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Republic of India

Accelerating Agricultural Productivity Growth

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PREFACE

The motivation for this study is to gain a deeper understanding of the constraints on agricultural productivity growth, the central challenge facing agriculture in India. The study aims to inform the ongoing debates on strategic issues of relevance to the Government of India's development objective of inclusive and sustainable growth.

A comprehensive study to tackle all of the numerous issues would be an enormous task. The present study is less ambitious. India is a large and heterogeneous country. No individual study is likely to be sufficiently broad and deep to do justice to the many and complex issues surrounding its agricultural development. For that reason, this study was designed with particular care to complement, build on, and avoid redundancy with the array of ongoing analytical efforts and recently completed studies that address some of the other pressing agricultural issues, such as water and irrigation.

As a result of extensive consultations, the scope of this study was deliberately narrowed to focus on drivers of productivity, including: (i) factors explaining the patterns of productivity growth; (ii) strategies to best support resource-poor areas and small and marginal farmers with specific focus on promoting faster growth in Eastern India, a priority area for the government owing to the concentration of Low-income States in the region; and (iii) an assessment of the implementation of specific programs—for example, the Rashtriya Krishi Vikas Yojana (National Agriculture Development Programme, RKVY), the Agricultural Technology Management Agency (ATMA), National Food Security Mission (NFSM), and the National Horticultural Mission—and policy reforms, such as the Agricultural Produce Market Committees (APMCs).

These initial consultations were followed by a national workshop in November 2011 in New Delhi, organized by the Indira Gandhi Institute of Development Research (IGIDR) and the Institute for Human Development (IHD) in collaboration with the Planning Commission and the Ministry of Agriculture. The preliminary papers and invited presentations provided important input on key issues in raising agricultural productivity. Following the workshop, the background papers were refined, and additional detailed studies on selected topics were commissioned. That information formed the basis for this report.

To ensure its relevance and to take advantage of the large knowledge base on Indian agriculture, the team collaborated closely with the major think-tanks and research organizations working in India, including IGIDR, the International Food Policy Research Institute (IFPRI), the National Centre for Agricultural Economics and Policy Research (NCAP), and the National Council for Applied Economic Research (NCAER). Researchers from several other academic and research organizations contributed to background papers and analyses. The Bill and Melinda Gates Foundation was also a partner in the study, with a specific interest in the low-income areas of Eastern India.

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A study of this kind requires significant input and support in the form of analytical input, data, and information. For that support, the study team wishes to thank IFPRI (New Delhi and Washington, DC); the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT, Hyderabad); the Indira Gandhi Institute of Development Research (IGIDR, Mumbai); the Indian Council for Agricultural Research; the Directorate of Rice Research (Hyderabad); the Directorate of Wheat Research (Karnal); the National Center for Agricultural Economics and Policy Research (NCAER, New Delhi); the FAO Regional Office for Asia and the Pacific (Bangkok); the International Water Management Institute (New Delhi); and the World Economic Forum (Geneva).

The study team also gratefully acknowledges the generous contributions of Keith Fuglie in making available the global Total Factor Productivity (TFP) database on agriculture; P.K. Joshi (IFPRI, New Delhi) for access to various databases on Indian agriculture, including the growth decomposition database; Parthasarthy Rao and the Village Dynamics in South Asia team at ICRISAT for providing the District Level database for India; Pradhuman Kumar for the historical Cost of Cultivation and research expenditures databases; Pramod Aggarwal for the simulations of potential rice and wheat yields; Seema Bathla for the data on the historical wholesale prices and public expenditures on infrastructure; Nicholas Rada for estimates of agricultural sector TFP; Tony Fischer and Derek Byerlee for estimates of global yield gaps; and Kailash Pradhan and Sudhir Kumar for the data management and processing of the NCAER-REDS database.

The core team initiating the study included Madhur Gautam, Deepak Ahluwalia, Severin Kodderitzsch, and Shilpa Phadke (from the World Bank); Gavin Wall, Bhaskar Goswami, Syed Saifullah, and Sumiter Broca (from FAO); and S. Mahendra Dev (IGIDR) as lead technical advisor. Madhur Gautam, Bhaskar Goswami, S. Mahendra Dev, and Srijit Mishra coordinated the background studies. IGIDR and the Institute for Human Development (New Delhi) organized the initial workshop in Delhi under the leadership of S. Mahendra Dev, Alakh Sharma, Srijit Mishra, and Sumit Mazumdar. Madhur Gautam wrote the final report with substantive input from Deepak Ahluwalia, Syud Amer Ahmed, Varun Kshirsagar, and Helen Leitch, under the overall guidance of Simeon Ehui, Sector Manager for Agriculture, Irrigation, and Natural Resources, South Asia Region and Onno Ruhl, Country Director for India.

At various stages, this study benefited from the perspectives and other contributions of a large number of people. Foremost among them are the many authors of the technical background papers and notes listed in the first part of the references. The feedback and comments from the many participants at the Delhi workshop was helpful in refining the background papers and also helped shape the agenda for the subsequent analysis used in this report. Comments and suggestions from peer reviewers Derek Byerlee, Dina-Umali Deininger, Peter Hazell and Robert Townsend improved the report. Advice and discussions with S. Ayyappan, Shawki Barghouti, Ramesh Chand, S. Mahendra Dev, Ashok Gulati, P.K. Joshi, Mukesh Khullar, Uma Lele, Prabhu Pingali, V.V. Sadamate and Abhijit Sen advanced the work significantly, as did the insights from Pramod Aggarwal, Raman Ahuja, Ganesh-Kumar Anandam, Suresh Babu, Seema Bathla, Pratap Birthal, Liz Drake, Tony Fischer, Keith Fuglie, Nilabja Ghosh, Raj Gupta, Girish Kumar Jha, Anjani Kumar, Pradhuman Kumar, Shaik Meera, Srijit Mishra, Hari Nagarajan, Tuu-Van Nguyen, Suresh Pal, Manoj Panda, Sumit Mazumdar, Gokul Patnaik, Nicholas Rada, Anil Rajput, Shobha Rani, Baskar Reddy, Mangal Sain, C.S.C. Sekhar, Alakh Sharma, Arun Kumar Sharma, Indu Sharma, R.K. Sharma, Jit Shrivastava, R.B. Singh, Randhir Singh, M. Srinivas Rao, Sukhadeo Thorat, V.C. Viraktamath, and J.S. Yadav. Finally, the study team appreciates the suggestions and support of colleagues at the World Bank Group and FAO, including Luis Alberto Andres, Ulrich Bartsch, Deepak Bhattasali, Dan Biller, Edward Cook, Paramita Dasgupta, Klaus Deninger, Grahame Dixie, Anju Gaur, Ejaz Ghani, Neeraj Gupta, Kalpana Kocchar, William Magrath, Ajay Markanday, William Martin, Elliot Mghenyi, Grant Milne, Rinku Murgai, Keith Oblitas, Manivannan Pathy, Jeeva Perumalpillai-Essex, Shilpa Phadke, Giovanna Prennushi, Martin Rama, Ranjan Samantaray, Animesh Shrivastava, Paul Sidhu, Dina Umali-Deininger, Harsh Vivek, Vinay Vutukuru, Melissa Williams, Winston Yu, Roberto Zagha, (all World Bank Group) and Peter Kenmore, Vinod Ahuja and Sumiter Broca (FAO). Sarita Rana and Lilac Thomas provided excellent administrative support. Kelly Cassaday edited the report.

ACRONYMS AND ABBREVIATIONS

AI	Artificial Insemination
APC	Agricultural Policy Costs
APEDA	Agricultural and Processed Food Products Export Development Authority
APMC	Agricultural Produce Market Committee
APM (D&R)	Agricultural Produce Markets (Development and Regulation) Act
AS	Assam
ASI	Annual Survey of Industries
ATMA	Agricultural Technology Management Agency
AY	Attainable Yield
BH	Bihar
BIIC	Brazil, India, Indonesia, China
Bt	Bacillus thuringiensis
CF	Contract Farming
CoC	Cost of Cultivation (database)
CRS	Constant returns to scale
CSO	Central Statistical Organization
DEA	Data Envelopment Analysis
DME	Directory Manufacturing Establishment
DWR	Directorate of Wheat Research
DRR	Directorate of Rice Research
EC	Efficiency change

ECA	Essential Commodities Act
ENSO	El Niño-Southern Oscillation
F&V	Fruits and vegetables
FAO	Food and Agriculture Organization of the United Nations
FDI	Foreign direct investment
FMD	Foot and mouth disease
FY	Farm yield
g	Gram
GA	Growth accounting
GCI	Global Competitiveness Index
GDP	Gross domestic product
GJ	Gujarat
GOI	Government of India
GSDP	Gross state domestic product
GVA	Gross value added
GWh	Gigawatt hour
ha	Hectare
HP	Himachal Pradesh
HY	Haryana
IBTC	Input-biased technical change
ICAR	Indian Council of Agricultural Research
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
ICT	Information and communication technology

IFPRI	International Food Policy Research Institute
IGIDR	Indira Gandhi Institute of Development Research
IHD	Institute for Human Development
IMD	India Meteorological Department
JH	Jharkhand
KE	Kerala
kg	Kilogram
km	Kilometer
KT	Karantaka
KVC	Krishi Vikas Cooperative (Sholapur, Maharashtra)
KVK	Krishi Vigyan Kendra
LIS	Low-income States
LQ	Location Quotient
MH	Maharashtra
MNREGA	Mahatma Gandhi National Rural Employment Guarantee Act
MP	Madhya Pradesh
MSP	Minimum Support Price
MT	Metric ton
MTC	Magnitude or neutral component
NCAER	National Council for Applied Economic Research
NCAP	National Centre for Agricultural Economics and Policy Research
NDME	Non-directory Manufacturing Establishment
NFSM	National Food Security Mission
NGO	Nongovernmental Organization
NIC	National Industries Classification
NPK	Nitrogen, phosphorus, potassium
NRA	Nominal Rate of Assistance

NSS	National Sample Survey
OAME	Own Account Manufacturing Enterprise
OBC	Other Backward Castes
OBTC	Output-biased technical change
OR	Odisha
PB	Punjab
PEC	Pure technical efficiency
PPP	Public-private partnership
PY	Potential yield
q	Quintal
QSR	Quick service restaurant
RBH	Rural business hubs
RDI	Relative Diversity Index
RKVY	Rashtriya Krishi Vikas Yojana (National Agriculture Development Programme)
RJ	Rajasthan
RRA	Relative Rate of Assistance
Rs	Rupees
RY	Realizable yield
SC/ST	Scheduled castes/scheduled tribes
SEC	Scale efficiency
TC	Technical change
TE	Triennial Ending
TFP	Total factor productivity
TFPG	Total factor productivity growth
TN	Tamil Nadu
UK	Uttarakhand
UP	Uttar Pradesh
WB	West Bengal
WPI	Wholesale Price Index

Accelerating Agricultural Productivity Growth in India

OVERVIEW

In the past 50 years, Indian agriculture has undergone a major transformation, from dependence on food aid to becoming a consistent net food exporter. The gradual reforms in the agricultural sector (following the broader macro-reforms of the early 1990s) spurred some unprecedented innovations and changes in the food sector driven by private investment. These impressive achievements must now be viewed in light of the policy and investment imperatives that lie ahead. Agricultural growth has improved in recent years (averaging about 3.5 percent since 2004/05), but at a long-term trend rate of growth of 3 percent, agriculture has underperformed relative to its potential. The pockets of post-reform dynamism that have emerged evidently have not reached a sufficiently large scale to influence the sector's performance. For the vast population that still derives a living directly or indirectly from agriculture, achieving "faster, more inclusive, and sustainable growth"—the objectives at the heart of the Twelfth Five Year Plan—depends critically on simultaneous efforts to improve agriculture's performance and develop new sources of employment for the disproportionately large share of the labor force still on the farm.

Maintaining India's hard-won food security *and* achieving shared prosperity are proving to be ambitious goals. In the past, India's unwavering focus on food production helped it to achieve self-sufficiency, but a legacy of that effort is a complex web of policies and institutions that now arguably constrain more robust, sustainable agricultural growth, limit the performance of agricultural markets, and discourage much-needed diversification. The natural resources that support productive agriculture (namely land and water) are declining in quality, and competition for them is intensifying. Rainfall remains a major source of volatility in Indian agriculture. Heavy public investments, particularly in irrigation and technology, have helped to offset the worst effects of weather, but the deceleration of growth in the late 1990s and early 2000s, persistent increases in food prices in recent years, and declining water tables have revived concerns over food security. Climate change will almost certainly magnify the challenges and expectations for agriculture.

India is a large, heterogeneous country. One study alone cannot address the multitude of issues surrounding agriculture, certainly not in sufficient depth to be meaningful. This study was designed through a broad-based consensus to focus on strategic issues related to agricultural productivity. It gives particular attention to the dynamics and sources of productivity growth, the sustainability of growth, and areas where the potential for growth has been overlooked, all with a view to informing the debates on strategic priorities and policy interventions.

The scope of this study is broad in the sense that it marshals considerable empirical evidence and analyses to address those issues. Yet the scope is restricted in the sense that the study does not address all of the issues. A wealth of knowledge exists (and continuing analytical work proceeds) on other major strategic issues—water and irrigation management, food grain management, and public expenditures on agriculture, for example—and the findings of this study must be seen in that context. The lack of sufficient quality data, and often the lack of access to such data, also prevent some issues from being explored in greater depth. Finally, some important issues require more focused and dedicated analysis, such as food safety and quality standards, agricultural trade, and food price increases. This relationship between longer-term strategic issues and contemporary concerns, such as water resource management and food prices, are highlighted in this study through the prism of productivity, but they too require further analysis to fully address the underlying issues.

The Conundrums of Contemporary Agriculture

Contemporary Indian agriculture presents a number of seeming contradictions and conundrums. India's traditional breadbaskets face the food security–sustainability tradeoff. The irrigated rice- and wheat-producing areas appear to be facing diminishing returns to the technology that sparked the green revolution. These areas are singularly focused on increasing production, often at the cost of mining the natural resource base, placing the hard-won productivity gains of the past—and the future—at risk. Other parts of the country face a dilemma of another sort. Although they are far less agriculturally developed, these Low-income States (LIS) could unleash considerable growth in agricultural productivity, yet weak public investments, undeveloped markets and weak institutional and governance capacity have long stood in the way.

A major puzzle seems to be the co-existence of widespread undernourishment and rising food prices on the one hand, and record production levels of food and overflowing stocks on the other. Across India, diversification into higher-value crops and livestock products has proceeded too slowly to increase agricultural growth appreciably. The supply of high-value commodities has not kept pace with demand generated by rising incomes and urbanization, resulting in rapid increases in their prices. Cereal prices have again started to rise, adding to an agricultural conundrum in which per capita availability of food is falling even as per capita production of cereals is at all-time highs and rising, and domestic markets are effectively insulated from global market pressures. Rising Minimum Support Prices (MSPs) create a cereal supply response, but the increased production is diverted to stock silos rather than benefiting consumers through lower prices. Thus MSPs drive domestic cereal prices—especially producer prices—higher, while a combination of trade and storage policies stabilize them. The resulting low risk-to-return ratio for cereals creates strong incentives for farmers to produce cereals rather than other (more risky) crops, limiting diversification and income growth, putting further pressure on prices—this time through the higher-valued non-cereal commodities.

The short-term welfare impacts appear to be contained, as rural wages have risen rapidly in recent years, compensating for rising prices. Rising real prices benefit the net-selling farmers, and rising real wages are good for workers, but both trends have implications for the sustainability of the ensuing growth. The critical question is whether the changed incentives afforded by rising real output prices are accompanied by growth in productivity—are the sources of that growth sustainable?

Trends in Agricultural Performance at the National and Subnational Level

Over the past six decades, agriculture grew at a steady but modest 3.0 percent, changing imperceptibly but becoming relatively more stable. After almost two decades of sustained expansion (with growth peaking in the early 1990s at about 3.6 percent), growth decelerated from 1996/97 to 2004/05. This prolonged slowdown was widespread, with few exceptions. The most recent period—from 2004/05 onwards—shows a marked, equally widespread return to growth of 3.5 percent per year.

Performance and rainfall. What started agriculture on its long decline after 1997, and what spurred the equally decisive turnaround after 2004? Explanations for the slowdown include slow generation of new technologies, poor dissemination of existing ones, weak and inefficient institutions, poor governance, and inadequate investment in public goods. Irrigation, terms of trade, and technology are the major determinants of agricultural GDP growth. These factors are crucial for long-term growth, but their immediate role in the post-reform slowdown and the subsequent recovery is less obvious. Because the slowdown coincided with the agricultural policy reforms of the mid-1990s (following the general economic reforms of the early 1990s), a natural conclusion often drawn is that the reforms triggered the weakness. The influence of rainfall on Indian agriculture is widely acknowledged—60 percent of it remains rainfed—but rainfall's role in patterns of growth has not been fully explored.

At the district level, a credible association emerges between rainfall shocks and productivity (defined as value of output per hectare). Aggregated up to the national level, these data show a strong association of an unusual sequence of sustained negative rainfall shocks and the prolonged stagnation in productivity growth between 1999 and 2004. The weather-induced weakness provides an explanation for the deviation in trends for several key indicators during the early 2000s, including the slowdown in wages identified in previous studies. By extension, poor rainfall in the more recent years may partly account for the sluggish supply response in noncereal crops, which are found to be more susceptible to such shocks, and perhaps partly explain the upward pressure on their prices.

The sensitivity of crop productivity to rainfall varies considerably across districts, reflecting the availability of irrigation to compensate for annual rainfall deficits. Over the long run, districts in the Semi-Arid Temperate Zone are generally less vulnerable to rainfall shocks and relatively more productive on average. But the sustained rainfall shocks between 1997 and 2004 hit those districts the hardest, with a large aggregate and cumulative impact on agricultural productivity. The cyclical as well as random anomalies that are characteristic of rainfall in the Indian sub-continent call for both ex ante risk mitigation and ex post adaptation/management strategies.

Coming back to the question of role of policy reforms in agriculture's performance, a key question is what growth rates might have prevailed had rainfall been normal from the 1960s to 2010. A simple simulation reveals a sharp deviation between the actual and the counterfactual (simulated assuming normal rainfall, all else remaining the same) trends starting in the mid-1990s, suggesting that had rainfall been normal, the growth trajectory would have been significantly different and may possibly have been higher than the actual observed trend, potentially ushering in a much-desired, positive structural change. An important implication of these findings is that there is little evidence to suggest that the policy reforms of the mid 1990s had a significant adverse impact on agriculture, as may be tempting to infer from the observed growth trend. Another, perhaps more important, implication is the urgency of improving agriculture's resilience to the shifting trends in anomalous weather patterns over the near to medium term, and the anticipated intensification of the spatial and inter-annual variability of rainfall over the very long term.

Dynamics of agricultural productivity growth. Wide differences in performance across states in the 1980s appear to have disappeared since 2004/05, suggesting that growth may now be more inclusive, with lagging states starting to grow at par with other states. But within states (and agro-ecological zones), performance has varied widely across districts over time. A few districts have done well but most have not, and the relative rankings across districts are mostly preserved with persistent large differences. The lagging districts are not growing fast enough yet to achieve real convergence. For example, in 2007–08, productivity was 50 times higher in the most productive versus the least productive districts. Within LIS, increased growth in some districts widened inequality—the exception being Odisha—but in the more advanced agricultural states, lagging districts are catching up with the others, indicating convergence in growth rates.

Messages and Implications

There is little evidence to support the assertion that the policy reforms of the 1990s likely had a negative impact on agriculture. At the same time, the long-term strategic public investments in technology and irrigation have been very successful in increasing food production and mitigating the worst effects of rainfall shocks. The large aggregate and cumulative impact of a series of negative rainfall shocks between 1999-2004 serves a very important purpose—as a harbinger of the potential impacts of changing weather patterns over the short to medium term and the highly uncertain climate change outcomes over the long term. The experience underscores the urgency to address the current strategic issues. It highlights the critical importance of more efficient water management practices to weatherproof agriculture; develop strategies and make investments to mitigate climatic variability and increase resilience amid climate change (climate-smart technologies, sustainable irrigation, water harvesting and watershed development); improve markets and marketing to allow real-time risk sharing across states and districts in response to emerging market signals; and diversify and stabilize sources of income (outside the crop sector) through livestock and productive nonfarm employment. It is essential to quantify the costs and benefits of alternative ex ante risk-mitigation strategies and ex post risk-sharing strategies—issues for further detailed study.

To more closely examine performance and drivers of productivity, districts are classified by growth typology based on their initial (1970s) yields (high or low) and their subsequent performance (relatively stable or fast-growing) over the study period (1970–2008). Most growth in agricultural productivity occurred in northern and southern districts. Agro-ecological conditions and rainfall anomalies by themselves do not sufficiently explain the disparities among districts. What sets the growth districts apart from the others is better access to irrigation (and fertilizer use, which is influenced by irrigation). In addition to intensification, diversification into nontraditional and higher-value crops is also a major driver of growth in the high performers. For example, the low-yield/growth districts, unlike the low-yield/stable districts, switched area from low-value crops to higher-value crops such as cotton, horticultural crops, and soybeans.

District-level indicators to explain changes in agricultural productivity are limited, but the available data convey some important information. *Markets per capita* declined in low-yield districts relative to the others, likely reducing producer incentives and productivity growth. *Road density* has improved in the laggard districts, bringing them on par with the other districts. But while roads continue to show significant positive impact in the high-yield areas, they have not yet translated into improved productivity in the lagging

Messages and Implications

At the subnational level, growth has been pervasive—but not sufficiently broad-based. While the pace of agricultural growth appears to be converging somewhat across states, at the district level the expansionary phase of the 1980s and early 1990s was not very inclusive. A few lagging districts "caught up" with the better-performing districts, but a substantial number fell further behind, despite registering positive but low levels of growth.

Differences across districts are rooted in strategy and the enabling environment—and that is where policy attention is needed. Weather alone does not explain the differences in performance as weather shocks affected the productive districts disproportionately. At the same time, the findings caution against a "silver bullet" approach, highlighting the complementarity of policies and investments tailored to particular circumstances. For example, roads and improved seeds alone do not account for differential performance among districts.

The main drivers of productivity at the district level—and hence the key entry points for action—appear to be markets and irrigation. Market density has fallen more in the low-yield/stable districts than in the others, likely constraining productivity growth (through producer incentives). Irrigation and the associated adoption of fertilizer have contributed to significant changes in productivity in the growth districts. Improved seeds, the other key element of the green revolution technology, have spread faster and wider, but by themselves they have not narrowed the productivity differentials across districts. The rapid expansion in irrigation occurred mainly through groundwater extraction, well-known among policy instruments as a double-edged sword. The recurrent theme of sustainable water management emerges as a policy priority, with the important lesson from the faster-growing districts, consistently appearing across the low–high yield typologies, that diversification needs to be prioritized for a possible win-win strategy. That said, some areas will inevitably have limited prospects for irrigation, and their agro-ecological endowments may limit the scope for certain types of agriculture. Localized strategies will be needed for these areas to identify viable opportunities, including livelihood options outside of agriculture.

districts, calling attention to the importance of complementary investments. A slightly higher share of the population in low-yield districts was rural to begin with; this indicator of *urbanization* has changed relatively slowly in the districts where yields were initially low but shows no obvious links with the pace of growth within the low- or high-yield cohorts. Similarly, literacy remains marginally lower in the low-yield districts, but this basic measure of *human capital development* has also improved more rapidly in those districts, again without a clear association with productivity growth.

An International Perspective on India's Structural Transformation

The slow pace of India's structural transformation (that is, the decline in the share of labor in agriculture relative to the decline in the share of agriculture in aggregate GDP) is reflected in the large gap in productivity between agricultural and nonagricultural workers. The widening of this gap is a worry for policy makers. The low productivity of a large proportion of the labor force places a heavy tax on overall well-being and shared prosperity. But how atypical is India's experience?

Evidence suggests that developing countries are now taking longer to reach their "turning point"—the point at which the inter-sectoral labor productivities start to converge. The implication is that the development context is changing, and it is increasingly harder to absorb labor outside agriculture. India seems to be experiencing this phenomenon and is behaving no differently than the average developing country (in a cohort of 88 developing countries). Consequently, India must pay particular attention to accelerating the pace of labor absorption outside of agriculture, and it must redouble efforts to increase labor productivity within agriculture. Making agricultural labor more productive is

Messages and Implications

Technology has been a consistent driver of productivity in all four countries. Investing in technology is a globally proven and tested strategy for promoting productivity growth. Brazil, India, and China are among the largest investors in public research, and all have benefited significantly from such investment. China's and Brazil's investments, however, have been relatively more effective, making them global leaders in agricultural innovation. In Indonesia, the benefits of technology have also been pivotal, but they have accrued through open trade rather than domestic research.

A second major driver was agricultural diversification, both for domestic and export markets, supported by appropriate technology, policy, institutional reforms, and investments. Brazil, Indonesia, and China all benefited significantly more than India from openness in trade.

The backbone of China's and Brazil's more rapid transformation has been a more predictable enabling and policy environment. With a strong record of implementation, continuous innovation in public sector management for agriculture and rural development, and more effective decentralization in decision making, they have achieved significantly greater productivity growth. For example, major and fundamental reforms have greatly increased water-use efficiency in Chinese agriculture. Conducive policies paid significant dividends in production efficiencies and diversification, and better access to technology, whether from the international public research system, national research organizations, or the private sector (notably in relation to genetically modified crops).

imperative in any case, because a declining farm population will have to meet the consumption and raw material requirements of a growing nonfarm population.

In this context, comparisons among four large developing countries, Brazil, Indonesia, India, and China, are useful. Starting with comparable conditions in 1961, China and Indonesia achieved more success in reducing poverty and improving rural well-being. Brazil was relatively more advanced from the start and has continued to perform well. While Brazil has reached and China has almost reached their turning points, structural transformation in India and Indonesia has been slower. If the status quo prevails, their turning points are projected to be at least two decades away.

China is a more relevant comparator in terms of the scale of farming. The main difference with India is that despite having a larger share of its workforce in agriculture, China has seen much higher growth in agricultural value-added, with significantly more rapid technological change and diversification, and a much greater reliance on efficiency than input use as the main driver of growth. With more rapid increases in labor productivity, living standards among China's agricultural population improved much faster.

A Micro-level Perspective on India's Structural Transformation

A unique longitudinal study at the village level in Bihar, one of India's poorest states, draws attention to major changes at the micro level. Semi-feudal production relations—long associated with Bihar's agriculture—have virtually disappeared, while numbers of poor peasants, shares of casual landless agricultural labor, and the proportion of nonagricultural households all increased. Nonagricultural income, dominated by remittances, is the main source of income for all economic classes. Poor peasants have similar sources of income, but they largely undertake nonagricultural production activities. The middle and big peasants have a higher share of agricultural income, but it is still less than half their total income.

Another aspect of structural transformation is the significant diversification in men's occupations. Levels of migration out of the village are high, and migration income is the largest share of household income. At least initially, migration seems to have been a response to the lack of opportunity in local labor markets. Migration affects rural production systems by pushing up local wages,

Messages and Implications

Even villages in poor and backward areas, typical of Bihar, are experiencing significant agricultural and socioeconomic change. Nonagricultural incomes, particularly remittances, dominate household incomes. But agriculture, with a steady increase in yields (faster than the national average for rice and wheat), has not been stagnant. Real incomes appear to be rising, along with agricultural productivity, and agricultural diversification is yielding significant benefits. Structural transformation is more challenging in Bihar than elsewhere in India. Despite high levels of migration (Bihar is unusual in this respect), a substantial proportion of the population remains in agriculture; consequently, the person-land ratio is significantly worse, keeping the productivity of agricultural labor low. Concerns about the sustainability of migration as the major engine of continued growth call for more rapid nonfarm and on-farm diversification as sources of income growth.

promoting labor-saving cultivation techniques, and increasing the feminization of agricultural labor markets.

Did the Drivers of Growth Change Qualitatively in the 2000s?

To assess whether the recent recovery in agricultural growth can be sustained, it is vital to learn whether the drivers of growth changed qualitatively in the mid-2000s. Agricultural growth is increasingly driven by the rising shares of high-value commodities in value terms, but food grains still occupy two-thirds of the cropped area, and the shares of rice and wheat are unchanged. Except for cotton, yields of high-value crops have not increased significantly, raising concerns about the sustainability of their growth. A decomposition of growth confirms these apprehensions.

Yields dominated growth until the mid-1990s, as green revolution technology spread. Diversification has been a consistent but moderate contributor to growth. Since the 1980s, diversification consistently accounted for about one-quarter of growth, somewhat less than might be expected from a rapidly transforming agriculture. Prices contributed increasingly to growth in the 1990s, and in recent years they have again become the main driver. Area and yields rebounded early in the recovery (after 2003), but since 2007, area expansion has slowed as expected. Importantly, yields' contribution to growth diminished considerably, and diversification remains modest despite rapidly changing diets and rising commodity prices.

Evolution of Productivity at the National, State, Household, and Farm Levels

Given India's binding land constraint, agricultural growth depends on making land (for crops) and animals (for livestock products) more productive. In the case of land, productivity, often equated to yields, can be enhanced through intensification (using more inputs per hectare), through technological advances (better inputs), and/or improved efficiency (using inputs more effectively). Total factor productivity (TFP) captures the contributions of technology and efficiency and provides a summary measure of the health of the production system. For growth to be ecologically and economically sustainable, TFP must improve.

To build a convincing body of evidence, TFP is assessed using multiple sources of data, at different levels of aggregation, and employing different methodologies. The various analyses consistently demonstrate that productive resources are being used highly inefficiently.

Messages and Implications

Two worrying trends emerge from the analysis: The contribution of yields to productivity is declining, and prices have emerged as the main driver of growth toward the end of the 2000s. In 2010, 55 percent of the increase in the real value of output resulted from price increases. This finding raises concerns about the sustainability of the recent growth spurt: Farmers (specifically the net-sellers) gain from higher prices, but without underlying improvements in productivity, the current growth may be short-lived.

At the national level. Analyses based on different methodologies and data sources suggest that the recovery in recent years has been robust, with TFP growing at its fastest rate. Previous studies noted decelerating growth after the mid-1990s, but a longer time horizon (and hindsight) demonstrate, as discussed earlier, that this unusually long slowdown coincided with an anomalous rainfall pattern. It also means that the recent growth in TFP needs to be interpreted with caution: the period of analysis is short, and the recent growth partially reflects a rebound from a sharp decline in the previous period (reaching the lowest point in 2003). It will be important to track performance with data from additional years to ascertain if the growth is robust.

Irrigation, an important long-term driver of growth, appears to be contributing less to output growth in the 2000s, perhaps reflecting limits on expansion. Increased inputs have historically contributed the most to output growth, but in the 2000s, TFP has been the main source. Other emerging trends are a rise in labor productivity and capital deepening in the most recent period.

When TFP growth is decomposed into the contributions of technology and efficiency, the key finding is that technical change has consistently been the primary driver of productivity growth over the past three decades, growing fastest during the past decade (showing sustained growth even during the slowdown period). In contrast, efficiency has stagnated over the long run. It improved in the 1980s but has started to decline in recent years, indicating that the gap between actual production and the realizable potential (production frontier) is widening.

Another important finding is strong divergence in TFP growth for the traditional crops (cereals, pulses, oilseeds, cotton, and sugarcane) from that of the agricultural sector—which includes higher-valued horticulture and livestock subsectors, both of which are important for inclusive growth, and both of which have been major drivers of agriculture value-added in recent years. Yet neither subsector has commanded the attention of policy and public expenditure to the same extent as the traditional crops. Given the magnitude of the resources tied up in traditional crops, their low TFP growth (0.28 percent) contrasts starkly with the sector-wide estimate (1.77 percent).

The continued reliance on subsidized inputs as the main driver of growth in traditional crops, with declining efficiency, is reason for serious concern. Intensification in the lagging states where input use has been lower may be less worrisome, but the continued or accelerated use of inputs (often imbalanced applications of nutrients and overexploitation of groundwater) in the advanced states demands corrective action.

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For traditional crops, which receive most of the resources devoted to agriculture, TFP growth has stagnated. Technical change has been the primary driver of productivity growth, while efficiency has stagnated and appears to be declining in recent years. The fact that three-quarters of the growth is still driven by inputs for the bulk of the sector (traditional crops) raises concerns about the quality and sustainability of agricultural growth.

At the state level. TFP varies widely across states, across crops, as well as across states for the same crops. The biggest gains are associated with new technologies for cotton and maize, but the impact of even these new technologies is not uniform across states. Among staples, rice TFP has improved in recent years for several states, but wheat TFP has slowed considerably, with the exception of reform-driven Gujarat. Sugarcane and cotton offer a telling comparison. Sugarcane experienced consistent declines in TFP growth across all major producing states, while cotton experienced consistent gains. The two differ in that there is substantial government intervention and significant subsidies for sugarcane, whereas the cotton sector has rapidly transformed since the private sector introduced Bt cotton technology in 2002.

What explains the wide variation in TFP across states? As a residual measure, TFP subsumes many unobserved factors, making it difficult to assess the role of important policy levers. An analysis of the determinants of TFP, using state-level estimates and controlling for some of the confounding factors, gives results with significant policy implications.

The analysis confirms the importance of state-specific factors (broadly reflecting the policy, institutional, and governance environment) for productivity growth. Beyond these, diversification (even within the more restricted group of traditional crops) and technology—primarily agricultural research—are the main drivers of productivity growth. Contrary to general perceptions, the analysis shows that the contribution of research has not diminished over time.

