production, and distribution of seeds in the country. Presently about 500 private-sector seed companies operate in India. Some of the private companies are into plant breeding and seed production, whereas the majority is into seed multiplication. The private sector's share in the total quality seeds produced in the country is about 41 percent[7] and its share in value is about 90 percent (Rao 2008). Unfortunately, there are no clear estimates on the exact share of the public and private sector for various crops or for different varieties of a single crop.

The production of breeder seeds for rice and wheat has increased more than twofold since 2003/04. The distribution of quality seeds of principal cereal crops has shown an upward trend since the 1990s (Figure 4.1). The private sector has played a significant role in widespread distribution of the seeds. This is also reflected in the gradually increasing Seed Replacement Rate (SRR) of the three crops (Table 4.1). Although the SRR has been increasing, it is still far away from the prescribed norm. Wheat and rice cultivation in India is still largely dependent on farm saved seeds; 91 percent and 85 percent, respectively.

Figure 4.1—Distribution of quality seeds of major cereal crops



Source: Ministry of Agriculture 2010a.

[7] Accessed from http://dacnet.nic.in/seednet/seeds/material/IndianSeedSector.htm.

Table 4.1—Seed replacement rates (percent) of major cereal crops

Years	Wheat	Rice	Maize
2001	13.04	19.22	20.98
2002	13	19.31	21.35
2003	13	19.16	24.41
2004	16.48	23.28	31.5
2005	17.64	24.35	35.39
2006	18.03	25.1	36.23

Source: Government of India 2010.

In fact, maize has been the only major cereal crop (among wheat, rice, and maize) that has been affected significantly by hybridization. Hybrid maize was promoted by the public sector in the 1980s, but it was the arrival of the private sector in the 1990s that helped spread hybrid maize production. A study by Singh and Morris (1997) provides a fair idea of how the dynamics in the hybrid maize industry changed with the entry of private sector. Based on a survey of 864 maize-growing households across six Indian states that account for more than 70 percent of the total area under maize in India, the study estimates that about 45 percent of the total area under maize in the country was sown with hybrid maize seeds and the private sector accounted for more than 90 percent of the total hybrid maize seeds sold in India. The study also found that commercial maize farming, largely in the states of Karnataka and Andhra Pradesh (which also have higher yields, as seen in the earlier section), was big on adopting hybrid maize seeds.

Research on hybrid rice was initiated from 1989 onward by the Indian Council of Agricultural Research (ICAR) via a national network for hybrid rice research, seed production, and extension of 12 research units and many voluntary agencies across India. Hybrids were first commercially released in 1994; by 2003, around 18 varieties were available, and during 2004/09, 24 more varieties were brought out. Based on seed quantity sold, India's hybrid rice acreage works out to a mere 1.4 million hectare or 3 percent of rice acreage in 2008 (Viraktamath et al. 2010). Although the scale of adoption is too low to show a marked improvement in national yields, yield increases over inbred high yielding varieties (HYVs) are estimated to be around 15–20 percent. Adoption has picked up since 2004, mainly in eastern regions, but hybrid rice cultivation is still concentrated in a few northern and eastern states, namely, Haryana, Punjab, Uttar Pradesh, Bihar, Jharkhand, and Chhattisgarh, which collectively account for more than 80 percent of hybrid rice area (Viraktamath et al. 2010). From a primary survey in selected Indian states, Janaiah (2002) identified low-yield advantage (of up to 16 percent; inbred varieties even outyielded the hybrids in many cases) as one of the reasons for low uptake by farmers. Because of inferior taste and grain quality, the hybrid rice also fetched relatively lower prices in the markets. Experiences in China suggest both yield advantages (hybrid rice varieties show yields of up to 7.2 ton/hectare; Li, Xin, and Yuan 2009) and grain-quality improvements are possible (Shi-hua et al. 2004). The experience with maize hybrids suggests that the private sector can play an important role in the development of suitable rice hybrids and that it is imperative to build partnerships between the public and private sector in research and marketing activities.

Policies and Challenges

During the 1950s and early 1960s, although good-quality seeds were recognized as a critical input, seed production and improvement was largely informal and unorganized, spread across farmers and scientists at the local level. Improving the quality of seeds was a hurdle to raising productivity. Finally, the government set up the National Seeds Corporation (NSC) in 1963 to streamline production, storage, and distribution of seeds. Although seed distribution from various research and development (R&D) centers was taken up by the government and private agencies, in the absence of an official framework to certify seeds, the process of production and distribution was fragile and lacked regulation. In 1966 the Seeds Act was passed, which laid down the first guidelines for seed certification in independent India. The Seeds Order (1983) further regulated and streamlined the marketing of the certified seeds. It established seed as an essential commodity under the purview of the Essential Commodities Act (1955) and made licensing of the dealers mandatory.

Simultaneously, the Indian government began to coordinate with international agricultural research centers to bring in HYV of principal crops such as rice, wheat, and maize, which contributed to initial successes under the Green Revolution. In keeping with the rising demand for improved seed varieties, the government expedited seed production via research centers such as the ICAR, the state agricultural universities, NSC, and so on. These actions led to a sudden surge in seed production in the country and according to Chaturvedi (2009) due to the glut like situation in the seed sector during 1968 to 1971 many companies closed down and there was a large-scale retrenchment.

In 1968, government appointed a Seed Review Team to review performance and requirements of the seed industry. The primary recommendation of the team was establishment of a quality infrastructure for seed production, certification, and storage. It required a perseverant effort. This led to the launch of the World Bank–assisted National Seeds Project (NSP). The NSP was implemented in three phases across the country and lasted for almost two decades (1976–1995). The NSP was able to provide a infrastructural boost to the seed-production industry, and later on gave rich economic dividends. The third phase of the NSP was instrumental in encouraging the private sector by providing concessional loans to the R&D-based private seed companies. This was a turning point in the history of Indian seed industry as the role of the private sector was getting extended from distribution to production as well. The turnaround was further supported by the policy initiatives from the government, such as the New Policy on Seed Development (1988) and the New Industrial Policy (1991), that opened doors for foreign investors in the Indian seed industry. Since then, a number of multinational companies have entered the Indian seed market.

With the entry of private seed companies, both domestic and multinational, and their increasing role in R&D, Intellectual Property Rights (IPR) issues and breeders rights have become dominant concerns in the seed sector. IPR issues came to the forefront following the initial experiences with the TRIPS Agreement of 1994. In response, the Protection of Plant Varieties and Farmers' Rights Act (PPVFR) was formulated in 2001, which gives breeders and farmers the right to produce, sell, market, distribute, import, and export. The criteria for protection are novelty, distinctness, uniformity, and stability for a new variety and all except novelty for an extant variety. The act aimed at encouraging the private sector to invest in R&D for development of plant varieties, which is evident from the increase in the number of private companies entering the seed industry. The act would, however, not affect public-sector research considerably (Rao 2004). The PPVFR Authority was established in November 2005 to implement the act.

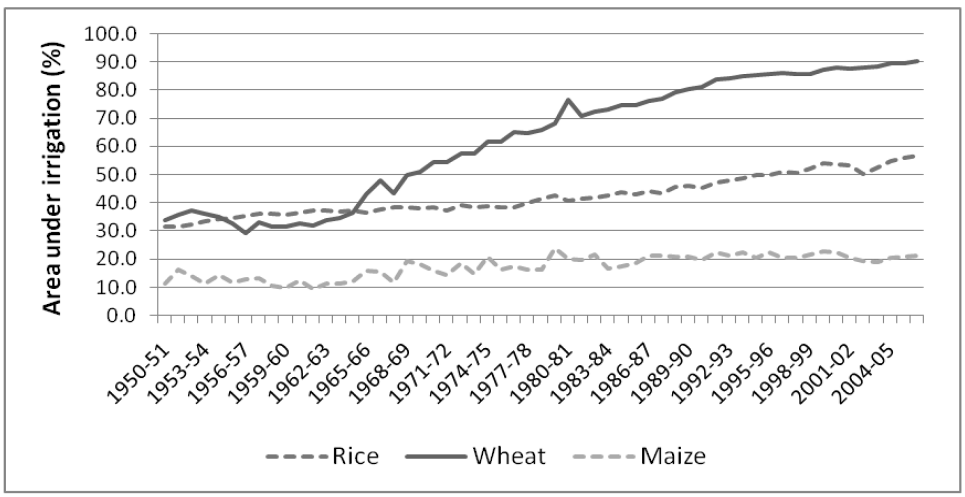
In 2002, National Seed Policy was drawn up, with an objective centered on "the provision of an appropriate climate for the seed industry to utilize available and prospective opportunities, safeguarding of the interests of Indian farmers and the conservation of agro-biodiversity. While unnecessary regulation needs to be dismantled, it must be ensured that gullible farmers are not exploited by unscrupulous elements. A regulatory system of a new genre is, therefore, needed, which will encompass quality assurance mechanisms coupled with facilitation of a vibrant and responsible seed industry" (MoA 2001). Thus, there is clear emphasis on the need for vibrant participation of the private sector in the Indian seed industry. It provides guidelines for aspects of production, distribution, and trade of seeds. The Seed Bill 2004 was formulated to meet the goals of the Seed Policy 2002. The 2004 bill also aims to improve upon the 1966 Seeds Act by incorporating the certain provisions of the PPVFR Act (2001). However, the 2004 bill has yet to be passed by the Parliament due to various concerns expressed by farmers' organizations and activist groups. Recently the government has proposed a Seed Bill 2010, with some changes to the 2004 bill, which seeks to address these concerns. Major changes include making registration of seed varieties compulsory for commercial sale of seeds (farmers have been exempted from this) and provision of more stringent penalties for violations. Until the bill is passed by the Parliament and becomes a law the current uncertainty over seed-sector regulation is likely to persist, which could hamper entry of more private seed R&D companies and affect the future investment plans of existing companies.

Irrigation-Sector Review

Current Status

Irrigation for the major cereal crops has grown significantly over time. Among rice, wheat, and maize, wheat enjoys the largest area under irrigation (90 percent), largely in the northern states, and maize has the least (21 percent) in TE 2006/07 (Figure 4.2). Though rice is a highly water-intensive crop, only 56 percent of the cultivated area is under irrigation. Overall, agriculture in India is mainly rainfed; only about 43 percent of the gross cropped area (GCA) is under any type of irrigation. As monsoons contribute about 75 percent of the total precipitation (Chand and Raju 2009), the vagaries of the monsoons continue to affect agricultural performance. Drought-proofing agriculture and water resource management are especially critical to ensure stability in crop output.

Figure 4.2—Irrigated area of rice, wheat, and maize: Percent share to total cropped area, 1950/51–2006/07

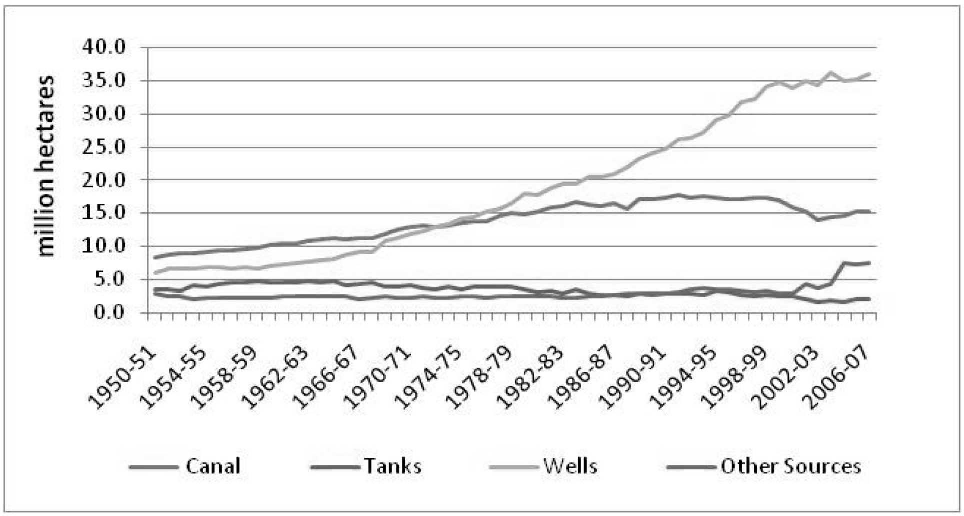


Source: Government of India 2010.

For the first decade after Independence water from canal networks was the main source of irrigation, accounting for about 41 percent of the net irrigated area. Canal irrigation broke into the 15 million hectare mark in 1978/79 (Figure 4.3). Astonishingly, in 2006/07, about 30 years later, it remains at almost the same level even though the government pumped in Rs 1.67 trillion (almost 5 percent of the total plan expenditure) for Major and Medium (M&M) projects during this period. The public investments in M&M projects (as a percentage of total plan expenditure) kept declining with each plan, resulting in the spilling over of M&M projects into the successive five-year plans. To arrest this trend, the central government came out with the Accelerated Irrigation Benefit Program (AIBP) in 1996/97 to help states complete the *last mile* projects. It was a central loan assistance scheme with a funding pattern of 2:1 (center is to state) for nonspecial category states and 3:1 for special category states. The Ministry of Water Resources (2009) reports that about 111 of the 272 M&M projects and 6,640 of the 10,236 surface minor schemes have been completed so far. Since its inception, about Rs 348 billion has been spent under AIBP, and it has reportedly generated about 6 million hectare of irrigation potential. However, the total area under canal irrigation since 1996 has gone down by about 1.8 million hectare, indicating possible decline in the utilization of the irrigation potential. This wide gap between the potential and utilization of irrigation facilities is one of the major issues that continue to plague the M&M projects.

In contrast to the stagnant situation of canal irrigation during the last two decades, groundwater irrigation experienced a boom after the Green Revolution. Within two decades groundwater irrigation became the *major* source of irrigation (Figure 4.3), accounting for about 60 percent (for TE 2006/07) of the country's net irrigated area. Development of groundwater irrigation has been fueled largely by private investments that were affordable in scale and assisted by some state-specific credit schemes, thriving groundwater markets, subsidies on credit (for pumps and borings), and huge subsidies on electricity. Electricity consumed by agriculture activities rose to 30 percent of the total power consumed in the 1990s, making it the single largest energy guzzler of all sectors. Although the percentage share of agriculture has come down to 21 percent, the actual consumption has increased. The State Electricity Boards (SEBs) charge almost negligible rates to agricultural consumers and try to cross-subsidize it by charging higher rates to the industry. But as revenues are still too low, SEBs make huge losses that are covered by the state governments. Power subsidies for TE 2007/08 were Rs 200 billion and accounted for about 29 percent of the total subsidy to agriculture (Figure 4.4).

Figure 4.3—Net irrigated area (in million hectare) in India from 1950/51 to 2006/07

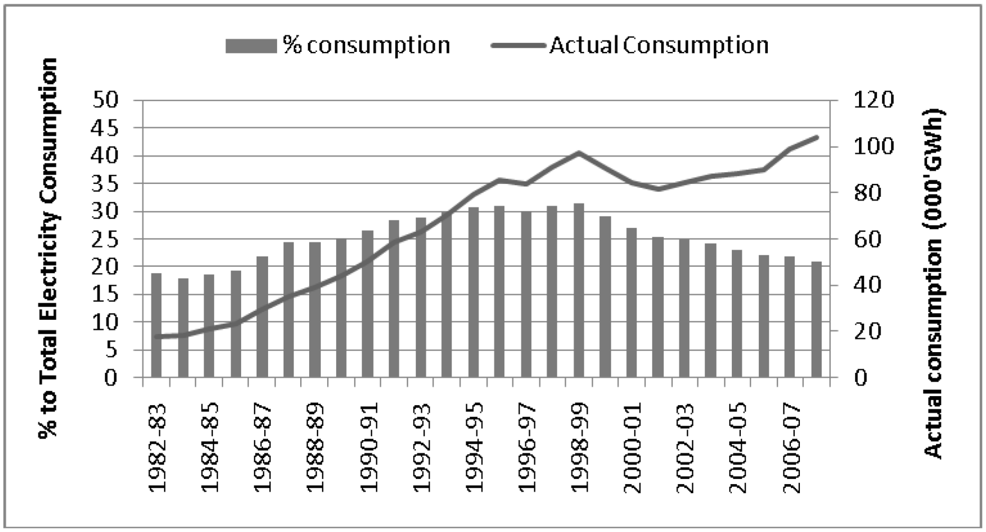


Source: Government of India 2009.

Excessive subsidies, poor canal networks, and lack of regulation have contributed to unsustainable levels of groundwater withdrawals. In a span of just seven years around 5 percent of villages in the country were added to the worst category with groundwater levels beyond 50 meters. At the state level current groundwater levels and rates of groundwater withdrawals present a snapshot of the current situation.[8] Figure 4.5 is a scatter diagram across these two dimensions of the top 15 cereal-producing states in India, which account for about 95 percent of the total cereal production in the country. Karnataka, Punjab, Haryana, and Rajasthan are the (relatively) worst off states in terms of the groundwater situation. Moreover, all these states hold single-digit ranks (respective ranks are in parenthesis) in terms of cereal production. The states near the origin have good groundwater levels and their withdrawals are also in the safe zone. Interestingly, almost all these states are at lower ranks in terms of cereal production. This supports the argument of reorienting rice cultivation to the states in the east.

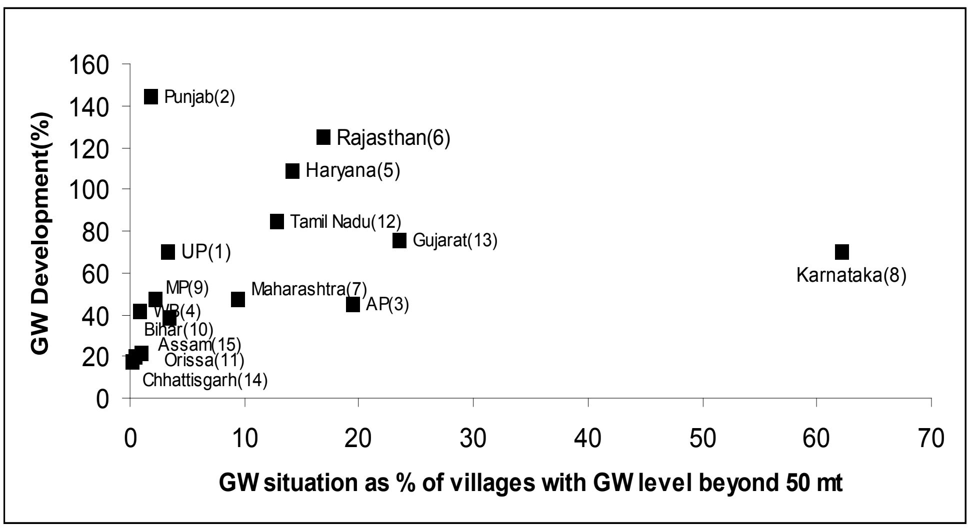
[8] We have used percentage of villages with groundwater levels beyond 50 meters as a proxy for the first dimension; a large percentage implies inferior position. For the rate of withdrawals we have used stage of groundwater development (percent), which is a standard statistic released by the Ministry of Water Resources. A 110 percent stage of groundwater development implies groundwater withdrawals are 1.1 times the natural recharge.

Figure 4.4—Electricity consumption by agricultural sector



Source: Government of India 2009.

Figure 4.5—Percentage of villages with groundwater level beyond 50 meters versus groundwater development (GW, percent)



Source: Ministry of Water Resources 1993–1994, 2000–2001 and Central Ground Water Board 2006.
Note: GW refers to groundwater; mt refers to meters.