In contrast, the impact of agricultural extension is considerably less visible. Persistent yield gaps, even for rice and wheat, suggest that extension has not enabled producers to benefit from current technology—even though traditional crops have long been a priority of public extension services. This result strongly suggests that the most immediate action to enhance productivity, and to counter “technology fatigue,” is to increase the effectiveness of extension services.

A telling result is that rural electrification has a large and highly significant *negative* impact, strongly suggesting that the large subsidies for electricity use in agriculture are adversely affecting TFP, probably by contributing to declining water tables (by promoting the unsustainable extraction of groundwater). Similarly, the negative and statistically significant impact of nutrient mix on TFP strongly supports the contention that subsidies promote indiscriminate applications of nitrogen that harm soils.

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At the state level, **policies and institutions** strongly influence productivity growth, along with **diversification and technology**. TFP is negatively affected by **excessive or imbalanced input use**, arguably driven by input subsidies. Ironically, instead of the intended impact of boosting productivity, subsidies may now be having quite the opposite effect, jeopardizing future productivity prospects. These results have major implications for the environment, productivity, and sustainable growth. An immediate area for action is more effective **extension services**. Extension services appear to have made little impact on productivity, even in traditional crops, but if they can help farmers to close the existing yield gaps, they could bring about substantial productivity gains.

At the household level. Using a completely different data source, the household-level analysis corroborates the major emerging finding that productive efficiency is low. It also shows that this inefficiency entails very high costs in terms of forgone farm income. Depending on the agro-ecological region, the average farmer is about 30–90 percent less efficient than the "best in class"—those farmers who are her/his peers within the study sample.

The micro-data confirm findings from the secondary data that technical change, rather than economic efficiency, has played the major role in productivity growth. Technical change has generally been good in recent years, with large gains in the formerly lagging semi-arid topics. Average efficiency fell significantly in the humid and arid zones, indicating that the average farmer is unable to keep up with the fast moving technological frontier, and is falling farther away from it. Arid areas have been the most vibrant, catching up with the meta-frontier at a rapid rate and closing their historical technology gap with the rest of the country.

The cost of inefficiency in terms of farmers' net returns or profits is high. A staggering 68 percent of potential short-run profits (on average) are *lost* relative to the optimal economic profit that was feasible in 2007 (albeit a slight improvement over the 73 percent lost in 1999). These losses can be attributed equally to technical and allocative inefficiencies, highlighting the roles of extension services and the policy environment in shaping farmers' choices. Smaller producers are more efficient, with higher allocative efficiency, whereas larger producers showed higher technical efficiency.

Changes in farm-level technical efficiency vary significantly by state. Farmers in Bihar represent the case of the "poor but efficient" producer—they operate at low input-output levels, but their input use is efficient (Schultz 1953). Punjabi farmers are equally efficient, but they represent the high input-output case. The absence of any obvious agro-ecological or geographical correlation with performance suggests that policies and the enabling environment at the state level play a strong role in determining efficiency outcomes.

In the most widely grown crops (rice and wheat), efficiency is lessening, and it is declining significantly for pulses and oilseeds. Only "other crops"—an aggregate of crops other than the cereals, pulses, and oilseeds—show marginal improvement in technical efficiency. Across households there is significant dispersion in efficiency levels for all crops.

Finally, an important finding is the difference in economic efficiency at the crop and whole-farm level. Higher allocative efficiency at the individual crop level suggests households are using resources (inputs) reasonably efficiently given the relative prices they face. But when

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Household-level analysis finds that inefficiency is high and very costly in terms of farm income. Although much of the debate on Indian agricultural productivity has focused on technical or technical production issues, these findings suggest significant scope to improve returns through more economically rational choices. **The role of policies, institutions, and the enabling environment, which is central to micro-level economic choices, needs be brought to the front and center of the debate if India's farmers are to move to a more profitable agriculture.**

it comes to the whole-farm level, allocative efficiency plunges, indicating that the bulk of economic inefficiency stems from farmers' crop choices. Household decisions to allocate resources are determined by the relative prices of crops and their associated risk levels, both of which are influenced considerably by the policy and institutional (especially market) environment.

What is driving inefficiency at the farm level? Among the range of factors explaining productivity and efficiency, the empirical analysis confirms the inverse land-productivity relationship, but smaller farms are less technically efficient. Another important finding is that at the margin family labor is *less* productive relative to hired labor, suggesting overuse of family labor (possibly because too many family members remain on the very small farms that are now more prevalent). Finally, as farm sizes decline through subdivision, land fragmentation is becoming a problem, with direct consequences for productivity through lower efficiency.

Younger and more educated households generally are more efficient at farming. The higher productivity of the newer generation of farmers suggests that greater access to productive land may be beneficial in terms of overall agricultural productivity and more efficient resource use.

Among public investments, the importance of access to *pucca* (paved) roads, technology, and extension services is reaffirmed by empirical results. An important insight on governance is the impact of women's participation in Gram Sabha meetings, which raises productive efficiency.

Are smaller farms still efficient and viable? The 25 years of household panel data from NCAER surveys provide a rare insight into the relationships between farm size (land owned by households) and three levels of farming returns: gross value of output per hectare, gross-margins per hectare (revenues less paid out costs, so in essence returns to family labor and land), and profits (revenues less paid costs and imputed costs of family labor—in other words, the returns to land only). The data show a significant and dramatic shift in the relationship between farm size and net revenues or profits per acre—from a strong inverse relationship in 1982 to an increasingly positive relationship in 1999 and 2007.

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Reforming the policy and regulatory framework governing land lease and rental markets is a high priority to sustain productivity and growth in farm incomes. The empirical findings reaffirm the well-established importance of factors like roads, technology, and irrigation while providing new insights. The findings on land fragmentation and the association of profitability with farm size ultimately suggest that some small farms may be getting too small to remain efficient or viable, despite the technical relationship between farm size and yield. Together with the findings that perhaps too much family labor remains and is used on small (and ever smaller) farms, these findings lend new urgency to reforming the tenancy laws and legalizing land lease markets. More efficient lease markets can help to consolidate land in the hands of the more productive farmers, perhaps by improving access to land for younger and more educated farmers, and can provide inefficient or unviable farmers the security to seek off-farm work without fear of losing their primary asset.

Given that most farms in India are under one hectare, these findings are significant—politically as well as economically—for growth and poverty reduction. The argument of "small and efficient" still applies from a technical perspective of higher yields or productivity (that is, the value of output per acre), as found in the productivity analysis discussed earlier, but the shift in the returns to farming indicates that "small and efficient" does not necessarily translate to more income (profits). The main reason behind this reversal is that the higher value of output per hectare is neutralized by very high family labor costs. These trends re-emphasize the point that family labor is overused on the farm.

Technology, Yield Gaps, and Growth Prospects

Many factors contribute to productivity growth (including infrastructure, markets, and education). Among these factors, technology plays a central role by helping to increase yields. Changes in yields are a joint outcome of contributions by research and extension. Research generates new technology that moves the production frontier (the yield potential) upward and outward. Extension assists farmers to better exploit the available technology—through access to new technology and advice to improve technical proficiency in using it—and in essence to close the "yield gap" (which is the difference between actual and potential yields). A combination of simulation models, research data, and actual yields helps to identify the yield gaps and how they have evolved over time. The analysis focuses on rice and wheat, for which abundant data are available, and which are an appropriate choice, given the heavy historical focus on these green revolution crops.

The all-India weighted averages show significant scope for increasing yields of both crops with technology that is already available. But India's biophysical heterogeneity argues against taking such a blanket assessment at face value. Indeed, the states vary considerably in their potential yields, their progress in closing the yield gaps, and the size of the remaining yield gaps. Some states have made good progress in rice in the last 15 years. Growth in wheat yields has slowed in most states, although Gujarat, Karnataka, and Maharashtra substantially narrowed their yield gaps.

Given that no country in the world has reduced its yield gap below 20 percent, 30 percent may be a realistic target. Some states are approaching this 30 percent target with current technology and face limited prospects for further improvement. Maharashtra and Gujarat seem to have exhausted their potential with the current wheat technology, whereas Punjab and Haryana have limited room to increase yields. West Bengal and Punjab are close to their potential for paddy, but most other states have significant scope for yield improvement. In interpreting these findings, two important caveats need to be kept in mind. One is that the attainable yield, used here as the benchmark for the yield gap, assumes that no biotic or abiotic stresses are present—rarely true in practice. Second, these are physical or output maximum potentials, not economically optimal potentials. Depending on the local policy and institutional environment, reducing the physical yield gaps may not be economically viable (as actual or observed farm yields may more accurately reflect).

The movement of the production frontier, or realizable yields, shows that the potential for wheat has continued to rise as new, better-yielding varieties are released, but rice potential has stagnated. Yet between 1995 and 2010, yield gaps widened for wheat and narrowed for rice. Growth in actual yields is similar for the two crops; the different trends in their yield gaps originate in the much faster rise in realizable yields for wheat—36 kilograms per hectare per year for rainfed wheat and 54 for irrigated wheat—whereas realizable yields for rice have stagnated since 1995, increasing by only 6 kilograms per hectare per year.

How do yield gaps in India compare to those in other major grain-growing areas of the world? The wheat yield gap in Punjab resembles the average across the other major production areas, with similar scope for doubling current yields. The yield gap for irrigated rice in Punjab is larger than the global average: Yields in Punjab need to rise by 75 percent to close the gap, whereas on average global yields need to double. The comparators for rainfed rice are limited, but the data show that Madhya Pradesh

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Yield gaps offer an opportunity, but their persistence reflects challenges in technology services. Yield gaps have narrowed over time, more for wheat than rice. But substantial gaps remain for both crops in rainfed as well as the green revolution areas, signaling potential for further gains and lending weight to the need to resolve the "extension problem." Research too has challenges to confront: dedicating more effort to crops other than rice and wheat, and working with a rapidly emerging private sector to align research priorities to tackle a changing climate and to address the multiple biotic and abiotic stresses prevalent in the LIS.

Investing for innovation and change requires institutional innovation. Technology capital is a critical input to accelerate agricultural productivity. India is among the world's preeminent investors in agricultural R&D. Yet success is more than the sum of public funding. The quality of innovation and the capacity of institutions to reconfigure and reorient themselves to a rapidly transforming agriculture are critical. To remain relevant and stimulate transformative change, the impressive institutions that ushered in the green revolution must take action:

- **In agricultural research**, public investment is increasing, but a number of reforms have also been proposed to reconfigure the research system to meet current needs and challenges. The issues of relevance, efficiency, and effectiveness of the research system are well understood, but bold action is needed to implement the reforms. At the same time, private sector investment in research is rapidly increasing, with significant potential to contribute to rapid growth in productivity and incomes, including in the poorer semi-arid parts of the country. To fully exploit this potential, the remaining constraints to private investment need to be removed.
- **In agricultural education**, the state agricultural universities face multiple crises in fulfilling their mandate to build the needed human capacity for technical innovation and undertake crucial adaptive research and extension activities. The crises in governance, resources, effectiveness, and ethics is widely acknowledged. These issues are revisited in the Bhubaneswar Declaration. The proposed roadmap for improving India's higher education system calls for fundamental changes but requires unwavering political will and commitment to overcome the ingrained resistance to change.
- **In agricultural extension**, the Agricultural Technology Development Agency models a decentralized, demand-driven approach for advisory and extension services to respond to local demands, priorities, and constraints. The lack of skilled, dedicated personnel in the agency, along with weak research-extension links, limited outreach to farmers, and limited operational flexibility, have yielded disappointing outcomes. Priorities are to renew and improve the focus on community outreach, reinforce organizational autonomy, and improve staff quality. Reforming current service delivery and promoting a pluralistic system is an urgent priority.

rainfed yields must grow by 150 percent to close the current yield gap.

Certainly yield is not the only metric of research achievements. Research also aims to develop varieties capable of withstanding specific growing conditions (evolving pests and diseases, for example) and supporting other local priorities (tastes or the timing of growing cycles, for example). Future research will need to emphasize varieties capable of adapting to the pressures of climate change. For example, early maturing varieties may be better adapted to rising temperatures, which are expected to reduce yields significantly. Varieties specifically suited to the needs of crop-livestock systems or agro-processors will also be in increasing demand.

Livestock Subsector: Significant Opportunities and Policy Priorities

The livestock subsector has grown at twice the rate of the food grain subsector. Continued income growth and demographic change in India will heighten demand for livestock products and offer significant opportunities to increase production and incomes. Mixed crop-livestock farming systems predominate among smallholders and are an important tool to target rural underemployment (particularly of unskilled and family labor), diversify risk, and stabilize income throughout the year. Livestock production is more inclusive than crop agriculture, with livestock ownership more widespread than land ownership. Women and other socioeconomically marginalized groups stand to benefit the most from better livestock productivity.

The potential. India has the world's largest livestock herd. It is unlikely to have a substantial dairy surplus for export, but it is already a leading exporter of bovine (buffalo) meat and a highly competitive exporter of mutton and pork. Expanding markets for processed meat and halal-certified products provide additional opportunities for export growth. Growth in meat output has mainly come at the extensive margin—from growth in livestock numbers. Substantial scope remains for improvement at the intensive margin.

More than two-thirds of livestock output is from the dairy industry. India leads the world in milk production, but milk yields are about half the world average. Formal milk processing has expanded rapidly, driven by deregulation of the dairy industry in the early 1990s. Even so, less than 20 percent of milk is formally processed.

The challenges. Despite this potential, India's public expenditure on livestock is low, declining, and ineffectively targeted. The impact of public programs must be monitored to inform policy, develop a strategy for the sector, and enhance service delivery. Most public funding goes to administrative rather than productivity-enhancing activities. Allocations for the smaller species (small ruminants, poultry, and pigs) that yield more benefits for smallholders remain low and have declined. The limited public expenditure on livestock must be rationalized between public and private goods.

The policy interventions. Policy interventions to raise productivity in the livestock subsector must target services and institutions for technology, marketing, and animal health. The National Dairy Plan is a multi-pronged approach along those lines that would work for the meat industry as well as poultry and pig production. Aside from encouraging commercial and

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Aside from additional and better-targeted public spending, priority actions include strengthening the institutions for technology, animal health, and smallholder marketing. The prospective socioeconomic and environmental gains from the livestock subsector offer substantial scope for economic and green growth. Measures that increase livestock productivity can enhance incomes, mitigate the environmental impact of livestock production, and enable livestock to adapt to India's challenging and changing climate. In this context, it is imperative to rely on intensification for growth. Improvements in breeds, feeds, and animal management and productivity are the other critical elements of any strategy to mitigate the environmental impacts of growth in the subsector.

large-scale operations, attention must be given to technologies, institutions, and policies enabling smallholders to produce more efficiently and sustainably and compete profitably in a price- and quality-conscious market.

The states urgently require better strategies to meet local requirements for animal breeding (cattle, small ruminants, pigs), improved nutrition and feed (to realize the gains from breeding), improved animal health systems with better livestock support services (including disease surveillance), and policies to attract private investment.

Investments in market infrastructure and quality standards are integral to the efficient distribution of livestock products, value addition, and food safety. Much of the investment will come from the private sector. Aside from encouraging such investment, the public sector must implement measures that help smallholders improve their bargaining power and build their capacity to absorb production and market risks.

Strategy and policy for the livestock sector must incorporate a range of environmental issues. Improvements in animal management and productivity are critical for mitigating greenhouse gas emissions and relieving pressure on land and water. Stocking rates in many areas are 5–10 times the recommended levels, and water use per liter of milk exceeds the world average in most intensive and semi-intensive systems. Producers must aim to maintain vegetative groundcover, reduce soil erosion and down-slope sedimentation, improve water infiltration and groundwater recharge, and increase pasture production. Greenhouse gas emissions per head of cattle depend greatly on animal breeds and the type of feed provided. Climate change will affect livestock productivity through a higher incidence of heat stress, drought, and flooding. A large number of adaptation strategies exist, but greater and better implementation is needed.

Investments in Agriculture for Growth and Sustainability

Private and public expenditures to expand productive capacity. Private investment in agriculture has increased rapidly since the mid-1990s. It accounts for more than 80 percent of the investment in agriculture and largely consists of on-farm investments, primarily in irrigation pumps and to a lesser degree in machinery. Overall investment on the farm remains low, and farmers prefer to allocate more of their disposable incomes to financial savings and expanding business capital.

Shares of public and private agricultural investments in capital formation are declining, however. For a sector deemed to be a priority, agriculture's diminishing share of public investment appears contradictory. When public expenditure is defined more broadly—to include expenditures *in* the sector (through agricultural programs and institutions) and expenditures *for* the sector (for complementary public investments like rural roads and electricity)—it is clear that agriculture does indeed command a much higher priority. Based on those criteria, public expenditures were equivalent to *one-third of agricultural GDP* in 2009, up from about one-fifth in 1995, about half of which was from the central (union) government. Infrastructure accounted for the largest share (34 percent) of these expenditures, with input support services following at 26 percent. Input support services (essentially private goods and subsidies) have grown the fastest (22 percent per year). In sharp contrast, research, education and extension services, which have been shown to have the largest returns among public expenditures in India, had a combined share of less than 2 percent.

Even those estimates do not capture the totality of subsidies supporting agriculture. A fuller (but still not exhaustive) accounting of subsidies (including food, fertilizer, irrigation, power, and others) shows that they dwarf public investments, irrespective of how the latter are defined. A vivid example is the pervasiveness of subsidies in two of the largest government programs or "missions" directed to increasing agricultural productivity (the National Food Security Mission and the Rashtriya Krishi Vikas Yojana). A review of their implementation in three states shows that 88-98 percent of funds under the NFSM and 42-87 percent under RKVY, depending on the state, were directed toward the provision of inputs or other private goods.

Private irrigation investments, public subsidies, and declining productivity. Two related trends in public and private investment are the rapid growth in private irrigation and the large and growing volume of subsidies in public expenditures. The importance of irrigation for agricultural growth is clear. But the dominant mode of private irrigation development—groundwater extraction—may not be sustainable in its current form. Distorted incentives encourage excessive extraction and highly inefficient use of water. Power and credit subsidies are the major drivers of groundwater extraction. Marginal returns to these subsidies in terms of improved productivity and poverty reduction were high in the 1960s and 1970s but are now significantly lower than returns to investments in rural roads and technology services.

The political economy of subsidies in India has relegated expenditure efficiency as well as budgetary implications to the extreme margins of public decision making. Yet concrete evidence is emerging that current policies will have an outsized negative impact over the long run. For example, electricity subsidies lead to an increase in the area planted to water-intensive crops such as rice and sugarcane but also lead to a large negative impact on groundwater levels. A fall in groundwater level by 1 meter is found to reduce production of food grains by 8 percent, water-intensive crops by 9 percent, and cash crops by 5 percent. A 10 percent reduction in the average electricity subsidy would reduce groundwater extraction by 6.7 percent.

Contrary to their intended objectives, electricity subsidies set a vicious circle in motion, jeopardizing agricultural productivity over the long run. Together with other policies such as MSPs, these distorted incentives have altered

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Although the budgetary implications of the large share of subsidies have little apparent weight in public policy decisions, policies intended to increase production and productivity clearly impose substantial costs in terms of resource degradation and lost future productivity. Consistent with the priority placed on agriculture, public spending has grown rapidly since the early 2000s and now equals one-third of agricultural value added. But only a small fraction of the public expenditure goes toward expanding the productive capacity of agriculture (to public investments or contribution to capital formation). Subsidies dwarf public investments. The substantial costs of these choices are also being borne now. If public policies that encourage these outcomes are not rationalized, they will further reduce productivity and returns to farmers—outcomes that are diametrically opposite to their intent.

crop composition to favor water-intensive crops, particularly in the Northwest and Mid-West, which are experiencing the most severe groundwater crises. This relationship is evident in the strong correlation between the "virtual water export" from the Northwest and public procurement of rice. *These policies urgently demand attention—especially in the interests of curbing the mounting risks occasioned by climate change.*

Consequences of imbalanced nutrient use. The current and long-term costs of imbalanced fertilizer use on productivity are widely recognized, but the associated changes in land productivity may not be equally well appreciated. The evidence suggests that productivity drops beyond a certain ratio of nitrogen to phosphorous. While the all-India median level is still below that threshold, half of the farmers in the breadbasket states (Punjab and Haryana) are above the threshold. In other words, they have reduced their productivity from the peak response level. Even in Bihar most farmers operate on the decreasing part of the response curve.

Marketing and Market Reform: Unfinished Business

India has long intervened in its agricultural markets. Regulations have eased since the 1990s, but reforms have been slow, uneven, and frequently reversed. When reforms are introduced, even partially, the private sector responds swiftly and dynamically—witness the emergence of contract farming, electronic exchanges, ICT-based market information systems and kiosks, and myriad value chain improvements. Yet the consensus is that the marketing, trade, value addition, agro-processing, and food safety capacity required by a diversified, vibrant, and modern agricultural sector has not materialized as expected. Government intervention continues. Parastatals dominate food grain markets, and private agricultural trade is heavily regulated.

The traditional chain, passing through agricultural wholesale markets and traditional urban retail, dominates the marketing of agricultural commodities, but it is inefficient, lacks integration, and is plagued by trader collusion in the regulated and restricted markets. Even so, alternatives—modern retail and the processing and food service sectors—are emerging, and even traditional value chains for staples are evolving, with changes in factor markets, innovations that shorten supply chains, wider access to information through mobile phones, and increasing downstream demand for quality and brand differentiation.

Innovations to improve marketing efficiency and link small and marginal producers to more remunerative value chains have been attempted on a limited scale, with mixed results. Firms or other private and public entities generally have preferred large and medium farmers for contract farming; established or corporate retail chains have preferred the more advanced agricultural states to the states where most poor smallholders reside. The main factors influencing those preferences appear to be difficulties in enforcing contracts, high transaction costs, and challenges in meeting quality standards. Initiatives to integrate small farmers to value chains failed to introduce or adapt appropriate technology over time, although producer companies appeared more effective than cooperatives at linking small-scale producers to markets.

Alternative market channels—traditional private sector traders, state-sponsored cooperatives, and Rural Business Hubs (a modern private sector innovation)—also show very mixed results. By and large, the benefits and costs differed little among the alternatives. The alternatives showed no clear improvement in smallholders' access to inputs or outputs, and smallholders experienced no significant price or quality discrimination in any market channel. What emerges is that medium and larger farmers have better access to state-sponsored cooperatives, indicating that subsidies (either through access or merely through the scale effect) are not as pro-poor as intended. Cooperatives are more beneficial in the more remote or backward areas of the states studied, where the private sector is thin or nonexistent.

This evidence from the ground level provides a useful backdrop to two pervasive regulations that have "stifled" agriculture and remain in effect for the most part: the Agricultural Produce Markets (Development and Regulation) Act—APM(D&R) Act—and the Essential Commodities Act (ECA). The issues related to these regulations are well recognized, including zoning and storage restrictions, market fragmentation and inefficiency, and the requirement to sell all produce at a limited number of licensed, regulated markets in often nontransparent transactions. The regulations discourage private investment in storage, handling, and marketing infrastructure; they also constrain contract farming or direct purchases by agro-processers and prevent improvements in value chain efficiencies.

To address the major problems, the government introduced a "Model Act" in 2003 and urged state governments to amend their legislation and regulations accordingly. Most states amended their legislation, but the extent and implementation of reforms remain limited. An in-depth study, including field assessments in five states, finds a largely unfinished agenda. Despite attempts to modify the ECA, its essential provisions remain intact. The multiplicity of control orders issued by multiple agencies (at the central and state levels) creates uncertainty and raises transaction costs. The lack of transparency prevails, restricting trade and maintaining market segmentation.

Different states interpret and implement reforms in different ways, prompting a need to rethink market governance. Agriculture is a state subject, but inter-state trade and commerce is under the Union list. For efficient markets, it is critical to establish common norms and ensure transparency and predictability of rules and regulations to facilitate private trade and investment. While overregulation is clearly a hindrance, the other

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In most cases, market reforms have not been implemented in full or in earnest, with provisions and omissions that effectively retain the status quo and restrict private investment and trade. India remains a segmented agricultural market; reforms to lift restrictions on movement, stock, and trade remain limited. Different states interpret and implement reforms and regulations in different ways, suggesting a need to rethink market governance. It may be advisable to place agricultural marketing on the Concurrent List and establish common norms for taxation and other charges/fees to make the system more transparent and predictable.

State governments face a conflict of interest with the proposed market reforms. Reform of APMCs have fiscal implications for state government, and as such have revenue implications. To overcome this obstacle, a cost-sharing strategy will need to be devised. Another conflict of interest is that state departments or marketing boards both run and regulate markets. An independent market regulator could level the playing field between the state and private markets.

extreme of an absence of any regulation is also not desirable. Markets need to be orderly and governed well to create a healthy environment for transactions, calling for an independent market regulator.

Beyond the Farm: Exploiting the Potential for Food Processing

Urbanization, the shift to nonfarm activities, rising incomes, women's increasing participation in the labor force, and changing consumption habits will create an outpouring of demand for processed foods. Food processing provides a natural entry point for India's sluggish "manufacturing" sector to move into predominantly agricultural areas and create much-needed off-farm employment. Food processing has among the largest multiplier effects across the economy. It can stimulate higher agricultural productivity through better and more stable farm prices, reduce wastage by transforming produce unsuitable for wet markets into value-added consumables (increasing returns to farmers), and promote diversification.

Food industry structure and investment. Like all manufacturing, the food-processing industry has a dualistic structure, with a relatively small (in number of units) but capital-intensive organized segment coexisting with a pervasive, mostly rural, and more labor-intensive unorganized segment. Rural firms are less capital intensive, less productive, and dominated by small family enterprises.

Shares of food processing in all manufacturing in terms of employment and numbers of units have been stable in most states over time, while the share of output has increased. Both the organized and unorganized segments have experienced capital deepening and declining labor intensities. The organized segment has generated jobs with an increased number of units, but the unorganized segment has lost enterprises and jobs over time. The remaining enterprises are larger in scale, with rapidly growing output per unit and slower but still growing employment per enterprise.

Labor productivity has risen fast, keeping pace with labor productivity in the non-food sector, but the associated rise in wages (also relative to the non-food sector) has restrained growth in employment, encouraging further capital intensity and scale of operating units. The preference for higher capital intensity and labor-saving technology reflects the perpetuation of informality and a reluctance to hire labor, perhaps due to labor laws and other factors in the business environment.

The significance of these trends for employment and transformation, even in the more rural food-based industry and in the more populous and poorer states, cannot be overstated. Encouraging new businesses to enter and existing businesses to expand employment more rapidly than in the past will create employment, but only with greater attention to the enabling environment and barriers to entry for smaller firms, especially in the lagging states.

Patterns and drivers of private investment in food manufacturing. Three major findings emerge from the analysis. First, the organized food industry is more prevalent in less industrially developed states with higher shares of income from agriculture; the unorganized segment is more prevalent across states, regardless of the level of development. Second, food manufacturing is more dominant in states with a higher percentage of poor people. Individuals tend to diversify out of agriculture by starting small nonagricultural enterprises or operating such enterprises alongside their agricultural ventures for supplemental income. Third, industrial investments in individual states are highly concentrated in specific sectors. Among the factors explaining investment patterns, the main results of interest for policy are backward linkages to agriculture, credit, and public infrastructure. The food industry's concentration in agricultural states clearly suggests that "location matters." Locations with higher agricultural productivity attract more private investment and employment in food processing. Finally, the findings on access to credit and infrastructure reconfirm their well-known importance as determinants of investment.

Productivity growth in the food-processing industry. TFP growth (TFPG) rebounded sharply after 2000, following a decline in the 1990s. For the unorganized segment, TFPG was positive but much lower than in the organized segment. The strong, positive correlation between TFPG for the organized and unorganized segments across states indicates that states doing better in one segment also do better in the other, suggesting a better overall investment

Messages and Implications

A dual focus on agricultural productivity and creating an appropriate investment climate to attract private investment is needed to promote more rapid rural transformation. States where agriculture is dominant have significant potential to attract private investment in the food industry. Higher agricultural productivity also attracts private investment in food processing, placing a premium on supportive investments in (for instance) irrigation, roads, and better functioning markets. Active promotion of this relatively more labor-intensive industry, through appropriate incentives, in states with low per capita income, high dependence on agriculture, and high incidence of poverty will help create off-farm jobs, which will absorb more people from agriculture and promote structural transformation. These arguments are even more relevant with respect to the unorganized segment of the industry, which is more widespread and has higher potential to absorb labor but currently suffers from low productivity. High levels of efficiency in many states signal that the food industry is well placed to compete in a more liberalized marketplace, with potential scope for foreign direct investment as well as exports. Policies to improve the investment climate for agro-processing, both for the organized and unorganized segments, is thus a high priority.

climate for food processing in some states. Key determinants of productivity differences across states include backward linkages to agriculture, infrastructure, and investor friendliness. Beyond the backward linkages, other agglomeration economies appear not to be significant.

The unorganized segment does not appear to grow through a complementary relationship (for example, through outsourcing or subcontracting) with organized food manufacturing. Both the organized and unorganized segments seem to be operating below optimal scales. The significantly suboptimal scale of operation in the unorganized segment suggests strong disincentives for employing labor in an otherwise efficient industry.

Transforming Agriculture in LIS: Challenges and Priorities for Bihar and Odisha

The eastern states offer enormous agricultural opportunities if their natural resources are managed judiciously, in a framework of appropriate policies and institutions and supportive infrastructure. Sufficient water, a suitable climate, and significant scope to improve yields make the eastern states a valuable resource for sustaining national food security, and their potential for high-value horticulture and livestock production portend a rapid economic transformation. Analysis in two of the poorest states, Bihar and Odisha, reveals the challenges and priorities involved in realizing this scenario and contributing to the inclusive growth agenda for LIS.

Challenges to productivity and diversification. In both states, low crop and livestock yields are typical, with large differentials across districts. Rapidly diversifying production has translated to faster growth and poverty reduction. Despite these seeming similarities, the two states have experienced distinct growth patterns. Diversification was strong and consistent in Bihar, with prices playing a lesser role in growth. Improved yield spurred growth in Odisha in the early 2000s, but now growth is led primarily by prices. As noted earlier, price-led growth raises concerns about its sustainability, given that yields are declining. In contrast, growth in Bihar appears more robust.

Small, fragmented holdings prevail in both Bihar (72 percent are under 0.5 hectare) and Odisha (60 percent smaller than 1 hectare). Tenancy and sharecropping arrangements discourage investment, while fragmented holdings and the small scale of operations are a drag on efficiency and constrain output marketing. Inevitably, transaction costs and market risks tend to be high.

Low input use intensity and efficiency limit productivity growth, although fertilizer use has grown faster than the national average in Bihar, approaching the levels in more advanced states. As in those states, fertilizer use is imbalanced, taxing productivity. The high level of biotic and abiotic stress from many sources—pests, diseases, drought, floods, acidic and sodic soils—means a very high level of agricultural risk, and likely constrains the adoption of new technology, reduces the efficiency of input use, and discourages productive investments.

Marketing remains a challenge. Relatively low and volatile prices result from thinly spread and underdeveloped markets; market density is low, and few markets have sophisticated infrastructure such as cold storage facilities. Bihar's bold abolition of the APM(D&R) Act seems to have unintentionally left a void in market governance, with allegations of noncompetitive behavior. Markets have been taken over by private entities; farmers continue to pay market fees but receive no services, and public and private investment in market infrastructure is nil. In Odisha the Act is intact, but most markets still have no mechanism for price discovery and price determination.

Bihar, Odisha, and other LIS historically received much less public funding for irrigation and infrastructure than other states. Allocations remain lower than the all-India average—inconsistent with the objective of inclusive growth. Both states improved road density, but other infrastructure deficiencies persist, particularly in rural electrification. Farmers invested in the more costly diesel pumps in Bihar, where irrigation intensity (at 62 percent of net sown area) now *surpasses* the all-India average (45 percent). Odisha's irrigation intensity remains low. Bihar has significant potential for surface water irrigation; Odisha already sources irrigation water from canals.

Messages and Implications

The top priorities for Bihar and Odisha are to tackle the multiple biotic and abiotic stresses, develop markets, and promote livestock development. Small holdings make it a priority to enable people to leave agriculture or diversify into higher-value agriculture. Technological solutions range from sustainable crop management strategies (for overcoming soil acidity and sodicity, multi-cropping, reducing water use, and conserving other resources) to better seed quality and faster seed replacement, and research on abiotic stresses (together with private companies).

Collective action—through producer organizations, cooperatives, farmer associations, or self-help groups—is important for scale economies and linking smallholders to value chains. Bihar has successful approaches that can be scaled up (for dairy, vegetables), and Odisha is innovating with farmers' markets and cluster approaches for specific horticultural crops. These initiatives need to be set within an **overall framework conducive to private investment in marketing, agro-processing, and land development**. Establishing a regulatory framework for fair, transparent, and efficient markets with free movement of goods and services is essential.

Livestock is a "quick win" for inclusive growth, nutritional outcomes, and employment. Priority actions include focusing research on diseases and production constraints; policy and other support for small ruminant, pig, and poultry production; and incentives for private investment in processing, value chains, feed production, and veterinary services.

1

A. Context and Objectives of this Report

INTRODUCTION TO THE ISSUES AND ANALYTICAL APPROACH

No longer a "sleeping giant,"[1] India has at last shaken off the persistent "Hindu" rate of growth[2] (averaging about 3.5 percent per year from 1950 until the mid-1980s) to attain sustained GDP growth of 8 percent per year in the last decade (2001–11). The timing and factors contributing to this structural break from historical growth rates are vigorously debated,[3] but the turnaround in growth since at least the early 1990s is undeniable.