One of the factors underlying low exploitation in the eastern states is the dismal electrification scenario of these states—only 59 percent of the villages in Bihar, Assam, Jharkhand, and Orissa are electrified, as opposed to the national average of 84 percent. This makes diesel/kerosene the main energy source for extracting groundwater in these states. For the four major eastern states of Bihar, West Bengal, Orissa, and Assam, about 92 percent of the pumps are operated on diesel. On the contrary, in the northern states of Punjab, Haryana, and Rajasthan, about 41 percent of the pumps run on diesel. This makes the economics of irrigation across states skewed. Good electrification coupled with electrical subsidies in the northern states makes pumping out groundwater (relatively) economical as compared to the eastern states. This goes well in accord with the groundwater situation in the two regions as well.

Policies and Challenges

Water management largely falls in the domain of state governments, though the center is entitled to regulate and develop interstate rivers through law, if required for public interest. However, so far the water policy has been a gray area in India; the first well-documented *national* water policy came out in as late as 1987. Box 4.1 lists some of the major milestones in irrigation policies in India.

Box 4.1—Evolution of irrigation policy in India

1970—Model Bill to regulate groundwater development
1972—Second Irrigation Commission Report
1974—Command Area Development Program (CADP)
1980s—Formation of the National Water Resource Council (NWRC)
1987—National policy was brought out by the NWRC
1992 and 1996—Revised Model Bill to regulate groundwater development
1997—Participatory Irrigation Management (PIM) at the state level with the Andhra Farmers Management of Irrigation Systems Act
1993—Vaidhyanathan Committee Report
2002—Revised national policy was brought out by the NWRC

Source: Authors' compilation.

Prior to the 1987 National Policy, canal irrigation was seen as the main method to develop water resources carried over from the colonial state. Accordingly, the majority of the policy interventions in independent India's irrigation history were in the domain of canal irrigation. Nevertheless, providing and maintaining existing canal systems has been a major challenge. During the colonial era irrigation projects were required to deliver a minimum rate of return. But in newly independent India, the recovery rates of large irrigation projects declined drastically in the initial stages although it increased later (the ratio of working expenses to direct receipts received through water fees collection during the third five-year plan (1961–1966) was 0.85 and increased to 14.4 by the end of the ninth plan (2002–2007)) (Svendson, Gulati, and Raju, unpublished draft). Despite the recommendations for upward revision by the Second Irrigation Commission 1972 and the Vaidhyanathan Committee 1993, water rates have remained unchanged for several decades in most of the states, probably due to the political undertones attached to the issue.

The under-recovery from irrigation projects means that the irrigation subsidy bill of the government has been ever growing. Irrigation subsidy stood at Rs 173 billion for TE 2007/08 and accounts for about 26 percent of the total subsidy to agriculture. The excessive financial burden and negligence in management of these systems have constrained Indian canal irrigation systems. Siltation of reservoirs and canals, lack of maintenance of the irrigation infrastructure, water-logging, and thin spreading of public investments are some of the reasons cited behind the deterioration in canal infrastructure and loss in canal irrigated area (Shah 2009; Gulati and Svendson 1995).

These problems have resulted in a widening gap between the potential created and the potential utilized from M&M irrigation projects, as seen earlier. The Second Irrigation Commission Report (1972), which was the first significant step in the history of canal irrigation policy in India, sought to address this issue. Following its recommendation, in 1974 the government established CADP for centrally sponsored M&M irrigation projects. About 162 of the total 310 projects under CADP have been completed so far, which makes about five projects per year. Nevertheless, the objective of reducing the gap between potential created and utilized is yet to be realized.

In 2004/05, on a recommendation from the Planning Commission, the mandate of CADP was extended and it was linked to PIM. PIM was first implemented by Andhra Pradesh through the Andhra Farmers Management of Irrigation Systems Act in 1997, followed by many states such as Madhya Pradesh, Rajasthan, Tamil Nadu, and so on. PIM aimed to empower water users, by handing over the administration and distribution of canal waters at the field level to user groups named Water User

Associations (WUAs). Though there have been thousands of registered WUAs, only some are functional and success has been limited to certain pockets. First, institutional reforms were not coupled with the much needed financial reforms and did not go beyond farm-level water management. Probably, reforms across the ladder could have produced better results. Second, the reforms initiated were far from complete as the collection of water charges was not in the domain of the WUAs. Finally, and most importantly, canal irrigation with all its internal problems was competing with groundwater, a much more reliable, sometimes cheaper, and more convenient source of irrigation for the farmers.

The tube well revolution that resulted in the rapid expansion of groundwater irrigation has been supported by large subsidies on credit and electricity. These subsidies have resulted in unsustainable use of groundwater in several parts of the country, especially in the main cereal-producing northern states. This unsustainable groundwater withdrawal needs to be checked immediately. New innovative legislations are needed to target the withdrawal rates as well as arrest increasing power subsidies. Apart from a top-down approach (through law) the government should come forward and promote community management of groundwater resources and conjunctive use of water. From the demand side, shifting of cereal procurement from the central pool to the eastern states would move the highly water-intensive rice cultivation to these states from the northern states of Punjab and Haryana.

The poor performance of canal irrigation in the last couple of decades cannot be neglected further. Canal networks provide water to irrigate the fields directly, but they augment the groundwater recharge as well. Canal irrigation and groundwater irrigation are supposed to contribute 42 percent and 46 percent respectively toward the total irrigation potential of the country. Out of the 64 million hectare usable irrigation potential through groundwater, 13.2 million hectare (about 21 percent) would be the potential augmented due to recharge from the canal systems (Government of India 2002). This elucidates the critical role canal irrigation is going to play in the future institutional and financial reforms that are indispensable in canal irrigation.

Finally, a large policy lacuna in the existing water and irrigation scenario in India is the lack of an effective water policy regime. The Ministry of Water Resources prepared a model bill to regulate groundwater development in 1970, which was revised in 1992 and in 1996; but it has still not been passed. NWRC was formed in the 1980s to construct an umbrella water policy. The first national policy was brought out by the NWRC in 1987. A revised policy in 2002 attempted to dovetail key issues related to water rights, water availability, fungible uses of water, competition among different sectors of the economy for water as an economic input, its sustainable use, and so on. But as this is not backed by law, the policy acts more like a guiding document than a regulatory one.

Fertilizer Sector Review[9]

Current Status

Since Independence, one of the dominant goals of fertilizer policy has been to attain self-sufficiency in nitrogenous and phosphorous fertilizers production,[10] as India depended heavily on international markets to meet domestic demand. At the dawn of the Green Revolution, 80 percent of the fertilizer demand was met through imports (1966–1967). The government was well aware of the need to have significant domestic fertilizer production capacity. Public investments grew to develop the required capacity for nitrogenous and phosphorous fertilizers. Due to efforts from the public, private, and cooperative sector, by 2009 India has a total production capacity of 12.06 million tons and 5.66 million tons of nitrogen and phosphorous fertilizers, respectively. In 2002/03 India was able to meet almost 90 percent of the total nutrient demand from domestically produced fertilizers; which dropped to about 72 percent for TE 2007/08; for Nitrogen (N) and Phosphorous (P) the percentage demand met was 81 percent for TE 2007/08 (Figure 4.6).

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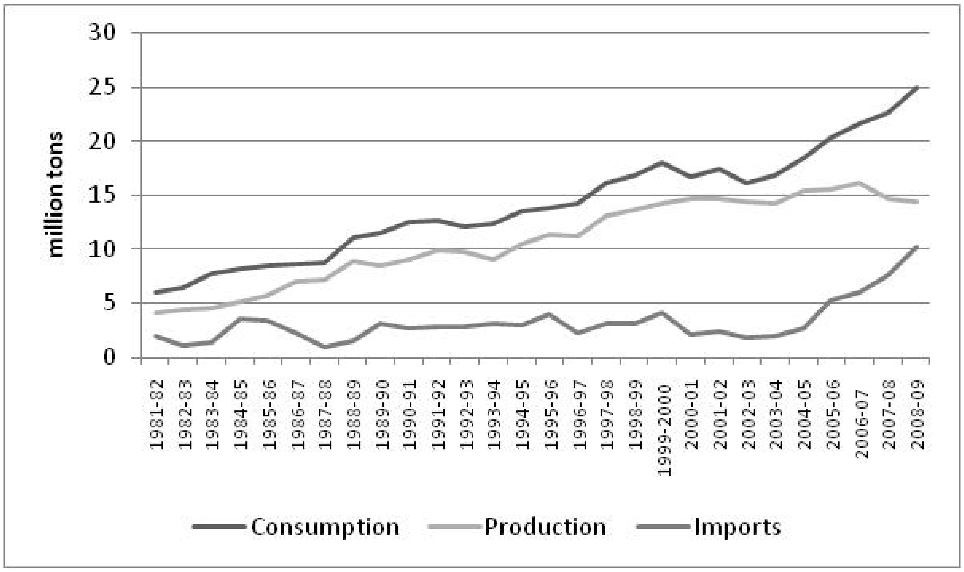
[9] This section heavily derives from Venkateshwarya and Sen (2002), Kumar (1999), and Gulati and Narayanan (2003).
[10] Potassium fertilizers could not be manufactured in the country due to unavailability of raw material of adequate quality.

Usage of fertilizers also grew as more farmers were applying more fertilizer to their crops. The gap between the consumption and production is met through imports. India is the largest importer of urea, MAP, and diammonium ortho hydrogen phosphate (DAP); second largest of ammonia; and fourth largest of potash fertilizers in the world (Sharma and Thaker 2010). Despite much growth in domestic production, imports remain a central issue in the fertilizer industry. In particular, urea, DAP, and murate of potash/potassium chloride (MOP) are of primary concern as they account for 93 percent and 92 percent of the total amount and value of fertilizer imports in India (TE 2008/09).

Figure 4.6—Production and consumption of fertilizers in India in terms of nutrients (Nitrogen (N) + Phosphorous (P) + Potassium (K))



Source: Government of India 2009.

Policies and Challenges

A key policy instrument that enabled the increase in use of fertilizers was the pricing of fertilizer. The government passed the Fertilizer Control Order (FCO) in 1957, to regulate fertilizer prices and fertilizer distribution. As per the FCO, the government first fixed a selling price of fertilizers (the farmgate prices) with the fertilizer producers being compensated through a subsidy scheme. This had the desired impact, and by 2001 about 81 percent, 91 percent, and 66 percent of the total area under paddy, wheat, and maize was applied with fertilizers. Interestingly, fertilizer is being applied for more than 90 percent of these three crops under irrigation, whereas under rainfed conditions fertilizer application covers about 60 percent of the area.

In the early stages, fertilizer subsidy was decided on the basis of the recommendations of the Tariff Commission, the chief account officer of the Ministry of Finance and the Fertilizer Association of India. If a unit was making a profit due to lower manufacturing costs, it had to refund the difference to the central fertilizer pool, making it unprofitable. Moreover, farmgate prices were lower than the realization price (given to the manufacturing units) and with the increase in the production of fertilizers the total subsidy bill of the government started swelling.

In 1973 the oil prices shot up and so did the urea prices, and the government almost doubled farmgate urea prices (from Rs 1,050 to Rs 2,000 per ton) in order to ease off the subsidy bill. However, the move backfired as the fertilizer consumption went down by about 9.3 percent (Venkateshwarya and Sen 2002). As a result, the government had to reduce the farmgate prices by almost 25 percent. The need for an umbrella scheme for the fertilizer industry was urgently felt and in 1976, the government set up a high-powered committee under S. S. Marathe, under whose recommendations the Retention Price Scheme (RPS) was launched in November 1977. The retention price was the ex-factory price given to a manufacturing unit based on its cost of production plus a posttax return of 12 percent. Initially only urea was under the RPS but later complex fertilizers (in 1979), single super phosphate (in 1982), and ammonium chloride (1985) were also included. But as urea forms the chunk of fertilizer consumed/produced, much of the debate has been around subsidies on account of urea.

The scheme has been criticized by many experts and studies (see Venkateshwarya and Sen 2002; Kumar 1999; Gulati and Narayanan 2003; Venugopal 2004). The key argument is that it does not encourage cost-efficiency and that it subsidizes units with higher manufacturing cost. Gulati and Narayanan (2003) also note that the government subsidized not only farmers, but urea-manufacturing units as well when compared to import parity prices of urea. This suggests that the urea plants were operating well below the efficiency levels as compared to their counterparts in other parts of the world. And with the subsidy regime in place there was no incentive for the manufacturers to improve upon the efficiencies. Although subsidies were initially aimed at increasing production to meet domestic demand, subsidies grew to unprecedented levels. According to Kumar (1999), the subsidy outgo of fertilizers increased from Rs 1.7 billion in 1980–1981 to Rs 83.5 billion in 1997–1998; in 2008–2009 it stood at a whopping Rs 758.5 billion.

In order to check the subsidy bill, the government instituted a fertilizer pricing policy review committee in 1997 under C. H. Hanumantha Rao, whose key recommendation was to abolish the RPS for urea and deregulate the fertilizer industry. The committee suggested using Long Term Marginal Cost of Plants as a base to fix the realization to the units. The fertilizer industry, however, found these recommendations too radical and went against the suggestions of the report. The Expenditure Reforms Commission was set up to suggest measures for reducing fertilizer subsidies along with other subsidies and recommended a four-phase scheme (spread over seven years) to gradually decontrol the urea sector. One of the key recommendations was to make groups of manufacturing units based on vintage and feedstock and further move away from unit-wise RPS to a group RPS system for the first three phases. But despite these efforts, subsidies kept growing—increasing from Rs 110 billion in 2002/03 to Rs 758 billion in 2008/09. The fertilizer subsidies accounted for about 38 percent of the total subsidies to agriculture TE 2007/08 (Government of India 2009) and of the total subsidies on account of fertilizers, urea's share is 61 percent (TE 2007/08).

Finally, in 2002, the government came out with the New Pricing Policy Schemes (NPS) to replace the existing RPS with the aim to "encourage efficiency parameters of international standards based on the usage of the most efficient feedstock, state-of-art technology and also ensure viable rate of return to the units."[11] Box 4.2 provides a brief description of the NPS. Although the NPS focused on the energy efficiency and has taken significant steps toward deregulation of the fertilizer industry, complete deregulation has not been under way.

[11] Government of India's circular dated January 30, 2003; http://fert.nic.in/Information_Act/urea.pdf.

Box 4.2—New Pricing Policy Schemes (NPS) 2002 for fertilizer

The NPS is a three-stage scheme to deregulate the fertilizer industry in a span of seven years, although there was much similarity with previous recommendations. The three stages are as follows:

Stage 1: April 1, 2003, to March 31, 2004

- The units are to be divided into six groups based on vintage and feedstock.
- Arrive at an average group retention price.
- The concessions would be based on the average group retention price for units having individual retention price above the average and based on individual retention prices for manufacturing units having retention prices below the group average.
- The outliers for phase one would be given concession and a period of one year to adjust.

Stage 2: April 18 to March 31, 2006 (but was extended up to September 31, 2006)

- No special treatment for the outliers, and the six groups and concession schemes remain the same for the other units.
- The concession rates would be adjusted to the new capita-related charges and group energy norms would be enforced for efficiency considerations.

Stage 3: October 1, 2006, to March 31, 2010

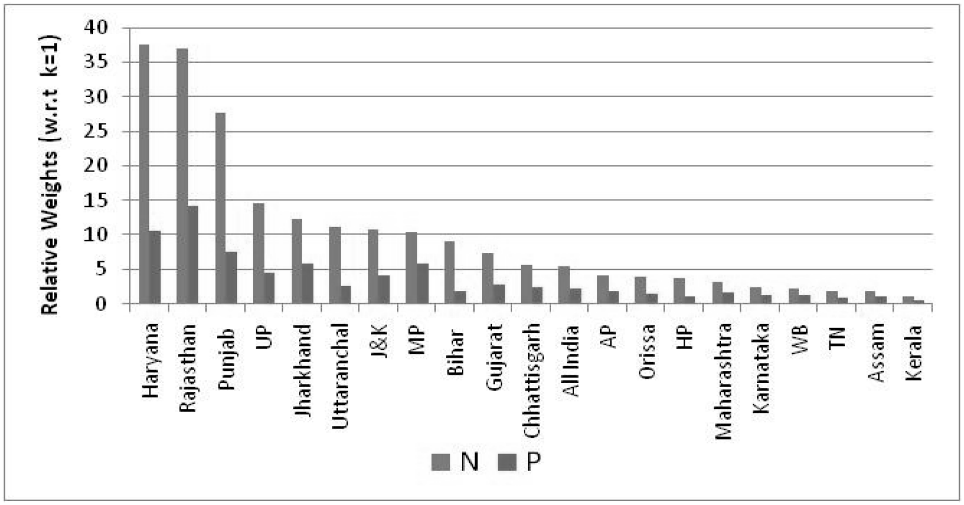
- Emphasize usage of most efficient feedstock for production of urea.
- Capital investment assistance to transform into gas-based manufacturing.
- Export norms were relaxed. In case urea units manufactured more than what was required by the government, they were free to sell it to complex fertilizer manufacturers or exports.
- The units were allowed to enter into joint ventures abroad where availability of gas can be ensured at reasonable prices.

Source: Government of India's circular dated January 30, 2003; http://fert.nic.in/Information_Act/urea.pdf.

Reducing the subsidy burden seems to have been the primary objective of the above efforts at reforming the fertilizer pricing policies. They largely ignored another serious impact of the prevailing subsidy regime. The relatively higher subsidies to nitrogenous fertilizers compared to P and K has contributed to a distorted NPK application ratio across Indian states. The nutrient ratio of the total fertilizer applied is critical for production (in the short run) and soil health (in the long run) and in India the average ideal ratio is estimated to be 4:2:1 for N, P, and K respectively (Sharma and Thaker 2010; Venkateshwarya and Sen 2002; Kumar 1999; Gulati and Narayanan 2003). The government-decontrolled phosphorous and potassic fertilizers have been seen to lead to the increase in prices of these fertilizers, which in turn affect the NPK ratio.[12] The NPK ratio in India was 7.2:1.8:1 in 1960/61, and had reached 10:2.9:1 in 1996/97 (although it was reduced to 5.5:2.1:1 in 2007/08). The large cereal-producing states of India have highly distorted NPK ratios (Figure 4.7)—Haryana, Rajasthan, Punjab, and Uttar Pradesh account for about 35 percent of the total fertilizer consumption in the country (TE 2007/08).

[12] According to Kumar (1999), "The NPK ratio prior to decontrol was 5.9:2.4:1 (the accepted ideal ratio being 4:2:1). This became 9.5:3.2:1 after the decontrol."

Figure 4.7—NPK ratio across major Indian states (TE 2007/08)



Source: India, Ministry of Agriculture 2009.
Note: UP refers to Uttar Pradesh, J&K refers to Jammu and Kashmir, MP refers to Madhya Pradesh, AP refers to Andhra Pradesh, HP refers to Himachal Pradesh, WB refers to West Bengal and TN refers to Tamil Nadu.

To correct this problem, a nutrient-based subsidy regime, instead of the product-based subsidy, has been advocated so as to arrive at prices and subsidy for different fertilizers such that their nutrient content is parallel to the ideal application ratio of 4:2:1. On April 1, 2010, the government came out with the Nutrient-Based Subsidy Scheme (NBS) for the fertilizer industry. As per the new scheme, nutrients N, P, K, and sulphur have been brought under the ambit of nutrient-based subsidies.[13] The scheme is applicable to 17 fertilizer products (excluding urea) that are controlled by the government. The only change related to urea is the increase in urea prices (farmgate) by 10 percent. The new approach has been welcomed by different stakeholders and seems to be a double-pronged strategy to arrest the growing fertilizer subsidy bill and restore soil health. It, however, remains to be seen how well the NBS is administered, and what its impacts will be.

Farm Mechanization and Agricultural Machinery in India

Current Status

During the Green Revolution and the period thereafter, with the introduction of improved seeds and high-yielding varieties (HYV), Indian agriculture also witnessed an increase in the use of purchased agricultural inputs such as fertilizers and pesticides and also a rise in irrigation. As farmers' investments in agricultural inputs saw an increase, there was a need for improving the input-use efficiency and precision. This provided the impetus for increased farm mechanization and use of agricultural equipment. An additional driving factor for increased farm mechanization, especially in recent years, has been the rising cost of human labor and animal power on farms (Singh 2005).

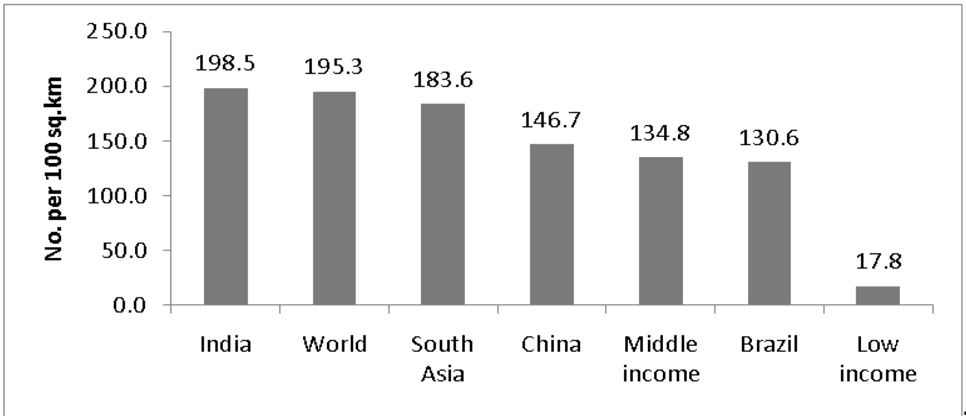
Historically, the use of improved farm implements and farm machinery in India stretches as far back as 1889.[14] Domestic manufacturing of tractors in India started off in 1961 and has been growing at a rapid pace since then. The tractor industry in India is now the largest in the world, accounting for nearly one-third of world tractor production (Jain 2006). The tractor density (per 100 square kilometer of arable

[13] Government of India circular dated March 4, 2010. Accessed from http://www.faidelhi.org/general/NBS-Policy.pdf on April 15, 2010.

[14] In 1889 modern plows, corn grinders, and chaff cutters were introduced from the Cawnpore Experimental Farm in Uttar Pradesh. Steam tractors were introduced in Punjab as far back as in 1914 (J. Singh 2005).

area) is much higher than other middle-income countries, and slightly higher than the world average (Figure 4.8). There has been rapid progress in other agricultural equipment and improved farm implements, too. Use of threshers has increased by nearly 20 percent, harvesters by 5 percent, reapers by more than 300 percent, and land levelers by more than 35 percent from 1994 to 2006 (Federation of Indian Chambers and Commerce and Industry [FICCI] 2008).

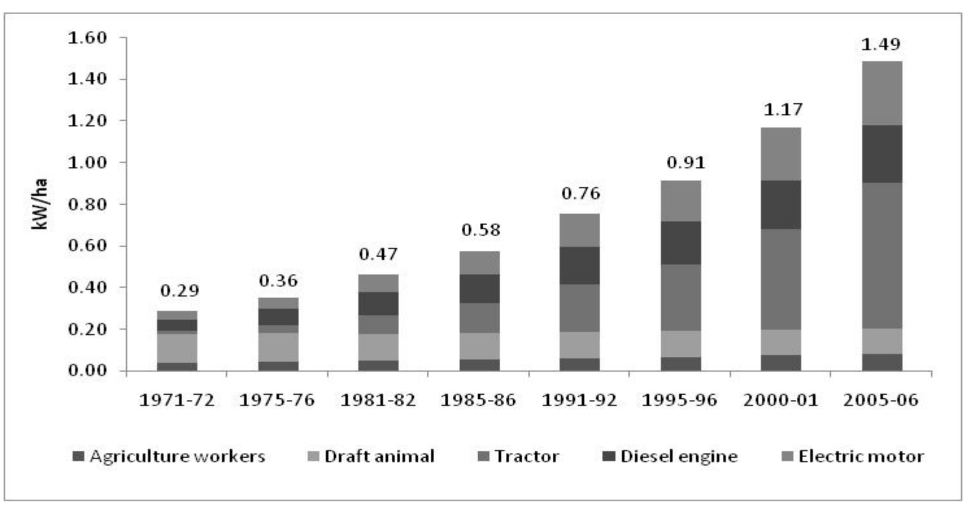
Figure 4.8—Number of tractors per 100 square kilometer of arable land, 2007



Source: World Bank 2010.
Note: Low- and middle-income countries refer to World Bank's classification of economies based on 2009 Gross National Income per capita, calculated using the World Bank Atlas method. The groups are: low income, US$995 or less, and middle income, US$996–$12,195.

Even with the advances seen in domestic production of agricultural equipment and improved farm implements, the level of farm mechanization in India as measured in terms of farm power availability still remains low. The total on-farm power availability from both animate and mechanical sources was estimated at around 1.5 kilowatt per hectare in 2005/06 (Figure 4.9). This comes out to be fairly low when compared to advanced economies such as South Korea, Japan, and the United States, which by 1996/97 already had farm power input per unit cultivated land of 7 kilowatt per hectare, 14 kilowatt per hectare, and 6 kilowatt per hectare, respectively (G. Singh 2005).

Figure 4.9—Contribution of various power sources for farm power in India (kilowatt per hectare of cultivable area (kW/ha))



Source: Indian Agricultural Statistics Research Institute 2009.

The share of animate power has been decreasing over time. Agricultural workers and draft animals made up more than 38 percent of farm power availability in 1981/82 whereas farm power from tractors was less than 20 percent. By 2005/06, animate power made up only 14 percent of farm power, and tractors' contribution was estimated to be nearly 47 percent. Nevertheless, it is estimated that for mobile power needs for farm activities such as plowing and seeding, the majority of farmers still use animate power. G. Singh (2005) notes that for more than 57 percent of the farming area in the country, the field operations are undertaken mainly by draft animals, and for field operations in hill regions and some difficult terrains human and animal power is still the dominant source of power. Power for fixed operations on-farm come from diesel engines and electric motors,[15] which has increased substantially in absolute terms from 0.05 and 0.04 kilowatt per hectare in 1971/72 to 0.27 and 0.31 kilowatt per hectare in 2005/06. But as a proportion of the total farm power, share of diesel engines has shown a slight decline, whereas the share of electric motors has more or less been constant (around 21 percent) (Indian Agricultural Statistics Research Institute 2009).

There are also significant disparities in the level of farm mechanization and the use of agricultural equipments across various regions of India. Punjab, Haryana, and western Uttar Pradesh have achieved a faster growth in mechanization, whereas the pace of mechanization in northeastern states has lagged (FICCI 2008). Factors impeding the spread include constraints such as hilly topography, socioeconomic conditions, high cost of transport, lack of institutional financing, and inadequate farm machinery manufacturing industries (FICCI 2008). Research development and testing of farm machinery and equipment, particularly suitable to small farms and rainfed farming; lack of standardization; insufficient quality control; and lack of education, training, and awareness among farmers about farm equipment have also impeded the rapid spread of farm mechanization in all regions of the country (J. Singh 2005).

The presence of a huge number of small and marginal farmers with small landholdings also poses a serious challenge. Single farm ownership and use of machinery on such small farms is likely to be economically unviable, and markets for custom hiring of farm equipment such as tractors, harvesters, and other machinery play an important role in ensuring that smallholders can also access mechanical farm equipment. Custom hiring has proved to be especially successful in Punjab and Haryana (Sharma, Singh, and Panesar 2005).

Policies and Challenges

Although there is no separate national policy on agricultural mechanization, the National Agricultural Policy 2000 (NAP) of the Government of India addresses some aspects of farm mechanization. Under the NAP, the government aims to promote agricultural mechanization with the overall objectives of sustainable yield increases; raising agricultural workers incomes; spreading benefits of mechanization to all classes of farmers; creating a worker-friendly environment, especially for women agricultural workers; and, finally, with the objective of ensuring lowered production costs of agricultural commodities, improving competitiveness in the international markets.

There are a number of programs for promotion of agricultural mechanization under both central and state governments in India. Central-sector schemes include the scheme for *Promotion and Strengthening of Agricultural Mechanization through Training, Testing and Demonstration*, under way since 2004/05. The training and testing component of the scheme is being undertaken through four Farm Machinery Training and Testing Institutes (FMTTIs) located at Budni (Madhya Pradesh), Hissar (Haryana), Garladinne (Andhra Pradesh), and Biswanath Chariali (Assam) whereas farm demonstration and other activities are to be undertaken by state governments, Indian Council of Agricultural Research (ICAR), and other government agencies. The scheme had an outlay of Rs 29 in 2009/10 (Department of Agriculture and Cooperation 2010).

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[15] Diesel engines and electric motors are largely used for stationery power purposes such as irrigation. Mobile power for on-farm activities such as plowing, seeding, weeding, and so on, is either human or animal based or mechanical power in the form of tractors and to some extent power tillers.

In addition, subsidy for farm machinery is also available as a part of other national programs such as the commodity-specific programs and missions for oilseeds, pulses, horticulture, and so on. At the state level, in addition to various direct capital subsidy schemes for purchase of farm machinery, many of the governments are also involved in programs for custom hiring of implements and manufacture of implements through various state-level agro-industrial development corporations (FICCI 2008).

The agricultural equipment industry in India is also fairly well regulated with regard to standards and quality and safety features. For standards and specifications, as well as quality testing, the overall responsibility lies with the Bureau of Indian Standards (BIS). The BIS prepares specifications for agricultural machinery and other equipment, maintains test codes, and also undertakes quality testing of equipment manufactured and marketed in India through its own network of testing centers. In addition, the government carries out testing and training activities through the FMTTIs mentioned earlier. Also in order to maintain the requisite safety standards for agricultural machinery in use, there are provisions and requirements laid under the Dangerous Machines (Regulation) Act of 1983, which the manufactured equipment has to fulfill. Enforcement of this act rests with the state governments and is monitored by the Department of Agriculture.

However, one must recognize that the gamut of agricultural machinery manufacturers in India is fairly wide, stretching from village-level/cottage artisans and units, small-scale industries, and state agro-industrial development corporations to large-scale, organized equipment manufacturers at the other end of the spectrum. A large number of equipment manufacturers are in the informal sector and outside of any regulations or quality monitoring. Also for many categories of agricultural machinery in India the requirement for certification of quality and safety standards is limited only to that agricultural machinery and equipment that is financed under government schemes (Government of India 2010).

In summary, even with rapid advancement in the domestic production and spread of agricultural machinery and farm mechanization, numerous challenges remain to be overcome—the uneven distribution of machinery across various regions of the country, the lack of adequate maintenance and service facilities, the need to ensure minimum quality standards, the lack of technology well suited for small farm sizes, and the inadequate access to credit for acquiring machinery by large sections of farmers.

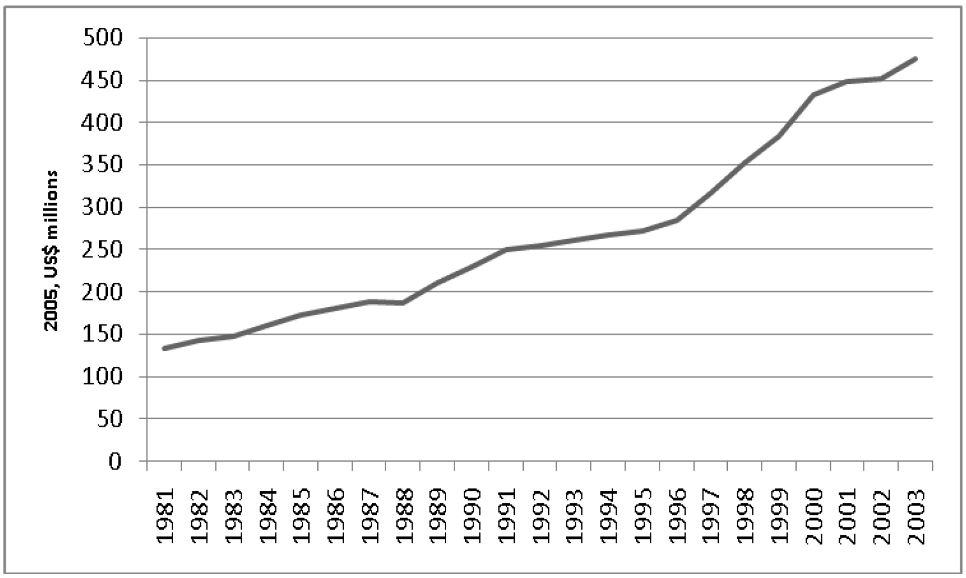
Agricultural Support Services: Agricultural Research, Extension, and Credit

Agricultural Research

Innovations in agricultural research and development (R&D) services were a critical driver in India's Green Revolution. Although the genesis of formal agricultural research institutions were in the colonial governments research laboratories for crop and livestock diseases (1905 and 1865), the first apex body to coordinate central and state activities and guide agricultural research activities was the Imperial (renamed Indian) Council of Agricultural Research (ICAR) set up in 1929 (Jha and Pal 2007). Major institutional changes in the organization of agricultural research occurred in the 1960s during the Green Revolution, when all research institutes under the Ministry of Agriculture (MoA) and commodity boards were placed under ICAR, which received additional funding and scientific manpower. State Agricultural Universities (SAUs—currently numbering more than 30) were opened to focus on teaching, research, and extension. The SAUs and ICAR were placed under the central Department of Agricultural Research and Education (DARE). Over time, the scope of these research institutes expanded to include soil management, water and resource management, and biotechnology, in addition to crop and livestock research. Until the 1980s, the number of research projects, SAUs, and even extension activities grew significantly (Evenson, Pray, and Rosegrant 1999), with public funding and partly with the large funding and organizational support from international organizations such as the Rockefeller Foundation, the U.S. Agency for International Development, World Bank, as well as research institutes such as Centro Internacional de Mejoramiento de Maiz y Trigo (CIMMYT) and IRRI for the development of high-yielding wheat and rice varieties (Pal and Byerlee 2006).

Public funding of agricultural R&D is via block grants to ICAR and the SAUs, with allocations decided in the five-year plans, in consultation with DARE, the Planning Commission, Ministry of Finance, and representatives of the research institutes themselves (Pal and Byerlee 2006). Overall, the center provides more than 50 percent of public funding, and the rest is constituted of externally aided projects, state government funds, and internal and other resources. The majority of funds are routed through the ICAR. Pal and Byerlee (2006) estimate that public research funding grew at 3.16 percent in the 1970s and 7.03 percent in the 1980s and slowed to 4.61 percent in the 1990s. A similar pattern is seen in state-level funding of agricultural research; it grew from 1.3 percent per year in the 1970s to 8.2 percent in the 1980s and slowed down to 3.8 percent in the 1990s. In 2003, India invested more than Rs 20 billion at 2005 prices (474.4 US$ million; Figure 4.10) in public agricultural research, whereas ICAR and the SAUs shared 43 and 50 percent, respectively, of the total public agricultural R&D investments (Beintema et al. 2008).

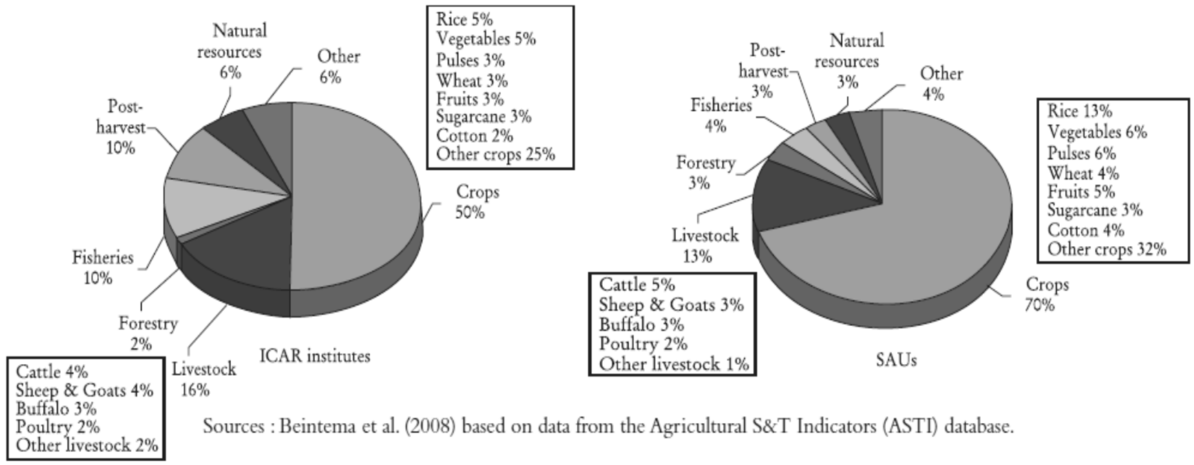
Figure 4.10—Total agricultural R&D spending by the public sector (2005 prices, US$ millions)



Source: Agricultural Science and Technology Indicators 2010.

These public institutes are not purely research based; they also have undertaken teaching, education, and extension activities. In 2003, the public agricultural research system was estimated to have about 16,700 full-time professional research staff members—13,089 researchers and 3,615 technicians with university degrees. Beintema et al. (2008) estimate that the annual average growth of full-time professional staff was only around 1 percent a year during 1991–2003. As staff strength has barely grown against investments, it is estimated that financial resources (salaries, operational costs, and capital investments) per professional staff rose from Rs 0.7 million in 1991 to more than Rs 1.2 million in 2003 (2005 prices). The most significant amount has been spent on salaries—during 2001–2003, the agencies under ICAR spent 50 percent and SAUs spent around 67 percent of their total investments on salaries. Funding on research sectors also reflects policy priorities. In 2003, more than half of ICAR researchers were engaged in crop research (Figure 4.11) whereas SAUs researchers spent more time on crops research (70 percent of research time), especially rice (Beintema et al. 2008).

Figure 4.11—Commodity focus of professional research staff of ICAR and SAUs, 2003



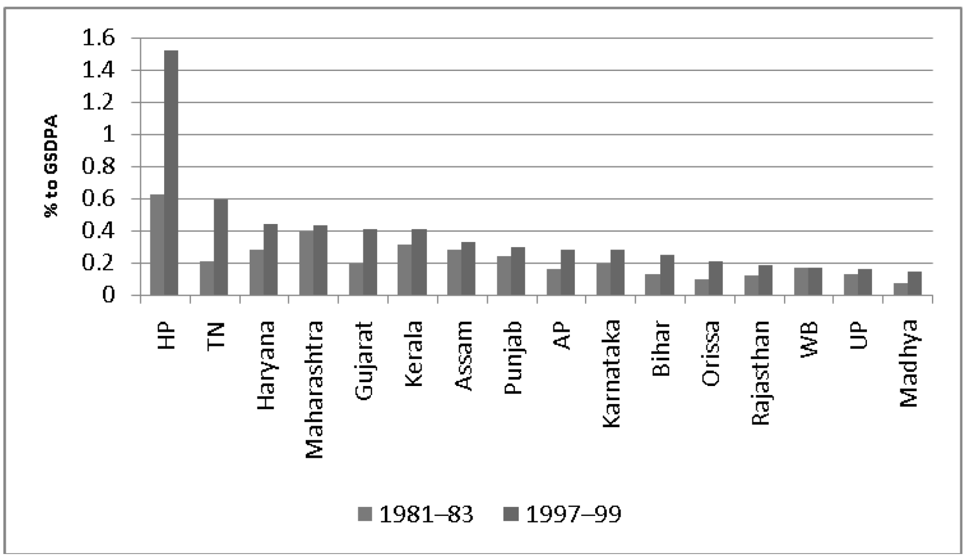
Source: Beintema et al. 2008.