Indian agriculture has also undergone some profound transformations. Food security has been an overriding priority in India's development strategy since the 1960s, underpinned by a comprehensive and directive policy, public investment and institutional support through a sharply focused program for urgent scale-up of the (then) new but relatively simple cereal production technologies. This strategy paid off with India's impressive transformation from a chronic food-deficit and food-aid-dependent country into a food-surplus country that is now a net food exporter. Growth in the production of staple foods (rice and wheat) has outpaced population growth. Per capita output of cereals is 20 percent higher today than in the 1960s, despite the population growing by two and half times.

With the economic reforms of 1991, gradual liberalization in the agricultural sector started in the Eighth Five Year Plan (1992–97), with successive plans increasingly emphasizing reforms in accord with evolving policy directions. Table A.1.1 (Annex 1) highlights some of the major policy reforms and other developments affecting the sector since 1990/91 and some of the private sector response to these changes. These incremental policy shifts, along with the trade-related reforms starting in the mid-1990s, set in motion other transformations. Once subject to heavy implicit taxation and other policy discrimination, agriculture now benefits from a heavily supportive (heavily subsidized) policy regime. India has emerged as a global agricultural powerhouse—it is the second-largest producer in terms of aggregate agricultural produce, as well as a top producer of several major commodities.[4]

Since the early 1990s, India's agricultural exports have also steadily grown and diversified, to the extent that its nontraditional exports now dominate the traditional exports

1 Bhagwati (2002).
2 Virmani (2006).
3 See, for example, Virmani (2006), Basu and Maertens (2007), Bosworth, Collins and Virmani (2007), and Kotwal, Ramaswamy, and Wadhwa (2011).

4 India ranks among the top two or three producers globally of wheat, rice, pulses, oilseeds, cotton, sugarcane, tea, milk, and fruits and vegetables.

of tea, coffee, spices, and cashews.[5] Growth in some of the nontraditional exports reflects sustained efforts by the government at export promotion and in some cases the introduction of new technology.[6] The performance of exports is all the more impressive considering that agricultural trade policy, while relatively more liberalized than before, has remained restrictive and unpredictable, with frequent changes (Gulati, Jain, and Hoda, 2013).

Rapid income growth following the economic reforms in the 1990s and some key policy changes attracted significant private interest and investment, encouraging a number of potentially transformative developments.[7] The most visible and dynamic changes have been the spread of Bt cotton in western India, soybeans in the center, poultry in the southern areas, and maize in the eastern areas, as well as remarkable innovations in e-trading, internet kiosks, and other value chain and marketing tools.

Despite the headline figures on growth, the increased elements of dynamism in agriculture, and India's export performance, concerns linger about the pattern of growth. India continues to face daunting challenges in reducing the number of poor, curbing high malnutrition, and achieving shared prosperity. Economic dualism persists. Modern *India*, popularly associated with the urbanized, highly skilled and outward-looking service sector, propelled India into the ranks of the world's fastest growing economies. But it exists alongside the largely agricultural and unskilled rural *Bharat*, which seems fixed on a path of low long-term growth fluctuating around a rate of 3 percent per year. Agricultural growth has picked up in the past decade (2002/03 to 2012/13) to about 3.5 percent (trend rate), almost as high as the previous peak reached in the mid-1990s, but it remains volatile and below potential. At present, the elements of dynamism noted previously do not appear sufficiently strong to influence agriculture's overall performance.

Progress on inclusiveness has been less than expected,[8] and inequality is on the rise (World Bank 2010). The rural-urban income divide is widening, with the key indicator of labor productivity showing growing differentials. In parts of the country, persistent poverty and farmer suicides appear to signal a pervasive agrarian crisis (Dev 2008a, 2013a; Mishra 2008; GoI 2006a). These facets of the economy are major concerns for the government, as reflected in the new Twelfth Five Year Plan's development objective: "Faster, More Inclusive, and Sustainable Growth."

The structural transformation of the economy has not progressed as fast or as widely as may be expected, and economic growth has been characterized as "lopsided" (Dev 2008b). With the majority of India's labor force still in rural areas, and over 68 percent employed in agriculture, India's development aspirations must inevitably reckon with agriculture's political, social, and economic importance.

5 In value terms, India's agricultural exports have consistently exceeded agricultural imports. India has emerged as the largest exporter of rice and beef (buffalo) meat in 2011–12. See Gulati, Jain, and Hoda (2013).

6 The Agricultural and Processed Food Products Export Development Authority (APEDA) was established in 1985 with a mandate to develop and promote exports of agricultural and processed food products from India. It has successfully engaged in sustained efforts to improve the transparency of supply and institute the traceability and quality standards required to negotiate entry into the European Union market for Indian grapes as well as the Japanese and United States markets for fresh mangoes.

7 Three key policy changes were to allow FDI in wholesale trade (1997), the de-licensing of Food Processing Industries (1999), and the New Seed Policy (1998).

8 Prime Minister's speech to the Full Planning Commission meeting to discuss the "Issues for Approach to the 12th Five Year Plan" (see the Planning Commission website, http://planningcommission.nic.in/).

Indeed the Eleventh and Twelfth Plans explicitly set a target of 4 percent for agricultural growth to achieve their overall economic growth targets and to ensure that growth is sufficiently inclusive.[9] Geographical inclusion—to focus on LIS and rainfed areas—and social inclusion—to respond to the feminization of agriculture and level the playing field for the disadvantaged social groups who are a substantial part of the agricultural economy—are well-recognized development priorities.

Agriculture's weak performance affects the livelihoods of a disproportionately large number of people, contributes to the slower-than-desirable decline in poverty,[10] and sustains the perception that national food security is under threat despite record harvests of the main staples.[11] Equally vexing is the recent phenomenon of seemingly "growth-less jobs" (Dev 2013b)—a rise in rural employment (as inferred from rising real farm wages) alongside sluggish agricultural productivity growth—which compounds the more widely recognized challenge of "job-less growth" (Bosworth and Collins 2008), referring to lack of "good jobs" in the more productive, nonagricultural and non-casual sectors, such as manufacturing (World Bank 2012a; GOI 2013a).

Going forward, the challenges of sustaining food security and promoting shared prosperity seem more difficult now than in the past. Growth and food security will need to be sustained with fewer degrees of freedom. The quality of land and water is declining, and agriculture faces intense competition for land and water from urbanization and nonagricultural uses. The sharp, sustained focus on food production helped India achieve self-sufficiency, but the complex web of policies and institutions that emerged in the process is now argued to constrain more robust, sustainable growth (Gulati, Ganguly, and Shreedhar 2011), limit the performance of markets (Gulati, Landes, and Ganguly 2009), and discourage much-needed diversification to accommodate changing consumption patterns (Joshi and Gulati 2007; Joshi, Gulati, and Cummings 2007).[12]

Weather—especially the vagaries of the monsoons—remains a major source of volatility in Indian agriculture. Heavy public investments and the green revolution technology helped India achieve its food security goals, and they have made India the world's most intensively cultivated and most irrigated country (in terms of area equipped for irrigation). Those investments have helped stabilize agricultural growth, shielding it to some extent from the worst effects of unpredictable weather,[13] yet

9 For the Eleventh Five Year Plan, the Planning Commission estimated that 4 percent growth in agriculture was necessary to achieve the overall GDP growth target of 9 percent without undue inflation and to meet its objective of inclusiveness (GOI 2011a). Similarly, for the Twelfth Five Year Plan, the Planning Commission has again set a goal to achieve agricultural growth of at least 4 percent to meet its targeted GDP growth of 9–9.5 percent and ensure that this growth is inclusive (GOI 2011b).

10 Datt and Ravallion (2009) find that rural growth has contributed relatively less to poverty reduction in the 1990s, compared to their earlier findings for the 1980s, when it was a more significant driver of poverty reduction than urban growth.

11 Revised estimates by the Expert Group on Methodology for Estimation of Poverty, chaired by S. D. Tendulkar, put the rural poverty headcount at 42 percent in 2004/05, up from the previous estimate of 28 percent and closer to the estimate of the proportion of people living under US$ 1.25 in international purchasing power parity terms. See the Planning Commission website, http://planningcommission.nic.in/eg_poverty.htm.

12 Since the initiation of the green revolution (with its focus on technology and water), agriculture has been characterized by a high degree of public support aimed at increasing the use of productivity-enhancing inputs (seed, fertilizer, water, and electricity), external trade controls, zoning and storage restrictions, output marketing regulations, and a vast system of food price policy and public procurement and distribution of food grains put in place to promote food security for the poor.

13 Government of India Planning Commission, Twelfth Five Year Plan 2012–17, http://planningcommission.gov.in/plans/planrel/12thplan/welcome.html.

the target of 4 percent growth has remained elusive. Slowing growth rates in the late 1990s and early 2000s[14] and food price increases in more recent years are stark reminders of threats to food and nutritional security. As the effects of climate change become more pronounced, they will likely magnify the threats to food security and growth and compound the challenges of developing new agricultural technology and managing scarce land and water resources.

Motivation and Scope of this Study

Agriculture's persistent low growth (especially its low productivity) jeopardizes achieving the goals of more inclusive and sustainable economic growth. The imperative of improving agricultural productivity is widely recognized.[15] It is reflected in efforts to reverse the perceived neglect of agriculture in the Eleventh Five Year Plan with the allocation of substantial resources to kick-start the sector.[16] The government adopted a fairly comprehensive strategy targeting technology, irrigation and water management, agricultural diversification, infrastructure, and private investment in marketing and food processing. The central question examined here is whether the current strategy adequately prioritizes actions to create the conditions for agriculture to achieve and sustain faster growth.

The scope and approach for this study were arrived at through a consultative process, which deliberately guided the study to focus on issues related to productivity growth, the central challenge facing Indian agriculture. India is a large and heterogeneous country, with widely varied agro-ecological and economic endowments. A comprehensive study that can do justice with sufficient breadth and depth to all of the complex issues surrounding its agricultural development would be an enormous undertaking. This study is less ambitious, focused on the specific issue of productivity growth and cognizant of the wealth of existing knowledge, completed studies, and ongoing analytical efforts (some of which address other major pressing issues, such as water and irrigation). Finally, the study takes a deliberate empirical and evidence-based approach, to objectively inform policy and institutional debates. Inevitably, lack of or insufficient quality of data, and at times challenges in obtaining data, prevent a deeper dive into some pertinent issues.

For these reasons, it is important to acknowledge that this study is not intended as an exhaustive exploration of all major issues affecting agriculture. Some of the issues have been well analyzed or are being studied; others are emerging and more complex, and their full analysis requires more focused and dedicated efforts. The former include, for example, irrigation and water management, food grain management, and the analysis of public expenditures. The latter include food safety and standards, agricultural trade, and food price increase, all of which are high priorities for the future analytical agenda.

14 The deceleration was widespread, affecting all categories of farmers (small and large) and virtually all regions of India, and it affected not only food grains but other subsectors, such as livestock and horticultural crops (Bhalla and Singh 2001, 2010).

15 Despite the Indian economy's rapid growth and changing structure, recent research shows that agricultural yields continue to have a substantial impact on poverty (see Himanshu et al. 2010).

16 The core challenges identified by the Steering Committee on Agriculture for the Eleventh Five Year Plan are long term in nature. They include increasing population pressure; technology fatigue (no major breakthroughs in agricultural technology); inefficient use of the available technology, owing to a weak extension system; falling groundwater levels and inefficient use of water; degradation of the natural resource base; no expansion in irrigated area; inefficient and distorted input markets (seed and fertilizer); and inefficient output marketing systems.

Nevertheless, the longer-term strategic issues related to productivity undoubtedly interact with a number of contemporary issues, such as food prices, and vice-versa. Several of these issues are naturally touched upon and discussed in context, but without the deeper diagnostics to fully inform the surrounding policy and institutional actions needed to address them.

Specific Objectives and Analytical Approach

To identify priorities for accelerating sustainable agricultural growth, this study specifically sets out to examine patterns of productivity growth, identify the drivers of past and current productivity growth, and outline the binding constraints to future growth.

To better analyze which policy, institutional, and investment factors constrain more rapid agricultural growth, this study attempts to take account of the agro-ecological heterogeneity of India to identify the main drivers of productivity growth. For example, productivity growth can result from higher yields (for crops or livestock) or increased diversification into higher-value crop or livestock outputs (by individual households or across geographical areas that still focus on traditional or subsistence crops).[17] Subject to the data available, the diagnostics rely on different measures of productivity—total factor productivity as well as land and labor productivity, broadly defined as the aggregate value of output per unit of land or labor.

To guide the identification of binding constraints, the diagnostics dig deeper into the drivers of productivity growth, analyzing the relative contributions of technological progress and efficiency, with further insights into the technical and economic aspects of efficiency improvement. This helps provide insights into whether technological progress, evident in the growth in physical food output over the years, is also contributing to income growth, and ultimately to greater prosperity in farming communities. In reality, a combination of factors is at play, and a rigorous approach helps to systematically identify the different sources of growth and the factors that may be driving or constraining their contributions to overall productivity.

The second important aspect of the diagnostic framework is the unit of analysis. Most analyses have relied on national or, to a limited extent, state-level, secondary data, which are reasonably abundant in India, although not necessarily easy for researchers to access. National averages, and to a relatively greater extent state averages, are useful to assess overall progress, but they are not particularly informative in developing a strategic approach when considerable heterogeneity is present. Because agriculture has performed significantly differently in different parts of India, the question arises as to whether this variation results from differences in access to appropriate technology, exogenous agro-ecological conditions, lack of economic (including market) and physical infrastructure, governance, or other reasons. The limited analyses available on these deeper aspects of agricultural performance results partly from a surprising scarcity of or lack of access to reliable subnational data.

This study seeks to overcome those limitations by using two relatively new datasets that

17 Improved incentives through higher prices are well-established determinants of farmers' adoption of productivity-enhancing technologies and investments. Clearly inflation is not desirable, but an improved share of farmgate prices in final consumer prices through improved marketing efficiency will contribute significantly to farm productivity and incomes.

can provide valuable insights into Indian agriculture. One dataset, from the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) and NCAP, is a compilation of key district-level variables from a myriad of agencies, ministries, state level databases, and other sources. The second dataset was collected by NCAER over three rounds of national household surveys conducted since 1982.

Finally, to complement these quantitative analyses, qualitative aspects of the enabling environment—such as local institutional and governance factors, or specific physical endowments that dictate which technological and economic options are available—are assessed through in-depth case-studies (with specific focus on agricultural extension, marketing and the tailored strategies to promote productivity in two lagging states, Bihar and Odisha).

The Broader Context and Structure of This Report

A broad characterization of agricultural performance that emerges from the literature and strategy documents is that parts of the country, specifically the irrigated rice- and wheat-producing areas that benefited greatly from green revolution technology, appear to be showing diminishing returns to that technology. This "technology fatigue" suggests that the scope for further growth in these areas is limited in the absence of major technological breakthroughs. At the same time, pervasive environmental degradation in these same areas threatens the hard-won gains they have achieved, suggestive of a "policy fatigue" as past policies may now warrant a fresh perspective.

Despite the progress achieved so far, large parts of the country remain much less developed. Formerly termed the "Lagging States" and now referred to as "Low-income States" (LIS), these generally resource-poor areas depend primarily on rainfed agriculture. They show considerable unexploited potential for productivity growth (often equated with cereal yield gaps in keeping with the concerns about food security). Technology could unleash that potential for cereals and other agricultural products, but the much needed complementary public investments have long bypassed these areas.

Diversification into higher-value crops and livestock products—an important source of productivity and income growth in a rapidly developing economy—is taking place almost across the entire country, yet the pace has been insufficient to provide an appreciative boost to agricultural growth. As a result, the supply of high-value commodities has not kept pace with demand, spurred by rising incomes and urbanization. The result has been higher prices and increased pressure on inflation.

Following this introduction (Part A), the study is organized into four analytical blocks, starting with an assessment of the performance of Indian agriculture (Part B). Part C contains extensive and detailed analyses of the sources of growth in agricultural productivity (including the livestock subsector). Part D reviews issues beyond the farm gate, focusing on investments, agricultural markets and the food processing industry. Given that an important element of the government's broader strategy is to promote growth in agricultural productivity in the eastern states, where the potential to transform agriculture and reduce poverty is substantial, Part E identifies priorities for achieving those objectives.

2

B. Performance of Indian Agriculture: Temporal, Spatial, and Comparative Perspectives

THE CONTEXT AND CONUNDRUMS OF CONTEMPORARY AGRICULTURE

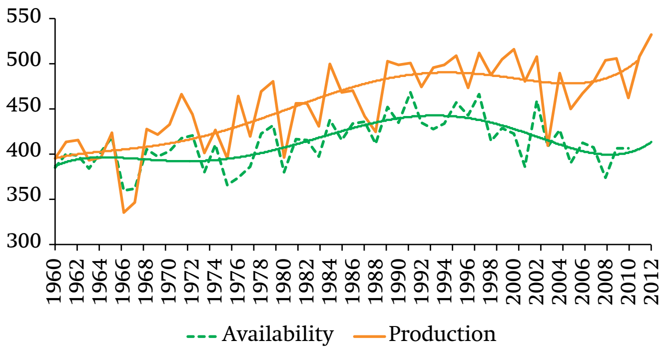
Indian agriculture has been widely studied.[18] Without going into a detailed review, this section highlights salient features of the current agricultural economy to provide an understanding of the background and context for the analyses that follow.

India's Food Security Puzzle

For India, the priority for agricultural policy and strategy historically has been to achieve food security. The performance of agriculture is thus most often assessed by Indian policy makers in terms of its success in achieving national food security—essentially self-sufficiency in food, specifically cereals (rice and wheat). By this yardstick, Indian agriculture has achieved significant success, given the rising per capita production of cereals between the 1960s and now (Figure 1).

The rapid increase in cereal production seen throughout the 1970s and 1980s came from growth in yields driven by the green revolution; net cultivated area has remained largely unchanged since the 1970s (Annex 2, Figure A.2.1). Irrigation development has increased gross cultivated area, but the prospects to bring new land into cultivation appear limited (Annex 2, Figure A.2.2). Following a sluggish decade from about the mid-1990s, production growth appears to be back on track.

Figure 1: Per capita availability and production of cereals (grams/day)

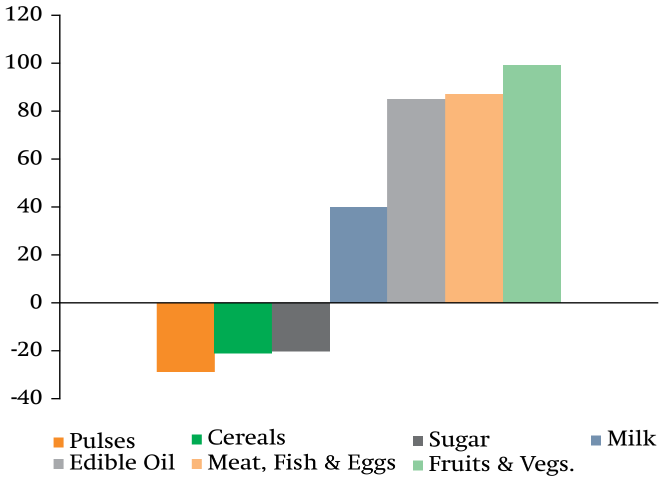


Source: Authors, using DES, MOA data.

Figure 1 also shows how per capita cereals availability (defined as production net of change in stocks and trade) has declined in recent years. After rising in the 1980s and 1990s, cereals availability has fallen to levels near those of the 1960s, causing concern among policy makers (GOI 2013a), who are also concerned by the persistence of hunger at a time when food production is at an all-time high. This disparity is as much of a puzzle as the income-calorie puzzle—the consistent decline in the

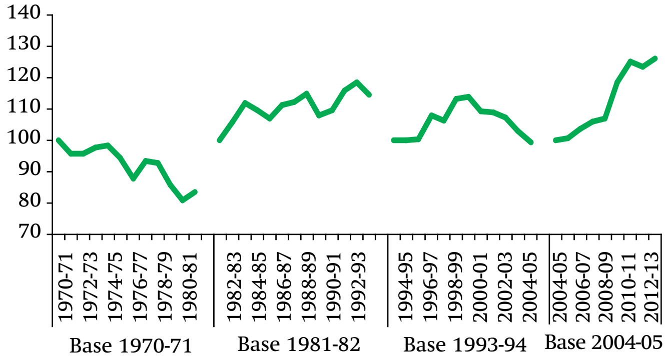
18 For technical background and discussions of some contemporary issues in Indian agriculture, see GOI (2007, 2012); Dev (2008); Gulati and Ganguly (2010); Kotwal, Ramaswamy, and Wadhwa (2011); Ferroni (2013); and Chand and Bajar (2012).

Figure 2: Percentage change in per capita consumption (kg/l/no.), 1983/84–2009/10



Source: NSS data 1983/84, 2009/10, national aggregates.

Figure 3: Food prices relative to prices of all commodities



Source: Authors, using RBI online database. Ratio of Food Articles to All Commodity indices, Annual Average WPI, preserving the base years for each time period.

consumption of calories seen since the 1980s, across all income categories, despite rising incomes.[19]

Since the 1980s, Indian diets appear to have become more diverse (Figure 2). Per capita consumption of grain (cereals and pulses) has fallen as consumption of other commodities has increased. This trend is consistent with theory, which suggests that the consumption of low-income-elasticity commodities declines as incomes rise.[20] The "puzzle" is that calorie intake has fallen consistently, even at low levels of income and in both rural and urban areas, despite the high incidence of undernutrition—that is, a basic calorie deficiency, without even accounting for the full extent of malnutrition.[21]

19 See Deaton and Dreze (2010); Gaiha et al. (2012).

20 Using a quadratic AIDS demand model, which allows a nonlinear expenditure effect on demand, Ganesh-Kumar et al. (2012) estimate expenditure elasticity for rice, wheat, and pulses to be negative, while they are positive for other commodities and greater than 1 for livestock products (eggs, chicken, meat, and fish). Similar estimates were obtained by Kumar et al. (2011).

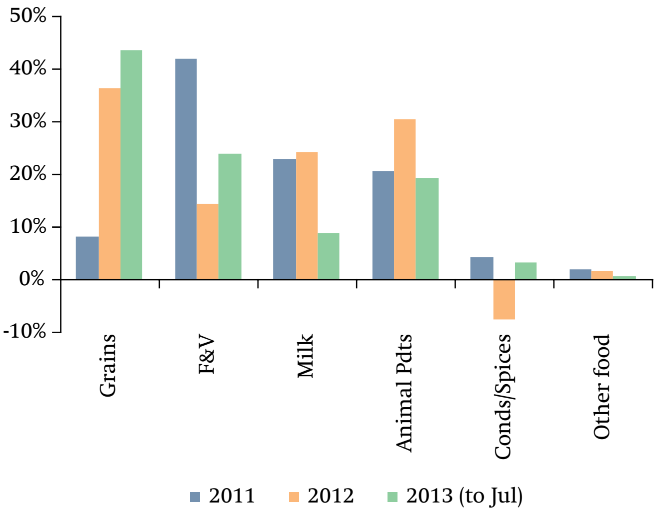
21 The debate continues on the level and trends in calorie consumption in India.

Persistent Food Price Rise

The previous discussion suggests that food insecurity may stem more from a lack of access to food than from the unavailability of food. One explanation for this outcome could be the persistent increase in food prices compared to prices of non-food commodities for most of the 1980s to the present, except for a brief period the mid-2000s (Figure 3).

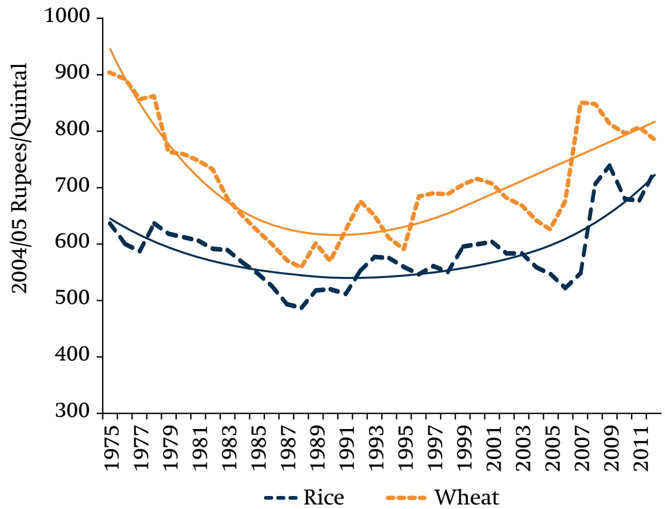
A significant share of the food price increase in recent years has been driven by high-value agricultural commodities, reflecting rising demand with changing dietary preferences as incomes and urbanization increase. This so-called "protein inflation" is thought to reflect a structural problem (Mohanty 2011) caused by a lag in the supply-response for the commodities increasingly in demand (Dev 2013a). The components of the Wholesale Price Index (WPI) confirm that high-value agricultural commodities (fruits, vegetables, and milk and other livestock products) account for the bulk of food price rise (Figure 4).

Figure 4: Contribution to food price rise (percent)



Source: Authors, using CSO data.

Figure 5: Real Minimum Support Prices



Source: Authors, using DES, MOA data.

Nevertheless, rising prices for food grains have been annoyingly persistent (2010 and 2011 are exceptions). After 2011, food grains reemerged as the largest single contributor to the food price rise, driven by the prices of cereals and the sheer size of cereals' continuing large share in the consumption basket. Real prices of staples have been rising since the early 1990s. This trend seems to follow that of the real Minimum Support Prices (MSPs) for rice and wheat (Figure 5), which have been empirically shown to drive domestic prices for these cereals (Bathla 2011; Acharya et al. 2012).

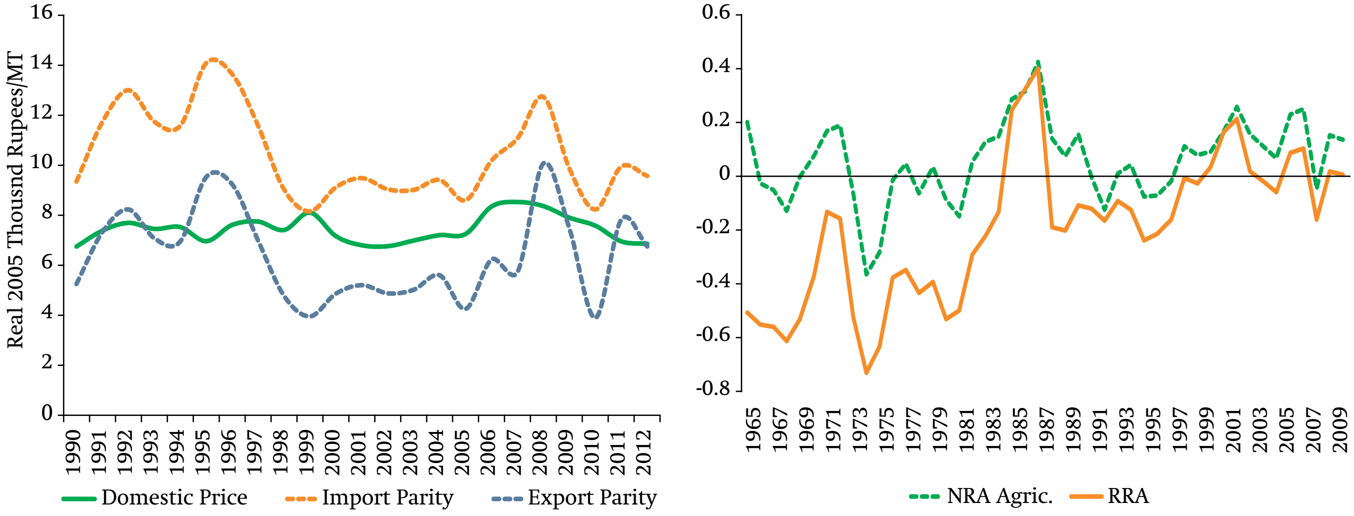
Farmers (the net-sellers) benefit from rising real prices, which translate directly to higher incomes. Food price increases driven by support prices may be masking underlying inefficiencies, however, as sluggish growth in productivity (yields) may be driving up the costs of cultivation (cost per quintal), which in turn provide the rationale for pushing up MSPs (Rao and Dev 2010). In any case, rising prices can have significant consequences, particularly on the welfare of the poor (a large proportion of whom are landless) and of small-scale farmers (who are net buyers of food) (Deaton 1989; Ivanic and Martin 2008, Ivanic, Martin and Zaman 2011, Anderson, Ivanic and Martin 2014).[22]

Estimates of nutrient demand elasticities reaffirm the intuitive conviction that higher prices affect the nutrients consumed, possibly contributing to malnutrition as households (rural and urban) reduce calorie and protein consumption through own and cross-price effects (Gaiha et al. 2012).[23] Given that cereals contribute 64 and 54 percent of calories (Gaiha et al. 2012, using 2009/10 NSS data), an increase in the cereal price may reduce food intake as households struggle to meet expenses other than food (Deaton and Dreze 2009). National Sample Survey (NSS) data show that households are spending less of their incremental income

22 Using 2003-04 data, Rawal (2008) estimated 42 percent of rural households to be landless (that is, they own no land other than the homestead).

23 Gaiha et al. (2012), using NSS data, find price effects to have weakened over time from 1993-94 to 2009-10, but the negative elasticities remain significant.

Figure 6: Relationship between domestic and external wheat prices in surplus producing areas, 2005 Rs./MT (left panel) and distortion in agricultural incentives (right panel)



Source: Authors, using Anderson and Nelgen (2012) database.
Note: RRA = Relative Rate of Assistance; NRA = Nominal Rate of Assistance.

on food and more on durable goods and services (health and education).

It is understandable that real prices of food other than cereals would rise with rising incomes and demand, but the recent sharp upward trend in cereal prices is puzzling, especially because per capita cereal consumption is falling, cereal production is growing steadily (notwithstanding the annual fluctuations caused by adverse weather), and food stocks remain at all-time highs. Analysts have raised questions about the irony of amassing large food grain stocks when prices of staples are high (Chand et al. 2010). Two sources of "leakage" from a purely domestic supply-demand regime could influence prices: trade (through imports or exports, if external prices are higher than domestic prices) and stocks (through excessive diversion of grain into silos or ill-timed procurement/release operations).

Trade Policy and Cereal Prices

India's trade policies have been unstable but restrictive (Gulati, Jain, and Hoda 2013), so export-led prices have not been a factor in the rise in food prices.[24] The government has periodically banned trade in staples (rice and wheat) other than aromatic rice, most recently between 2008 and 2011. The extent of protection is demonstrated by the limited transmission of global price volatility to Indian markets (Imai, Gaiha, and Thapa 2008; Rajmal and Misra 2009; Dasgupta, Dubey, and Satish 2011). Gouel, Gautam and Martin 2014) find that Indian trade policies offset 94 percent of global price volatility for wheat, confirming the great insulation of Indian cereal markets. Figure 6 (left panel) shows the stability in domestic wheat prices relative to global prices.

24 On the import side, oilseeds and pulses are major imports, which are likely transmitting global prices to domestic prices for these commodities.

Despite trade restrictions, Indian prices have tracked the long-term trend in global prices, but without the short-term volatility (GOI 2013b). India has also generally maintained domestic prices between import and export parity prices, making commercial trade economically unviable in most years (Figure 6). This alignment of domestic and external prices has been achieved as a managed policy rather than a market- or trade-determined outcome, with the government using the global price trend as a key determinant of MSPs (Acharya et al. 2012).

As noted, farmers benefit from cereal prices that appear globally competitive but do not experience the volatility of global prices. The two policies—trade and MSP-driven storage (discussed later)—are inconsistent, however, in the sense that the restrictive trade policy pushes prices down (favoring consumers), while the MSP-based storage policy effectively creates a floor price (favoring farmers). Despite prices being competitive, produce cannot find its way out to external markets, so national cereal stocks are ballooning, because the government is obligated to buy whatever farmers have to offer—at least in the traditional, politically influential grain-basket states. As might be expected, bulging food stocks entail a significant budgetary cost for the government (GOI 2013a). This experience is not unique to India; the United States, European Union, and Australia have faced identical situations. In those instances, governments with open-ended public procurement systems and large food stocks subsequently either abandoned their programs or adopted alternative mechanisms with significant added costs to reduce the pressure to buy (such as acreage set-aside schemes). Finding viable and more cost-effective options for managing food grains is clearly a priority. Such analysis is beyond the scope of this study, but it is the subject of a separate ongoing technical study (Gouel, Gautam and Martin 2014).