The 1980s and 1990s saw increasing private-sector (including multinationals) involvement in research activities, especially in the seed sector as seen earlier. Recent years have seen the growing presence of private nonprofit organizations, private foundations, and nongovernmental institutes in agricultural research, such as M. S. Swaminathan Research Foundation and Mahyco Research Foundation. Whereas many conduct independent research, others work closely with the government ICAR/SAU and extension system as well. Private research has been focused especially in the area of hybrid seeds and biotechnology. Despite the growth in private research, public-sector research institutes dominate most agricultural research activities in India. Although favorable government policies combined with substantial financial support from the public and other sectors have given India a broad-based and diverse research network, a number of constraints still need to be removed to revitalize India's R&D sector.

- Public funding in India's agricultural R&D is still among the highest in the developing world after China; however, in relation to input subsidies, there is still much scope to increase funding. Investments in agricultural R&D have been known to augment productivity growth with annual rates of return to investment in research ranging from 35 to 155 percent (Evenson, Pray, and Rosegrant 1999). They are also known to have poverty-reducing impacts across Indian states (Fan 2003; Fan, Gulati, and Dalafi 2008). This is especially critical as state government funding of SAUs has dwindled in recent years. In many cases the income levels of the state significantly affect agricultural R&D funding. Poorer eastern states have seen lower investment levels compared to other states, through most of the 1980s and 1990s, contributing to the underdevelopment of the research infrastructure here (Figure 4.12). Thus there is an urgent need to infuse funds, especially into SAUs, given the poverty-reducing and productivity-enhancing benefits of agricultural R&D in these states (Pal and Byerlee 2006).
- Salaries constitute the majority share of expenditure, leaving less for operational overheads and costs to maintain existing infrastructure. Institutional dynamism has slowed since the Green Revolution period, and qualitative deficiencies in agricultural education policy, deteriorating infrastructure, and research activities exist (Jha and Pal 2007). The Indian agricultural research system remains centralized with underdeveloped local research capacities and infrastructure. These deficiencies persist at both the central and state levels. Correcting the reward and incentive structures via monitoring and evaluating existing projects and also by implementing competitive funding processes can be instrumental in removing these constraints and making the entire system more competitive from within.

- Although the crop sector has dominated the research agenda so far, the research portfolio has to be widened to include contemporary concerns such as sustainable resource use for agriculture, food quality, and safety as well as other initiatives like biofortification and biotechnology. Biotechnology especially has come to be a critical new frontier in agricultural research, where the private sector has emerged as a crucial new player, spurring on legislations such as the Protection of Plant Varieties and Farmers' Rights Act (PPVFR) Act (2001), and reforms to seed policies discussed earlier. Private-sector research in biotechnology includes both commercial and high-value crops (Bt cotton and Bt *brinjal*) as well as cereals such as Bt rice and Bt maize (Kolady, Spielman, and Cavalieri 2010). India is supposed to be among the fastest growing countries in crop biotechnology investments after China and Brazil—one estimate puts public investments in crop biotechnology over the last five years at around US$1.5 billion and private investments at around US$200 million (James 2009). In this regard, greater private–public cooperation and joint research can do much to strengthen research capacities on both sides.

Figure 4.12—State government funding of agricultural research as a share of gross state domestic product of agriculture (percent)



Source: Pal and Byerlee 2006.

Agricultural Extension

The extension system in India has undergone a number of changes in the information delivery and institutional front. In the pre–Green Revolution period, extension was seen as another function of the Department of Agriculture. The first large-scale extension project was undertaken by the Community Development Program (CDP) from 1952 onward at the village level followed by the National Extension Services from 1953, covering agriculture and animal husbandry, apart from development of rural industries and social education activities. These two programs form the basis of much of India's future extension mechanism.

Extension activities in the foodgrain sector specifically received emphasis under the Intensive Agriculture Development Program and the Green Revolution from the 1960s onward, with the introduction of high-yielding seed varieties and modern inputs like chemical fertilizers (Swanson and Mathur 2003). By the mid-1970s, the need for a more organized extension system and delivery mechanism was felt and the Training and Visit (T&V) system was introduced to substitute for the CDP.

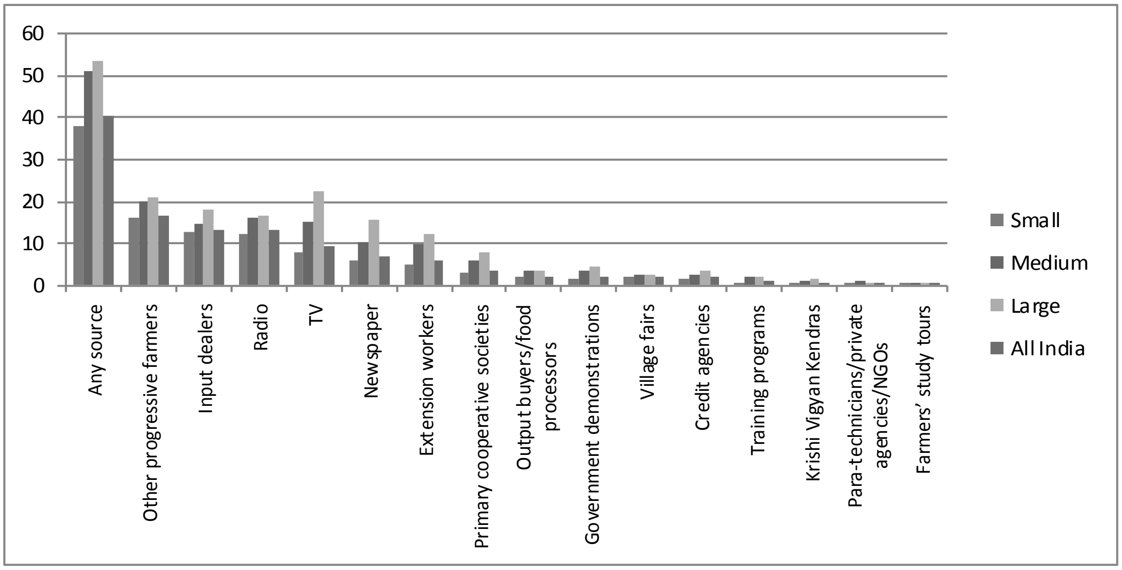
Unlike earlier programs, the T&V system used a single line of control from the director of agriculture down to the village level. The emphasis was on regular training and supervision of extension workers and farmers. This attempted to streamline extension efforts, but the system became too centralized, top-down, and technology-input supply driven rather than demand driven. As with the Green Revolution, this model also excluded many rainfed areas and did not directly involve the private sector and other nongovernmental actors that were beginning to take an interest in extension activities (Swanson and Mathur 2003). Throughout this period, extension (along with research) was approached as a public good and therefore handled almost entirely by the public sector. As agriculture is a state subject, extension is also under the purview of state governments. State agricultural departments provide extension services at the district, block, and village levels. The ICAR, too, provides extension support via 40 agriculture technology information centers, 569 district-level farm science centers, SAUs, and farmer field schools.

The 1990s saw the entry of private-sector (such as e-Choupal by ITC), nongovernmental organizations (NGOs), and farmer-based organizations in the provision of extension services (Glendenning and Babu 2010). Some of these new players work alongside the public-sector extension agencies at the field level through public–private partnerships. The potential for extension to be undertaken by multiple parties was partly facilitated by two research and extension reform initiatives, namely, the 1998–2004 Diversified Agricultural Support Project (DASP) and the 1999–2005 National Agricultural Technology Project (NATP) (Raabe 2008). These initiatives aimed to pump up productivity through intensive and diversified agricultural development (DASP) and reorganize ICAR, increase the effectiveness of research programs and the capacity to respond to the technological needs of farmers, and increase the effectiveness and financial sustainability of the system with greater accountability (NATP). Under these initiatives the Agricultural Technology Management Agency (ATMA) was also launched on a pilot basis in 1998, and then extended to the rest of the country in 2007 (Glendenning and Babu 2010).

ATMA aims to support the state extension programs for extension reforms scheme and acts as a platform to integrate extension programs across line departments, research organizations, nongovernmental organizations, and agencies associated with agricultural development in the district. ATMA uses a participatory approach wherein Farm Information and Advisory Centers at the block level act as a platform where farmers, the private sector, and extension field staff members from each line department meet to discuss, plan, and execute extension programs. After a block plan is prepared it is presented to the ATMA board for approval and funding, after which farmer groups, NGOs, self-help groups (SHGs), and other interested parties are organized and trained by the extension staff (which in turn are ideally trained by State Agricultural Management and Extension Training Institute).

Most studies agree this is a more decentralized and demand-driven approach to provisioning extension services in India; however, the program still has to fully take off in order to be a success and actually meet farmers' technology and information needs and have a significant impact on agricultural productivity growth (Sulaiman and Holt 2001; Birner and Anderson 2007; Sulaiman and van der Ban 2003; Swanson and Mathur 2003; Glendenning and Babu 2010; Raabe 2008). As noted by Glendenning and Babu (2010), the National Sample Survey Organization (NSSO) 2003 survey showed that 60 percent of farmers had not accessed any source of information on modern technology to assist in their farming practices in the past year. Adhiguru, Birthal, and Ganesh Kumar (2009) indicate that only 4.8 percent of the small farmers had access to public extension workers as compared to 12.4 percent of large farmers (Figure 4.13). In this respect making the extension system more inclusive and efficient is the need of the hour.

Figure 4.13—Access to information from different sources across farm sizes in India



Source: Adhiguru, Birthal, and Ganesh Kumar 2009.

Agricultural Credit

The spatial variability in the social, politico-economic, and agricultural situation across India spawned the development of a wide variety of informal lending institutions across the country's rural expanse. With agricultural fortunes being tied to erratic weather conditions, interest rates were almost always high. Consequently, indebtedness and poverty have been persistent characteristics of many rural households, affecting private investments in agriculture. In an effort to tackle the problem, the colonial government began to extend credit to farm household during drought years in the 1870s and consequently the Co-operative Societies Act was passed in 1904 to disburse agricultural credit. Given the depth and spread of credit shortage, the Reserve Bank of India (RBI) established in 1935 had special provisions to cater to agricultural credit, and it focused on building short- and long-term cooperative credit infrastructure. But even by 1951 credit disbursed through cooperatives reached only 3.3 percent of the cultivators (0.9 percent from commercial banks) (Mohan 2006).

In 1966, the All India Rural Credit Review Committee, set up to review agricultural credit supply, recommended that commercial banks alongside cooperatives should play a greater role in increasing credit supply. Following nationalization of commercial banks in 1969 and 1980, agriculture was made a priority sector for lending, as Green Revolution technologies required increased input supply, (Mohan 2006). In 1982 the National Bank for Agriculture and Rural Development (NABARD) was set up to play a pivotal role in facilitating credit flow to agriculture. Its scope was expanded to accommodate refinancing requirements of state cooperatives and RRBs (previously done by RBI), administering the Rural Infrastructure Development Fund (RIDF) and coordinating microcredit activities through SHGs.

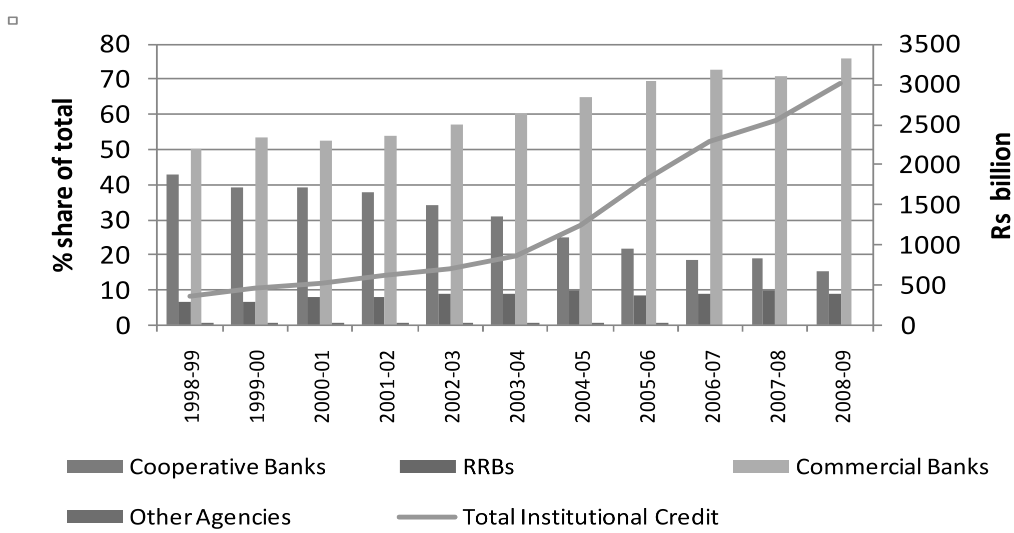
Financial-sector reform undertaken as a part of the broad-based economic reforms of 1991 also affected agricultural credit institutions. Some of the changes included deregulation of interest rates of cooperatives, RRBs, and commercial banks for loans above a certain amount; recapitalization of select RRBs; provisioning requirements for all rural credit agencies; increased refinance support from RBI; capital contribution to NABARD; constitution of RIDF; introduction of Kissan Credit Card; and so on (Mohan 2006).

These institutional innovations in the credit system, especially the spread of rural financial institutions, led to the growth of formal credit among cultivars. The share of rural branches of commercial banks steadily increased from 17.6 percent in 1969 to 58.2 percent in 1990 (Satish 2007). Despite the proliferation of formal rural and agricultural credit institutions during the 1980s the institutions remained weak and inefficient; poor funding resulted in losses in some cases. By 2005, 19 percent of State Cooperative Banks, 22 percent of District Central Cooperative Banks, 37 percent of Primary Agricultural Cooperative Credit Societies, 45 percent of State Cooperative Agriculture Rural Development Banks, and 65 percent of Primary Cooperative Agriculture and Rural Development Banks suffered losses (estimated from Satish 2007). Since the 1990s, the number of rural institutions is estimated to have declined—the total number of rural branches declined from 35,390 in 1993–1994 to 32,673 in 1999–2000, and 30,750 in 2005–2006 (58.2 percent in 1989–1990 to 44.5 percent in 2005–2006 of total; Satish 2007).

Dev (2006) summarizes the main challenges facing the agricultural credit sector during the 1990s: narrowing of the branch network in rural areas, falling credit deposit ratios in rural areas, disproportionate declining in agriculture credit to small and marginal farmers, worsening regional inequalities in rural banking (especially eastern and northeastern states), poor performing of RRBs, and in some cases *political interfering* in areas such as loan write-offs and functioning of financial institutions.

Although various committees (for example, Capoor Committee in 2000, Vikhe-Patil Committee in 2002, Vyas Committee in 2001, Vaidyanathan Committee in 2004, and so on) have reviewed the performance of the credit system, their recommendations have yet to be fully implemented. In 2004, the Government of India instituted many measures to increase the flow of agricultural credit during the period 2004/05 to 2006/07, and, as seen in the Figure 4.14, credit flow in the following period has picked up. It is relevant to note that although share of cooperative credit has fallen in this period, commercial banks have come to constitute more than 70 percent of formal credit flow. At present, direct finance to agriculture under priority-sector lending includes credit for the purchase of transport equipment to assist the transport of agricultural inputs and farm produce. Direct finance also includes credit for the construction and running of cold storage facilities, warehouses, and so on.

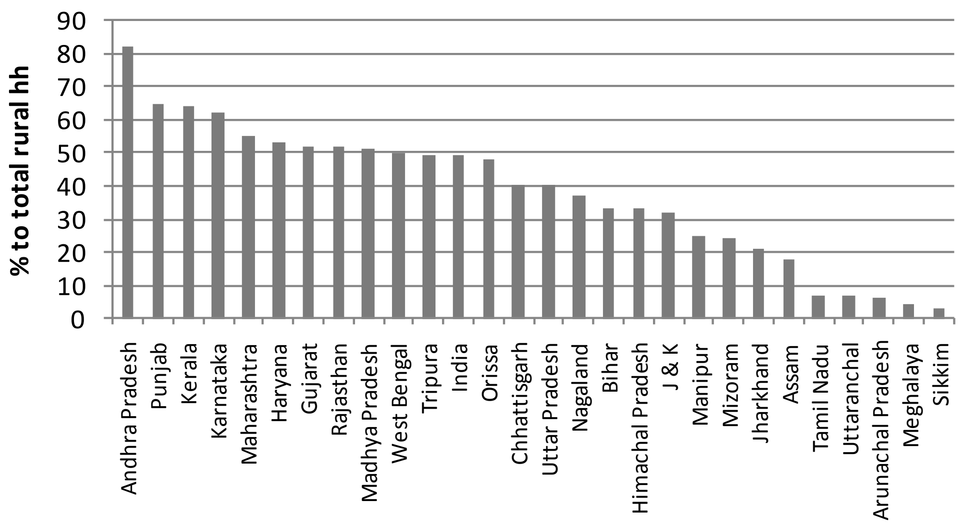
Figure 4.14—Flow of institutional credit to agriculture: Total (Rs billion) and share of various institutions (percent of total)



Source: India, Ministry of Agriculture 2010a.

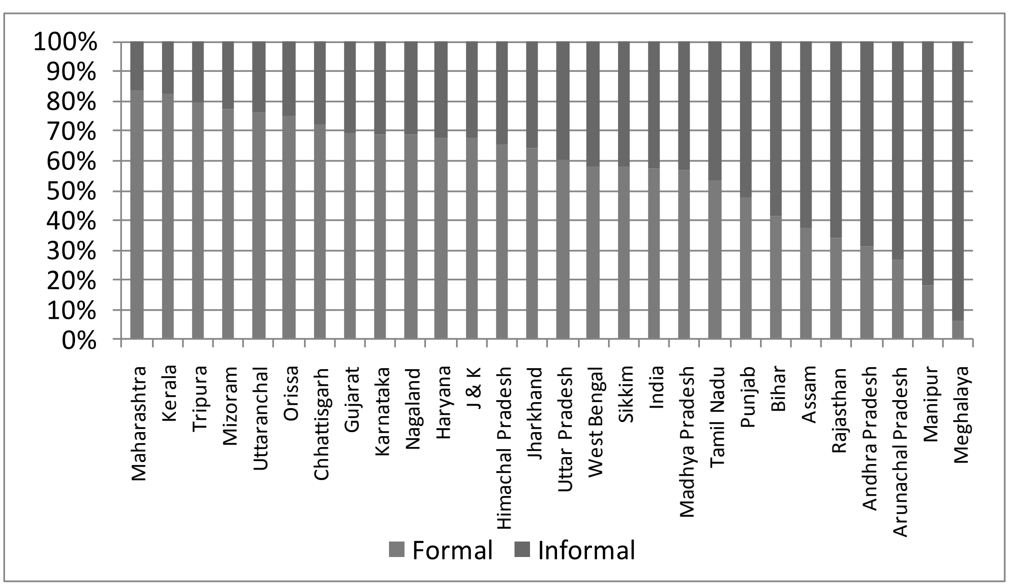
Although this recent trend is a positive development, the cumulative impact of such institutional stagnation has contributed to significant exclusion of farm households from formal credit institutions. The NSSO 59th Round (2003) data reveals only 27 percent of the total number of cultivator households received formal credit, whereas 22 percent received credit from informal source, and the rest had no credit outstanding (Planning Commission 2008). Moreover, state-level figures show extreme variations (Figure 4.15). In Andhra Pradesh, for instance, indebtedness is high, but a closer look at the source of credit reveals that the informal sector still plays a dominant role (Figure 4.16). Such high indebtedness and exclusion of poor and marginal farmers have perpetuated a reliance on informal lending institutions, which have sometimes been reported to cause farmers' suicides across pockets in the country. It is relevant to note that 80 percent of the total indebted farm households on an average own less than 2 hectare (MoA 2010a). In 2003, the share of formal loans varies from 23 percent to 58 percent for small and marginal farmers; it is on average more than 60 percent for medium to large farmers (Dev 2006).

Figure 4.15—Percentage indebted farming households in total rural households, 2003



Source: Dev 2006.

Figure 4.16—Percentage distribution of outstanding loan by source, 2003



Source: Dev 2006.

Partly in response to these problems, the government announced the Agricultural Credit and Debt Waiver Scheme in 2008, which provides debt relief on overdue and unpaid loans extended to farm households. Total expenditure in 2008/09 was Rs 150 billion (about $US3.3 billion) and the projected write-offs in 2009/10, 2010/11, and 2011/12 are, respectively, Rs 150 billion, Rs 120 billion, and Rs 80 billion. As pointed out by Dev (2008) the new scheme will once again create a serious and likely long-lasting moral hazard problem for the banks in their agricultural lending operations. As such the scheme only covers about 27 percent of farm households and excludes many smallholders who don't depend on formal institutions. Dev (2008) also notes that the scheme excludes dryland farmers without irrigation who periodically have to deal with extremely stressful situations, especially due to droughts.

An important development in the past decade has been the development of microcredit and SHGs. Institutional support for these schemes can be traced back to NABARDs' SHG–bank linkage program, started in 1992. Following its initial success in the southern states the program become national and every year an estimated 600,000 SHGs are added (Dev 2006). Alongside such governmental microfinance initiatives nongovernmental microfinance institutions (MFIs) have also grown although there have been reports of mixed results (Ruchismita and Varma 2009). In particular, although women are seen to be important players in the SHG movement, some studies indicate that of total credit supplied in 2006 only about 12 percent of the individual bank loan accounts and 24.7 percent of the individual bank deposit accounts belonged to women (Chavan 2008).

To sum up, the formal financial sector has made significant progress in reaching out to farmers in India. Nevertheless, many millions of farmers remain financially excluded and a lot more needs to be done to respond to the needs of the farmers to strengthen agricultural productivity and farm systems. Innovative approaches and solutions are required to ensure all farmers are financially included. All players in the formal financial system, such as commercial banks, microfinance institutions, the regulatory bodies, and so on, have to perform their roles in unison to ensure that this objective is met. Fortunately, the government and the RBI have clearly enunciated financial inclusion as a goal (Ministry of Finance 2008) and in this they have recognized the role and the need to leverage modern technologies such as in the sphere of information technology, telecommunications, and so on. In doing so, they have also recognized that traditional formal financial institutions (such as commercial banks, cooperatives, RRBs) by themselves may not be able to promote financial inclusion. They recognize the importance of partnerships between the traditional formal financial institutions and the new set of players such as technology providers (telecommunication and information technology companies), nongovernmental organizations, and other service providers such as village retailers, to provide "credit plus services" (like farm advisory) and doorstep banking services. The rapid progress in technologies has meant that the potential for such partnerships to deliver is much higher currently than at any time in the past.

5. OUTPUT POLICIES

Ensuring adequate supply of various farm inputs and providing necessary support through research, extension, and credit were no doubt essential to the success of Green Revolution in India. However, easing input supply constraints by itself would not have had the desired effects if farmers did not adopt the new technologies on offer. A critical element that paved the way for the acceptance of the new technologies by farmers was the support that the government provided on the output side.

The government intervened in the markets for foodgrains in several ways: through its pricing, procurement, storage, and distribution operations, and through controls over external and internal trade. This section reviews these policies in detail and provides an assessment of their functioning and impacts. As will be seen below, the overall objective of the government was to ensure that farmers received a sufficient return, with minimal risk, that encouraged them to adopt new technologies that would help increase productivity and production. At the same time the government had to do a balancing act to ensure that the prices of critical food items were not so high that it hurt the interest of the consumers in both urban and rural areas, a sizable percentage of whom were solely dependent on the market for meeting their consumption needs. Policies and institutions were accordingly designed keeping in mind the conflicting needs of both producers and consumers. These policies had the desired results and paved the way for the success of the Green Revolution. But over the years several problems have come up in the functioning of these policies and institutions that warrant another look at the government's approach to providing output support to farmers that encourages technology adoption.

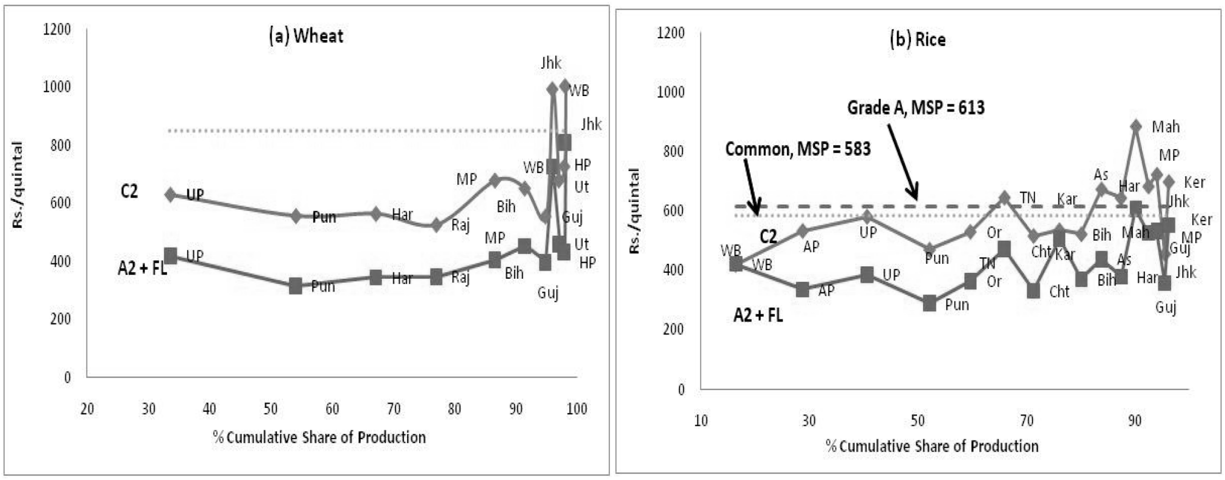
Agricultural Pricing Policy

The first element in foodgrain output management is the regulation of output prices. Initially, foodgrain pricing was mostly consumer oriented as the colonial government was faced with acute food shortages and inflation. But after the Agricultural Prices Commission (APC) was constituted, the official price support policy had three main objectives—producer welfare to incentivize grains production and encourage the adoption of modern technologies, consumer welfare by assuring affordable consumer prices, and, finally, controlling speculative trading activities. To meet these objectives, a guaranteed floor price called the *minimum support price* (MSP) is given to farmers as a risk protection. In order to maintain stocks and ensure food reaches the poor at affordable prices, the Indian government also purchased grains in the open market at fixed and pre-set *procurement prices*. Lastly, foodgrains were distributed to state-level fair-price shops under the Public Distribution System (PDS) and other welfare schemes at the issue price. In addition, rice millers/processors and dealers have to sell a certain portion of their output to the government at a *levy price* set by the government.

Wheat and rice received strong price support often with significant *bonuses* (above the recommended MSP from both state and central governments) to insulate farmers against adverse weather and other contingencies. Zonal restrictions in the movement of foodgrains were also common practice. These policies contributed to the skewing of the production basket, first toward foodgrains, second toward rice and wheat within foodgrains, and finally toward the Green Revolution regions. In the 1980s, the pricing policy was reviewed and the Commission for Agricultural Costs and Prices (CACP; APC was renamed in 1985) was encouraged to allocate resources in a balanced manner to all crops (Chand 2003). Nonetheless, pricing policy still remained strongly in favor of rice and wheat crops without any radical change. At present MSP is set for around 25 crops according to the Cost of Production (COP) criteria for each crop, as well as other factors like demand–supply situation and trends, changes in input prices, effect on cost of living, intercrop parity, international economic situation, and so on.

Initially, the government maintained a distinction between procurement price as a production incentive and MSP for risk protection. But from the 1970s onward the MSP acted as a de facto procurement price and became an important instrument to induce production in various regions. In most states, the MSP for both rice and wheat is much higher than the actual paid-out cost (A2) as well as full costs (C2), that is, including family labor, land, and management expenses (Figure 5.1). This indicates that the initial rationale of using MSP as risk coverage may not be valid anymore; instead it functions more like an income transfer mechanism.

Figure 5.1—Cumulative production (percent share) and costs (C2 and A2 + FL), TE 2006/07

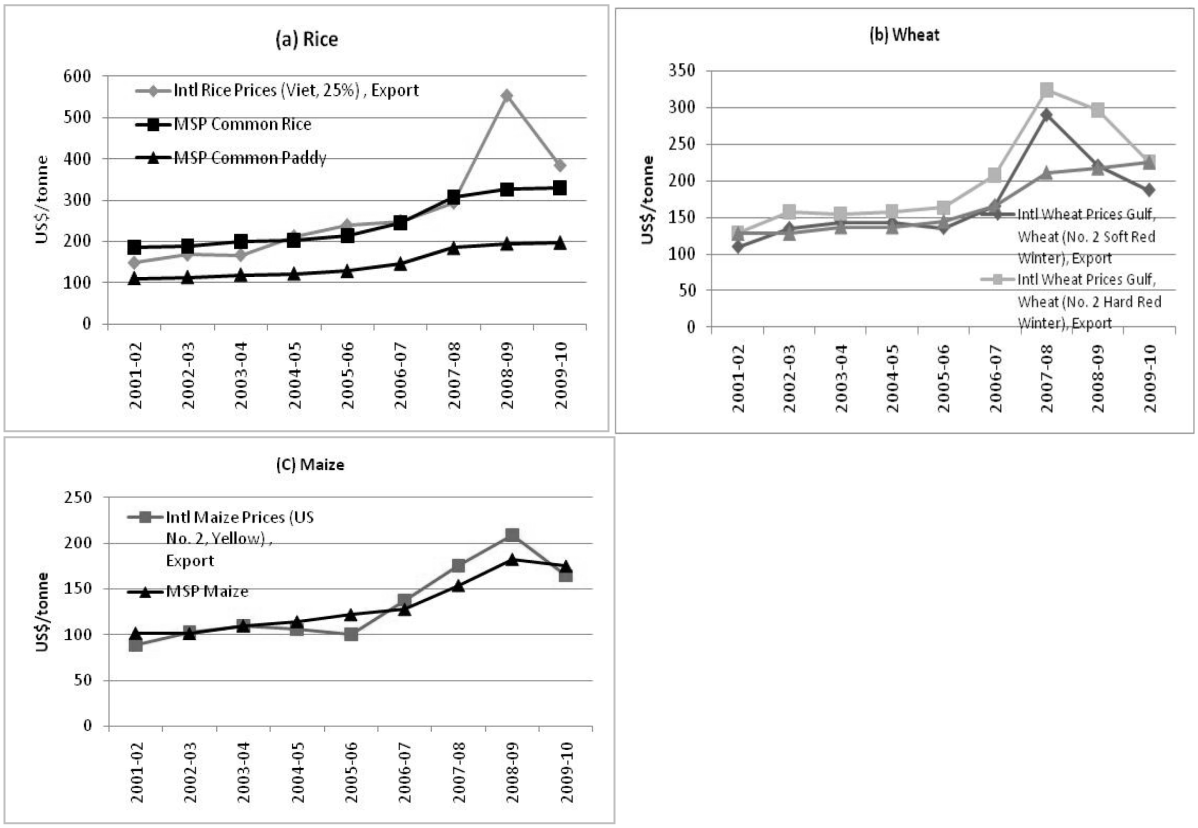


Source: Source: India, Ministry of Agriculture 2010; CACP 2009; http://www.indiastat.com.
Note: Minimum support prices include bonuses. Due to unavailability of 2006/07 Paddy A2+ FL costs, the figure for Paddy A2 + FL refers to average value of 2004/05 and 2005/06.

Although the objective of the government's pricing policy is ostensibly to 'protect the farmers' interest', in reality it has often acted as a tax on farmers and rice millers. Several studies have shown that Indian domestic prices have been lower than international market prices during most of the years in the past few decades (Gulati and Pursell 2009). In response to these criticisms, the government has tried to take into account the international prices while setting the MSP. In practice, however, the government has not been successful but instead has ended up introducing greater volatility in the MSP with attendant consequences for its procurement and stocking operations. For example, in response to the low international prices following the Asian financial crisis, the government increased MSP to levels higher than world prices. Wheat MSP, for instance, began to deviate from the COP from 1997/98 and MSP increased at more than 6 percent during 1998/01 (Chand 2009).

Indian grains being costlier in the world market resulted in high procurement and excess stock accumulation by 2002/03. Following this, the government raised wheat MSP by only 1.6 percent per year (during 2003/06) and also disposed of excess stock through export subsidies. However, from 2005/06 onward international prices rose significantly and government wheat stocks were at an all-time low in 2006/07. To incentivize domestic production and safeguard against the international price volatility, the government again raised MSP by 15.4 percent in 2006/07, by 33.3 percent in 2007/08, and 8 percent in 2008/09 over the previous year (Figure 5.2). The resultant supply response has contributed to a glut-like situation and the government is currently saddled with excess stocks and the problem of rising domestic prices.

Figure 5.2—Increases in minimum support price and international prices: Rice, wheat, and maize



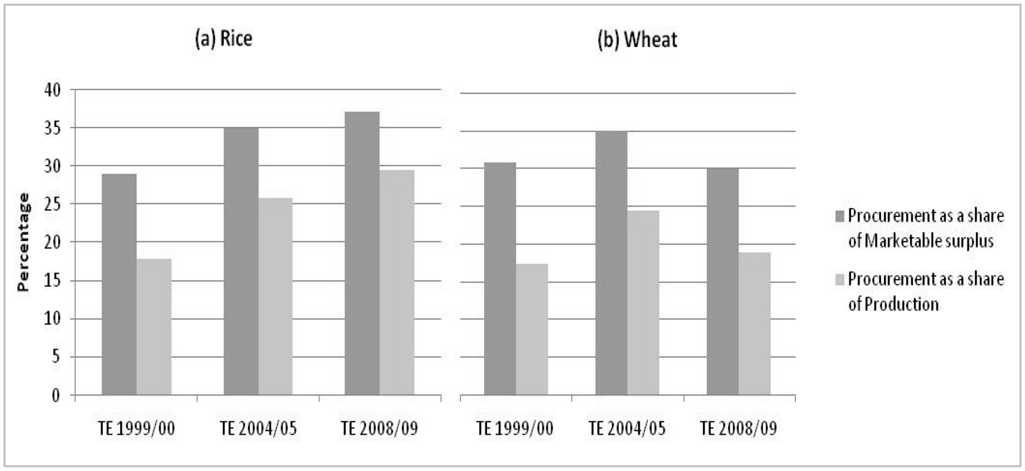
Source: India, Ministry of Agriculture 2010.

Procurement and Stocking of Foodgrains

The second element in foodgrain management policies in India relates to procuring foodgrains to maintain stipulated stocks requirements. Government procurement of foodgrains started after the Bengal famine in 1943 as foodgrains markets across the country were fragmented and supplies were unable to reach the areas hit by famine. The colonial state set up the Department of Food to maintain and distribute central foodgrain reserves. Currently the Food Corporation of India (FCI) is the main parastatal agency responsible for procurement, storage, movement, transportation, distribution, and sale of foodgrains. Other parastatals involved in these operations include the Central and State Warehousing Corporations, Indian Grain Storage Management and Research Institute for R&D activities relating to grain storage and handling, and quality control offices to check the quality of foodgrains procured and distributed.

The procurement operations of the FCI were designed to complement the APC in providing support to farmers with a view to augmenting production during the Green Revolution. Although the initial rationale for government intervention in rice and wheat was primarily motivated by scarcity conditions and the underdeveloped domestic market, the extent of state intervention via procurement has increased with time (Figure 5.3). Though this had some positive impacts during the Green Revolution years, the rationale for extensive government intervention in foodgrain managements is now weak as there has been tremendous improvement in production and yield levels, infrastructure, market integration, overall economic growth, and a consolidation of India’s foreign reserves (Rashid et al. 2008).

Figure 5.3—Public procurement as a percentage of production



Source: Economic Survey, Various Issues. Dev 2003, quoted in Rashid et al. 2008.
Notes: All years taken as triennium ending. * Wheat figure is taken only for the single year 2008/09, since 2006/07 was an unusual year. Production figures used in 2008/09 are fourth advance estimates.

As mentioned earlier, FCI procurement shows large concentration in the Green Revolution states. Distributing the grains procured from these surplus states imposed a huge transport burden. To correct this regional imbalance and to reduce costs, in 1997/98, the De-Centralized Procurement Scheme (DCPS) was introduced. The DCPS was also expected to enable state agencies to directly procure from farmers within the state at minimum support and levy prices, directly interface with local farmers, and distribute stocks via various safety nets programs and fair-price shops. However, this has not had much success. In 2008/09, Punjab, Haryana, Uttar Pradesh, and Andhra Pradesh still contributed 67.5 percent of the rice procured and Punjab and Haryana contributed 66.9 percent of wheat procured.

The FCI maintains stocks to feed the PDS and cater to emergency situations, natural or otherwise. Stocks can be conceptually divided into three types—operational stocks to even out intraseasonal supplies; basic buffer stocks to even out interseasonal shortages throughout the year, promptly address scarcity situations, and maintain independence from imports; and baseline stocks, which are a minimum level of stock to be maintained at all times (Dantwala 1969).

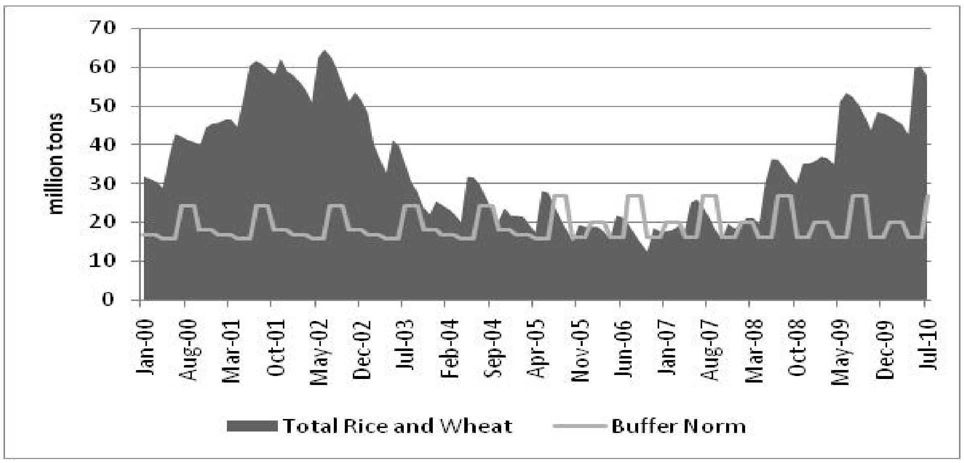
A key question facing policymakers is "what ought to be the optimal buffer stock?"16 Buffer stocks norms are arrived at based on numerous considerations centered on what the government wishes to achieve (production performance, price stabilization, overall economic scenario, storage and finance abilities), apart from political considerations (buffer stocks help avoiding external pressure and prevent sudden flight of foreign exchange to finance imports if there are food shortages; Gulati et al. 1996). Norms are stipulated for every quarter and have been increasing over the years (as of January 1, 1980, total foodgrain buffer norm was 16.7 million tons, in 1991 it was 17.9 million tons). At present buffer norms of rice and wheat range from 16.2 to 26.9 million tons (across quarters beginning April 1) with a strategic reserve requirement of 5 million tons.