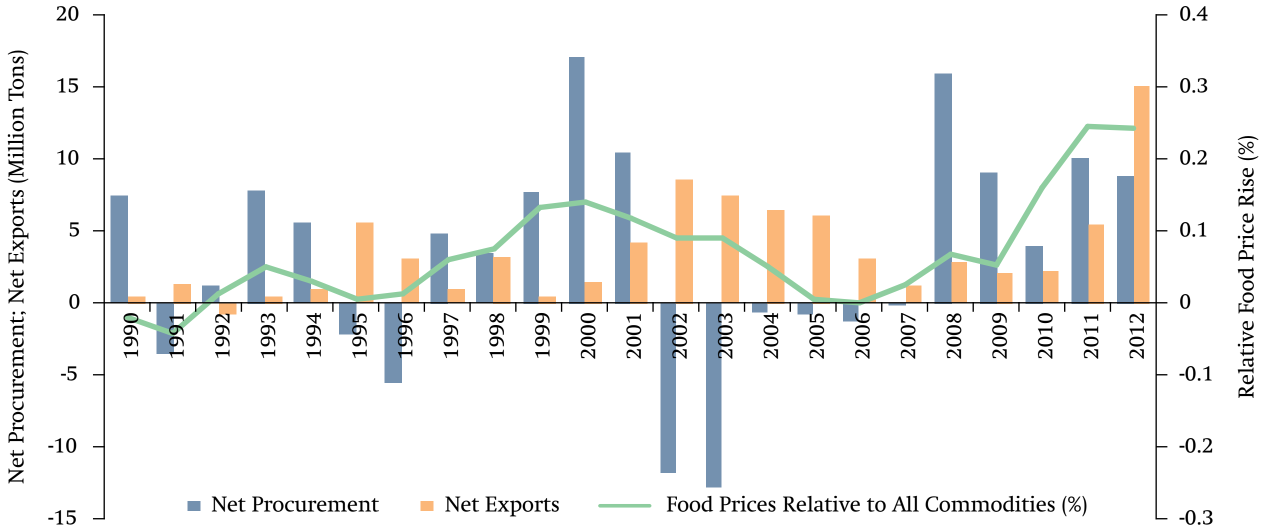
More good news for farmers comes with the shift away from a bias against agriculture (implicit tax) in domestic incentives toward a more supportive regime, as indicated by the trend in the Relative Rate of Assistance to agriculture (Figure 6, right panel) (Pursell, Gulati and Gupta 2009, Anderson and Nelgen 2012). The implicit taxation of agriculture observed in the 1970s–90s has steadily improved to a more neutral and often more favorable (subsidy) regime in the 2000s. Other than the explicit output price policy, the farmers are also benefiting more significantly through input subsidies and other forms of support, as reflected in the positive and rising Nominal Rate Assistance (NRA) for agriculture since the late 1990s. The gross subsidy equivalent of this assistance amounts to 30–40 percent of the total value of agricultural production, indicating the significance of subsidies to agriculture apart from the border distortions (which seem relatively minor) indicated by the difference in domestic and global prices.

Food Grain Management and Food Prices

In principle, stock operations should be an infra-marginal transfer; as such, they should not be a cause for food price increase. In practice in India, however, stock-management appears to be suboptimal (Basu 2011).[25]

25 The government is obligated to buy at the MSP. Procurement remains biased in favor of the traditional “grain baskets” in the country, but there is no defined, rules-based “release” policy, effectively making it very inefficient and cumbersome to release stocks when necessary—whether to release excessive stocks or to moderate rising prices, as the case may be.

Figure 7: Cereal trade, procurement, and food price index, 1988–2012



Source: Authors, using DES, MOA, and UN COMTRADE data.

Figure 7 depicts net exports (exports less imports) of the main cereals (rice and wheat) and net procurement (procurement less offtake by various programs such as the Public Distribution System). The figure also shows the extent to which food prices (Food Articles Index) deviate from the overall Wholesale Price (All Commodities) Index. Net exports and food prices show no obvious correlation, but net procurement and price changes increasingly appear to coincide beginning in the early 1990s. Simple statistical tests confirm that after 1995, stock operations are correlated with food prices (the association with exports is not statistically significant), suggesting that procurement in excess of releases and sales is diverting grain from the market to already overflowing silos.[26]

26 Other than the large exports in 2012, when the most recent ban was lifted, notable exports were in the early 2000s when the previous ban (1996–2000) was lifted. Those exports were triggered by subsidized stock releases (Below Poverty Line prices) for direct exports (Ganesh-Kumar et al. 2010). The situation in the early 2000s was also an outcome of excessive stock accumulation during the previous ban of 1996–2000. Net procurement, on the other hand, was lowest in 2002/03 owing to the severe drought at the time (though stocks continued to be released for exports).

The impact of public grain management operations can also be gauged by the sheer magnitude of the current level of stocks and the share of procurement in total production. In 2013, stocks peaked (in June) at over 77 million tons, almost two and half times the highest established norm of 32 million tons (for midyear). As a share of production, government procurement has increased steadily over time (Annex 2, Figure A.2.3). Government procurement now represents 32 percent of the rice and 46 percent of the wheat produced in the country, which amounts to 42 percent of the marketed surplus for rice and 66 percent of the marketed surplus for wheat, effectively dominating and influencing these markets. Given the scale of intervention, MSP has effectively become the floor price in the major producing areas, with the rising real MSP pushing up the cost of basic staples and adding to upward price pressures.

Rising Real Rural Wages

From a poverty perspective, the good news (at least in the short run) is that the immediate negative consequences of higher food prices have been compensated by rising real wages. Jacoby (2013) finds that nominal wages for manual labor (within and outside) agriculture have responded elastically to higher food prices, with wages rising faster in rural districts that saw greater increases in crop prices between 2004 and 2009. Wage adjustments helped to protect the welfare of the poor, apparently more effectively than the Public Distribution System. Gulati, Jain, and Saltija (2013) find that real wages have risen over the long term, growing at a consistent and more rapid pace in the 1990s than in the 2000s, despite the much-debated impact of the Mahatma Gandhi National Rural Employment Guarantee Act (MNREGA). After falling in the early part of the decade since 2000, real wages rose sharply after 2006/07 and resumed their long-term upward trend. The study also finds that while MNREGA does put upward pressure on wages, the "pull" factors associated with growth (GDP, agricultural GDP, or construction-GDP) are much more significant factors driving wages.[27]

Persistent Questions about the Sustainability of Growth

The discussion above suggests that the constraints to growth appear to be less binding on the demand side. Consumer incomes and habits appear to be driving the demand for high-value agricultural commodities and, ironically, public procurement maintains a steady source of absorption (even as consumer demand is shrinking) for cereals. A combination of domestic industrial demand as well as export demand has driven specific "green shoots" in the economy, such as cotton (for exports and textiles), maize (for exports and the rapidly emerging domestic poultry industry), and soybeans (for exports of soy de-oiled cake as animal feed).

These developments aside, the overall production structure of the sector has changed relatively slowly (Annex 2, Figure A.2.4), with the main cereals (rice and wheat) continuing to dominate the area allocation. The slow transformation, even in the face of strong growth in demand (for example, for horticultural commodities), reflects the incentives facing farmers. The price policy, specifically the MSPs for rice and wheat, has been highly successful, inducing a supply response for cereals by keeping prices high, while trade and storage policies have been equally successful in stabilizing prices (at least in the major grain-basket areas for these crops). The resulting low risk-return ratio for cereals creates strong incentives for farmers to emphasize cereals in their crop portfolios—as reflected in area allocation—rather than venturing into crops that offer relatively higher returns but also face relatively greater market price risks.

Rising real prices are good news for farmers (who are net-sellers of food) and rising real wages for those engaged in wage labor (on and off the farm), but both trends have implications for the sustainability of the ensuing growth. The critical question is whether the changed incentives afforded by rising real output prices are accompanied by growth in agricultural productivity. Rising real wages have potential implications for employment both on and off the farm, as they are likely to induce greater mechanization on the farm and more capital intensity off the farm. Understanding developments in the underlying productivity (total as well as factor) is important to assess whether they are underpinned by a sustainable, virtuous circle of growth—as the next chapters will attempt to discern.

27 Gulati, Jain, and Saltija (2013) find that MNREGA does have a significant impact on wages, but the broader growth "pull" factors are 4–6 times more effective in raising incomes.

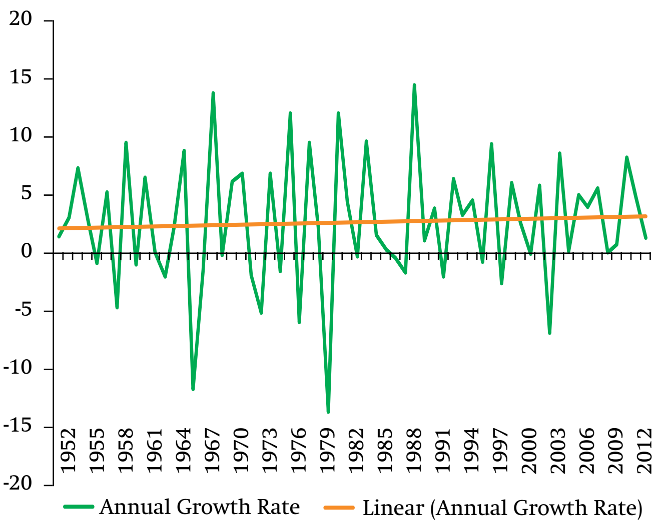
3 TEMPORAL TRENDS IN AGRICULTURAL OUTPUT AND PRODUCTIVITY

Evolution of Agricultural Growth

Large annual fluctuations in agricultural growth in India are a direct outcome of variable rainfall, as over 60 percent of cultivated area is still rainfed (Figure 8). The long-term average growth of just under 3.0 percent has improved almost imperceptibly over the past six decades (see the linear trend in the figure), although the reduced dispersion in recent years suggests increased stability.

This rather bleak picture raises questions about the prospects for agricultural growth to increase shared prosperity, yet the underlying story—as usual—is more complicated. Indian agriculture has seen a series of significant transformations. The green revolution (in cereal production) was succeeded by the white revolution (in milk production) and the more recent "rainbow" revolution (in high-value production of fruits and vegetables) as the demand patterns shifted with rising incomes in the rest of the economy. Agriculture also felt the effects of the broader economic reforms of the early 1990s and the agricultural policy reforms of the mid-1990s. The outcomes of those reforms continue to be debated.[28]

Figure 8: Agricultural Growth Rate, 1952–2012

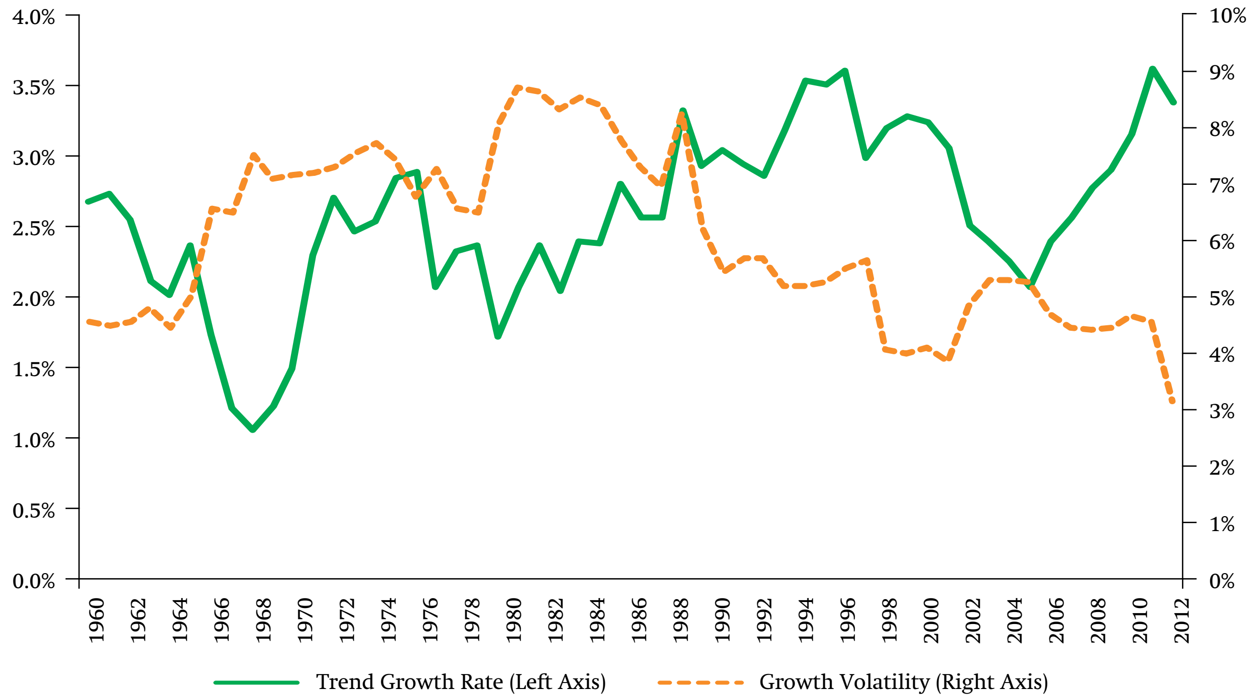


Source: Authors, using CSO data.

More nuanced analyses of temporal and spatial patterns of growth illuminate the major factors behind agriculture's varied performance and help to identify the appropriate policy levers. Chand and Parappurathu (2012) use decadal trend growth rates to analyze performance

28 Agricultural trade liberalization has been debated for a long time in India (see Chand and Bajar 2012). One school of thought (the so-called "trade liberalization proponents") views trade restrictions as a major constraint to growth and diversification, associated with a significant opportunity cost in terms of potential export earnings (for example, see Gulati et al. 2012; Ganesh-Kumar and Parikh 1998).Trade is also viewed as a better option for ensuring domestic supply and price stability (Jha and Srinivasan 1999). The other school of thought is more skeptical of gains from trade, arguing that international prices are highly distorted, do not represent the opportunity cost of resources, and are much more volatile than may be desirable. Hence the proponents of this view argue for "strategic openness" rather than full liberalization and promote reliance on buffer stocks rather than trade to ensure stable prices (Chand 2003a, Chand and Bajar 2012).

Figure 9: Temporal performance of Indian agriculture GDP: Trend growth rate and growth volatility for decades ending 1960/61 to 2012/13



Source: Authors using CSO data, following Chand and Parappurathu's (2012) approach for trend growth rates.

over time. Figure 9 shows how growth evolved since 1950. The solid line represents the trend growth rates in agricultural GDP for each of the 10-year periods ending in 1960/61–2012/13. The dashed line indicates the change in volatility of growth (standard deviation of growth for the same 10-year periods). When the noise associated with annual fluctuations in production is filtered out, distinct episodes of varying performance become apparent. Volatility increased until 1980 and then declined markedly. Growth remained stubbornly below the 4 percent target throughout but reached its highest level in the most recent period. The high growth rate of about 7.9 in 2010/11 followed by 3.9 percent in 2011/12 brought the trend rate to the high of 3.6 percent reached in the mid-1990s, but slower growth of 1.9 percent for 2012/13 has kept the target out of reach.

Based on statistically estimated endogenous break points, Chand and Parappurathu (2012) identify six distinct periods of performance (Table 1). After the initial decline into the 1960s, which led to the concerted policy push for the green revolution, the late 1960s to early 1970s saw the initial green revolution results. Sustained growth followed through the 1980s as the green revolution technology spread to other parts of the country. The early 1990s were a period of diversification, with growth rates reaching their highest levels of just over 3.5 percent. A prolonged slowdown followed from about 1996/97 to 2004/05. Growth remained positive throughout but slowed progressively to a low of 2 percent.

This deceleration has been cited as an outcome of the general neglect of agriculture

Table 1: Sectoral Trend Growth Rates by Period (%/yr)

Sector	PGR (1960/61–1968/69)	EGR (1968/69–1975/76	WTD (1975/76–1988/89)	DIV (1988/89–1995/96)	PR (1995/96–2004/05)	REC (2004/05–2010/11)
Agric. and Allied Activities	1.03	1.98	2.42	3.24	2.35	3.31
Agriculture*	0.70	1.93	2.71	3.21	2.30	3.37
Crops (VOP)	1.11	1.90	2.56	2.64	1.88	3.01
Livestock (VOP)	0.40	2.69	4.89	4.12	3.43	4.29
Forestry and Logging	3.70	2.01	-1.77	0.74	2.05	2.25
Fishery	3.91	4.19	3.45	7.37	3.28	4.42
Nonagriculture	4.90	3.67	5.23	5.91	7.05	9.68
All sectors	3.19	2.99	4.25	5.14	5.95	8.57

Sources: Chand and Parappurathu 2012.

Notes: The original table by the authors is based on data to 2010/11. The growth rate given in the text is slightly higher, as it is based on data to 2011/12. PGR = Pre-green revolution period (1960/61–1968/69); EGR = early green revolution period (1968/69–1975/76); WTD = period of wider technology dissemination (1975/76–1988/89); DIV = period of diversification (1988/89–1995/96); PR = post-reform period (1995/96–2004/05); and REC = period of recovery (2004/05–2010/11).

that occurred as policy shifted attention away from agriculture in favor of the faster-growing secondary and tertiary sectors. Because the deceleration coincided with the general economic reforms of the 1990s and the agricultural reforms initiated in earnest around 1994, the reforms are also generally perceived to have had a significant adverse impact on the sector (reflected in also Chand and Parappurathu's classification of these years as the "post-reform period"). The most recent period (2004/05–2011/12) shows a marked return to growth of about 3.5 percent per annum.

Subsector and crop-specific growth rates follow these broad trends, with some notable exceptions, indicating that the slowdown in the post-reform period was widespread (Chand and Parappurathu 2012).[29] The rebound during the last (recovery) period appears equally widespread, with historically high growth rates in fruits, vegetables, fiber crops (primarily cotton), and pulses. At the same time, overall growth in the value of output of the crop sector remains modest at about 3 percent. The value of output in the livestock sector has grown significantly faster than crops through all phases since the 1970s. Although it too experienced a slowdown between 1995/96 and 2004/05, it fared much better.

A number of explanations are forwarded in the literature for the performance of Indian agriculture, especially the deceleration after almost two decades of sustained expansion (Chand, Raju, and Pande 2007; GOI 2007). But two sets of fundamental questions remain (and were raised by policy makers during consultations for this study) about the causes of the slowdown and the post-2004/05 recovery:

1. What were the main factors behind the slowdown? Was it the reforms of the

29 Bhalla and Singh (2001, 2010) provided earlier accounts of the deceleration. Notable exceptions to the general trends included high growth rates of soybeans in the 1980s and 1990s, rapid growth in maize during the period of slowdown, and the very high growth rates for cotton after 2004/05.

1990s, contrary to what proponents of reform expected? Is the post-2004/05 rebound just a result of good weather, or is it a robust and sustainable move toward a different growth trajectory?

2. Digging deeper into the drivers of growth, how has technology driven performance in agriculture? Has the policy framework been supportive of growth, given the vigorous debates on various aspects of agricultural policy? Most importantly, what are the strategic implications for the sector and for India's broader development strategy?

The first set of questions is addressed in the remainder of this section; the second set will be addressed in subsequent sections. Given the limitations of specific analytical tools and the data available, it is important to highlight that the analysis presented here does not provide definitive answers, but rather adds new and rigorous findings to promote discussion and perhaps stimulate further investigation to better inform policy and development debates.

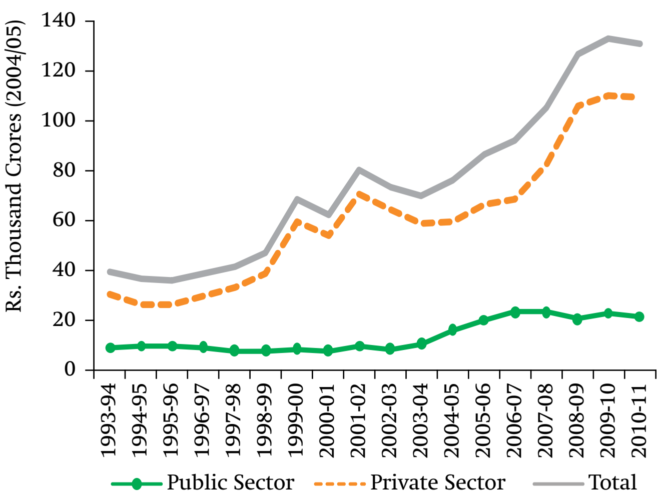
Why Did Growth Stagnate from 1997 to 2005?

Several explanations have been forwarded for the growth slowdown between 1997 and 2005. They include slow generation of new technologies, poor dissemination of existing ones, weak and inefficient institutions, poor governance, and perhaps most critically the inadequate investment in public goods, as the fiscal space was crowded out by the provision of private goods.

While these determinants of agricultural productivity and growth are important over the long run, their immediate role in the post-reform slowdown is less obvious. They do not explain the seemingly discrete downward shift in the trend growth rate in agriculture starting in 1997, or what seems to be the equally decisive turnaround in 2005 (both are visually obvious, without any formal statistical tests). For example, private investment in groundwater has been the major driver of irrigation, now accounting for almost two-thirds of all irrigated area. Capital formation data show that private investment actually went up prior to and during the post-reform slowdown (Figure 10). Public investment rose significantly after 2003/04 and likely played a role in the recovery after 2004/05, but no obvious trigger is apparent from the pre-1997 trend.

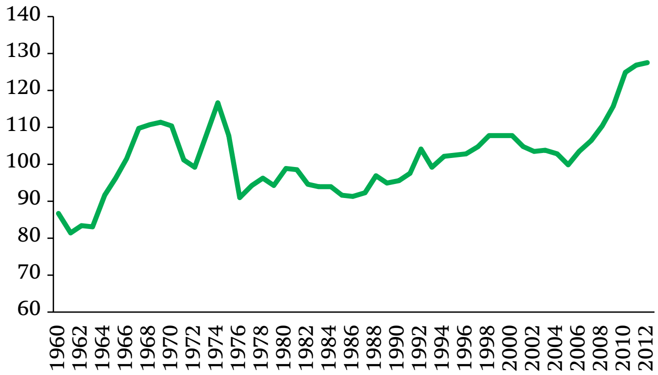
Similarly, despite rising wages and farmer's perceptions of increasing costs of cultivation (Rao and Dev 2010), agricultural terms of trade provide no explanation for the sudden downturn in 1997 (Figure 11). Terms of trade improved for agriculture from the mid-1980s

Figure 10: Gross fixed capital formation in agriculture



Source: Authors, using CSO data.

Figure 11: **Agriculture terms of trade**



Source: Authors, using RBI online database.
Note: Derived as Ag. All. Act. GDP deflator/Total GDP Deflator.

to about 2000 and seemed to have followed the slowdown rather than precede it.

Two factors that may help understand the growth deceleration are rainfall and policy reforms. Virtually all analyses of Indian agriculture recognize the importance of rainfall for agricultural performance, but temporal or cyclical rainfall patterns have not been sufficiently analyzed for their potential to explain growth patterns in agriculture. And although the performance of agriculture following the reforms of the 1990s continues to be debated,[30] Kumar and Jain (2012) doubt that policy reforms can explain the slowdown, considering that growth has rebounded after 2004/05 with no major policy change. It is plausible that the agricultural sector went through an adjustment when the reforms were first introduced, or that the agricultural programs initiated during the Eleventh Five Year Plan (around 2004/05) have contributed to the subsequent growth. It is thus important to explore which factors were most likely to have contributed to the slowdown in agricultural growth after the reforms were introduced. The possible roles of rainfall and policy reforms in the slowdown are explored in greater detail next.

Rainfall shocks and productivity growth

To what extent can rainfall shocks explain changes in productivity growth, especially the deceleration of 1997–2005? The answer to this question is important because it has implications for policy and for strategic tradeoffs, for example between investments to mitigate sustained rainfall shocks (as may be expected with climate change) versus investments to adapt to large but idiosyncratic shocks.

For example, investments to mitigate sustained shocks would need to focus on safeguarding and economizing the use of scarce "water stocks" to deal with sequential droughts, calling for more sustainable irrigation options (such as more efficient irrigation techniques, policies to promote water use efficiency, water harvesting, and so forth), developing better technological solutions (such as crop varieties for rainfed ecologies and the diversification of crops and farming systems), as well as diversifying and transforming sources of livelihoods. Adapting to large but idiosyncratic shocks would involve better ex-post coping mechanisms, including efficient markets to ensure smoother flows of food to affected areas, safety net programs, and smarter agricultural insurance mechanisms. In reality, both sets of options are necessary, but it is important strike an informed strategic balance between the two, especially given the increasing need to deal with changing and unpredictable climatic cycles and events.

30 See Chand and Parappurathu (2012); Gulati et al. (2013); Chand and Bajar (2012).

A district-level picture of productivity and rainfall between 1970 and 2007

Given the heterogeneity of India's agroecological environments and especially the variability in rainfall across those environments, disaggregated data can provide a more credible analysis and better insights than national averages or and trends. Kshirsagar and Gautam (2013) use district data on production and rainfall to develop a picture of aggregate agricultural productivity.[31] Their analysis finds a reasonably convincing association between growth and deviations in rainfall from the long-term rainfall trend, which provides additional insights into the observed growth episodes.

Agricultural productivity—measured here as the real value of agricultural production per hectare—grew by 2.5 percent on average between 1970 and 1996. The value of production and productivity between 1997 and 2004 declined in parallel with GDP. As discussed, agricultural productivity began to recover after 2004 at a steady but slow 1.9 percent up to 2007.[32] All crops showed significant fluctuations in productivity around trend, but the productivity of crops other than cereals proved more volatile.

The fluctuations in productivity occurring around 2000 were not unprecedented,[33] but the sustained decline in growth rates between 1997 and 2004 was unusual.[34] As expected, rainfall anomalies explain the deviations from trend in agricultural production and productivity.[35] Figure 12 depicts the correlation between large negative rainfall shocks and the prolonged stagnation in productivity growth between 1999 and 2004; it also shows the correlation between surges in productivity and favorable rainfall in 1988–90 and 1993–97.[36] Aside from influencing productivity, rainfall has an even larger influence on deviations in *total production* as households adjust the area they plant in response to rainfall deviations. These impacts on productivity also help explain the decline in real wages between 1999 and 2004 noted by Lanjouw and Murgai (2008) and Gulati, Jain, and Saltija (2013).

The varied incidence and impact of sustained rainfall shocks between 1970 and 2007

Cereal crops are better able to withstand rainfall shocks than noncereal crops,[37] so risk-averse households often respond by favoring cereals in their crop portfolios (Annex 3, Figure A.3.4). Cereals may be the less risky

31 The data are from the district database compiled by ICRISAT and NCAP. Data for consistent dynamic analysis are available for 1970–2007 and for 297 "original" rural districts (districts existing in 1970). Subsequent divisions of districts and states are mapped to these original administrative units. These data cover about 88 percent of the aggregate cereal production, providing a reasonably representative picture at the national level. See ICRISAT (2013) for a detailed description of the data.

32 The data are relatively more consistent and reliable for cereals than for noncereals. Cereal productivity increased at 3 percent per year between 1970 and 1996, and at 2.5 percent over the longer period from 1970 to 2007.

33 Deep declines occurred in the early 1970s and in 1979, and less severe declines occurred in the late 1980s.

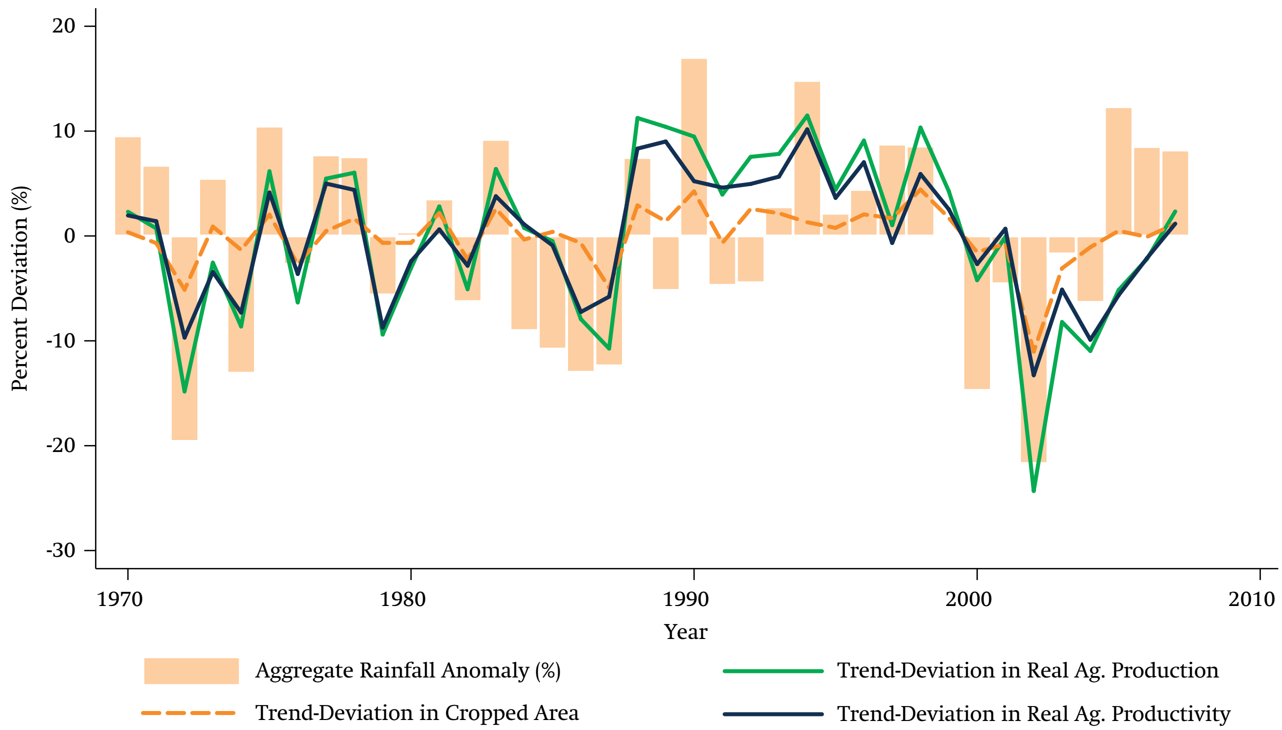
34 Kshirsagar and Gautam's analysis used data from 1970 onward. Extending the analysis back into the 1960s shows the relationship between the severe rainfall shock of the 1960s and the widespread famines experienced then.

35 Anomalies are defined as percentage deviations from the period average.

36 The data used in Figure 12 are for the 207 districts that have complete data on annual rainfall levels, area and production in the ICRISAT/NCAP district database. The estimated district rainfall anomalies bear a very close relationship with anomalies estimated using the national-level aggregate monsoon rainfall data from the Indian Meteorological Department, as shown in Annex 3, Figure A.3.1. The deviations in production and productivity using all 297 districts also show a very similar association with rainfall anomalies from the national aggregate monsoon rainfall data from IMD, shown in Annex 3, Figure A.3.2.

37 Figure A.3.3 in Annex 3 shows relatively larger deviations in the productivity of noncereal crops.

Figure 12: Relationship between agricultural productivity and rainfall



Source: Kshirsagar and Gautam 2013.

choice, but they are less remunerative than noncereal crops, so producers' incomes grow more slowly.

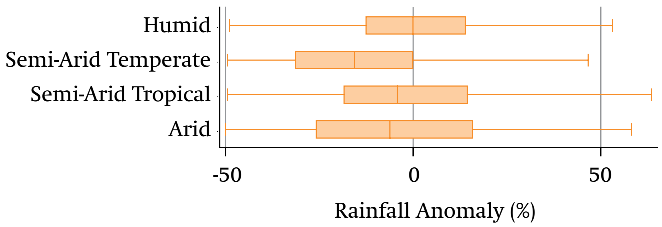
The consequences of these rainfall shocks are thus significant—in total production as well as in the relative differences between cereal and noncereal crops. District data after 2007 are not available, but rainfall anomalies from the longer rainfall time series (discussed later) show that rainfall was below average in 2008–12, with 2009 being an exceptionally dry year. Rainfall risk may be partly contributing to the sluggish supply response in noncereal crops, amplifying the upward pressure on their prices.

There is considerable variation in the sensitivity of productivity to rainfall across districts.[38] One explanation is that rainfall shocks are idiosyncratic. Another may be that irrigation in some districts compensates for rainfall deficits. Over the long run, evidence shows that districts in the Semi-Arid Temperate Zone are generally less vulnerable to rainfall shocks.[39] Even so, the districts that experienced the most severe rainfall shocks between 2000 and 2007 were *not* those with greater vulnerability to rainfall shocks over the long term, namely districts in the Arid or Semi-Arid

38 Kshirsagar and Gautam (2013) estimate rainfall sensitivity using dynamic regressions for districts with a minimum of 25 years of observations—277 districts (out of a total of 297). Of those 277 districts, 121 emerged as "rainfall-dependent," confirming that districts are not equally affected by rainfall shocks.

39 The zones are grouped into the four broad agro-ecological classifications developed by ICRISAT. Most districts in Uttar Pradesh, Punjab, and Haryana are grouped with the Semi-Arid Temperate Zone.

Figure 13: Distribution of rainfall shocks across zones, 2000–07



Source: Kshirsagar and Gautam 2013.

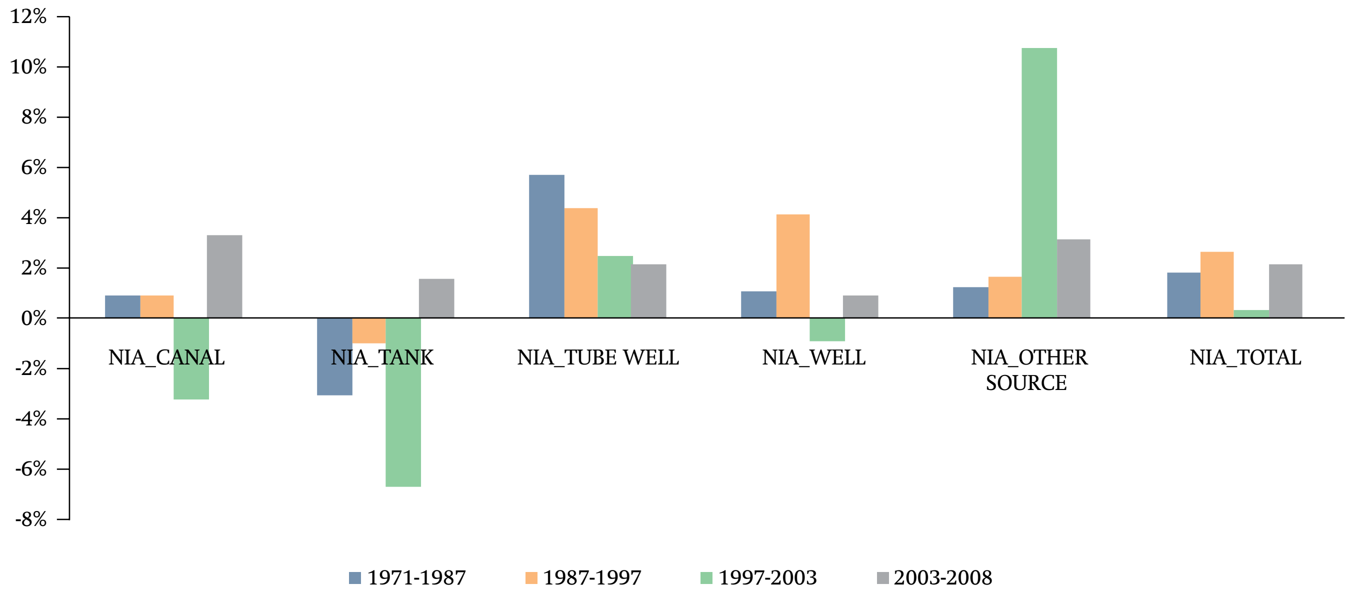
Tropical Zones (Figure 13). Semi-arid temperate districts, which are relatively less vulnerable and more productive on average, were the worst hit. Given the magnitude and the succession of negative rainfall anomalies over six years, the cumulative aggregate impact on agricultural productivity was large.

The severity of sustained rainfall deficits is also evident in patterns of change in irrigation. Figure 14 shows the expansion in irrigated acreage by source from 1970 and 2006. During the post-reform period, sustained rainfall scarcity depleted the water available for canals, tanks, and dug wells, slowing their importance as sources of irrigation. The reliance on groundwater, via tubewells, was a relatively more important source of irrigation expansion in this period. Over time, however, this growth slowed, probably as the potential to install new tubewells diminished or existing tubewells went out of commission as groundwater was depleted. The only source of irrigation that shows a spike in growth is "other sources"—most likely streams and rivers, as in hilly Himachal Pradesh.

Three questions raised by recent rainfall anomalies

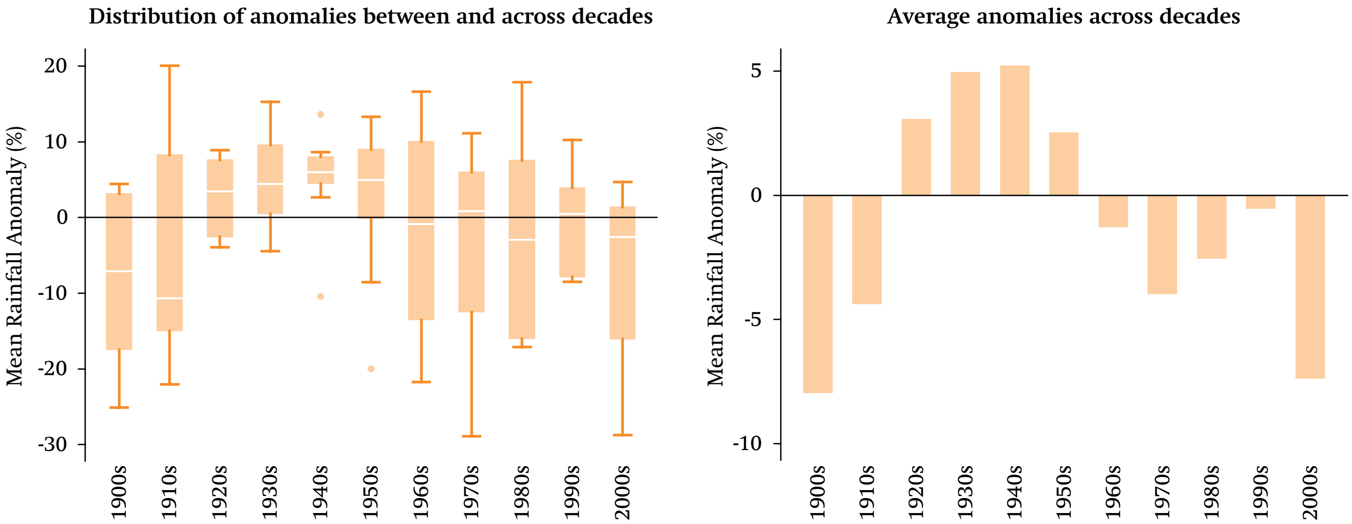
The district analysis of rainfall anomalies between 1970 and 2007 raises three questions. First, how do the rainfall anomalies in that period compare to rainfall patterns over a much longer period? Second, are the 1970–2007

Figure 14: Growth in irrigated area by source



Source: Authors, using ICRISAT-NCAP district database.

Figure 15: Historical rainfall patterns, 1901–2010



Source: Calculations based on Monsoon (June–September) national rainfall data from IMD.
Note: The left panel describes the distribution of rainfall anomalies. The white line in the rectangle shows the decade median. The ends of the rectangles indicate the 25th and 75th percentiles, respectively, and the bars at the end the lines are the 5th and 95th percentiles. The right panel describes the mean decadal rainfall.

anomalies nationally representative? Finally, what has happened since 2007? Homogenous (consistent) rainfall data (totals from June to September) from the India Meteorological Department (IMD) at the national level, from 1901 to the end of 2010, help to answer those questions.

The long-term rainfall patterns, over the 110 years for which data are available, do not show a secular monotonic pattern (Figure 15). From the 1900s to 1950s, India saw a sustained increase in rainfall, with the three decades from the 1930s to the 1950s experiencing above-average rainfall. The 1950s ushered in a long-term decline. The most unfavorable rainfall patterns—with historic lows in average rainfall—occurred from 2000 to 2009. The median anomalies in the 2000s are comparable to those in some earlier decades, but unlike other decades, the 2000s saw no years with substantial positive rainfall anomalies (defined as anomalies above +5 percent). Instead, the decade had three years of exceptionally low rainfall: 2004 (fourteenth lowest), 2002 (sixth lowest), and 2009 (second lowest). Finally, the anomalies that explained the stagnation in agricultural productivity of the early 2000s, analyzed in the previous section, appear to be representative of national patterns.

Mechanisms for coping with the risk of rainfall shocks

The trends presented here raise important policy issues that are beyond the scope of this study, but clearly mechanisms to mitigate the impacts of rainfall shocks as well as to permit better and faster adjustment will be critical in the future. It will be vital to quantify the costs and benefits from adopting alternative *ex ante risk-mitigation strategies* (for example, sustainable irrigation, percolation tanks, and other strategies) and *ex post risk-sharing strategies* (such as regulatory changes that engender greater trade across districts, states, and countries). One advantage of risk mitigation policies is that they directly address entitlement risk. In contrast, ex post risk-sharing strategies rely more on well-functioning markets and/or national and local governance systems for successful implementation.[40]

Given that rainfall anomalies exhibit temporal dependence, and given the growing evidence of a relationship between ENSO cycles and anomalous monsoon patterns in India, an Early Warning System could be very effective. Such a system would provide input to extension services to advise farmers on crop allocation and input use contingent on expected rainfall. Consequently, programs that include the establishment of drought management systems and measures to reduce the reliance on rainfed agriculture are urgently needed and have a larger Net Present Value than may be expected.[41]

In addition to ex ante strategies to mitigate risk, ex post strategies will remain essential. Rainfall shocks are correlated across districts, but with significant dispersion in rainfall anomalies in any given year (Figure 16).[42] The average sensitivity of districts to a 1 percent increase in the rainfall anomaly is 0.82 percentage points, with considerable variation across the districts. At the low end (25th percentile), sensitivity is 0.5, while at the high end (the 75th percentile) it is 1.2. This suggests potential for risk sharing across districts in a given year, which may be more cost-efficient than (or in addition to) risk sharing across time. Risk sharing across districts is implemented more effectively when local prices reflect local (relative) shortages or surpluses, and it requires a smoothly functioning market system.

Rainfall shocks and the impact of policy reforms, revisited

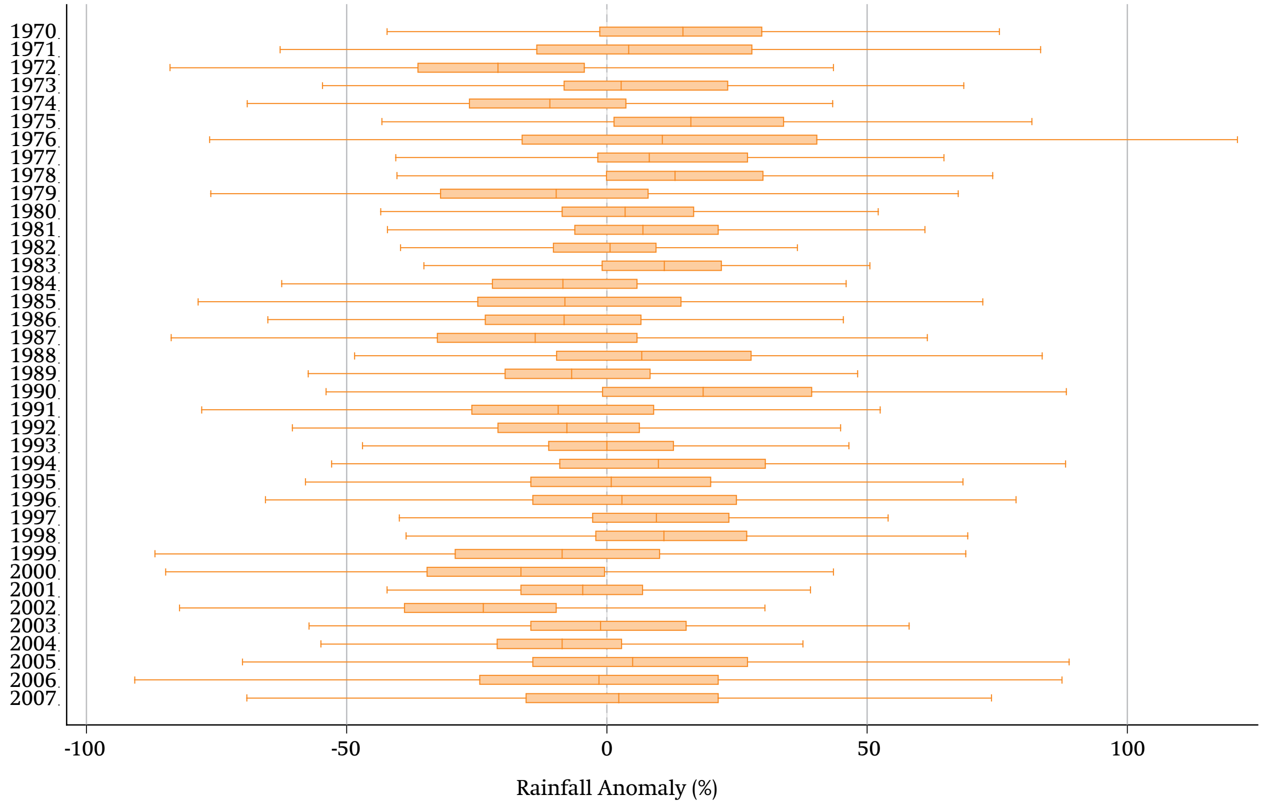
The findings above could be refined in several ways, but the influential role of rainfall shocks during the 1997–2004 productivity stagnation is quite apparent. It is worth noting that weather shocks have not featured sufficiently in discussions on the long-term performance of India's agricultural sector. Given that successive rainfall shocks followed soon after the policy reforms, it is crucial to revisit the question of the reforms' impact on agricultural performance. One approach is to use time-series data on monsoon rainfall and aggregate data on agricultural GDP to simulate agricultural growth rates that might have prevailed had rainfall been normal for the entire period

40 Basu (2011) makes a compelling case for the more efficient distribution of food grains using direct transfers that take advantage of technological advances (smart cards, biometric identification). This approach would address food security concerns while also (potentially) incentivizing agricultural production and improving the functioning of grain markets.

41 A first step in any such cost-benefit analysis—one in which the government has invested significant resources (see http://www.indiawaterportal.org/taxonomy/3/Aquifer-Mapping)—is to map all aquifers. This information will make it possible to quantify the relationship between rainfall and groundwater levels under alternative modes of irrigation and farming, thus making it possible to value (and prioritize) returns to prospective water and irrigation investments.

42 The standard deviation for the entire sample of 10,546 annual (district-year) rainfall observations is 697.6 millimeters, the *between* standard deviation (deviation of the district means from the overall mean) is 598 millimeters (297 observations), and the *within* standard deviation (deviation of the observations from the district mean) is 340.8 millimeters (average of 35.5 observations per district). Although some of these "observations" were inferred using interpolation, it is still clear that considerable rainfall variation is present both within and across districts.

Figure 16: Distribution of rainfall anomalies across districts and years



Source: Kshirsagar and Gautam 2013.

(1961 to 2010).[43] The actual and counterfactual growth rates for agricultural GDP are averaged over rolling 10-year periods, and the decadal averages are plotted in Figure 17.[44] The latent long-term growth trends are highlighted using a polynomial trend for each time series.

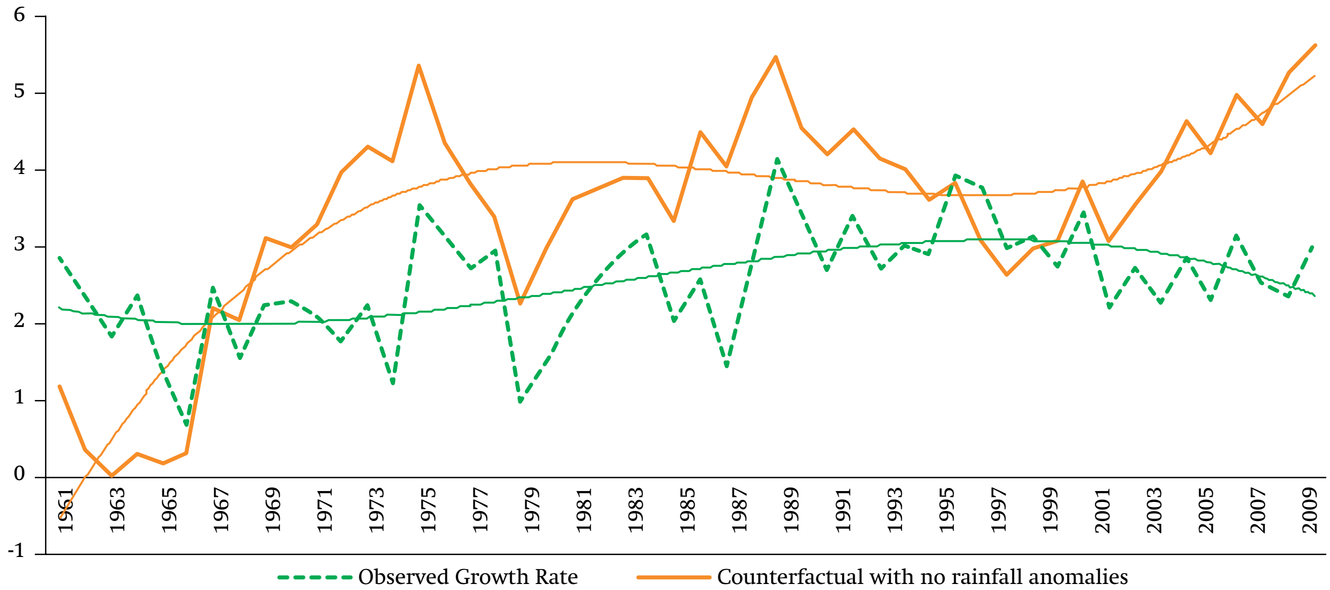
What is remarkable about the trends is the sharp deviation between the actual and counterfactual trends starting just after the mid-1990s, following the agricultural sector reforms (which in turn followed the general reforms implemented in 1991). Assuming normal rainfall, with all else remaining the same, the simulated growth trend shows a significantly different trajectory than the actual observed growth rate.[45] It more dramatically highlights the significant impact of the green revolution in the 1960s and 1970s. The counterfactual scenario further suggests that growth after the mid-1990s may possibly have been higher

43 Time-series data on aggregate agricultural GDP from 1950/51 and monsoon rainfall data from 1900 onward from IMD are used to estimate the impact of rainfall on agricultural GDP growth. Using the estimated parameters, a counterfactual scenario of zero rainfall anomaly (normal rainfall) is estimated for each year.

44 The dynamic growth regression explains about 61 percent of the variation. Note also that the regression does not completely eliminate the impact of rainfall but does account for a significant part of it. Furthermore, the general equilibrium effects are not accounted for, especially for the early years when the Indian economy was much more susceptible to rainfall shocks, given the more significant downstream linkages of agriculture with other sectors.

45 Had the anomalies been just random annual events, as in the earlier years, the two trends would have followed each other in a parallel fashion.

Figure 17: Ten-year average agricultural GDP growth rates (actual and counterfactual scenarios)



Source: Authors, using CSO and IMD data.

than the historical trend, improving upon the sustained expansion observed in the 1980s and early 1990s. Thus, contrary to general perceptions, there is little evidence to suggest that the policy reforms in the 1990s had a significant adverse impact on agriculture, as may be inferred from the observed growth trend. More optimistically, it is tempting to infer that had rainfall cooperated, the reforms could have ushered in the intended structural change, as is often ascribed to the broader reforms in the aggregate economy.

Implications of Findings

The implications of these findings are more significant than the hypothesized impacts of economic reforms. They dramatically illustrate the importance of mitigating the impacts of sustained weather shocks and the changing climate. The very long term (100-year) predictions by the Intergovernmental Panel on Climate Change suggest that precipitation may likely increase for South Asia but also that spatial and inter-annual variability will *intensify* (IPCC 2013).[46] Over the short and medium term, the more immediate need will be to tackle the shifting trend in weather anomalies, with the 2000s being the worst period for anomalies in the past century (see Figure 15). In this context, the 1997–2005 growth slowdown heavily underscores the urgency of addressing critical policy issues in anticipation of the highly uncertain outcomes of climate change:

- The need to improve resilience as the likelihood of cyclical and random rainfall shocks increases, by:
    - Improving the management and efficient use of water resources,

46 The high degree of variability in the predicted patterns of the El Niño Southern Oscillation, the dominant mode of the predicted precipitation variability, provides low confidence in the predictions of outcomes.

while promoting investments in sustainable irrigation to weather-proof agriculture.

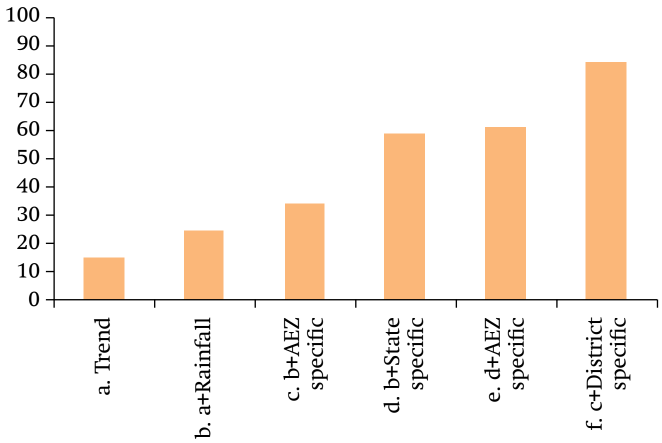
- Promoting public and private investment, as well as greater openness, in introducing suitable technology to mitigate and potentially adapt to climate variability.

- The importance of improved markets and marketing to allow real-time risk sharing across states and districts in response to clear market signals.
- The need to diversify and stabilize sources of income (outside the crop sector), both on-farm (through livestock) and off-farm (through productive nonfarm employment).
- The need to improve the effectiveness of safety net programs such as the Public Distribution System.

4 SPATIAL HETEROGENEITY: PERFORMANCE AT THE SUBNATIONAL LEVEL

National averages provide an aggregate picture of progress, but Figure 18 shows why a deeper analysis at the subnational level is essential to understand the variation in productivity and identify constraints to growth. The time trend (measure of long-term average growth) alone provides a limited explanation for variations in productivity for cereal crops. Rainfall and agro-ecological zone indicators explain more of the variation, but their explanatory power is still limited (34 percent). State-specific factors make a substantial difference, highlighting the key role of state policy and institutions. Another substantial part of the variation in productivity is explained by district-specific factors (which subsume state factors). Clearly, substantial local effects would be missed by focusing only on the national or even the state level.

Figure 18: Factors explaining variation in productivity of cereal crops



Source: Authors, using ICRISAT-NCAP district database.
Note: AEZ = agro-ecological zone.

District-level analysis has other advantages. It helps to reveal how broad-based growth is, as well as the drivers of differential performance across geographical areas—drivers such as access to technology, exogenous agro-ecological conditions, the lack of economic or physical infrastructure, human capital, governance, and other variables. After a brief review of agricultural growth at the state level, the main analysis in this chapter will concentrate on the performance of agriculture at the district level.

Agricultural Growth across States

Over the long run, agriculture has performed very differently across states (Table 2). Long-term aggregate trends, however, mask important structural shifts at the state level. Structural transformation appears to have started in some states, and convergence appears to have started in some state economies (Binswanger-Mkhize and D'Souza 2011).

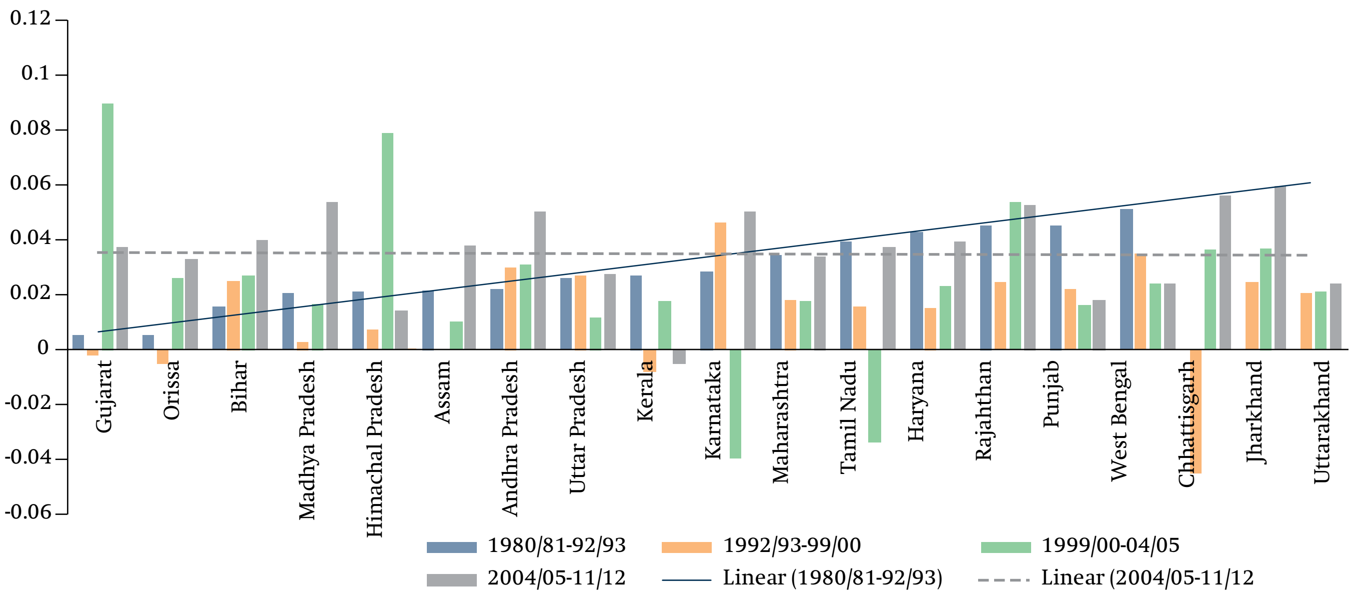
Breaking down agricultural performance by time period throws light on whether

Table 2: Trend growth in Net State Domestic Product, 2004/05–2012/13 (at 2004/2005 prices)

Low (<2.0%)		Medium (2-4%)		High (>4%)	
State	TGR	State	TGR	State	TGR
Kerala[a]	-1.2	Uttar Pradesh	2.2	Gujarat[a]	4.0
Himachal Pradesh	0.4	Uttarakhand	2.4	Maharashtra	4.3
Punjab	1.3	Odisha	3.2	Andhra Pradesh	4.7
West Bengal	1.9	Tamil Nadu	3.4	Karnataka	5.1
		Assam	3.8	Jharkhand	5.3
		Bihar	3.8	Rajasthan[a]	5.5
		Haryana	3.9	Chhattisgarh	6.0
				Madhya Pradesh	6.1

Source: Authors, using National Accounts Statistics, CSO, as on August 1, 2013.
Note: TGR = trend growth rate. [a] Based on data from 2004/05 to 2011/12.

Figure 19: State agriculture growth rates by time period, 1980/81–2011/12



Source: Authors, using CSO data on state GDP.

growth rates across states are converging.[47] Growth rates for the major agricultural states appear in Figure 19. Focusing attention on the first and last period, which better represent pre- and post-reform performance and avoid the confounding effects of rainfall in the slowdown period, it is clear that many of the previously laggard states are participating more fully in the growth process. The trend lines by period show that wide differences in performance

47 Central Statistical Organization (CSO) estimates of State Agriculture GDP are used to calculate trend growth rates in four time periods. The GDP series are available in real prices corresponding to four base periods: 1981/82, 1992/93, 1999/2000, and 2004/05. The growth rates are estimated for each period using the time series denominated to the relevant base year, assuming that the weights used to derive the series within each period are most appropriate.

across states in the 1980s and early 1990s have disappeared after 2004/05, demonstrating a shift toward convergence. In other words, growth has become more inclusive across states.

Individually, many of the LIS have performed better since 2004/05, with growth rates significantly above the base trend line in Assam, Bihar, Madhya Pradesh, Odisha, and Rajasthan. Of the relatively new states created from previous LIS in 1990, Jharkhand and Chhattisgarh have experienced impressive growth in the last period. On the other hand, growth has gradually slowed in previously good performers (Punjab and West Bengal) and in Kerala. Gujarat and Himachal Pradesh recorded phenomenal performance between 1999 and 2005, which has subsequently slowed.

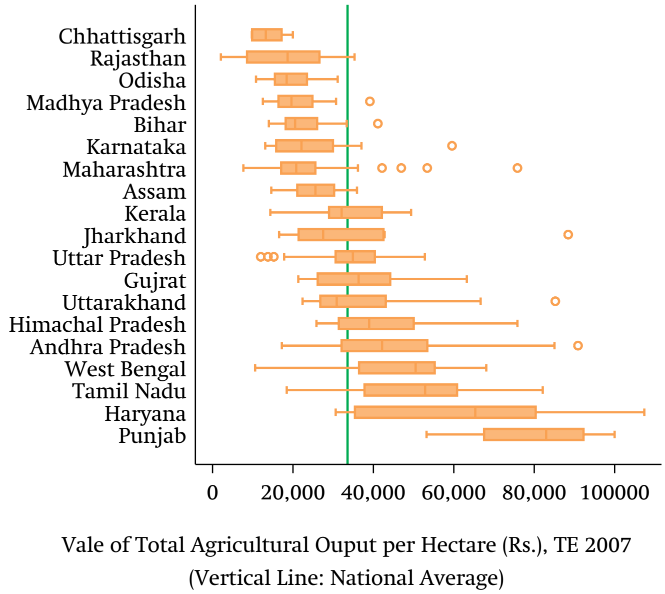
The drivers of growth have differed for each state, but some commonalities have emerged. The highlights are the importance of diversification into high-value agriculture and specialty crops. Examples include Bt cotton in Gujarat and Maharashtra, soybeans in Madhya Pradesh, maize and horticulture in Bihar, and horticulture in some southern states.

Productivity Changes at the District Level

Figure 20 depicts the variation in productivity across districts, based on Kumar and Jain's (2012) estimates.[48] Despite some clustering, there is significant variation within states and agro-ecological zones. Low productivity is common in arid parts of West India and the relatively remote interior districts.

48 Kumar and Jain (2012) estimate crop productivity (value of production per hectare) for 388 districts using triennial averages ending in 1991–92, 2001–02, and 2007–08.

Figure 20: Real value of agricultural output per hectare, 2005–07



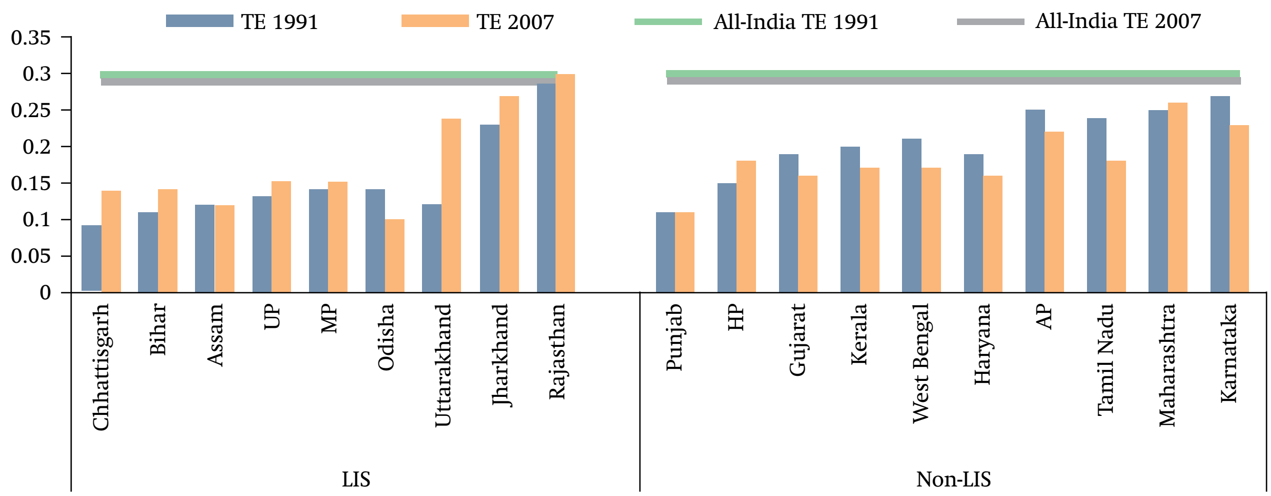
Source: Kshirsagar and Gautam 2013.

Figure 21: Productivity changes by district, 1990–2007

Source: Estimates of district-level productivity from Kumar and Jain 2012.
Note: TE = triennium ending.

Figure 21 shows the range of productivity and changes in productivity between 1990–92 and 2006–08. The districts are arranged in increasing level of productivity in the base year. The level of productivity varies widely across districts, being 50 times higher in the

Figure 22: Changes in inter-district equality (Gini Coefficient), 1991–2007



Source: Authors, using estimates from Kumar and Jain 2012.

most productive district compared to the least productive district.[49] Changes in productivity over time at the district level also vary, but the trend lines show fairly consistent, broad patterns over time.

Districts that were more productive in 1990–91 experienced higher growth throughout the 1990s. After 2000, however, districts at the lower end of the productivity spectrum grew faster. Despite those advances, large differences persist. The relative rankings are largely preserved over time.

Variability has increased at the two extremes of the productivity scale. At the lower end, some districts experienced greater growth than their peers, whereas some of the more productive districts performed poorly compared to the others, recording lower productivity in 2007 relative to 1990. A vast majority of the districts in the middle range show less variability but had more modest growth rates.

Even within states there is considerable inter-district variability (see Annex 4, Table A.4.1). The coefficient of variation across all districts in India was 58.3 percent in TE 1991, increasing slightly to 60 percent in TE 2001 before declining to 56.9 in TE 2007. The Gini coefficient shows the same trend, with minor changes in equality over time (Figure 22). One distinct pattern that emerges is that the LIS have typically seen an increase in cross-district inequality (with the notable exception of Odisha), whereas the other states, also previously more productive and diverse, have seen a decline.[50] In other words, as growth increases in selected districts within the LIS, inequality increases as well. In the more advanced agricultural states, the previously lagging districts appear to be catching up, indicating convergence.

49 Productivity ranged from Rs. 2,068 per hectare in Barmer District of Rajasthan to Rs. 107,376 in Karnal District of Haryana in the Triennium Ending (TE) 2007–08.

50 Punjab is an exception among non-LIS with low inequality across districts, indicating more uniformly high productivity levels across districts starting in 1991, which appears to have been maintained through time.

Dynamics of Agricultural Productivity at the District Level

The unusual slowdown in Indian agriculture from the late 1990s to mid-2000s, with its close relation to unusual rainfall patterns, clouds the analysis of agricultural performance and its likely drivers between 1990 and 2008. To obtain more robust results, Kshirsagar and Gautam (2013) extend the period of the district-level analysis to start from 1970 onward. They address two key issues.[51] First, has agricultural growth been geographically inclusive? The evidence suggests that the modest sectoral growth over the period was not shared across districts. Instead agricultural productivity differences between districts increased between the 1970s and 2000s. Despite the spread of technology (the green revolution technology), data suggest only mild convergence. A few districts are "catching up," while a substantial number are falling further behind despite positive but low levels of growth. Addressing this imbalance remains central to achieve broad-based growth. Importantly, the evidence shows that "laggard" districts are not at a disadvantage because of rainfall levels. On average they received *more* rainfall than their faster-growing counterparts, suggesting that policy rather than exogenous factors may be more important in addressing inequalities in agricultural productivity between districts.