For the most part actual stocks have been at deviance from the norm, especially since 2000 (Figure 5.4). A major reason for this, as mentioned earlier, is that the MSP fixed by the government often runs counter to the movements in world prices. When the MSP is higher than the international prices, as was the case during the late 1990s and early 2000, stock buildup takes place. In July 2002, it reached the unprecedented level of 63 million tons of rice and wheat against a norm of 24.3 million tons and a storage

[16] The Technical Group in 1981 recommended the buffer stock should be 10 million tons (5 million tons of wheat and 5 million tons of rice) in addition to the operational stocks required for PDS. The Expenditure Reforms Commission (2000) quotes a study by Parikh that confirms a buffer stock level of around 10 million (wheat 4 million tons, rice 6 million tons) as adequate, notwithstanding the increase in population in the last two decades.

capacity of 28 million tons. To run down these excessive stocks, the government had to almost freeze the MSP and provide subsidies to export the grains. Subsequently, stock fell to levels below the norm; wheat stocks were especially meager and rolled down to 2 million tons as of April 2006, triggering panic imports by the government. Recent months again have seen burgeoning stocks and as of July 2010, the total rice and wheat stock held by the center and states were 57.8 million tons. These wild fluctuations in the stock levels portray a clear picture of mismanagement on the part of the government emanating from its price-setting policies.

Figure 5.4—Monthly stock of rice and wheat with the central pool



Source: Food Corporation of India 2010.

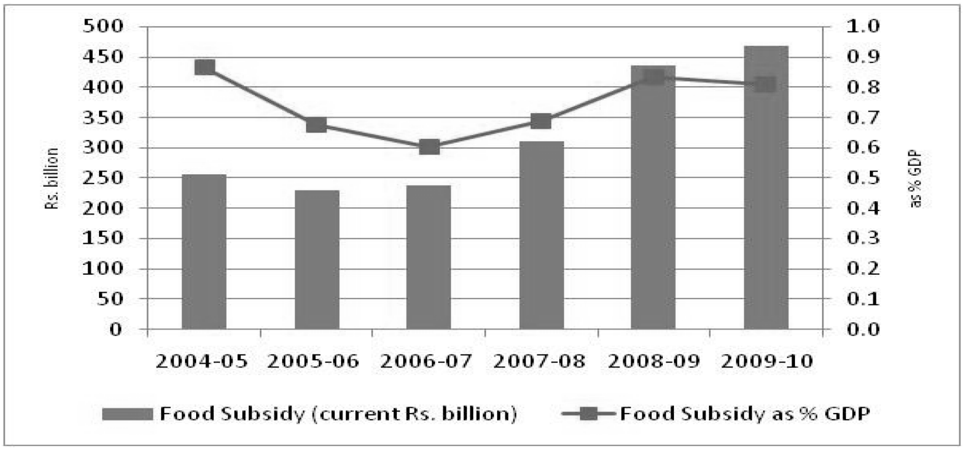
To cope with the rising procurement and the levels of stocks, the scale of FCI operations has increased. From less than 4,000 employees in 1965, today FCI reports more than 5,500 regular and 17,000 casual employees, who exert significant lobbying power to raise wages higher than market rates (Rashid et al.).[17] The scale of operations of government-led distribution mechanisms responsible for off-loading operational stocks has also increased. By the end of the 1990s, half a million ration or fair-price shops and more than 6,000 state marketing and regulatory bodies were established.

Distribution of grains takes place at a fixed Central Issue Price (CIP), which is revised from time to time. The last revision to CIP of PDS was made in 2002,[18] despite constantly increasing FCI's total *economic cost* composed of the MSP (and bonuses), procurement incidentals (including taxes and levies on procurement of processed foodgrains in states like Punjab, Haryana, and Andhra Pradesh), and the distribution cost (that is, costs attached to carrying buffer stocks, interest payments, hiring godowns, transport/freight expenditure, and so on). The difference between the FCI's economic cost and the CIP is the food subsidy borne by the government. The government's food subsidy bill has been rising steadily, from less than 0.4 percent in the early 1990s to 0.8 percent of the GDP in 2008/09 (Figure 5.5) at more than Rs 400 billion.

[17] The *Report on the Operations of the Food Corporation of India* (1991), by the Bureau of Industrial Costs and Prices, recommended that staff strength could be reduced by at least 30 percent to improve capacity use, which was only 34.3 percent in 1998/99, down from 77.5 in 1984/85 (reported in Jha and Srinivasan 2001).

[18] CIP is fixed for rice and wheat at different levels for below and above poverty line distribution under the targeted PDS. From December 2000, CIP of rice and wheat for distribution under Antyodaya Anna Yojna (AAY) has been constant at Rs 2 and Rs 3, respectively.

Figure 5.5—Growth of food subsidy in India



Source: Economic Survey (various) and Central Statistical Organization 2010.

Apart from this direct cost, there are additional costs that go unaccounted in the form of leakages, illegal diversion of foodgrains, and significant wastage due to poor storage and transport facilities. In the case of storage, for instance,[19] the *High Level Committee Report* in 2002 observes that though FCI has been regularizing losses up to 1 percent for wheat, 1.5 percent for rice, and 2.5 percent for paddy on quantities issued, this share is an underestimate as new stocks are constantly being added apart from those *killed*. Although there are efforts to move toward covered storage facilities, the CAP (that is, open storage) method is still widely used. In 2009 FCI alone had around 2.7 million tons CAP capacity (down from 5 million tons in 2003). When CAP storage with FCI is taken as a percentage of total stock, the figure is much larger—26 percent in 2003, 15 percent in 2006, and 6 percent in 2008 (in April). Reports in newspapers give us an additional idea of storage losses—according to an article dated March 17, 2010, wheat worth around Rs 5–8 billion has been rotting away in the open for the past two years in Punjab alone, where around 6.5 million tons of wheat were in CAP storage. Another report provided by the FCI in response to a Right to Information (RTI) inquiry states that from 1997 to 2007, around one million tons of foodgrains were damaged, including 0.18 million tons of wheat and 0.42 million tons of rice.[20]

Many studies have shown that FCI operations are cost-inefficient relative to private players. Gulati and Kahkonen (1996) estimate FCI suffered losses ranging from 29 percent for rice and 68 percent for wheat whereas private traders earned profits of 9–10 percent (Jha and Srinivasan 2001). Evidence from various studies show that FCIs unit costs are higher than the private sector's and they are constantly increasing (see Rashid et al. 2008). It has been noted that FCIs costs are not entirely comparable to private players as they have a larger public mandate as well as activities that span across the entire country. Nonetheless, it is instructive to note that even where comparable per unit costs are much higher for FCI, as reported in Jha and Srinivasan (2001) estimates that FCIs per unit storage costs are almost 30 percent higher, labor costs are four times higher for rice and seven times higher for wheat, and, finally, interest

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[19]Storage activities are undertaken by FCI (mainly foodgrains), Central Warehousing Corporation, and 17 State Warehousing Corporations (SWC) (foodgrains and other commodities).There are broadly three main types of storage (which are either owned/hired), namely, silos, godowns, and an indigenous method developed by FCI called Cover and Plinth (CAP). CAP storage refers to storage of foodgrains in the open with precautions such as rat-proof, damp-proof plinths and covering of stacks with fabricated polythene. Since CAP storage is in the open (sometimes for more than one year) grains are exposed to greater moisture/pest attacks/rodents leading to deteriorating grain quality. Damaged foodgrains are sold off as feed through an open market scheme via public tenders subject to certain quality standards.

[20] See "Food Grain Rots in Punjab as Prices Soar," accessed from http://www.ndtv.com/news/india/food-grain-rots-in-punjab-as-prices-soar-17934.php on March 20, 2010; "10 Lakh Tons of Foodgrains Damaged in FCI Godowns," accessed from http://www.financialexpress.com/news/10-lakh-tons-of-food-grains-damaged-in-fci-godowns/330283/ on March 22, 2010; and "India Food Grain Waste Revealed," accessed from http://news.bbc.co.uk/2/hi/business/7489816.stm on March 20, 2010.

payments are four and 2.5 times higher for rice and wheat respectively than private players. The continuation of these inefficient operations partly lies in the political economy of the system, which has spawned a large number of stakeholders and interest groups. In surplus states, for example, due to higher than market MSPs received by farmers, land under wheat and rice has grown more than 20 percent in Punjab and Haryana and at 15 percent in Andhra Pradesh, resulting in higher incomes for farmers and tax revenue for the state government (Dev 2003; Rashid et al. 2008).

The large-scale intervention by the government in grain markets requires self-serving, enabling conditions in the form of severe controls over the private sector with regard to both domestic and international trade. The following sections examine these two complementary set of controls that have restricted the role of the private sector in grain markets.

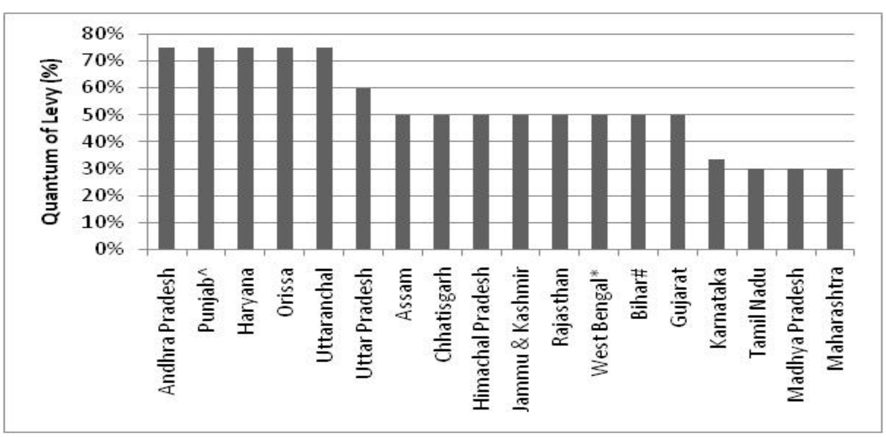
Domestic Trade Controls

In the domestic market, there are a variety of legal restrictions that facilitate FCI operations and limit private-sector activity, including zonal and movement restrictions, compulsory levies, differential access to credit and transport facilities, regulated markets, and so on. These controls on domestic trade reflect the belief that the operations of private traders are speculative and destabilizing for prices.

Some of these restrictions even date back to the colonial era; for instance, restrictions on movements of commodities across regions were introduced in 1941. Initially storage and movement controls were placed on traders via the Essential Commodities Act 1955 (ECA) mainly to prevent private hoarding. However, these controls have enabled the government to manipulate prices to MSP levels in surplus areas to reach procurement and stock targets. Alongside national level controls, there are considerable interstate variations in trade regulations and stocking limits on goods.

Restrictions on sale of processed/milled rice were imposed from 1958 onward under the Rice Milling Industry Act, which makes it mandatory for rice millers to sell a certain portion of their output to FCI at a fixed levy price with fixed processing margins (that is, the difference between levy price and rice-equivalent MSP). The percentage of levy rice is fixed by state governments with the approval of central government, taking into account requirements for the Central Pool, domestic consumption, and marketable surplus. Levy requirements are especially diverse across states, going up to even 75 percent (Figure 5.6). These high rice levies discourage miller's investment, increase transaction costs, and promote rent-seeking behavior.

Figure 5.6—Percentage of levy rice to be delivered in states under levy orders during kharif marketing season, 2008–2009



Source: Government of India 2009; Department of Food and Public Distribution accessible from http://fcamin.nic.in/.
Note: Permission to millers from Andhra Pradesh to deliver advance levy up to 100 percent in form of raw rice up to March 31, 2009, was given on December 15, 2008. The state governments of Bihar, Gujarat, Karnataka, Madhya Pradesh, Maharashtra, and Tamil Nadu, where levy percent is less than 50 percent, were requested to increase the levy percent to 50 percent. Governments of Bihar and Gujarat have increased the levy percent to 50 percent.

On the marketing side also there are a plethora of restrictions, illustrated in statewide Agricultural Produce and Marketing Regulations (APMC) Acts. Under the APMC Acts, only state governments were allowed to set up agricultural commodity markets in notified areas (called *mandis*) in order to promote transparent marketing practices and safeguard the interest of the farmers. However, over time these markets have been observed to be poorly organized and have not delivered the envisioned objectives. Elaborate licensing requirements gave rise to rent-seeking behavior and nurtured a class of commission agents who charge exorbitant fees for carrying the auctions, over the legally prescribed rates. For instance, a farmer selling at the Azadpur market in New Delhi has to pay a commission agent a fee ranging from 6 percent to 10 percent for an auction that lasts about five minutes (Gulati 2009). Similarly, in Vashi market in Mumbai, the commission agent's fee is about 8 percent and goes up to even 15 percent.

Reforms in the domestic market occurred mainly during the 1990s and early 2000 period after liberalization. In 2002 the Removal of Licensing Requirements, Stock Limits and Movement Restrictions on Specified Foodstuffs Order was passed and amended in 2003 to allow any dealer to freely buy, stock, sell, transport, distribute, dispose, acquire, use, or consume any quantity of wheat, paddy/rice, coarse grains, pulses, wheat products, and some other commodities without a license. This also requires state governments to get the prior approval from the center before passing new orders. Although these changes have reduced the barriers to internal trade to a large extent, certain other restrictions continue to limit interstate trade. For example, traders are required to own national and interstate permits, pay state-specific taxes for sale of certain goods, and suffer additional transactions costs (poor roads, extensive paperwork, multiple checking, and clearance requirements) (Jha, Srinivasan, and Ganesh Kumar 2010).

Agricultural marketing was also reviewed by an Expert Committee on Agricultural Marketing (2001) and Inter-Ministerial Task Force on Marketing Reforms (2002), who suggested the need to promote greater market dynamism, private participation, and direct interaction between farmers and buyers. After these consultations, the Model Act on Agricultural Produce and Marketing (Development and Regulations) Act was formulated in 2003 and circulated to state governments, recommending promotion of agricultural markets in the private and cooperative sectors, direct marketing, contract farming, rationalization of market fee, and so on. Though this is a step in the right direction, the states lack the political will in implementing this model act to promote direct marketing and contract farming arrangements with the private players. This has resulted in much diversity in how the model act has been implemented across states with a large variety of local farming and marketing arrangements. Currently the private sector has slowly starting entering grain markets—large players such as Imperial Tobacco Company (ITC), Cargill, and Britannia for wheat; PepsiCo Foods for rice; and ConAgra Foods for maize are active although in small volumes apart from some smaller domestic players.

International Trade and Foreign Exchange Reserves

External trade policies are highly interventionist as India's guiding objective remains self-sufficiency from domestic supplies. Up to the 1970s, agricultural exports were restricted and when allowed they were subject to numerous tariffs and nontariff barriers; imports licensing was common. Trade was canalized through State Trading Corporations (STCs) like Vegetable Oils Corporation for edible oils or FCI for cereals, especially rice and wheat. Further, the prevailing exchange rate policies had an anti-agriculture bias and the sector was overall net taxed due to the overvalued rupee.

After June 1966 the rupee was gradually devalued and by 1980 the Real Effective Exchange Rate declined by 46 percent (Gulati and Pursell 2009). After this the rupee was devalued in real terms from April 1985[21] until the Balance of Payment (BOP) crisis in 1991, when the rupee was sharply devalued. Between 1985 and 1992 the rupee was devalued in real terms by 145 percent (Gulati and Pursell 2009), after which the rupee was eventually made fully convertible on the current account. These changes

[21] Given the fragile BOP situation, two BOP crises were avoided in 1980 and 1981 with the help of the International Monetary Fund loan, which helped maintain the real value of the rupee.

improved the terms of trade for manufactured exports as well as agriculture and eased India's transition to a liberalized economy. But actual external trade policy liberalization mainly targeted the manufacturing sector via relaxation of licensing and entry requirements, restrictions on scale of expansion, limits on foreign direct investment, and so on (Gulati and Pursell 2009).

Though agricultural trade was not directly liberalized, overall macroeconomic and structural changes adopted in 1991 had two broad indirect impacts on the agricultural sector. First, higher economic growth and rising per capita incomes resulted in growing demand for food including nonfood-grain crops like fruits and vegetables, meat, and dairy. Second, there was improvement in domestic terms of trade and incentive for private investments in the agricultural sector (Landes and Gulati 2004). India officially started to liberalize its agricultural trade policy in 1994, after it signed the Uruguay Round Agreement on Agriculture (URAA, under General Agreement on Tariffs and Trade, now the World Trade Organization [WTO]). There were three main areas of commitment—improving market access, decreasing domestic support, and promoting export competition (Gulati and Kelly 1999). As its aggregate measure of support was below required standards and India did not subsidize exports, only the market access commitment really affected India.

Import Policy

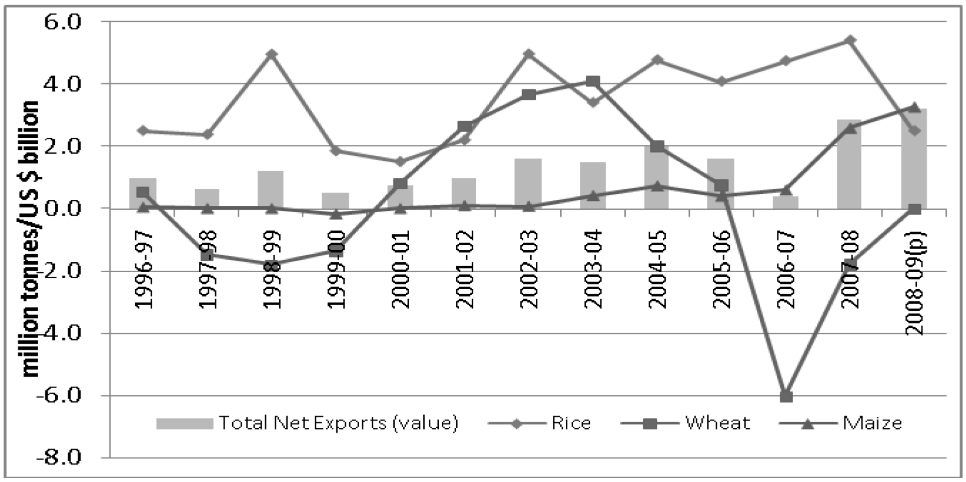
Under market access, all members were supposed to convert nontariff barriers to barrier tariffs (tariffication of quantitative restrictions, that is, QRs) with ceiling tariff bindings. India submitted high tariff bindings of 100 percent, 150 percent, and 300 percent for raw agricommodities, processed products, and edible oils, respectively (albeit with some exceptions; soya had binding of only 45 percent and some other commodities like rice, maize, sorghum, and millet had zero ceiling binding). Controls on sugar and cotton were lifted and the highly protected edible oils sector was brought under Open General License in 1994. Duty on edible oils was reduced from 65 percent to 35 percent in 1995 and to 10 percent in 1998 and for pulses to only 5 percent in 1995 (Gulati and Kelly 1999). But applied tariffs were mainly reduced; high ceilings gave considerable space for India to raise tariffs as and when it felt necessary apart from already existing QRs (due to its BOP problem, permitted under XVIII-B of the URAA). India, in fact, renegotiated tariffs on commodities like maize seeds, rice, rape oil, mustard oil, and so on, to new bound rates ranging from 80 to 40 percent (Hoda and Gulati 2005). The only significant change in import policy has been the phasing out of QRs; from 1998 onward India has agreed to eliminate its BOP restrictions. The general import licensing system was slowly dismantled, and in 2001 the last 715 tariff lines (which included 147 agricultural tariff lines) were removed and the system itself was abolished (Pursell, Gulati, and Gupta 2007). But though systematic tariff reduction was undertaken for nonagricultural goods in the 2000s, agriculture was omitted from this agenda; in 2006, trade-weighted average actual tariffs were still around 44.4 percent (World Trade Organization 2010).

Export Policy

Other than traditional exports like spices, cashews, tea, and coffee, there were several quantitative and price restrictions. In 1994, India lifted the minimum export price (MEP) of rice and exports of nondurum wheat were allowed (subject to quantitative restrictions). Other reforms included elimination of export quotas (except for some goods including onion, paddy, some seeds, and so on), opening up credit lines for exports and setting up agricultural export zones.

All these measures led to a sudden rise in foodgrain exports in the mid-1990s, especially of rice exports, which grew from less than 1 million tons in 1994 to more than 5 million tons in 1995 (Figure 5.7). Wheat exports also went up from 86.6 thousand tons in 1994 to 1.1 million tons in 1996 (Food and Agricultural Organization 2010). But toward the end of the 1990s as the international prices of agricultural commodities fell, Indian grain exports became uncompetitive (due to the pricing and buffer policies followed by the government as seen earlier) and cheaper imports of edible oils and wheat went up. To guard against a domestic glut in foodgrains, as buffer stocks kept growing, the government again raised tariffs and subsidized freight and stock holding to encourage traders to export in 2000/01 (Fan, Gulati and Dalafi 2008). Wheat exports jumped to 4 million tons in 2003 but then plummeted, as was seen in 2006/07. However, despite food security concerns and policy flip-flops in trade decisions, India has been a significant exporter of rice since the liberalization of rice markets. Export of maize, as indicated earlier, has gone up over time and far exceeds the import levels. It was only in 2006/07 that India imported more than a billion dollars' worth of wheat.

Figure 5.7—Net exports of rice, wheat, and maize



Source: Ministry of Commerce and Industry 2010.

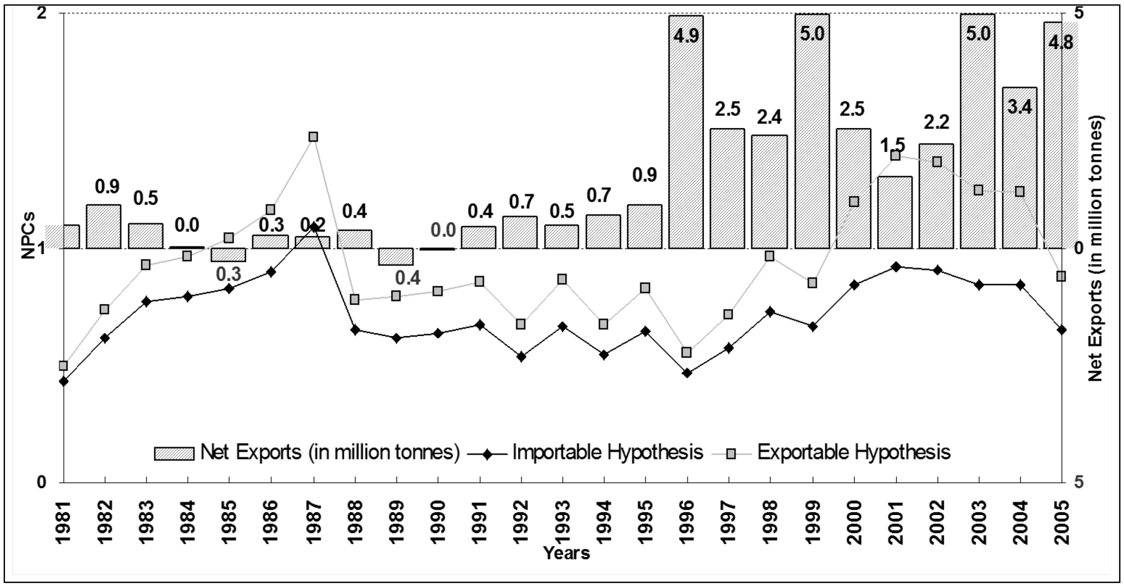
As world prices again started rising from 2006/07 onward, the Indian government banned wheat exports in February 2007 and raised MEP of rice in October 2007, fearing transmission of price volatility into the domestic market. The fear psychosis reached a new high in March 2008 when all the countries imposed bans on rice exports. These export restrictions by rice-trading nations was followed by emergency buying by several importing nations, such as the Philippines, further restricting the global rice supplies. It can be observed that these panic-driven policy responses by rice-exporting nations have aggravated the existing crisis by reducing producer incentives and increasing price volatility and uncertainty in the international rice market. However, one cannot put the entire blame only on Indian policymakers as these measures were initiated only as a preliminary response to stabilize the domestic economy.

Though these bans were partially lifted for some countries, including Bangladesh, Nepal, and some south Asian and African countries, highly restrictive export policies remained in place in late 2009. These interventions contributed not only to rising domestic stocks, but also to much uncertainty in world rice prices, which soared from October 2007 to a peak in May 2008, followed by a collapse over the following six months. Despite these measures, India was still a net exporter of grain—more than 2 million tons of rice and wheat respectively (Pursell, Gulati, and Shreedhar 2010). During this period the government also reduced tariffs for some key goods especially edible oils (for example, palm oil tariffs fell to zero) and introduced some import and export subsidies (for example, for pulses and sugar). The only cereal that shows some dynamism is maize, where imports that were traditionally higher than exports have fallen behind. Exports have shot up especially in the post-2000 period and peaked at around 2.7 million tons in 2007, due to rising demand from mainly south Asian and Gulf countries.

Gulati and Hoda (2008) estimate that rice has been largely competitive since its protection coefficient has been below unity for most years (Figure 5.8). Not surprisingly, the country has been a steady net exporter of rice since the 1990s. As for wheat, India was export competitive from 1989 to 1998 except for a temporary decline in international prices in 1991 (Figure 5.9). Export of wheat has undergone frequent policy changes mainly due to national concern over food security issues. The occasional dip in

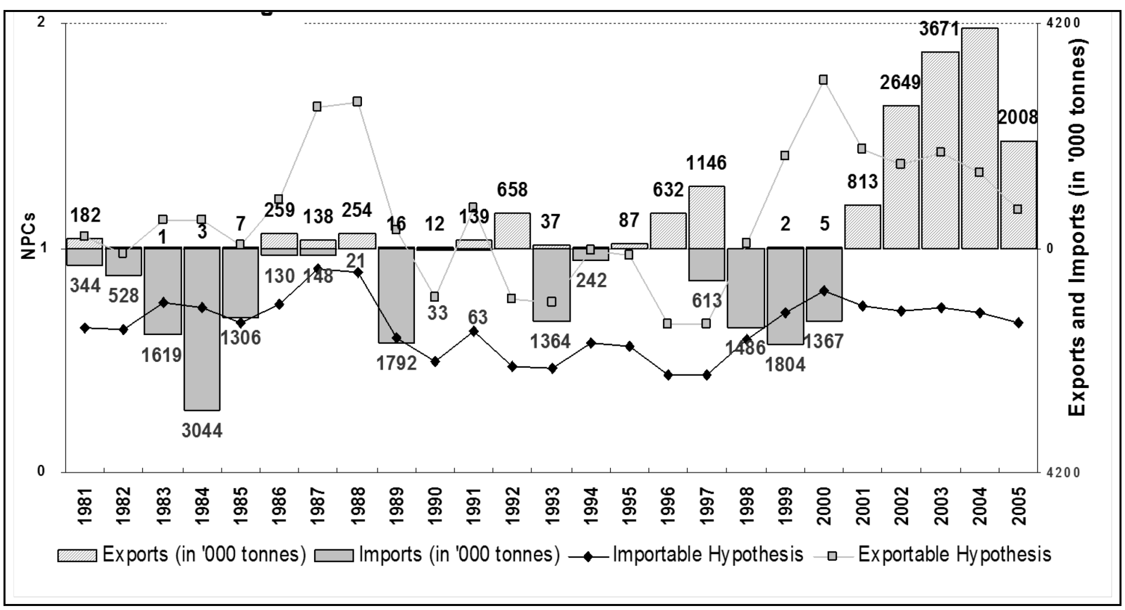
India's export competitiveness observed in both rice and wheat has essentially been due to sharp drops in the international prices, rather than due to changes in the production conditions of these two crops.

Figure 5.8—Rice trade and protection in India, 1981–2005



Source: Gulati and Hoda 2008.
Note: NPC refers to Nominal Protection Coefficient.

Figure 5.9—Wheat trade and protection in India, 1981–2005



Source: Gulati and Hoda 2008.
Note: NPC refers to Nominal Protection Coefficient.

Futures Trading in Foodgrains

The current approach of the government in fixing the MSP for grains in relation to the cost of production has given rise to several problems, as described earlier. Yet, the objective of providing a reasonable return to the farmer with minimal risk remains valid and even essential to accelerating adoption of new technologies that can augment productivity and production. In this context, there have been several suggestions for using more market-friendly approaches to address the core issue. One such suggestion is the role the futures market can play in price discovery and risk mitigation and also offer a guidepost for the government to take corrective actions to ensure price stability and orderly markets (Ganesh-Kumar, Gulati, and Cummings Jr. 2009). The basic argument is that futures markets can provide important signals on the evolving scenarios with regard to both supply and demand, not just based on domestic factors, but also taking into account the global market conditions. Thus, they can provide early warnings about the impending price movements, which can be used effectively by the government to take corrective actions such as through its stocking or international trade operations.

Futures trading in commodities in India first began in 1875, when the Bombay Cotton Trade Association Ltd. introduced contracts in cotton. Futures trading in oilseeds soon followed, when the Gujarat Vyapar Mandali was set up in 1900 for oilseeds and a host of smaller regional exchanges mushroomed all over for other commodities including jute, turmeric, sugar and *gur*, pepper, and so on; in 1939 there were more than 300 such exchanges. These centers functioned independently, with no common regulator or uniform trading, clearing, and settlement systems. After Independence, stock exchanges and futures trading were brought under the union list and became a central government subject. The Futures Contract (Regulation) (FCR) Act was passed in 1952 and the Forward Markets Commission (FMC) was set up in 1953 to regulate the workings of this nascent market. The FCR and FMC decided which commodities were allowed to be traded under recognized associations, which would be prohibited from futures trading, and which were *free* commodities (that fell under neither bracket).

By the mid-1960s, futures trading for many commodities were prohibited partly in response to food security concerns; in the 1970s, most registered associations became inactive, as futures and forward trading were either suspended or prohibited altogether despite the recommendations of the Dantewada Committee (1966). The Khusro Committee (1980) recommended the reintroduction of futures trading in most major commodities (cotton, raw jute, and jute goods) and also suggested extending futures trading to nontraditional goods like potatoes, onions, and so on (see Government of India 2010). But by 1990, just 6 commodities in 21 small exchanges were active (Kabra 2007).

In 1994, the Committee on Futures Markets (chaired by Professor Kabra) recommended that futures trading be reintroduced in some agrigoods, including cotton, basmati rice, rice bran oil, and certain other oilseeds. But items important for food security that witnessed heavy government intervention in markets, including wheat, non-basmati rice, tea coffee, sugar, and so on, were omitted. In 1999, futures trading was still limited with only seven commodities permitted.[22] Finally, in 2003, the government issued a notification that opened up futures trading to almost 95 commodities (including essential goods like rice, wheat, pulses, and sugar) and revoked its prohibition on merchandise trading. Three national commodity exchanges, the National Multi-Commodity Exchange (NMCE, Ahmadabad), Multi-Commodity Exchange (MCX, Mumbai), and National Commodity and Derivative Exchange (NCDEX, Mumbai) were officially recognized as well. Turnover grew rapidly with more than 100 percent growth in 2006/07 over the previous year. MCX has emerged with the largest market share of more than 70 percent of the total turnover, followed by NCDEX and NMCE and more than 20 other regional futures exchanges. Almost 97 percent of the trade volume is routed through the three government-regulated exchanges alone.

Initially agricultural products constituted the largest share in traded volume, accounting for more than 50 percent of total volume traded in 2005/06 and much of the initial growth. From 2006/07 onward,

[22] Two important policy documents that supported futures trading were the National Agricultural Policy 2000 and the Expert Committee on Strengthening and Developing Agricultural Marketing, which emphasized the role of futures trading in price risk management as well as marketing of agricultural produce.

metals and bullion have grown rapidly and agriculture has taken the backseat (Government of India 2010; Kabra 2007). By the end of 2006/07, rice and wheat (and *tur* and *urad* pulses) were prohibited from futures trading, given the shortage in domestic supplies and stocks. In 2007/08, the share and volume of some other key agricultural goods (including maize, guar seed, potato, and chilies) went down. Though some new commodities were introduced in 2008 for futures trading, a small number of them were agricultural commodities and prohibitions on key cereals remained. This could have possibly been influenced by the dampening of the market sentiment due to the government's frequent interventions, apart from the already stringent regulations in place (Government of India 2010). However futures' trading was resumed in chana, soy oil, rubber, and potato in December 2008, followed by wheat in May 2009. Agriculture futures staged a commendable recovery with 16.3 percent of the total trading value and 38 percent of the volume traded representing 48 percent growth over the previous year (Ministry of Finance 2010), although it is still far below potential levels.

6. WAY FORWARD

A review of the past performance and policies of India's foodgrain sector reveals that the main drivers of growth have been modern inputs and technology, institutions, and markets with the changing role of the public and private sectors. The present challenge facing Indian policymakers is to efficiently balance food security concerns and higher growth objectives. This will require not only pushing the production frontier to sustainably augment supply, but also ensuring strategic management of foodgrains including procurement and distribution of the same.

Challenges and Opportunities in the Foodgrain Sector

Although rice- and wheat-sector performance drove foodgrain output growth during the Green Revolution period, their growth rates in the past two decades have begun to plateau. Although the level of output has constantly grown, it still remains a matter of concern, primarily due to long-run food security needs. The high-spatial variation in productivity reveals that there is much scope to pump up output performance, especially in the eastern belt in rice, as these states have performed below their potential, primarily due to lack of modern input and output marketing support. Although efforts such as the recently launched National Food Security Mission and Second Green Revolution are steps in the right direction, it is too early to assess their impacts on the ground.

The only cereal crop that has shown dynamism in the recent years is maize, where the southern states, especially Karnataka and Andhra Pradesh, are emerging as high-growth and high-output regions. Two key drivers of growth in maize production and productivity seem to be the availability of high-quality hybrid seeds and high market demand from the poultry sector for its feed requirements. It is worth noting that both hybrid seeds and poultry are dominated by the private sector.

Policy Implications of Input- and Output-Sector Review

Currently existing input and output policies have evolved out of the Green Revolution framework; the review and evaluation presented in the previous sections raise the question of whether many of these policies have outlived their relevance in the present period.

The review of input policies highlights the pressure placed on foodgrain systems, in a business-as-usual scenario that extensively subsidizes input and promotes their intensive usage. Fallouts such as excessive groundwater withdrawals and distorted application of nitrogenous fertilizers have implications on the environmental sustainability of natural resources such as groundwater and soil quality, apart from being a considerable fiscal burden. The current policy of subsidizing agricultural power, irrigation, and fertilizers has outlived its relevance and is actually constraining agricultural investments in areas where the returns are higher. Although it is difficult to completely remove these subsidies, they still need to be gradually phased out and converted into investments in rural infrastructure (especially roads) and research and extension systems, which desperately need to be vitalized. It is time the government started to actively partner with the private sector (in infrastructure creation and research) and civil society organizations (n extension), as they have played an increasingly important role in recent years.

The role of the private sector is aptly highlighted in the seed sector, in hybrid maize, and even recently in hybrid rice seed production and sales. For the government to facilitate private-sector partnership and participation in a meaningful way, legislative action such as passing the Seed Bill 2004 and safeguarding Intellectual Property Rights (IPR), is a must. It encourages firms to invest in research, production, and marketing of quality seeds, and possibly even extension activities.

Similarly in the water and irrigation sector, legally binding water management regulatory framework can help clear uncertainties over water rights and usage issues. In the absence of these regulations, well-functioning canal networks and huge subsidies for electricity and high groundwater withdrawals have become increasingly predominant, instead of the conjunctive use of canals and groundwater, which is more resource and environmentally friendly. Water governance is thus an important policy concern at present and the government must focus on revitalizing canal irrigation systems and monitoring groundwater usage, to drought-proof large tracts of agricultural land in India that still remain vulnerable to erratic monsoons.

A good place to start the phasing out of subsidies is in the fertilizer sector. The Nutrient-Based Subsidy Scheme (NBS) is a promising start; however, it remains to be seen how the scheme will be implemented and its potential impact. Apart from this, it is also necessary to educate farmers on how best to apply these chemical fertilizers to balance yield performance with soil health. Government extension systems can play an important role in promoting eco-friendly farming practices, as can civil society organizations albeit on a lower scale (for instance, in organic market, a fast-emerging niche market in urban centers).

In the long run, agricultural support services such as research, extension, and credit are essential to ensuring foodgrain security. Research institutes must rigorously examine emerging technologies, including biotechnology options in crops, as the future lies in this direction and farmers have already indicated some acceptance toward such technologies such as Bt cotton. Collaborations with the private sector are critical, as mentioned earlier, as it is the presence of a strong extension network. Regular monitoring of these systems and incentivization through reward-recognition mechanisms can infuse some dynamism into this sector. Mainstreaming farmers into organized credit institutions is essential for them to access modern input such as agricultural machinery. The government has now recognized the need to work with commercial financial and microcredit institutions to promote financial inclusion. Other players such as technology providers (telecommunication and information technology companies), NGOs, and service providers such as village retailers to provide *credit plus services* (like farm advisory) and doorstep banking services should play an increasing role in this arena.

The review of the output management policies show that the current policy paradigm consisting of public procurement of grains at a preannounced minimum support price, public storage, and public distribution has resulted in distortions across crops, especially rice and wheat, as well periodic buildup of large stockpiles and stock rundown of these grains at a high cost to the government. Moreover, public procurement and stocking, coupled with interventionist international trade policies, is often at variance with the trends in international markets, resulting in lost opportunities for Indian exporters of rice and wheat. The regional concentration of the system of public procurement in the northern states, aided by intracountry trade and movement restrictions, has also resulted in large spatial disparity in agricultural productivity and farm income as well as uneven development of output markets across states. As a result, producer and consumer welfare is often compromised, even though the government's objective is to maintain a balance between them.

This calls for major reforms to the system of foodgrain management in India. Critically, the government's MSP policy needs to be linked with market prices and here futures markets can provide a cue on the emerging trend in supply, demand, and prices. Futures markets also have the potential to guard private traders against price risks. Alongside this, the government needs to liberalize the foodgrain trade, both international and domestic, to ensure that allocation of resources (land, water, and so on) is not distorted through subsidies. Liberalizing domestic trade is also critical to ensuring that output markets are more uniformly developed across states and that the country has a truly integrated market for foodgrains (if not for all other agricultural commodities). This is essential to avert local food scarcities and to reduce spatial inequities in farm incomes.

At the micro-level, the uneven development of output markets and value chains is an opportunity for the backward regions to leapfrog in terms of postharvest technologies and improving output storage and management practices. Here Cereal Systems Initiative for South Asia (CSISA) can play an important role in developing appropriate postharvest technologies to increase cereal production and to raise incomes in these regions.