The second key issue addressed by the analysis is which policy drivers are consistent with improvements in agricultural productivity at the district level. Even in districts previously characterized by low cereal yields, the main driver of productivity has been irrigation and the associated adoption of seed-fertilizer technology.[52] The analysis supporting these findings is presented in the sections that follow.

It is important to note that while the focus of this analysis is agricultural productivity, inevitably there will be some districts (as well as areas within districts) with few or no prospects for irrigation. Given their agro-ecological endowments (their rainfall, soils, and so on), the scope for productive agriculture may be limited. Development strategies thus need to be tailored to specific locations, and in some areas agriculture (or certain types of agriculture, such as cereal production) may not be viable. Livelihood options outside agriculture will be essential for sustainable poverty reduction in such areas.

51 The analysis uses the district-level database compiled by ICRISAT and NCAP. Kumar and Jain (2012) use a subset of that database in their analysis. The data are from 1970 to 2008 for 19 major agricultural states. The districts and states created through splits and divisions are mapped to the original districts as they existed in the 1960s (the "apportioned data"). These original administrative districts (and states) are used in the analysis. Data on output and area are most reliable for cereals and a few other crops. For reliability the analysis focusses on cereals, but consistency checks are made with productivity across all crops. The broader measure is an approximation based on available prices. Only districts with data for the complete period of analysis are retained, totalling 297 of the 317 districts in the database. These districts accounted for 78 percent of aggregate cereal production in 2005–07. Kshirsagar and Gautam (2012) show that the data provide a very good approximation of long-term trends as well as inter-annual fluctuations in the aggregate performance of agriculture in India.

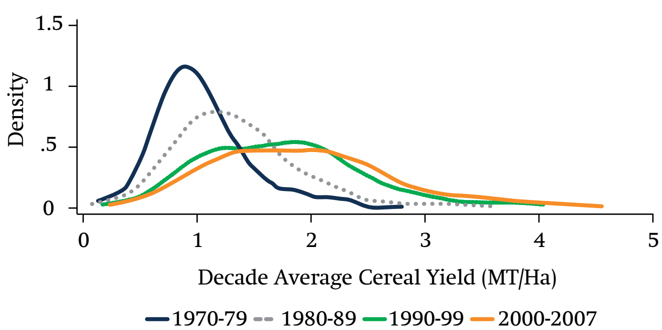
52 Some caveats should be noted. First, the analysis is based on econometric estimations using both district and year fixed effects. Nevertheless, regardless of the technique employed, it is not possible to control for all unobservable time-varying factors. Second, all measures of agricultural productivity are volatile (partly due to weather, but also likely measurement error). For these reasons, decade averages are used for some of the analysis, but econometric analysis uses yearly data. The analysis is based on district aggregates and not individual household-level responses. As such, inferences about household behavioral responses will be subject to the ecological fallacy (Freedman 2001; Freedman, Pisani, and Purves 2007).

District performance by growth typology

The distribution of yields has become more dispersed over time.[53] The progressive "flattening" of the distribution curve (yields across districts) seen in Figure 23 means that over time more districts have experienced productivity growth, with a larger shift in the 1970s and 1980s than in the 1990s.

Although more districts have experienced productivity growth, not all districts have participated. A significant number seem to be stuck at low productivity levels. To identify the drivers of productivity growth, districts are categorized by long-run growth typologies, based on initial conditions and subsequent

Figure 23: Distribution of yields across districts by decade



Source: Kshirsagar and Gautam 2013.

Table 3: District growth typologies

	Low growth (<100%)	High growth (>100%)
Low yields (<1.25 MT)	Laggard	Low yield/growth
High yields (>1.25 MT)	High yield/stable	High yield/ growth

Source: Kshirsagar and Gautam 2013.
Note: "Growth" is defined as percent change in average yields from the 1970s to 2000s. The "high-yield" cutoff is the 75th percentile in the 1970s.

performance (Table 3).[54] This helps distinguish between districts that show slow growth but do not necessarily have low productivity—for example, districts that were more advanced to begin with and likely closer to the prevailing technological frontier, with perhaps fewer prospects of increasing growth in productivity.[55]

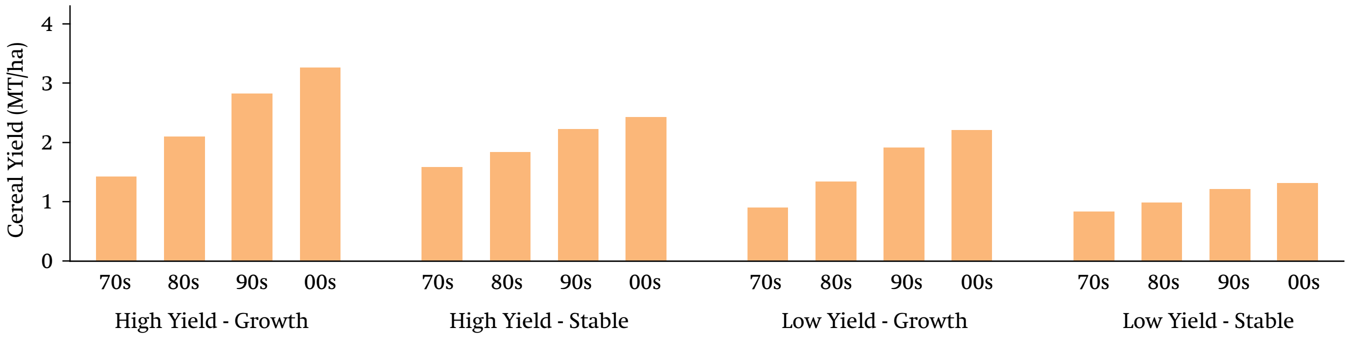
Figure 24 shows the magnitudes of changes in productivity by decade and typology. As noted, most of the analysis here is based on cereal productivity; it mirrors the performance based on the broader agricultural productivity measure (including other crops) providing confidence that the findings are robust (see Annex 4, Figure A.4.2, for the broader measure of productivity).

53 For three reasons, levels and changes in cereal yields are used for most of the analysis to characterize district-level agricultural performance. First, at the district level, historical output data on fruits, vegetables, and spices are not available, making it difficult to estimate yields or value changes over time. Results for states that rely heavily on these crops (such as Kerala) will thus be biased downwards. Second, prices for many (noncereal) products are unavailable at the district (or state) level for many years. Using prices from only a few years will likely introduce other biases in the analysis. Third, the data for cereal yields closely match aggregate cereal data used by the GOI, FAO, and the World Development Indicators. Nevertheless, consistency checks are made with the broader productivity measure, as discussed later.

54 Using a short-run growth typology provides qualitatively similar findings.

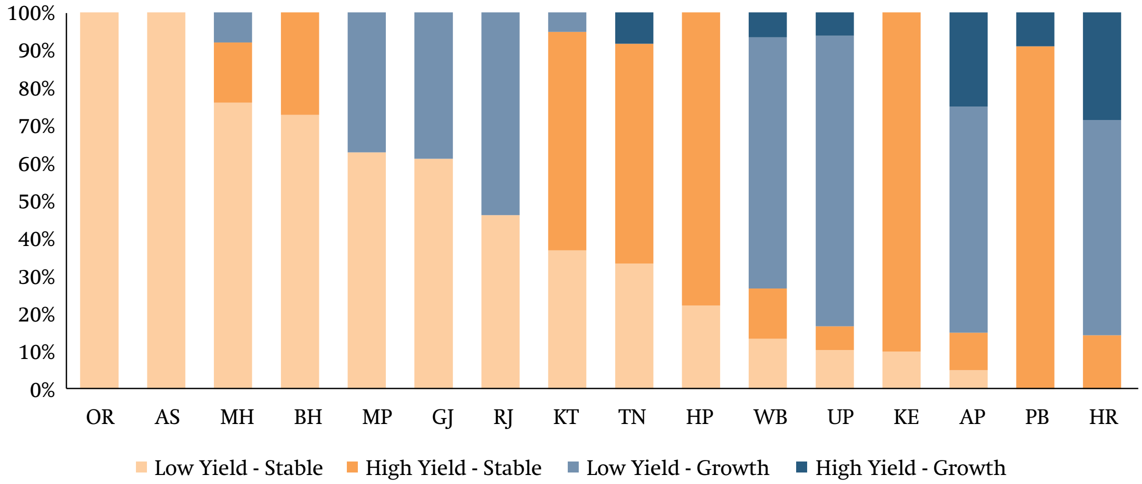
55 An alternative typology considered for this study sought to exploit the more intuitive rainfed-irrigated categorization of agriculture, using the proportion of area in a district that is irrigated. The analysis using that kind of typology is complicated by the fact that irrigation development is not static; irrigated area can change rapidly over time in many districts (see Annex 4, Table A.4.2). Another consideration is that additional irrigation development may be less of a priority in areas endowed with good rainfall. Some of the highly irrigated districts are located in the "arid" zone, while a number of districts with little or no irrigation are in the "humid" zone, with nontrivial productivity trends, as shown in Annex 4, Figure A.4.1.

Figure 24: Long-run productivity typology of districts based on cereal yields



Source: Kshirsagar and Gautam 2013.

Figure 25: Dispersion of districts by agricultural productivity typology



Source: Kshirsagar and Gautam 2013.

Figure 25 maps the districts by growth typology. Except for some districts in Central India, Gujarat, and West Bengal, most of the productivity growth has been concentrated in northern and southern districts. Table 4 more clearly shows the distribution of districts by typology and state. Of the districts with initially low yields (225 of the total 297 districts), less than half had doubled productivity by the 2000s. Of these, 86 percent were from just five states. Within states, in only four were the vast majority of districts doing well (Andhra Pradesh, Haryana, Uttar Pradesh, and West Bengal), accounting for 62 percent of the low-yield/growth districts. On the other hand, those states had just 32 percent of all low-yield districts in the 1970s. In contrast, Assam, Bihar, Maharashtra, Madhya Pradesh, and Odisha had a disproportionately large fraction of districts that failed to raise productivity appreciably over three decades despite very low productivity in the 1970s.

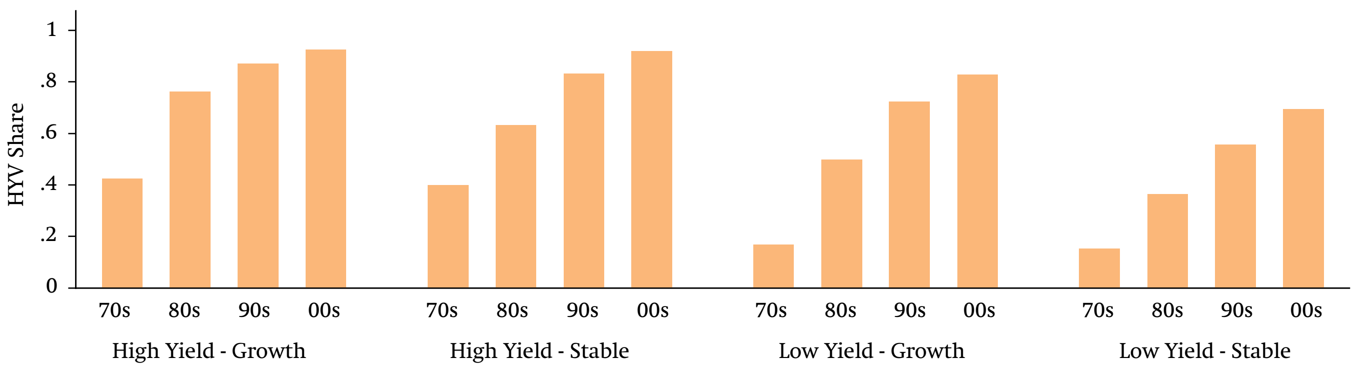
The analysis by growth typology provides a number of key insights into the patterns and

Table 4: District growth typologies by state (long run, 1970–2007)

State	High yield/ growth	High yield/ stable	Low yield/ growth	Low yield/ stable	Total
Andhra Pradesh	5	2	12	1	20
Assam	0	0	0	10	10
Bihar	0	3	0	8	11
Gujarat	0	0	7	11	18
Haryana	2	1	4	0	7
Himachal Pradesh	0	7	0	2	9
Karnataka	0	11	1	7	19
Kerala	0	9	0	1	10
Madhya Pradesh	0	0	16	27	43
Maharashtra	0	4	2	19	25
Odisha	0	0	0	13	13
Punjab	1	10	0	0	11
Rajasthan	0	0	14	12	26
Tamil Nadu	1	7	0	4	12
Uttar Pradesh	3	3	37	5	48
West Bengal	1	2	10	2	15
Total	**13**	**59**	**103**	**122**	**297**

Source: Kshirsagar and Gautam 2013.

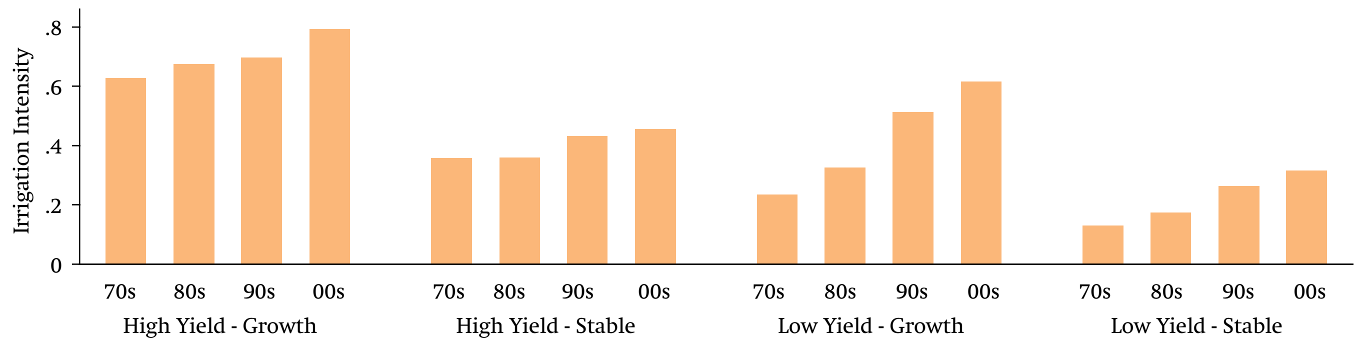
Figure 26: Share of cereal area planted to high-yielding varieties



Source: Kshirsagar and Gautam 2013.

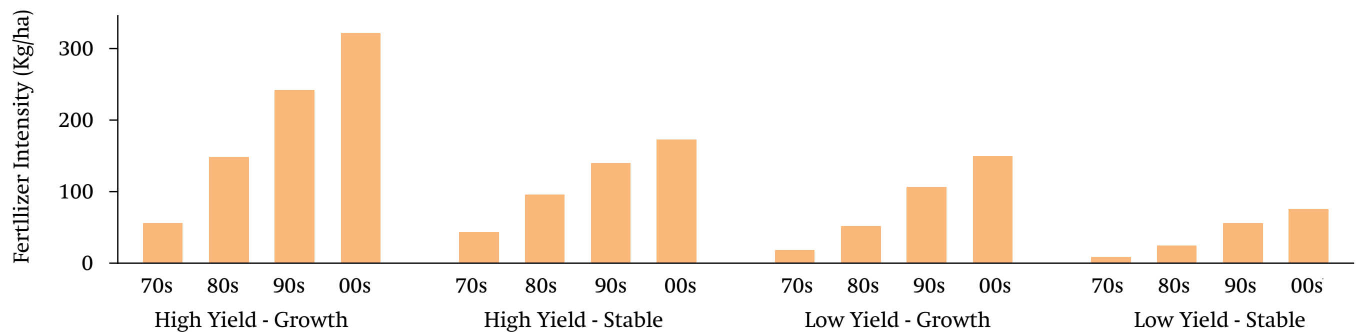
sources of productivity growth across districts. *First, improved seeds alone do not prove to be a sufficient driver of growth.* High-yielding varieties (HYVs) were more commonly planted in the high-yield districts in the 1970s at the start of the green revolution, but improved seeds have now diffused widely. Use of HYVs grew significantly in the laggard districts, yet no corresponding productivity improvement occurred (Figure 26). Given the rapid rate of adoption across all types of districts, HYVs do not offer a sufficient

Figure 27: Irrigation intensity across district typologies by decade



Source: Kshirsagar and Gautam 2013.

Figure 28: Fertilizer intensity across district typologies by decade



Source: Kshirsagar and Gautam 2013.

explanation for the differences in productivity growth.[56]

Second, agro-ecological conditions alone also do not sufficiently account for the disparities in productivity among districts. A little over half of the low-yield districts in the Semi-Arid Tropical Zone did not experience significant growth—but one-third did. Similarly, a majority of low-yield districts in the Temperate Zone saw yields grow, yet almost one-quarter did not (Annex 4, Table A.4.3). *Third, rainfall patterns and anomalies also do not provide a convincing explanation.* On average, high- and low-yield districts where productivity increased most received *less* rainfall on average, and in fact suffered *greater negative anomalies* in the 2000s relative to their more stable counterparts (Annex 4, Figures A.4.3 and A.4.4).

Irrigation and fertilizer set the growth districts apart from the others. High-yield districts had better irrigation to begin with (Figure 27), but a key difference between the growth and stable districts is the growth in irrigation intensity, especially in the low-yield/growth districts. Fertilizer use has also grown much faster in the growth districts, likely influenced by irrigation (Figure 28).

56 This finding needs to be examined at a lower level of aggregation (using household or plot-level data). There may be substantial differences in the efficacy of HYV seed, or the varieties that are available may not be suited to the agro-ecological conditions in particular districts.

An analysis of growth typology by the dynamics of irrigation confirms the strong association of irrigation in the growth districts and provides additional insights (see Annex 4, Table A.4.4). The majority of the growth districts are concentrated in high-irrigation districts or those that have developed irrigation over time.[57] However, there are important exceptions. About one-third of the high-yield/stable districts had low irrigation and still have low irrigation. Almost all of these are in the "humid" zone, either in the coastal areas or the ghats of Kerala, Karnataka, and Maharashtra. At the same time, more than half of the laggard (low-yield/stable) districts either had a high level of irrigation or developed irrigation capacity over time but have not seen significant increases in cereal or overall productivity.[58] Importantly, a substantial number of districts (50 of 295, or about 30 percent) are in the laggard and low-irrigation category. They have developed no significant irrigation capacity so far, and the micro-level data on their potential for irrigation development are not available.

Changes in the mode of irrigation are also revealing (Annex 4, Figure A.4.5). The use of pumps and wells to extract groundwater increased consistently over the decades, with extraordinary increases in the low-yield/growth districts. Irrigation intensity in laggard districts and high-yield/stable districts increased mostly through the use of tanks. The high-yield/growth districts initially had a large area under canal irrigation (in absolute terms and relative to other districts), but their share in area irrigated has declined consistently in each subsequent decade.

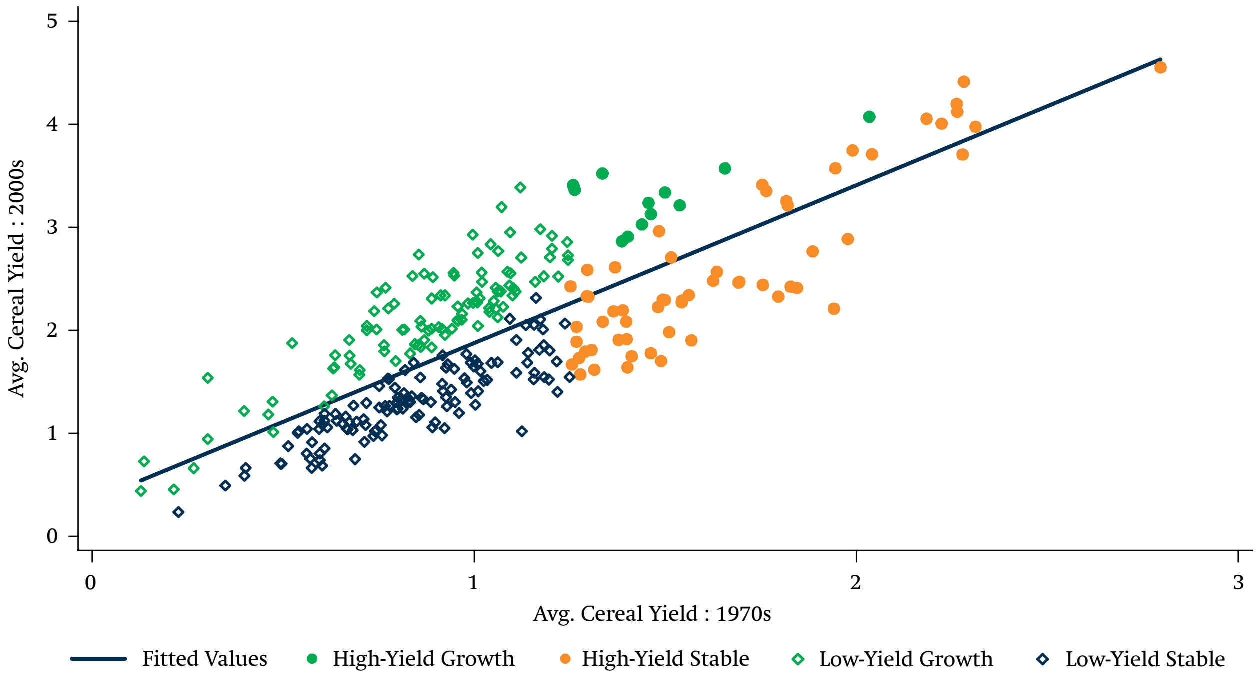
One of two key questions posed earlier was the degree to which growth has been inclusive. The fact that more districts are participating in growth may suggest convergence across districts. But despite the growth in the laggard districts, the difference between the laggards and high performers is *rising* (Figure 29). Clearly, convergence in cereal productivity across districts is modest and limited to a few districts. When the analysis included all crops for which data are available, not just cereals, the results suggest *divergence* rather than convergence. Except for a handful of districts where productivity was initially very low, there is little evidence to support convergence (Annex 4, Figure A.4.6). The more advanced districts appear to be distancing themselves from the others.

The persistence of a large number of laggard districts, confirmed by the lack of convergence across districts, suggests a need for more detailed assessments of their agro-ecological potential. In some districts, or even in parts of districts, it is likely that the natural environment may not be conducive for rapid productivity growth. Development strategies thus need to be tailored to specific locations, based on detailed analyses of the types of agricultural activities that may be viable. It is inevitable that in some locations, sustainable income growth and poverty reduction objectives may be better served by supporting avenues toward livelihoods outside of agriculture.

57 Districts are categorized in terms of their irrigation dynamics for this analysis. The "low" group is the set of districts that had a low level of irrigation (less than 25 percent cultivated area) in the 1970s and continues to have low irrigation. The moderate/dynamic group comprises districts that had low or moderate (25–50 percent area) levels of irrigation in 1970s but have since increased irrigated area. The "high" group has had a high level of irrigation (more than 50 percent area) since the 1970s.

58 Some level of crop diversification (toward high-value crops such as horticultural crops) is evident in all districts, but has been the highest in low-yield/growth districts.

Figure 29: Changes in district agricultural productivity



Source: Kshirsagar and Gautam 2013.

Drivers of productivity growth

Productivity can grow through intensification or through switching to crops that are more productive (in value per hectare). Area changes show some shifts, but no obvious patterns emerge across district types (Annex 4, Table A.4.6). The area under cereals has declined only marginally. Most cropped area remains under cereals in all types of districts, and cereal area is still highest in the high-yield/stable group, the original green revolution strongholds. While the area under horticulture grew in all districts, it remains relatively lower in the low-yield districts, and the share of pulses and oilseeds remains relatively higher. The low-yield/growth districts have departed from the laggards in that they have reduced their area under pulses and switched to higher-value crops, including cotton, horticultural crops, and newer oilseeds (soybeans)—clearly highlighting the importance of new technology and nontraditional crops in driving productivity and growth.

Data for indicators that explain productivity changes are limited. Despite poor quality and missing data for different years and districts, the main changes observed are presented in Table 5.

Markets per capita have declined in low-yield districts relative to the other districts. This change may represent a reduction in incentives for producers, constraining productivity growth. Road density was low in the early years in low-yield districts, but has since grown faster than in the other districts. But the increased investment in infrastructure has not yet translated to productivity growth in the laggard (low-yield and stable) districts. Low-yield districts had relatively lower levels

Table 5: Levels and changes in key indicators of changes in agricultural productivity

	High yield/growth			High yield/stable			Low yield/growth			Low yield/stable		
Area share	1970s	2000s	% change	1970s	2000s	% change	1970s	2000s	% change	1970s	2000s	% change
Markets/capita	0.02	0.02	-15.9	0.02	0.02	9.6	0.01	0.01	-20.1	0.02	0.01	-25.2
Road density	3.6	7.3	100.9	5.7	10.1	78.8	2.1	5.2	150.0	2.9	7.1	150.4
Fraction rural	0.79	0.71	-10.1	0.81	0.72	-11.3	0.82	0.76	-6.7	0.86	0.79	-7.6
Rural literacy	0.22	0.52	131.0	0.33	0.62	87.2	0.19	0.47	152.8	0.22	0.49	123.6

Source: Kshirsagar and Gautam 2013.

of urbanization (higher fraction of rural population) to begin with; they have seen slower change in this indicator, with the laggard districts at the greatest disadvantage. Finally, literacy levels have increased but remain marginally low in the low-yield districts.

The descriptive analysis above is substantiated by econometric estimates of the determinants of productivity growth (Annex 4, Tables A.4.7–A.4.10). In brief, increases in irrigation use appear to have driven productivity growth in districts that had low yields in the 1970s, whereas growth in the more mature districts was driven by a more balanced constellation of factors:

- Rainfall is a significant determinant (for all crops) in the low-yield districts, as is irrigation. The insignificance of rainfall in high-yield districts reinforces the importance of irrigation in mitigating rainfall shocks—confirmed by the insignificance of rainfall in the high-irrigation districts. At the same time, rainfall's significant impact in low-irrigation districts indicates quite clearly that the potential payoffs to irrigation development in low-yield/low-irrigation districts are significant. Importantly, irrigation also drove productivity in noncereal crops in high-yield/growth districts, implying a potential role for reorienting investments to promote growth in noncereal crops in low-productivity areas.
- Fertilizer shows a consistent impact on cereal productivity across all districts, but its impact on noncereal crops is limited, possibly reflecting their higher risk or inappropriate use.
- Roads appear to have a greater impact in high-yield areas (across crops), confirming the importance of roads for productivity growth. This result suggests that increased road density (noted earlier) has not yet translated to productivity in low-yield areas, calling attention to complementary productivity-enhancing investments which may be lacking.
- To pick up the location-specific time-invariant factors, cross-sectional regressions show high sensitivity of productivity to both mean rainfall (location effects) and the variability in rainfall (risk). Analyses at a lower level of aggregation are needed to uncover causal mechanisms, but these findings suggest that within states and agro-ecological zones, weather risk has a detrimental impact on productivity an growth.

- Irrigation intensity and market density have strong positive impacts on productivity, after accounting for rainfall and agro-ecological diversity. But their influence becomes statistically insignificant when state effects are introduced, suggesting high a correlation with state-level effects, highlighting the important role of state policies governing investments and institutions as key drivers of productivity growth.

Implications of the Subnational Analysis

The main messages emerging from the analysis of agricultural performance at the subnational level are:

- *Policy reform, risk and agricultural performance.* Consistent with the previous finding that the policy reforms of the 1990s likely had a stimulatory impact on productivity, several previously laggard states have significantly improved growth after 2004–05 under relatively normal rainfall. The slowing of growth in states that previously were highly productive is a cause for concern, however. These conclusions are reinforced by the empirical importance of the detrimental impact of weather risk on productivity and long-term growth prospects for agriculture.

- *Promoting broad-based growth.* Agricultural productivity has grown unevenly across districts—even within states and agro-ecological zones. A significant share of districts did not participate fully in growth, with disparities between districts increasing between 1970 and 2007. The analysis, however, defies the search for a "silver bullet." For example, investment in roads alone has not yet boosted the laggard districts, but it does show significant impact in high-yield districts. Similarly technology alone has not spurred growth. Complementary investments in irrigation and market intensity show large impacts, importantly through diversification, distinguishing better performers from laggard districts. But the effectiveness of these instruments varies by state, highlighting the critical importance of state policies governing institutions and investments to promote inclusive growth.

- *Water and productivity.* Districts that have increased productivity most rapidly since the 1970s did so with significant increases in irrigation—mostly groundwater extraction—and closely correlated adoption of HYVs and fertilizer. Groundwater extraction is already unsustainable in many parts of the country,[59] rapidly reducing aquifers[60] and threatening ecological sustainability.[61] A direct link to energy

59 While the design and implementation of a "rational water policy" is a national priority—see, for example, Ahluwalia's (2011) discussion of such a policy in the context of India's Twelfth Five Year Plan—several relevant actions involve state-level decisions in a context in which inter-state externalities are large and a consensus is still emerging.

60 Confirmed in recent publications from the Groundwater Board. See also Rodell, Velicogna, and Famiglietti (2009) on effects in Punjab, Haryana, and Rajasthan between 2002 and 2008.

61 M.S. Swaminathan has often referred to the use of subsidies for excessive groundwater abstraction for irrigation as ecological suicide or "ecocide." See, for example, the interview reported in the *Frontline* magazine (Volume 17, Issue 11, May 27-June 9, 2000) accessible at: http://www.frontline.in/navigation/?type=static&page=flonnet&rdurl=fl1711/17110770.htm.

subsidies has also been shown by a recent rigorous study (as discussed later). At the same time, mere availability of water does not guarantee success. More than half of the laggard districts have good access to water (or have developed it over time), but they have not managed to improve their performance, pointing to other binding constraints to productivity growth.

5 STRUCTURAL CHANGE

The worrisome and growing gap in productivity between agricultural and nonagricultural workers—a key indicator of economic well-being—traces back to the slow transition of labor out of agriculture. Large numbers of people remain "stuck" in agriculture because growth and job creation have not been sufficiently rapid in the more labor-intensive manufacturing sector (Bosworth, Collins, and Virmani 2007; Bosworth and Collins 2008; Binswanger-Mkhize and D'Souza 2011; World Bank 2012a; GOI 2013a). The stylized process of structural transformation, in which labor exits from agriculture as an economy develops (Box 1), appears to be occurring more slowly in India

Box 1: Structural transformation of economies

Based on historical evidence, several distinct processes are associated with structural transformation of economies: (1) the share of agriculture in GDP declines, (2) the share of agriculture in employment declines, (3) rural–urban migration increases, (4) the service and manufacturing sectors grow rapidly, and (5) a demographic transition occurs with a reduction in population growth rates.[a] The final outcome of structural transformation is a state in which differences in labor productivity between the agricultural and nonagricultural sectors disappear.

Growth in agricultural productivity is fundamental for structural transformation to proceed at a steady pace, because as growth in other sectors accelerates, agriculture's share in GDP declines rapidly, yet the share of the population deriving a living from the agricultural sector declines more slowly. Income inequalities across sectors thus tend to widen initially with a concentration of poverty in agriculture. Eventually a turning point is reached, and labor productivities in the agricultural and nonagricultural sectors begin to converge.[b]

For the turning point to occur, agricultural productivity must increase—partial (land and labor) but also total factor productivity. As structural transformation proceeds, labor will move out of agriculture, making it critical that the remaining resources become more productive to provide the food, savings, and investments for development of the nonagricultural sector. Unless that happens, inter-sectoral terms of trade can move in favor of agriculture, raising food prices, arresting transformation, and even threatening sociopolitical stability.[c] These insights from theory and historical experience are pertinent to India, which has experienced a strong movement in the terms of trade in favor of agriculture, less-than-desirable poverty reduction, and a disproportionate share of the labor force in agriculture despite the rapid economic growth of the past two decades.

Source: [a] Lele et al.2013, using Kuznets 1955, 1966; Chenery and Taylor 1968, Chenery et al 1974, Chenery and Syrquin 1975; Timmer 2009. [b] Lewis 1954; Johnston and Mellor 1961; Timmer 2009. [c] Kuznets 1955, 1966; Lewis 1954; Johnston and Mellor 1961; Lele and Mellor 1981; Mellor and Lele 1973.

than elsewhere (Hazell et al. 2011; Foster and Rozensweig 2010). India's transformation has also been characterized as "stunted" (Binswanger-Mkhize and D'Souza 2011), with the exiting labor moving primarily into the rural nonfarm and informal sector and becoming increasingly "casualized" (World Bank 2010; Lanjouw and Murgai 2009, Himanshu et al. 2010).

This atypical demographic transition places a heavy tax on rural well-being and prosperity. Agricultural labor productivity as a ratio of land productivity has declined by almost 1 percent per year between 1980 and 2009. In other words, physical productivity growth (modest as it is) has not commensurately improved the standard of living of those engaged in agriculture.

This chapter examines India's structural transformation. It compares India's experience to that of other countries to identify issues for consideration as India moves forward. An equally useful aperture into structural change in India comes from village-level analysis. A longitudinal study provides insights into the development process in one of the poorest states, Bihar.

India's Structural Transformation in an International Perspective

Lele et al. (2013) compare India's performance with that of three other large developing countries—Brazil, China, and Indonesia. Together the four countries (henceforth BIIC) contain 44 percent of the global population and produce slightly more than one-third of all cereals. All are rapidly growing emerging countries.[62] In 1961, condition in the three Asian countries were comparable. Since then, China and Indonesia have achieved more success in reducing poverty and hunger. Brazil was relatively more advanced from the start, and it has continued to perform well since. India's agricultural productivity growth has been slower than that of the other countries. How well have each of these countries done in agriculture to meet their development challenges? Going forward, what are the implications and priorities for policy and investment in India?

Divergent patterns of structural transformation

Building on earlier studies of structural transformation, Lele et al. (2013) assess the agricultural performance of the four countries against the background of an analysis of panel data for 109 developed and developing countries between 1980 and 2009. The data reaffirm the stylized facts about structural transformation and development. The shares of value added and employment in agriculture decline as per capita incomes rise (albeit at a decelerating rate). The total value added in agriculture and value added per worker (a measure of labor productivity) increase with per capita income. Significantly, labor productivity rises faster when the developed countries are included in the analysis, but it rises more slowly when only developing

62 Brazil and Indonesia, each with populations of around 200 million or more, are rich in agricultural, forest, and other natural resources, and they are already major exporters of food and agricultural products. China and India, each with a population exceeding one billion, cannot bring more land under cultivation, and future agricultural growth is contingent on more efficient use of a limited natural resource base. The increasing scarcity of land and water are two particularly binding constraints.

Table 6: Turning points for BIIC

Country	Per capita income, 2010 (2000 US$)	2004-08 growth rate (Number of years needed)	2009-10 growth rate (Number of years needed)
Brazil	4699.4	Already reached	
China	2425.5	4	5
India	822.8	23	21
Indonesia	1143.8	27	29

Source: Lele et al. 2013.

countries are included (88 total). This discrepancy may signal that the development context is changing; as a result, today's developing countries may find that raising labor productivity is now a more challenging task than it was for countries that developed in the past.

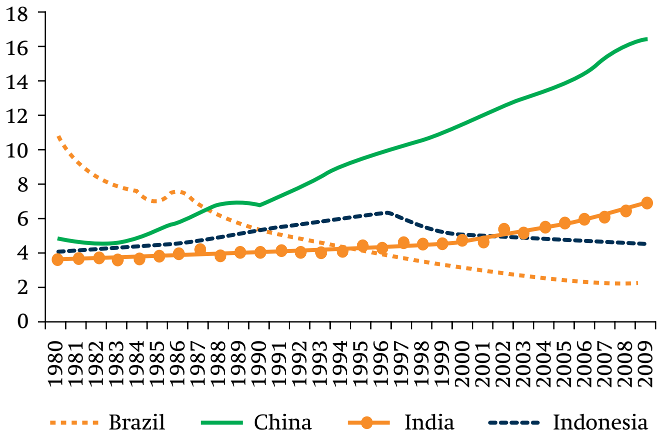
The gap between the share of value added originating in agriculture and the share of employment in agriculture is an indicator for the level and pace of structural transformation. It reflects the degree of convergence in the per capita productivity and incomes of workers in agriculture and the rest of the economy. An earlier study (Timmer and Akkus 2008) found that rapidly growing economies (current developed countries) are reaching the turning point (when labor productivities begin to converge across sectors) at increasingly later stages in their structural transformation. The implication is that industry and services are finding it increasingly difficult to absorb labor out of agriculture—a phenomenon that India too seems to be experiencing.

Using updated data and more detailed analysis, Lele et al. (2013) find that different regions behave differently and in a much more complex fashion. For the sample of developing countries only, they estimate the number of years it will take Brazil, India, Indonesia, and China to reach their respective turning points (Table 6).[63] The turning points are based on the per capita income in each country in 2010 and vary according to the assumptions about growth rate of the per capita income. Based on recent growth rates (2004–08), Brazil has passed its turning point. China is almost there, thanks to rapid growth in agricultural value-added despite having a higher share of its population in agriculture than India. In contrast, India and Indonesia will take longer to reach their turning points (about two decades for India and almost three for Indonesia).

Overall, Asia seems to be behaving much as Kuznets predicted, with increasing inter-sector duality in initial stages (Figure 30). Labor productivity grew much faster in the nonagricultural sectors than in agriculture in China. In Indonesia the difference increased up to the time of the Asian financial crisis but has since been stable. Nonagricultural labor productivity rose in India as well (but less steeply than in China); India's growth in agricultural labor productivity was relatively slower, and the gap has continued to widen. On the other hand, it declined continuously in Brazil over the 1980–2009 study period, owing

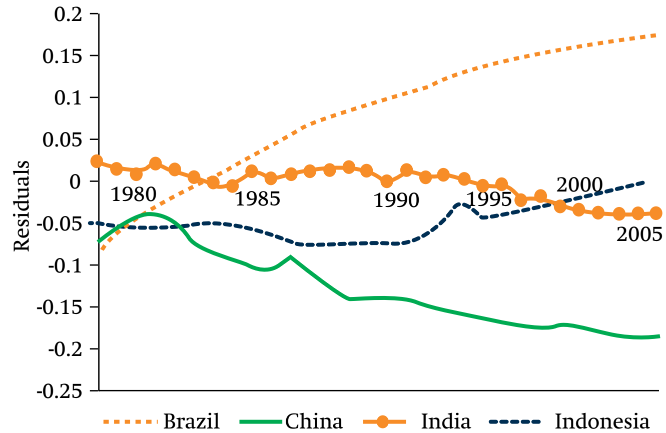
63 Using an alternative specification of the annual fixed effects, they find that the turning points would be approximately a decade later than reported in Table 7, which is based on a regression using decade fixed effects.

Figure 30: Ratio of value added per worker (BIIC), nonagriculture/agriculture: 1980–2009



Source: Lele et al. 2013.

Figure 31: Share of value added minus share of employment in agriculture, residuals (BIIC): 1980–2009



Source: Lele et al. 2013.

to a combination of very rapid growth of labor productivity in agriculture (fastest among the BIICs) as well as a surprising decline in nonagricultural labor productivity.

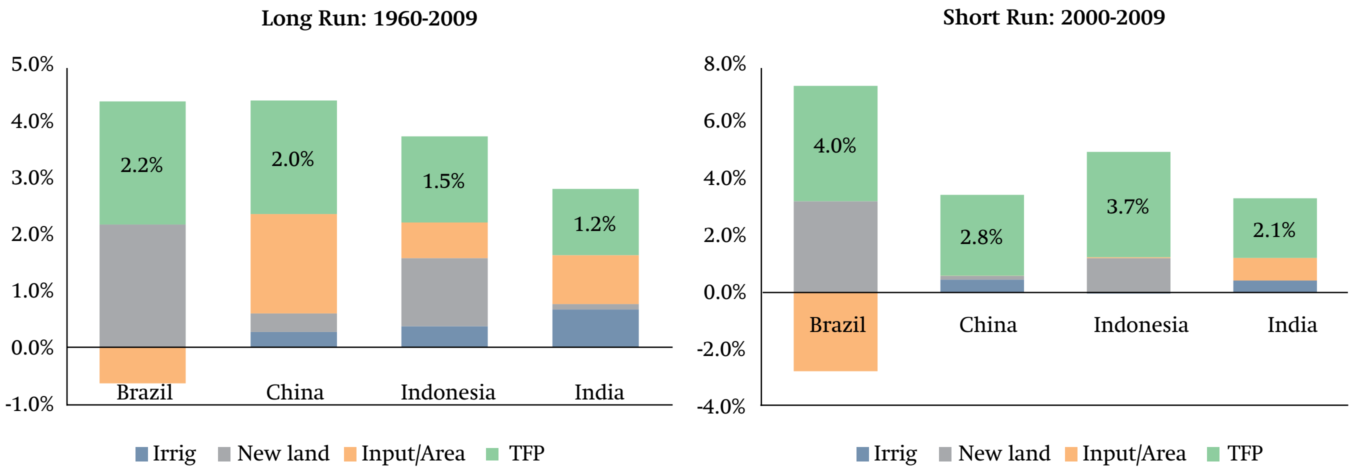
The share of the labor force in agriculture also shows divergent patterns across the four countries. China is an outlier, in that it appears to be losing agricultural labor much more slowly than predicted by the cross-country experience. Brazil is an outlier in the other direction, shedding labor much more rapidly than predicted. India and Indonesia behave like other developing countries. The share of agricultural value added has also been close to the model predictions for India and Indonesia, whereas agriculture in China and Brazil has grown rapidly and retained a significantly *larger* share of the overall economy compared to the other developing countries.

India's progress on structural transformation—measured as the difference between agriculture's shares of value added and the overall labor force—has been consistent with the pattern seen in the 88 developing countries in the sample (Figure 31). Progress has slowed since about 2000, however, indicating that labor is not exiting agriculture as fast as agriculture's share of value added is falling. China and Brazil are outliers, reflecting their trends in labor shares, while Indonesia has remained stable and close to the cross-country average.

Although China retained a large percentage of workers in agriculture (concerns about data on China's agricultural labor force notwithstanding),[64] it is clear that rapid growth in agriculture has led to substantial gains in valued added per worker in China. Growth in labor productivity is lower in China than in Brazil, but it is substantially higher than in India and Indonesia. Sluggish growth in India's agricultural productivity, despite a lower share of the labor force in agriculture, has meant that India's agricultural population has seen less

64 There is an ongoing debate about the quality of the labor data on China. Some have argued that labor in agriculture is significantly less than reported.

Figure 32: Decomposition of output growth, BIIC, over the long and short run



Source: Authors, using data from Fuglie 2012.

improvement in its standard of living relative to China.[65]

The role of total factor productivity

Even if labor is slow to exit from agriculture in India, labor productivity could still be made to rise—as it has in China—by increasing land productivity or using inputs more efficiently. Figure 32 shows sources of growth in agricultural output for each country over the long (1960–2009) and short (2000–09) runs. Land-abundant Brazil and Indonesia expanded agricultural area more than India and China. China has intensified input use over the long run, whereas India relied on inputs and irrigation to increase output. In Brazil, China, and Indonesia, total factor productivity (TFP)—a comprehensive measure of how effectively inputs are used in production—has been the primary source of growth in agricultural output, indicating significantly improved efficiency in the use of inputs. TFP growth has been slowest in India, though with some improvement in the recent decade. And in significant contrast to India, Brazil's input use has declined, while for China and Indonesia the contribution of inputs to output growth has been virtually nil.

Productivity growth (net of inputs) can be enhanced through higher yields (better technology) or diversification into higher-value crops. Brazil diversified heavily into soybeans and livestock, for example, and Indonesia into oil palm. China diversified significantly, with a rapid expansion in livestock and high-value fruits and vegetables. India has started to diversify, but agriculture remains heavily concentrated in food grains. Yields of wheat, sugarcane, fruits, and vegetables have grown relatively well since the 1980s, but yields of other crops are significantly lower than in the other three countries.

How do TFP growth rates compare across BIIC and selected regions? India's performance was comparable to that of Brazil, Indonesia, and

65 Agricultural terms of trade in all three Asian countries show similar trends since 1980, indicating that shifts in terms of trade alone do not explain the significantly better performance in living standards in China. From 1980 to the mid-1990s, Brazil saw a rapid decline from very high terms of trade in favor of agriculture, which have since stabilized.

China to about 1980 (Figure 33). Yet despite the benefits of the green revolution, the long-run TFP growth has been lower in India than in the other countries and regions—except for sub-Saharan Africa (as a whole).

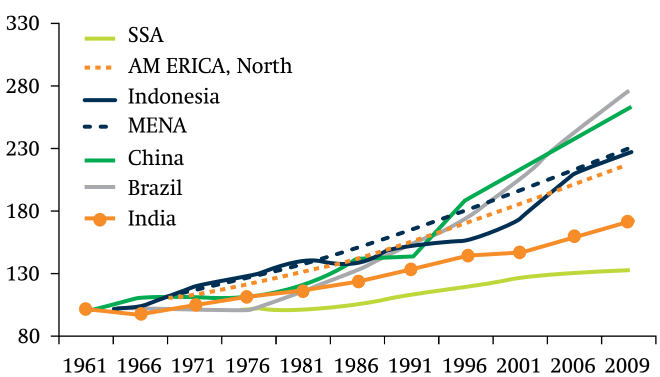
Nin-Pratt, Yu and Fan (2009) analyze the contribution of technical change and efficiency in explaining TFP growth in India and China between 1961 to 2006 (Figure 34). Their findings provide an insightful comparison of each country's respective pre- and post-reform performance (using 1980 as the reform cut-off for China and 1991 for India). They reiterate the widely recognized importance of a conducive policy environment for efficiency and growth.

Both countries benefited from positive technical change through the green revolution, *irrespective of economic reforms*, underscoring the critical role of technology in driving productivity. But with more fundamental institutional reforms, the movement of workers into rural enterprises (small manufacturing), fiscal decentralization, and the steady introduction of market incentives through consistent and sustained reforms, Chinese agriculture has become much more efficient.

China's industrial reforms in the early 1990s sustained the TFP boost from the earlier more fundamental reforms of the 1980s, enabling labor to move out of agriculture to help raise labor productivity. Continuous capital investment and technical change sustained output per worker in addition to promoting further growth in agriculture. In India, after the initial boost of technology in the 1970s reversed the declining TFP of the 1960s, growth has been sustained, but comparatively slow, with much slower movement of workers out of agriculture.

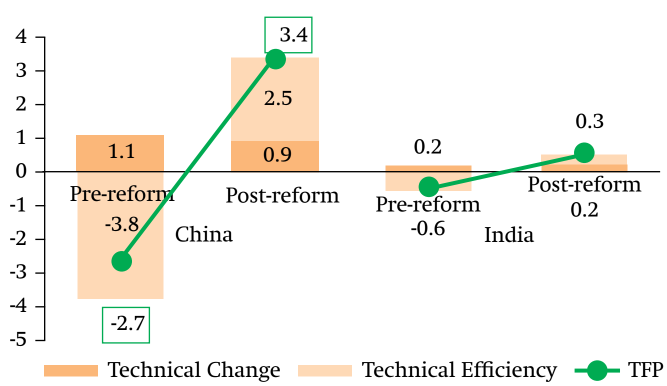
While the impact of policy reforms in India was likely stifled by rainfall shocks as previously highlighted, the role of the current agricultural policy environment nevertheless remains important. How important this may be is demonstrated by an independent comparative assessment of the policy environment provided by the World Economic Forum's Global Competitiveness Index (GCI). One component of the GCI is an index on Agricultural Policy Costs (APC), which is a window on the views of global and national economic and business leaders. Of 142 countries surveyed for the APC, India ranks 79th, just below the median for all countries and significantly below Brazil, Indonesia, and

Figure 33: TFP growth in BIIC and selected regions



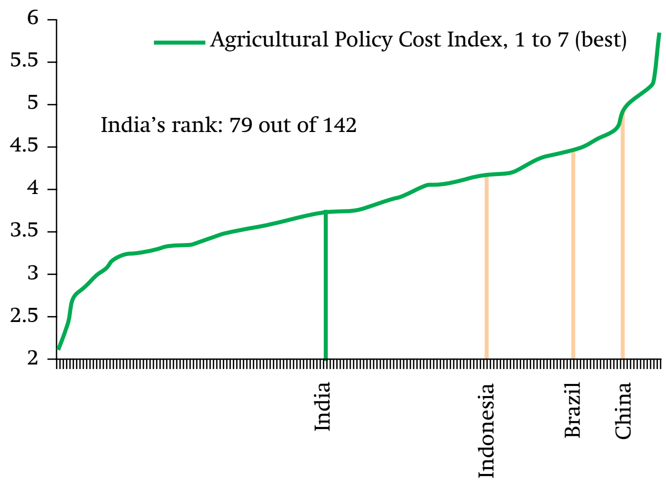
Source: Authors, using data from Fuglie 2012.

Figure 34: Drivers of TFP, India and China, 1961–2006



Source: Based on data from Nin-Pratt, Yu and Fan 2009.

Figure 35: The World Economic Forum's Global Competitiveness Index



Source: World Economic Forum 2012.

China in terms of the policy environment for agriculture (Figure 35). The big difference in rankings helps explain the significant difference in efficiency as a driver of productivity, discussed earlier.

Drivers of growth in the comparator countries: Implications for India

The comparator countries differ significantly in their physical endowments and political and institutional systems, but they offer valuable perspectives on Indian agriculture. The "small-scale and efficient" experiences of China and Indonesia are more suitable to India than the "large-scale, mechanized, and efficient" model of Brazil, but important insights emerge for both environments.

Investment in technology. The first—and perhaps most important—factor driving productivity in all four countries, irrespective of the policy environment, has been technology. Investing in technology is a globally proven and tested strategy for promoting growth. Brazil, India, and China all invested heavily in technology and research. They are among the largest investors in public research, from which they have benefited significantly. China has made sustained and substantially more investments, and its investments have also been more effective. Despite operating in a different environment, Brazil has also invested heavily and very effectively in technology. Through Embrapa[66] (its national research organization) and farmer-led innovation, Brazil has emerged as a global leader in agricultural exports (Rada and Valdes 2012). Technology has been pivotal in Indonesia as well. Even though its domestic research has not been as productive as that of the other countries, Indonesia benefited from a policy of open trade, enabling imported technology from Malaysia to unleash extraordinary development in palm oil production and processing (Rada and Fuglie 2012).

Diversification. A second major driver of growth in productivity was the diversification of agriculture, both for domestic and export markets, supported by appropriate technology, policy, and institutional capital. Brazil, Indonesia, and China all benefited significantly more than India from openness in trade. India, driven primarily by food security, has only recently and slowly started to diversify out of cereals. China and Brazil diversified out of cereals and into livestock; Brazil and Indonesia moved heavily into the production and export of soybeans and palm oil—all major sources of growth.

Enabling policy environment. China and Brazil have a more predictable overall

66 Empresa Brasileira de Pesquisa Agropecuária.

enabling policy environment for agriculture, with a strong record of implementation and continuous innovation in public sector management for agriculture and rural development. Major and fundamental reforms greatly increased TFP growth and are now promoting rapid gains in water-use efficiency in Chinese agriculture. Total water use dropped sharply with diversification into less water-intensive crops and better technology. The greater openness of Brazil, Indonesia, and China has also paid significant dividends in production efficiencies and diversification, as well as better access to technology, whether from international public research systems, other national public research organizations, or the private sector (notably in relation to genetically modified crops). More efficient use of scarce resources is the only way for India to sustainably raise land and labor productivity. Collectively, BIIC can benefit from technological collaboration in developing and adapting environmentally friendly and climate-smart technologies for sustainable agricultural growth.

Change at the Micro Level: Insights from Village Studies

Perspectives on structural change at the micro level provide insights to complement the macro-level analysis by pointing to the likely impacts of policies and institutions on farmers' productivity and incomes. This section presents findings from a longitudinal study examining structural changes at the village level.

Longitudinal analysis of change in 36 villages of Bihar

A longitudinal study by Rodgers and Sharma (2011) spanned the period from 1981–83 to 2009–11 with three rounds of panel surveys in 36 villages of Bihar—among the poorest and least-developed states in India. Socioeconomic patterns shifted dramatically over that period, as the semi-feudal production relations long associated with Bihar's agriculture virtually disappeared. The number of attached laborers and landlords has declined significantly, while casual landless agricultural labor and numbers of poor peasants have increased. High and growing population pressure on limited land has also led to an increase in the proportion of nonagricultural households and migration.

The challenges of structural transformation are more acute in Bihar relative to India as a whole. Agriculture's share of GSDP is declining rapidly (from 43 percent in 1980–81 to 18 percent in 2009–10). The reduction in agricultural labor has been much slower, resulting in low labor productivity. These developments do not imply stagnation, however. Land productivity has changed considerably: Average yields rose at 2.5 percent per year for rice and 2.3 percent per year for wheat.

Within the state, diversification has distinct regional patterns. For example, cereals continue to dominate in some districts (as in Rohtas), and noncereal production is more prevalent in others (as in Gaya, Nalanda, and Purnia). The spread of new technology also shows significant regional differences.

Another aspect of structural transformation is the significant diversification in men's occupations (Table 7). Only 27 percent of income now comes from agriculture (either from own production or wage work in agriculture), and only 37 percent of males classify agriculture as their primary occupation. Levels of migration out of the village are high. Migration income

Table 7: Distribution of income by source and caste, 2011 (%)

Caste/ community	Own agricultural production	Wage work in agriculture	All agricultural income	Nonagric. own production	Casual wage in non-agric. sector	Regular employment income	Other income	Remittances
Brahmin/ Kayastha	32.7	0.2	33.0	10.5	0.5	13.1	23.0	20.0
Bhumihar/ Kshatriya	24.8	0.1	24.9	6.1	0.3	19.6	13.7	35.4
Kurmi	19.0	1.9	20.8	12.8	1.9	27.3	25.1	12.0
Yadav	45.4	2.2	47.6	8.4	2.4	10.0	14.0	17.6
Koeri	13.1	0.6	13.7	50.3	0.2	3.1	6.2	26.5
OBC II	14.2	1.3	15.5	32.0	9.9	14.4	10.9	17.4
OBC I	20.5	7.7	28.3	9.7	10.1	7.0	11.8	33.1
SC/ST	11.8	9.2	21.0	4.3	18.0	6.9	16.7	33.0
Muslim	18.8	3.9	22.7	4.4	15.8	7.6	16.9	32.5
Total	**22.3**	**4.2**	**26.5**	**10.7**	**8.2**	**10.6**	**16.0**	**28.0**

Source: Rodgers and Sharma 2013.
Note: SC/ST = scheduled castes and tribes. OBC = Other backward castes.

is the largest share of household income (at 28 percent, just above agriculture). At least initially, migration seems to have been a response to the lack of opportunity in local labor markets. Migration affects rural production systems by pushing up local wages, promoting labor-saving cultivation techniques, and increasing the feminization of agricultural labor markets.

Income sources vary by caste (Table 7). The highest share of income comes from agriculture for Yadav and Brahmin/Kayastha castes; it comes from wage or other income for scheduled castes and tribes (SC/ST), and from nonagricultural production activities for Koeri and other backward castes (OBC) II. Remittances are important for all, but especially for Bhumihar/ Kshatriya, OBC I, SC/ST, and Muslims.

Nonagricultural income, dominated by remittances, is the main source of income for all economic classes (Annex 5, Figure A.5.1). Even agricultural laborers derive only 25 percent of their income from agriculture and 34 percent from remittances. Poor peasants have similar sources of income, but they largely undertake nonagricultural production activities. The middle and big peasants have a higher share of agricultural income. Even so, it is still less than half their income.

Implications of Observations at the Micro Level

This study reveals that even villages in poor and backward areas are experiencing significant changes. There is evidence of rising real incomes, increasing agricultural productivity, and significant benefits from agricultural diversification. Structural transformation has started, but a substantial share of the population remains in agriculture, with falling labor productivity. Bihar is somewhat unusual in the role that migration has played in its development. Migration has paid dividends, but Rodgers and Sharma (2011) raise concerns about its sustainability as an engine of continued growth. Nevertheless, the person-land ratio is worsening, calling for more rapid nonfarm and on-farm diversification of incomes.

These findings provide unique granularity to the macro perspective on structural transformation at the national and international level. They highlight the complexity of the development challenge and indicate the need for more customized analysis to identify strategic priorities at the local level, an issue addressed later in Section E of this report.

C. Sources of Agricultural Growth

As labor exits agriculture, increasing the productivity of the labor force that stays behind becomes critical to sustain inclusive growth and food security, with a progressively smaller agricultural labor force feeding a correspondingly growing nonagricultural population. When labor is leaving agriculture more slowly than desirable—as it is in India—increasing output becomes an even more important means of increasing labor productivity. Chapter 2 established the critical role of weather—sustained negative rainfall anomalies—in the slowdown in agricultural growth from the mid-1990s to mid-2000s. A key outstanding question related to the subsequent recovery in growth is whether the drivers of growth changed qualitatively in the mid-2000s. Answering this question is important for assessing whether the current growth episode can be sustained.

This section uses a number of analytical tools and methodologies to dig deeper into the sources of agricultural productivity growth and identify key constraints. Productivity is broadly defined as the total (real) value of output per unit of input. A comprehensive measure of productivity is Total Factor Productivity (TFP), which estimates the returns to the total input mix used in production. Multiple sources of data are used at different levels of aggregation to put together a comprehensive picture of productivity in Indian agriculture.

The analyses are conducted at the (i) national level for the sector using data going back to the 1960s; (ii) at the state level using data going back to the 1980s; (iii) at the individual crop level using the aggregate state-level Cost of Cultivation data, derived from extensive annual surveys undertaken by the Ministry of Agriculture; and (iv) at the household level—both at the whole farm and individual crop level—using the NCAER-REDS database, which has unique panel data on over 4,000 households from across 17 states for the years 1982, 1999, and 2007. These data help triangulate the main findings at different levels, using different data sources and using different methodologies to provide a comprehensive assessment from different perspectives. The picture that emerges is thus a robust assessment of the current status of Indian agricultural productivity.

6 GROWTH DECOMPOSITION

Changes in Subsector Contributions

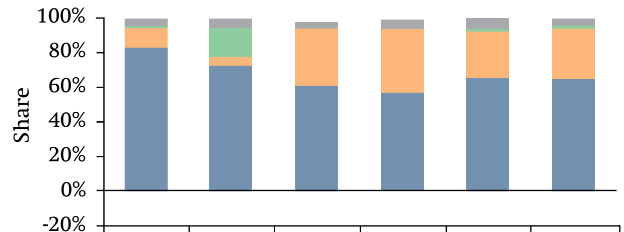
The Indian National Accounts define the primary sector to include agriculture (crops and livestock), forestry and logging, and fisheries in the category of Agriculture and Allied Activities (AAA), on which aggregate statistics are reported. AAA GDP grew at an annual average of 3 percent (in 2004/05 constant rupees) between 1980/81 and 2011/12. Agriculture more narrowly defined as crops and livestock grew at an almost identical rate.[67] Total GDP has grown much faster, resulting in a rapid decline in agriculture's share from 52 percent in 1950/51 to 37 percent in 1980/81 and 14.5 percent in 2011/12.[68] The structure of subsectoral growth has changed relatively little over time (Figure 36).

Within the crops sector, growth is increasingly driven by growth in high-value commodities other than food grains, but the overall structure of the sector in terms of area and value shares has changed relatively slowly (Annex 6, Table A.6.1). The contribution of high-value fruits and vegetables to overall crop growth rose dramatically, from 22 percent in the 1980s to 54 percent in the 2000s (Birthal et al. 2014) (Figure 37). Fibers also increased their contribution.

67 Between 1950–51 and 2011–12, the annual agricultural growth rate is estimated to be 2.6 percent.

68 Total GDP growth rate was on average 5.9 percent per year between 1980–81 and 20011–12. GDP growth in the 2000s averaged 7.6 percent per year.

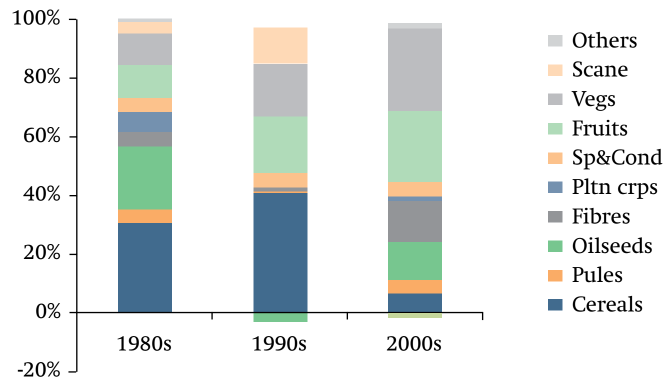
Figure 36: Contribution of subsectors to growth in agricultural GDP



	1950-59	1960-69	1970-79	1980-89	1990-99	2000-07
Fish	4.46	5.92	4.03	5.92	6.44	4.02
Forest	0.88	15.98	-2.3	-0.54	1.13	1.43
Livestock	11.04	4.45	34.36	37.03	27.26	29.12
Crop Sector	83.62	73.64	63.9	5758	65.17	65.43

Source: National Accounts Statistics, CSO, in Kumar and Jain 2012.

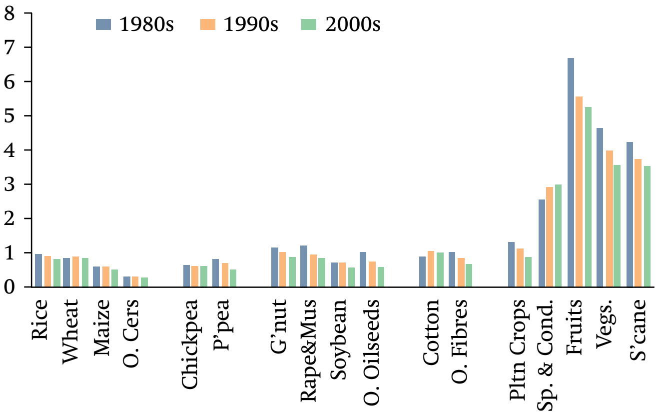
Figure 37: Shares of crops in sectoral growth



Source: Birthal et al. 2014.

The current structure of the crops sector suggests a misallocation of resources, as reflected in the divergence of the share of

Figure 38: Share of value divided by share of area by crop type



Source: Authors, using data from Birthal et al. 2014.

Table 8: Growth in crop yields

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

Source: Birthal et al. 2014

area allocated to individual crops relative to their share in the total value of output. Traditional food grains and oilseeds contribute proportionately less to value than the area they occupy (ratio less than 1), while the high-value crops contribute significantly more (Figure 38). High-value crops thus account for an increasing share of the value of agricultural output, but they do not occupy a correspondingly large share of cropped area. Food grains occupy about 65 percent of the cropped area and contribute 41 percent to the value of production, whereas horticultural crops contribute 27 percent to the value and occupy 7 percent of cropped area. This pattern may reflect structural constraints or other distortions facing different crops.

Several crops saw impressive growth in the value of output.[69] Area reallocation, especially starting from a low base, explains some growth, but yields of most crops have stagnated, with the notable exception of cotton (Table 8). Growth thus seems to be rooted in rising prices, rather than area or yields.

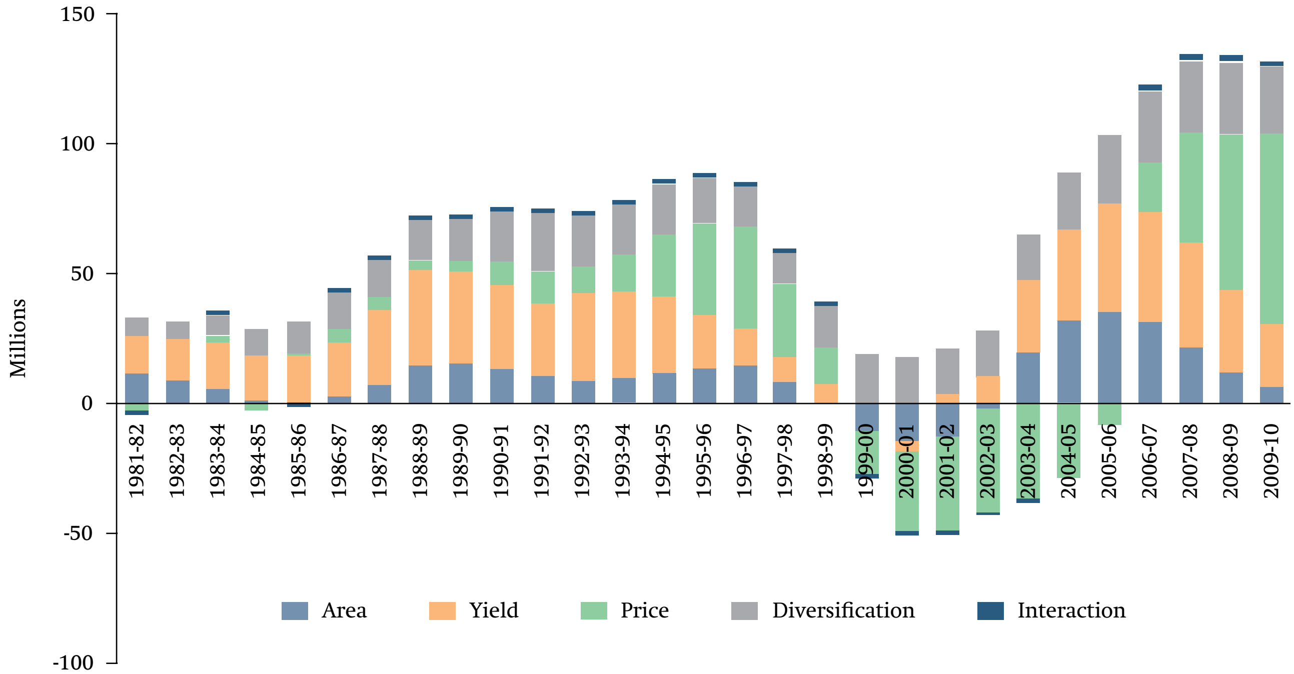
Components Driving the Value of Crop Production

Given the changes and uneven performance in agriculture over the past three decades (Chapter 2), it is important to analyze sources and patterns of growth. Using data from 1980–81 to 2009–10, Birthal et al. (2014) decompose the value of total crop production into contributions by area, yield, price, and diversification.[70] The data and methodology are described in Annex 6. The 20 major agricultural states used in the analysis are clustered into four regions—North, East,

69 High growth was recorded in cotton (10.7 percent annual growth in the 2000s) and soybeans (30 percent growth in the 1980s, with continued growth of about 9 percent into the 2000s). Maize, chickpeas, and other oilseeds experienced growth at or above 5 percent in the 2000s. Plantation crops, fruits, and vegetables also had high growth rates in the 1990s and 2000s.

70 Increases in the gross value of output can be due to price increases of individual crops, increased output of each crop, or a shift in the crop mix toward higher-value crops. Output is a product of area and yield. The fifth component (interaction; see Annex 6), represents the residual or unexplained change, but it is empirically insignificant so is not discussed here.