Building Partnerships with CSISA

The review also highlights several areas where there is potential for CSISA to contribute meaningfully to the government's efforts to promote foodgrain production under the National Food Security Mission (NFSM) and other ongoing efforts at promoting a second Green Revolution. These relate primarily in the area of input supply, technology, and farm management practices to raise crop yields. Some specific issues on the input side and where CSISA can contribute are as follows:

Seeds

The India seed sector has moved forward in a big way and is self-reliant in meeting the seed requirement of the major cereal crops. However, distribution of quality seeds needs further improvement to push replacement rates to the desired level. Apart from this there has been no significant achievement in the development of new varieties for rice and wheat since the Green Revolution. The research needs to be strengthened in order to push yield frontiers beyond the current level. Partnership with the private sector will be the key for future success in research and development (R&D). With the agricultural land shrinking, promotion of hybrids and genetically modified crops are necessary to obtain high yields and reduce on-farm wastages through pests and diseases. Here CSISA can play a significant role as its primary objective relates to developing and ensuring the adoption of high-yielding, abiotic stress-tolerant, and disease- and insect-resistant rice, wheat, and maize varieties and hybrids for current and future cereal and mixed crop–livestock systems. This can be done in partnership with Indian public-sector research institutions as well as private research organizations.

Irrigation

Among the sectors discussed, irrigation seems to be the sector in (relative) disarray. The subsidies are increasing and there is huge pressure on water resources. It is critical to overcome the problems with the irrigation sector through policy and institutional innovations to avert a major water crisis. Some alternatives that emerge from the above discussion are as follows. First, we must rejuvenate canal irrigation and promote conjunctive use of water. Institutional and financial reforms are indispensable in canal irrigation. The level of irrigation subsidies are unsustainable, constraining investments in the expansion and maintenance of the existing canal network. The government has to come out with policies and institutions that can revive the sick canal irrigation system.

Second, there must be regulation and rationalization of the groundwater withdrawals. The unsustainable groundwater withdrawals, especially in the cereal-growing northern states, need to be checked immediately. New innovative legislations are needed to target the withdrawal rates as well as arrest increasing power subsidies. Apart from a top-down approach (through law) the government should come forward and promote community management of groundwater resources and conjunctive use of water. From the demand side, shifting of cereal procurement for the central pool to the eastern states would move the highly water-intensive rice cultivation to these states from the northern states of Punjab and Haryana. At the farm level, too, sustainable water management is important through the use of appropriate seed varieties, water conservation practices, and resource conservation agriculture. Here, CSISA can play a major role in developing sustainable technologies and water management practices.

Fertilizers

Similar to the seed sector, the fertilizer industry in India has also gone through a number of policy changes. Fortunately, since 2000 the government has emphasized efficient fertilizer production (especially urea) and has come out with a positive outlook. The New Pricing Policy introduced in 2003 was a step toward deregulation and the launching of the Nutrient-Based Scheme (NBS) was a much needed reform to arrest the subsidy bill and deteriorating soil health. The reforms have just started and should not end here. The NBS needs to be extended to urea, which is unarguably the most important fertilizer. Moreover, it is essential to provide the farmer with an informed choice of the quantity and proportion of fertilizer to be applied to a particular crop given the soil condition. That needs soil testing at the farm level at regular intervals. The right proportion and quantity applied would help in maintaining soil health and will have a positive effect on the yields. In this, CSISA can provide the knowledge support through training and demonstrations of efficient and sustainable nutrient management practices to ensure good soil health.

Research and extension

Despite India's large research and extension machinery and recent systemic reforms such as ATMA reaching out to farmers, both large and small (especially small), research and extension remain huge hurdles. Major constraints for providing effective extension services remain the weak linkage between research laboratories and extension service providers on the one side and poor feedback from farmers to researchers on the other side. Innovative methods that take advantage of new information and communication technology tools such as the mobile telephony services, the Internet, and so on, show much promise. CSISA's objectives include ensuring widespread delivery and adaptation of production and postharvest technologies and crop and resource management practices to increase cereal production and raise incomes via technology targeting. Each CSISA hub developing location-specific technologies and partnering with state and local research and extension organizations can help in creating a new generation of scientists and professional agronomists for cereal systems research and management. Hub-level innovations can help in revitalizing existing extension services and networks.

REFERENCES

Adhiguru, P., P. Birthal, and B. Ganesh Kumar. 2009. Strengthening Pluralistic Agricultural Information Delivery Systems in India. *Agricultural Economics Research Review*. Vol 22(1); 71–79.

Aiyar, S. 2010. New Miracle Economies: Bihar, Poor States. *Times of India*, January 3.

ASTI. 2010. Agricultural Science and Technology Indicators. Accessed November. www.asti.cgiar.org/data/?exportgeo1=IND.

Beintema, N., P. Adhiguru, P. S. Birthal, and A. Bawa. 2008. *Public Agricultural Research Investments: India in a Global Context.* New Delhi: National Centre for Agricultural Economics and Policy Research.

Birner, R., and J. R. Anderson. 2007. *How to Make Agricultural Extension Demand-Driven?* IFPRI Discussion Paper 00729. Washington, DC: International Food Policy Research Institute.

Central Ground Water Board. 2006. *Dynamic Groundwater Resources of India (as on March 2004).* New Delhi: Government of India.

Central Statistical Organization. 2010. National Accounts Statistics. Accessed August 18. http://mospi.nic.in/.

Chand, R. 2003. Minimum Support Price in Agriculture. Economic and Political Weekly. 38, 3027-28.

Chand, R. 2009. The Wheat Market: Distortions Caused by Government Intervention in Wheat Markets. *Economic and Political Weekly*. Vol 44; 41-46.

Chand, R., and S. Raju. 2009. Dealing with Effects of Monsoon Failures. *Economic and Political Weekly.* Vol 44; 29–34.

Chaturvedi, S. 2009. *Innovation and Technology Development: Evidence from Indian Seed Industry. Draft Report*. Washington, DC: International Food Policy Research Institute.

Chavan, P. 2008. Gender Inequality in Banking Services. *Economic and Political Weekly*. Vol 43; 18–21.

Cereal Systems Initiative for South Asia. 2010. Project Summary: CSISA. Accessed October 2. http://sites.google.com/site/csisaportal/project-summary.

Dantwala, M. 1969. Problems of Buffer Stocks. *Economic and Political Weekly*. Vol IV; A63–68.

Department of Agriculture and Cooperation. 2010. *Compendium of Plan Schemes in DAC.* New Delhi: Ministry of Agriculture, Government of India.

Dev, M. 2008. Agriculture: Absence of a big push. Economic and Political Weekly. Vol 43, 33-36.

Dev, M. 2006. Financial Inclusion: Issues and Challenges. *Economic and Political Weekly*. Vol 41; 4310–4313.

Economist. 2010. A Remarkable Turnaround in India's Most Troubled State. http://news.economist.com/cgi-bin1/DM/y/eB8YJ0Z5ci20Mo0GMsQ0Ej.

Evenson, R. E., C. E. Pray, and M. W. Rosegrant. 1999. *Agricultural Research and Productivity Growth in India*. IFPRI Research Report 109. Washington, DC: International Food Policy Research Institute.

Fan, S. 2003. Agricultural Research and Urban Poverty in India. *Quarterly Journal of International Agriculture*. Vol 42 (1); 63-78.

Fan, S., A. Gulati, and S. Dalafi. 2008. Reforms and Development in China and India. In *The Dragon and the Elephant*, edited by S. Fan and A. Gulati. New Delhi: Oxford University Press.

Fan, S., A. Gulati, and S. Thorat. 2008. Investment, Subsidies and Pro-Poor Growth in India. *Agricultural Economics.* Vol 39; 163–170.

Fan, S., and P. Hazell. 2000. Are Returns to Public Investment Lower in Less-Favored Areas? An Empirical Analysis of India. *Economic and Political Weekly.* Vol 35; 1455–1464.

Federation of Indian Chambers and Commerce and Industry. 2008. Agricultural Machinery Sector in India. Accessed November 9. www.agrievolution.com/atti/ficci.pdf.

Food and Agricultural Organization. 2010b. Accessed March 4 2010. FAOSTAT. http://faostat.fao.org.

Food Corporation of India. 2010. Accessed on March 4 2011. http://fciweb.nic.in/

Ganesh-Kumar, A., A. Gulati, and R. Cummings Jr. 2009. Reforming Foodgrains Management: Achieving Food Security with Cost-Effectiveness. In *Changing Contours of Asian Agriculture: Essays in Honour of Prof. V. S. Vyas*, edited by S. S. Reddy. New Delhi: Academic Foundation.

Glendenning, C., and S. Babu. 2010. Review of the Indian Agricultural Extension System—Are Farmers Information Needs Being Met? IFPRI draft paper.

Government of Bihar. 2010. Implementation Status of National Food Security Mission in Bihar. Accessed March 4 2010. http://nfsm.gov.in/.

Government of India. 2002. Master Plan for Artificial Recharge to Groundwater in India. Central Ground Water Board, Government of India. http://cgwb.gov.in/documents/MASTER PLAN Final-2002.pdf.

Government of India. 2010. *Seed Statistics. SeednetIndia Portal*. New Delhi: Government of India.

Government of Maharashtra. 2010. National Food Security Mission in Maharashtra. http://nsfm.gov.in.

Government of Uttar Pradesh. 2010. National Food Security Mission in Uttar Pradesh. http://nfsm.gov.in.

Gulati, A. 2009. *Emerging Trends in Indian Agriculture*. New Delhi: Dayanatha Jha Memorial Lecture, National Center for Agricultural Economics and Policy Research.

Gulati, A., J. R. Cummings, and K. Ganguly. 2009. *Punjab Agriculture at the CrossRoads.* IFPRI draft paper.

Gulati, A., and A. Hoda. 2008. *WTO Negotiations on Agriculture and Developing Countries*. New Delhi: Oxford University Press.

Gulati, A., and T. Kelly. 1999. *Trade Liberalization and Indian Agriculture*. New Delhi: Oxford University Press.

Gulati, A., and S. Narayanan. 2003. *The Subsidy Syndrome in Indian Agriculture*. New Delhi: Oxford University Press.

Gulati, A., and G. Pursell. 2009. India and Other South Asian Countries. In *Distortions to Agricultural Incentives in Asia*, edited by K. Anderson and W. Martin. Washington, DC: World Bank.

Gulati, A., and M. Svendson. 1995. *Strategic Change in Indian Irrigation*. New Delhi: Macmillan India.

Gulati, A and S Kahkonen (1996): 'The Food Corporation of India: Successes and Failures in Indian Foodgrain Marketing', NCAER-IRIS Collabourative Project, November, Mimeo.

Hoda, A., and A. Gulati. 2005. Indian Agriculture, Food Security and the WTO-AOA. In *Economic Reforms and Food Security*, edited by S. Babu and A. Gulati. New York: Food Products Press and International Press.

Indian Agricultural Statistics Research Institute (IASRI). 2009. *Agricultural Research Data Book.* New Delhi: IASRI.

Jain, R. C. 2006. Tractor Industry in India—Present and Future. Accessed November 10. www.unapcaem.org/Activities percent20Files/A0611/P-In.pdf.

James, C. 2009. *Global Status of Commercialized Botech/GM Crops:* 2009 (Vol. 41). International Service for the Acquisition of Agri-biotech Applications.

Janaiah, A. 2002. Hybrid Rice for Indian Farmers: Myths and Realities. *Economic and Political Weekly.* Vol 37;4319–4328.

Jha, D., and S. Pal. 2007. Agricultural Research and Technology in India: Status, Impact and Contemporary Issues. In *The Dragon and the Elephant: Agriculture and Rural Reforms in China and India*, edited by S. Fan and A. Gulati, 160–179. New Delhi: Oxford University Press.

Jha, S., and P. Srinivasan. 2001. Taking the PDS: Directions for Further Reform. *Economic and Political Weekly*. Vol 37; 3379–3386.

Jha, S., P. Srinivasan, and A. Ganesh Kumar. 2010. Achieving Food Security in a Cost-Effective Way. In *Liberalizing Food Grains Markets: Experiences, Impacts and Lessons from South Asia*, edited by A. Ganesh Kumar, D. Roy, and A. Gulati. New Delhi: Oxford University Press.

Johl, S., and S. Ray. 2002. *Future of Agriculture in Punjab.* New Delhi: Center for Research in Rural and Industrial Development.

Kabra, K. N. 2007. Commodity Futures Markets in India. *Economic and Political Weekly*. Vol 42; 1163–1170.

Kolady, D., D. J. Speilman, and A. J. Cavalieri. 2010. *Intellectual Property Rights, Private Investment in Research, and Productivity Growth in Indian Agriculture*. IFPRI Discussion Paper 01031. Washington, DC: International Food Policy Research Institute.

Kumar, S. 1999. New Fertilizer Policy. *Economic and Political Weekly*. Vol 34; 57–63.

Landes, R., and A. Gulati. 2004. Farm Sector Performance and Reform Agenda. *Economic and Political Weekly*. Vol 39; 3611–3619.

Li, J., Y. Xin, and L. Yuan. 2009. Pushing the Yield Frontier: Hybrid Rice in China. In *Millions Fed: Proven Successes in Agricultural Development*, edited by D. Speilman and R. Pandya-Lorch, 77–82. Washington DC: International Food Policy Research Institute.

Ministry of Agriculture. 2001. *Input Survey Report*. New Delhi: Government of India.

Ministry of Agriculture. 2010a. *Agricultural Statistics at a Glance 2009*. New Delhi: Government of India.

Ministry of Agriculture. 2010b. Agricultural Statistics at a Glance 2010. http://dacnet.nic.in/eands/latest_2006.htm.

Ministry of Agriculture. 2010c. Land Use Statistics. Accessed March 4. http://dacnet.nic.in/eands/LUS-2006-07/Summary/tb2.11.pdf.

Ministry of Agriculture. 2010d. National Food Security Mission. http://nfsm.gov.in/.

Ministry of Commerce and Industry. 2010. Export Import Databank. Accessed March 4. http://commerce.nic.in/eidb/default.asp.

Ministry of Finance. 2008. *Report of the Committee on Financial Inclusion (Chairman: Dr. C. Rangarajan)*. New Delhi: Government of India.

Ministry of Finance. 2010. Economic Survey 2010. Accessed June 4 2010. http://indiabudget.nic.in/.

Ministry of Water Resources. 2009. *MIC-Minor Irrigation Census: 1993/94 and 2000-01*. New Delhi: Government of India.

Mohan, R. 2006. Agricultural Credit in India: Status, Issues and Future Agenda. *Economic and Political Weekly*. Vol 41; 1013–1021.

Narayanan, S., S. Dalafi, and A. Gulati. 2008. India: Maize Economy, Incentives and Policies. In *Maize in Asia: Changing Markets and Incentives*, edited by A. Gulati and J Dixon. New Delhi: Oxford University Press.

National Sample Survey Organization. 2006. Level and Pattern of Consumer Expenditure, 2004–05. www.mospi.nic.in.

National Sample Survey Organization. 2007. Nutritional Intake in India, 2004–05. www.mospi.nic.in.

Pal, S., and D. Byerlee. 2006. India: The Funding and Organization of Agricultural R&D. In *Agricultural R&D in the Developing World: Too Little Too Late?*, edited by P. G. Pardey, M. A. Julian, and R. R. Piggott. Washington, DC: International Food Policy Research Institute.

Planning Commission. 2008. *Eleventh Five Year Plan (2007–12): Volume 3.* New Delhi: Government of India.

Pursell, G., A. Gulati, and K. Gupta. 2007. *Distortions to Agricultural Incentives in India*. Washington, DC: World Bank.

Pursell, G., A. Gulati, and G. Shreedhar. 2010. *Indian Agriculture and the Global and Financial Crisis*. IFPRI draft paper.

Raabe, K. 2008. *Reforming the Agricultural Extension System in India: What Do We Know About What Works and Why?* IFPRI Discussion Paper 00775. Washington, DC: International Food Policy Research Institute.

Rao, C. 2004. Indian Seed System and Plant Variety Protection. *Economic and Political Weekly*.

Rao, P. 2008. The Seed and Biotech Industry: Past, Present and Future. Paper presented at the National Seeds Association of India.

Rashid, S, Gulati, A and Cummings-Jr., R. 2008. *From Parastatals to Private Trade*. Oxford Press. New Delhi.

Ruchismita, R., and S. Varma. 2009. *Providing Insurance through Microfinance Institutions: The Indian Experience*. IFPRI 2020 Vision Focus Brief: 13. Washington, DC: International Food Policy Research Institute.

Satish, P. 2007. Agricultural Credit in the Post-Reform Era: A Target of Systematic Policy Coarctation. *Economic and Political Weekly*. Vol 42; 2567–2575.

Shah, T. 2009. *Taming the Anarchy: Groundwater Governance in South Asia*. Washington, DC: Resources for the Future Press.

Sharma, B., A. Gulati, N. Gupta, and P. Hemant. 2010. *Putting Bihar Agriculture on the Takeoff Trajectory: Nurturing the Seeds of Growth*. IWMI-IFPRI Joint report (draft). Washington, DC: International Food Policy Research Institute.

Sharma, V., K. Singh, and B. Panesar. 2005. Custom Hiring of Agricultural Machinery and Its Future Scope. In *Status of Farm Mechanization in India*, edited by K. Tyagi, H. Bathla, and S. Sharma. New Delhi: Indian Agricultural Statistics Research Institute.

Sharma, V., and H. Thaker. 2010. Fertilizer Subsidy in India: Who Are the Beneficiaries? *Economic and Political Weekly*. Vol 45; 68–76.

Shi-hua, C., C. Li-yong, Y. Shi-hua, and Z. Hu-qu. 2004. Forty Years' Development of Hybrid Rice: China's Experience. *Rice Science* 11 (5–6): 225–230.

Singh, G. 2005. Agricultural Machinery Industry in India (Manufacturing, Marketing and Mechanization Promotion). In *Status of Farm Mechanization in India*, edited by K. Tyagi, H. Bathla, and S. Sharma. New Delhi: Indian Agriculture Statistics Research Institute.

Singh, J. 2005. Scope, Progress and Constraints of Farm Mechanization in India. In *Status of Farm Mechanization in India*, edited by K. Tyagi, H. Bathla, and S. Sharma. New Delhi: Indian Agricultural Statistics Research Institute.

Singh, R., and M. Morris. 1997. *Adoption, Management, and Impact of Hybrid Maize Seed in India*. CIMMYT Economics Working Paper No. 97-06. New Mexico. CIMMYT.

Sulaiman V. R., and G. Holt. 2001. *Extension, Poverty and Vulnerability in India*. Overseas Development Institute.

Sulaiman V. R., and A. van der Ban. 2003. Funding and Delivering Agricultural Extension in India. *Journal of International Agriculture and Extension Education* 10 (1): 21–30.

Svendson, M., A. Gulati, and K. Raju. Unpublished draft. *Financial and Institutional Reforms in Indian Canal Irrigation.*

Swanson, B., and P. N. Mathur. 2003. *Review of the Agricultural Extension System in India*.

Venkateshwarlu, S., and A. Sen. 2002. Fertilizer Industry in India: Moulded by Government Policies. *Economic and Political Weekly*. Vol37; 326–336.

Venugopal, P. 2004. *State of the India Framer: Volume 8*. New Delhi: Academic Foundation.

Viraktamath, B., A. H. Prasad, M. Ramesha, and M. I. Ahmed. 2010. *Hybrid Rice in India. Directorate of Rice Research*. Hyderabad: Indian Council of Agricultural Research.

World Bank. 2010. World Bank Online Database. Accessed July 21. http://data.worldbank.org/.

World Trade Organization. 2010. Accessed on March 4 2010. www.wto.org/english/res_e/statis_e/statis_e.htm.

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