Figure 39: Decomposition of growth in the crops sector



Source: Birthal et al. 2014.

West, and South, described in Annex 6 – and regional decompositions are done to account for the effects of heterogeneity (for example, in resources, climate, infrastructure, and institutions) on crop choice and outcomes.[71]

Clear dynamics emerge at the national level, along with worrying recent trends. The dynamics of agricultural growth through the distinct growth periods emerge clearly in the decomposition of growth (Figure 39). Yields dominated growth until the mid-1990s, as green revolution technology spread, supported by policies and investments promoting irrigation, fertilizer, and HYVs. Diversification has also made a consistent, moderate contribution to growth throughout the study period—about one-quarter of total growth, somewhat less than might be expected from a rapidly transforming production structure. This picture is consistent with the observation that the broad structure of agriculture has changed relatively little at the national level. Shares of cereals and pulses in output have declined somewhat (from 42 percent in the 1980s to 37 percent in the 2000s), and shares of horticultural crops have risen (from about 20 percent to 28 percent).[72] Rice and wheat maintained their shares in production. The reduction in cereals was almost entirely in coarse cereals and pulses.

The contribution of prices to growth increased through the 1990s. Prices were the dominant

71 The East includes Assam, Bihar, Jharkhand, Odisha, and West Bengal; North includes Haryana, Himachal Pradesh, Punjab, Uttarakhand, and Uttar Pradesh; West includes Chhattisgarh, Gujarat, Madhya Pradesh, Maharashtra, and Rajasthan; and South consists of Andhra Pradesh, Karnataka, Kerala, and Tamil Nadu. Data on other states were not available.

72 Soybeans and cotton gained shares over time but remain a relatively small part of aggregate output.

source of growth in the mid-1990s, coinciding with significant increases in the MSPs for rice and wheat and favorable terms of trade for agriculture.

As seen in Chapter 2, growth slowed sharply between 1996-97 and 2002-03, as real prices declined, yields stagnated, area declined,[73] and adverse rainfall anomalies beset agriculture. Throughout that turbulent period, diversification proved to be a steady source of growth in absolute terms; in relative terms, diversification was the predominant source of growth.

During the 2000s, the average contribution of the four factors—area, yield, price, and diversification—appears balanced, but in fact important shifts occurred within the decade. Area and yields propelled growth early in the recovery phase, as area came back into production and yields rebounded with normal rainfall. Real prices continued to decline for another couple of years, slowing recovery somewhat.[74] Since 2007, as one would expect, area expansion has slowed. Diversification, in absolute and relative terms, remains a consistent but modest source of growth.[75]

The two worrying trends are the declining contribution of yields and the emergence of prices as the main driver of growth toward the end of the 2000s. In 2010, 55 percent of the increase in the real value of output resulted from price increases. Yield and diversification (to high-value crops) made relatively small contributions, raising serious concerns about the sustainability of growth.

The four regions of the country are experiencing agricultural change in different ways. Cereals still dominate the area under production in the North and East, but they now share the lead with horticulture in terms of value. The West and South are more diversified. The West has benefited from the new cotton and soybean technology, and the South from horticulture and spices. The main driver of growth in the North—through the late 2000s—was yield (Figure 40), and the continued predominance of rice and wheat reflects the impact of research on those crops. Prices have become an increasingly important driver of growth in the East, with important contributions also from yields and diversification. The four components of growth are more balanced in the South and West, but diversification has been the major driver in both regions. In the South, as surface irrigation systems recovered from prolonged rainfall deficits, area made a fair contribution to growth.

Summary of Findings

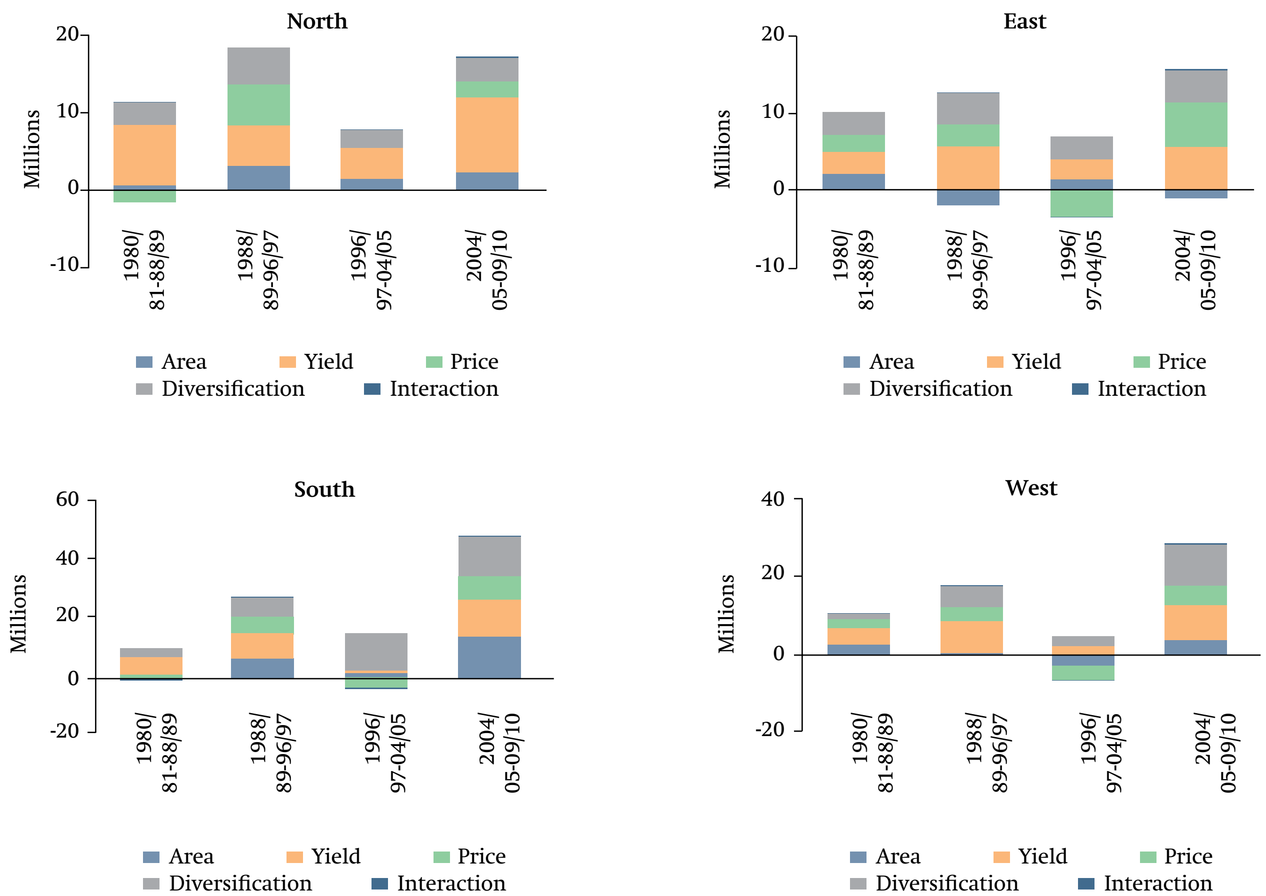
Recent growth had little to do with sustainable sources such as yield or productivity. Despite diversification in the value of output, the national and regional analyses find that the production structure has changed little. Note the important regional variations: The South

73 To facilitate analysis, area, production, and price series are smoothed using the HP filter, so the trends appear smoother than if raw annual data had been used. The output trend thus approximates the decadal growth trend discussed in Chapter 2.

74 Trends in the components of WPI inflation indicate that real prices for agricultural commodities—the WPI index for agricultural commodities, divided by the total WPI index—fell broadly, with the exception of fruits and vegetables, on account of a faster rise in nonagricultural WPI components.

75 For the past four decades, net area under cultivation has remained steady at about 140 million hectares (not exceeding 143 million hectares) (Ministry of Agriculture Land Use Statistics). The slow expansion of irrigation has meant that irrigation intensity and hence gross cultivated area have not expanded much since 2004/05.

Figure 40: Sources of agricultural growth by region



Source: Birthal et al. 2014.

and West have diversified, whereas the North remains largely invested in traditional cereal crops, and in terms of value, production in the East is now dominated by cereals and horticultural crops.

A cause for concern is that the recent growth spurt, while good for farmers in the short term, was mainly spurred by real price changes rather than growth in yields or productivity. This worrisome development indicates that growth is not underpinned by a more sustainable source—productivity. The next chapter looks closely at how productivity has evolved, especially in recent years, across India's heterogeneous agricultural landscape.

7 TOTAL FACTOR PRODUCTIVITY GROWTH

India's binding land constraint means that agricultural growth depends crucially on making land more productive. Land productivity is often equated with yields—generically referring to output per hectare for crops and per animal for livestock.[76] Yet for some time analysts have warned about declining productivity, based on worrisome trends in rice and wheat performance.[77] Despite its position in the vanguard of the green revolution, over time India has performed less impressively than other major agricultural producers (Chapter 3), and evidence has emerged that soil and water degradation may now limit productivity in the pioneering green revolution states.[78]

Previous chapters presented evidence that agricultural growth is being driven less by sustainable improvements in yields than by rising real prices and possibly unsustainable input use. To be clear, rising real prices are important to raise agricultural incomes and give farmers an incentive to invest in agriculture. But rising prices—especially if managed by policy—may mask growing inefficiencies by boosting farm profits even as yields decline (Rao and Dev 2010). The critical question is whether growth is underpinned by improvements in productivity in response to the improved incentives, or if growth is the result of higher input use (perhaps made further financially enticing through continued subsidies). The risks to overall economic growth, environmental sustainability, and food security look very different depending on the answer to that question.

Agriculture has rebounded since 2004/05. In a context of increasingly binding resource constraints and the uncertainties posed by climate change, it becomes important to understand how productivity has evolved in recent years to identify potential policy and strategic issues. This chapter seeks to shed light on the parallel issues of "technology fatigue" and "policy fatigue" to help guide strategy and policy in support of sustainable growth in agricultural productivity. It does so by analyzing Total Factor Productivity (TFP) over space and time, building on past work by updating and deepening the analysis, and seeking to reconcile divergent findings from different studies using existing secondary data. The next chapter

76 As noted, since the 1960s the government's agricultural policies have focused on intensification, with particular attention to rice and wheat yields. Agricultural technology and inputs have been actively promoted in Indian agriculture since the 1950s and were the basic ingredients of the green revolution—HYVs, fertilizer and other agro-chemicals, irrigation, and mechanization. The progressive impact of this effort through the 1970s and 1980s is visible in agricultural growth and aggregate GDP growth (Bosworth, Collins, and Virmani 2007).

77 See, for example, Kumar and Mittal (2006); Chand, Kumar and Kumar (2011).

78 See, for example, Murgai, Ali, and Byerlee (2001).

provides complementary evidence from micro-level data to add a fresh perspective.

Earlier studies of TFP in Indian agriculture have yielded mixed empirical results (Annex 7 summarizes the literature). Most of these studies cover periods prior to the recovery in 2004/05. To build a convincing body of evidence, the analysis relies on results from complementary ongoing independent studies, updates of recent insightful studies when possible, and new background studies conducted to fill some of the knowledge gaps. What sets the new studies apart is their use of more recent data (vetted for reliability); an effort to triangulate and deepen the understanding of key issues through analyses at different levels of disaggregation; the use of alternative methodologies that allow more insight into the main drivers of productivity; and an assessment of changes in productivity at the micro/farm level based on panel data.

The methodology and data are detailed in Annex 7. Very briefly, yield improvement—broadly defined to refer to land productivity—can be achieved by using more inputs other than land (intensification), using better inputs (new technology), and/or using inputs more effectively (efficiency).[79] Understanding how each of these drivers contributes to productivity gains is important. In traditional analyses of sources of growth, the contributions of technology and efficiency are referred to jointly as Total Factor Productivity (TFP). TFP is typically measured as a residual after "accounting" for the contribution of all factor inputs to the growth in output. For growth to be sustainable in both ecological and economic terms, it is critical to improve TFP (Ehui and Spencer 1993, Cassman and Pingali 1995). Ecologically, improved TFP ensures that critical natural resources such as land and water are used effectively; economically, it reflects income growth.

Drivers of Productivity Growth at the National Level

Recent estimates (and updates) of TFP for Indian agriculture provide important insights into the nature and drivers of productivity growth. Depending on the methodology and level of aggregation, however, results vary substantially across studies, so careful scrutiny is required to reconcile and interpret the findings. This exercise reveals that the differences primarily result from the level of aggregation used in each study and also depend somewhat on the level of accounting for different inputs.

At the highest level of aggregation—the sector-wide level, including all crops and livestock products—there are four estimates of TFP, based on the method and data used. Given the changing structure of Indian agriculture, where horticultural crops and livestock have increasing shares in aggregate output but the relatively lower-value crops continue to absorb more resources (their historically large share of public expenditures, considerable policy support, and natural resources such as land and water), an alternative series is also estimated. This alternative series is restricted to crops that have traditionally been considered important. Not by coincidence, these are the major crops that are grown in the main agricultural states and covered in the Ministry of Agriculture's

79 "Intensification" implies moving along the production surface with a given technology, "new technology" is an outward shift of the production surface, and "efficiency" measures the distance between the current level of output and the optimal level that could be achieved, as defined by the current level of technology (or a move toward the production surface).

annual Cost of Cultivation (CoC) surveys. These CoC data provide a comprehensive cost breakdown by input and permit a much better accounting of the inputs used in production. The state-level input-output estimates provided by the CoC database are based on large annual surveys and form the basis for estimating the costs of cultivation to establish the official Minimum Support Prices for certain crops (MSPs).[80] For those reasons, the data provide a much better and a more comprehensive basis to "account" for inputs when deriving TFP estimates. The data also make it possible to calculate reliable TFP estimates at the state level, which can be aggregated to the national level as a weighted average using area shares in total.

An important difference between the CoC data and the National Accounts data—and the main difference between the TFP estimates that follow for all of agriculture versus the "traditional" or major crops—is the exclusion of high-value agricultural sectors, namely livestock and horticultural crops (with the exception of potatoes and onions for major producing states) in the CoC data. The estimates using only the traditional crops provide a useful contrast with the performance of the full sector.

TFP estimates for all crops from four sector-wide studies

Table 9 summarizes the main results from the four sector-wide studies. The *GA-FAO* refers to the growth accounting method using a gross output index covering all crops and livestock derived from FAO data (from a comprehensive and internationally comparable database put together by Fuglie, 2012). The *DEA-FAO* refers to the nonparametric Data Envelopment Analysis (DEA) methodology applied to the same database, which allows a "clean" comparison of the two methodologies without concerns about differences in data. The *GA-GDP* also uses the growth accounting technique but a slightly different accounting procedure and agricultural GDP (valued added for crops and livestock) data. The *GA-NA* is an application of growth accounting using more detailed national accounts data for the value of output (for all crops and livestock) combined with secondary data on factor inputs from different official national sources. In sum, the main differences in the three GA series is their use of different data and their method of accounting for inputs (discussed in Annex 7). The period of analysis is from 1980 onward, when the green revolution was well established. The analysis focuses on the distinct growth episodes described in previous chapters.[81]

Table 9: TFP estimates at the national, sector-wide level

Period	DEA-FAO	GA-FAO	GA-GDP	GA-NA
1980–2008	1.3	1.4	1.5	1.9
1980–1997	1.6	1.6	1.6	2.2
1997–2003	0.9	0.4	0.9	0.6
2003–2008	2.2	3.2	1.8	5.3
2003–2009	1.7	2.5	–	–

Source: Authors, using data from Fuglie 2012; updated Bosworth and Collins database (World Bank 2012a); Rada 2013; and Nin-Pratt 2013 (personal communication).

Major conclusion and substantive findings. A major conclusion from the findings is

80 The detailed survey data are not available to the public. Only the processed data, including yields and costs of cultivation by individual inputs on a per hectare basis, are available. The cost elements covered are comprehensive, however, and include imputed costs of family labor, land, and other variable costs such as cost of capital.

81 The slowdown between 1997 and 2005 "bottomed" out in 2003, the year with the large negative shock to agricultural production and productivity since 1980.

that over the long run (from 1980 to 2008 or 2009, depending on the study) different methodologies and models delineate very similar trends (see Annex 7, Figure A.7.1), allaying concerns that different methodologies may give different results (Coelli and Rao 2006; Fuglie 2012; Lele et al. 2013). In fact, the biggest difference arises between estimates that use the same method but different data.

Two substantive findings emerge from Table 9. *First, the TFP growth estimate varies significantly depending on the choice of years, highlighting the role of the exogenous weather shocks identified earlier.* The start and end dates make a significant difference in the growth rate. For example, 2009 was a severe drought year, whereas the previous three years experienced good rainfall, so changing the terminal period by just one year makes a big difference in the TFP estimate, as seen in the last row of Table 9.

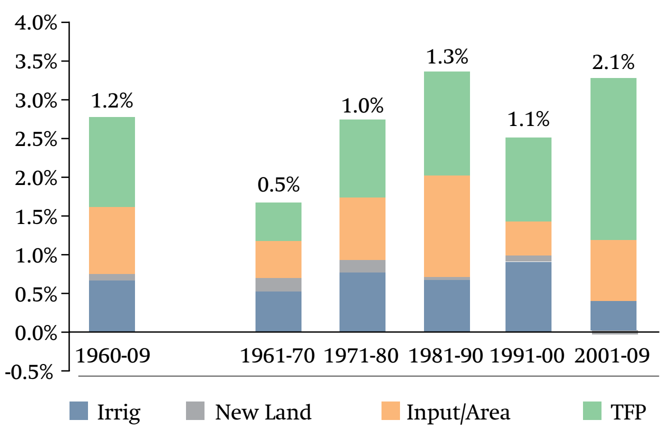
Second, the TFP estimates for the post-2003 period show strong growth, but this finding needs to be treated with guarded optimism. Previous studies noted decelerating TFP trends after the mid-1990s, but with the benefit of a longer time horizon (and hindsight), it is clear that the decline was associated with negative rainfall shocks. Since 2003, TFP has started to recover, but this finding needs to be tested with additional years' data to determine whether it is robust or reflects a recovery from the previous slowdown.

Insights from each methodology. The comparability of estimates derived from these varied methodologies and data sources provides confidence that the evidence of recovery is strong. This consistency in the estimates also provides some confidence that the specific insights provided by each methodology are useful for characterizing the underlying dynamics of productivity growth.

The GA-FAO estimates (Figure 41), using data from 1961 onward, show progressive improvement in TFP over the decades, except for the 1990s, with their weather anomalies. Among individual inputs, irrigation was an important driver of growth in the earlier decades; irrigation expanded much more slowly in the 2000s, suggesting that expansion may be reaching its limits. Growth in inputs other than land and irrigation has been an important source of growth, but most of the recent growth in output is due to growth in TFP.

Using different growth accounts, the Bosworth-Collins model (Bosworth and Collins 2003) provides a different perspective on the basic sources of growth (Table 10). It shows the limited role of education in agricultural productivity over time along with two encouraging emerging trends. First, the pace at

Figure 41: Contribution of inputs and TFP to output growth



Source: Calculated from Fuglie database, 2011.

Table 10: Agricultural sector growth accounts by growth episode, 1980–2008 (trend growth rates)

Period	Output Growth	Employment	Output/ worker	Output/worker—contribution of:			
				Capital	Education	Land	TFP
1980–1997	3.2	1.2	1.9	0.2	0.2	-0.2	1.6
1997–2003	2.3	0.9	1.3	0.6	0.3	-0.6	0.9
2003–2008	3.5	-0.2	3.7	1.2	0.2	0.5	1.8

Source: Updated Bosworth and Collins data (World Bank 2012a).

which labor is shifting out of agriculture and into more productive sectors appears to have picked up since 2003, with implications for the structural transformation in the economy. Another trend—the lack of capital deepening in agriculture—also appears to be changing, with significantly faster growth in capital stock between 2003 and 2008 relative to earlier periods. With land remaining constant over time, these trends translate into rising labor productivity, which shows growth rates in the post-2003 period to be almost double those in earlier periods. As noted, these results must be viewed with guarded optimism, as the period of analysis after 2003 is relatively short, but they do suggest that growth dynamics in agriculture may be changing.

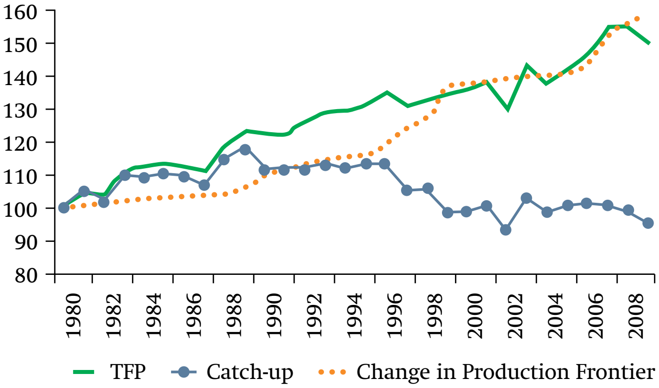
An important advantage of the DEA methodology (other than the implied production structure or assumption of competitive markets implicit in the GA methodology) is that it makes it possible to disentangle two key components of TFP: technical change and efficiency. This decomposition helps to identify whether productivity has grown because of changes in technology or changes in efficiency. Each measure reflects the influence of different factors with different policy implications.

Specifically, *technical change* indicates an outward movement of the production frontier, a result of technological progress.[82] *Efficiency change* measures a movement toward the production frontier, or a closing of the gap between the current level of production and the frontier—which is the level that is technically feasible with the same set of inputs ("catching up"). Efficiency change is a joint outcome of several factors, including knowledge about available technology, the proper use of inputs, the incentives that influence farmers' choice of technology and inputs, access to markets (for inputs and outputs), and other policies and institutions affecting input-use decisions.

The DEA results are presented in Figure 42, which shows trends in the indices for TFP, technical change, and efficiency growth. Table 11 summarizes the growth rates by time period. Four important conclusions emerge from these findings. *First,* technological progress has been the primary, consistent driver of productivity growth over the past three decades. *Second,* efficiency improved in the 1980s but then plateaued in the early 1990s, indicating that as the production

82 In the case of a single output or a homogenous group of outputs, technical change is straightforward technological progress—an outward shift in the production function. In the context of a composite output (such as a sector-wide aggregate), technical change is an outward shift of the observed production surface that could occur because of pure technological progress (as for individual products) or a change in the output-mix, with a shift to more "productive" products in terms of input use.

Figure 42: Productivity change in agriculture: Technical progress versus "catching up" with the frontier



Source: Authors, using FAO data.

Table 11: Decomposing TFP growth

Period	TFP growth	Efficiency change	Technical change
1980-2009	1.3	-0.4	1.7
1981-1997	1.6	0.4	1.2
1997-2003	0.9	-1.1	2.0
2003-2009	1.7	-0.8	2.5

Source: Authors, using FAO data.

frontier continued to shift outwards, production kept pace but the "yield gap" was not closed further—in other words, no change in efficiency occurred. *Third,* efficiency declined in the period from 1997 to 2003, likely due to weather shocks, but positive TFP growth was maintained with strong movement of the production frontier—which more than compensated for falling efficiency. *Fourth,* an even stronger surge in the production frontier has occurred since 2003, but efficiency levels have continued to decline, though not as rapidly as between 1997 and 2003. The implication is that the gap between realized and realizable productivity has widened.

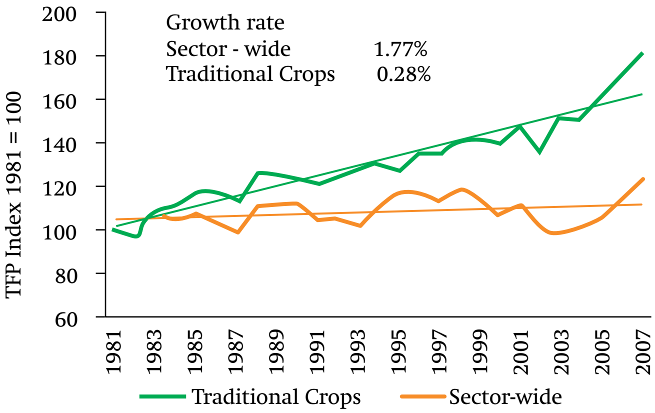
TFP growth in traditional crops and agriculture as a whole: Sobering results

As noted, analyses at the sector-wide level include the fast-growing livestock and horticulture (fruits, vegetables, and spices/condiments) subsectors, generally referred to as high-value agriculture. Both subsectors are important for inclusive growth. Both have been major drivers of growth in agricultural value added in recent years. Yet neither subsector has commanded the attention of policy and public expenditure—which translates to resource allocation priorities at the farm level—to the same extent as the politically important traditional crops (cereals, pulses, oilseeds, cotton, sugarcane). Together the traditional crops account for about 90 percent of the area under cultivation (average 2000–10), and they have been the focus of policy, public expenditures (including substantial input subsidies), and public services.

These traditional crops contributed less than half of the sector's growth in 2000s (see Figure 37). With an overwhelming majority of resources tied up in these crops, a natural question is how their productivity compares to that of the sector overall. Using the CoC data described earlier, Kumar, Gautam, and Joshi (2013) estimate TFP for the traditional crops. The crops used for the estimation contribute about half of the value of crop production but account for about 80 percent of the national area (Annex 7, Table A.7.1 lists the crops included by state).

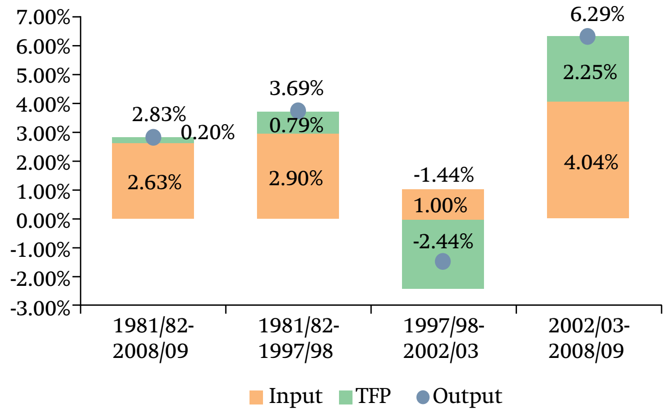
The results from this alternative growth accounting exercise are summarized in Figures 43 and 44. Figure 43 compares trends in TFP growth at the sector-wide level and for the traditional crops. The comparison is stark

Figure 43: TFP trends, sector-wide and for traditional crops



Source: Kumar, Gautam, and Joshi 2013 and Rada 2013.

Figure 44: Sources of growth in the traditional crops subsector



Source: Kumar, Gautam, and Joshi 2013.

and sobering. Long-term TFP growth (between 1980 and 2008) is estimated at only 0.28 percent for traditional crops, much less than the rate of more than 1.77 percent estimated for the sector as a whole. Most of the growth in productivity over the long run has come from a change in the mix of outputs—from the increased shares of high-value crops and livestock products. Productivity growth in the major crops appears to have stagnated.

Breaking down TFP performance for the traditional crops by growth period provides a more nuanced assessment, but one that shows a now-familiar pattern (Figure 44). An outstanding feature through all periods is that inputs have been the primary drivers of growth in output. TFP growth was modest—significantly less than at the sector-wide level (about 0.8 percent versus 1.6 percent, even during the extended period of expansion following the green revolution (1980–97). With three-quarters of the growth being driven by inputs, concerns raised by previous studies about the quality and sustainability of agricultural growth were well warranted.

In the slowdown period, traditional crops saw a more dramatic downturn: TFP declined rapidly, at –2.4 percent per annum. The subsequent rebound has been impressive. TFP has grown at about 2.3 percent, but it bears repeating that this growth should be treated with cautious optimism, as it may reflect a reversion to the trend that prevailed prior to 1997. The major share (64 percent) of output growth still comes from increased input use.

The more pronounced periodic shifts in TFP for the traditional crops than for the entire sector indicate that productivity in traditional crops may be more susceptible to weather shocks. This is consistent with the earlier finding that the livestock sector experienced only a mild deceleration during the 1997–2005 slowdown, likely cushioning the aggregate TFP shock. The continued reliance on subsidized input use as the main driver of growth for traditional crops may be a cause for concern. Starting from a low base, an increase in input use (intensification) in the lagging states where it has historically been very low may suggest more inclusive growth, with the expectation that TFP will improve as farmers gain more experience in using inputs. But the continued or accelerated use of imbalanced chemical inputs and overexploitation of natural resources such as groundwater in the states already heavily using these inputs would warrant urgent corrective action. Such analysis requires more disaggregated analysis, accounting for the heterogeneity across the country, an issue that is covered next.

TFP at the State Level

Agro-ecological as well as policy and institutional diversity are hidden in aggregated analysis. Agriculture is a State Subject, so performance may vary considerably depending on the prevailing governance environment. Few previous studies have looked at productivity at the disaggregated level. Chand et al. (2010) provide more detailed, crop-specific TFP estimates for different states, offering rare insight into a third level of disaggregation (the crop level). An important finding from their study is that TFP growth varies widely across crops and states. No previous studies have assessed TFP at the state level for all of the agricultural sector to determine how the states have performed in terms of productivity. Such an analysis is important to identify broader sectoral policy levers to promote growth.

Following the approach used at the aggregate national level, two new studies by Rada (2013) and Kumar, Gautam, and Joshi (2013) estimate state-level TFP for 1980–2008 at the sector-wide and traditional crop levels, respectively. As before, the analysis covers about 54 percent of the aggregate gross output from the crop sector and excludes the horticulture, spices/condiments, and livestock subsectors.

Substantial variation in TFP across states. Table 12 shows the estimated TFP growth rates from both studies. Over the long run, both TFP estimates are close for some states (Gujarat, Haryana, and Tamil Nadu, for example) but show substantial differences for others (such as Andhra Pradesh, Maharashtra, Odisha, Rajasthan, and West Bengal). The main reason for these differences (spatially as well as temporally) is the scope of coverage of the crops sector, specifically the exclusion of livestock and high-value crops in the estimate for traditional crops.

In recent years, the subsectors driving productivity growth have been increasingly diversified. Even when livestock and high-value horticultural crops are excluded, TFP growth is highly varied across crops and across states for the same crop. Most states have improved their overall performance significantly since 2003 compared to the period before 1997 (ignoring for the present the years of poor performance falling between 1997 and 2003). Among those states, Bihar, Karnataka, Maharashtra, and Odisha show remarkable improvement, while Gujarat, Himachal Pradesh, and West Bengal are the outliers with negative growth rates. TFP stagnated in Rajasthan and Uttar Pradesh.

Different states have benefited from different crops, the biggest gains being associated with new technologies for cotton and maize. But the impact of the new technologies on productivity growth has not been uniform across states, as indicated by the highly varied performance across states even for the same crops (shown for selected crops in Annex 7, Figure A.7.2). Among the major cereals, productivity in rice has improved for several states, but it has slowed considerably for wheat, except in reform-driven Gujarat (Shah et al. 2009). New technologies for

Table 12: TFP estimates by state, traditional crops and sector-wide, 1998–2008

State	Major crops				Sector-wide
	1980–1997	1997–2003	2003–2008	1980–2008	1980–2008
AP	0.9	0.5	3.1	0.7	3.2
Assam	0.6	-1.0	2.0	0.3	1.5
Bihar	0.3	-0.1	5.1	0.2	1.3
Gujarat	5.3	-2.2	-5.4	2.3	1.8
Haryana	2.6	-0.7	4.6	1.6	1.4
HP	0.7	-0.7	-1.8	0.2	1.6
Karnataka	1.0	-4.4	3.7	0.4	2.1
Maharashtra	0.5	-0.7	8.4	0.2	2.4
MP	1.0	-5.7	3.0	0.0	1.6
Odisha	-2.8	-1.8	4.2	-1.6	0.6
Punjab	1.1	0.1	3.2	0.9	1.6
Rajasthan	0.8	-9.3	0.1	-1.8	2.3
Tamil Nadu	3.1	-3.2	5.7	2.2	2.7
UP	-0.8	-0.2	1.1	0.7	1.4
West Bengal	1.4	-3.0	-1.2	0.2	2.7
Kerala					3.3

Source: Kumar, Gautam, and Joshi 2013; Rada 2013.

maize and oilseeds benefited only some states. Notably, the significant success of Madhya Pradesh in increasing soybean output (which has been an important driver of agricultural growth in Madhya Pradesh) appears to have been through increased input use, as TFP growth was weak for soybeans in Madhya Pradesh. On the other hand, TFP improved significantly for sunflowers in Maharashtra and Karnataka.

A vast difference can be seen in the performance of cotton and sugarcane, two major cash crops in a number of states. Cotton shows consistent gains across states, except for Karnataka, but sugarcane shows consistent declines in TFP growth across all major sugarcane-growing states and for both periods (before and after 1995). As is well known, new Bt cotton technology has been a major driver of cotton productivity, making a huge impact very soon after its introduction in 2002. Sugarcane, on the other hand, has been subject to more government interventions and significant subsidies, which appear to be driving up input use even as productivity declines.

Determinants of TFP at the state level. Given the wide variation in TFP across states, the obvious question is what explains that variation. Several factors are likely to influence productivity, including research, extension, human capital, and infrastructure development, not to mention climatic factors. TFP subsumes a large number of unobserved factors, making it difficult to assess the role of important policy levers and potentially yielding a misleading interpretation with policy implications.

For example, technology is well established as a key driver of productivity both globally as well as in India. But slowing growth in agriculture, accompanied by slowing growth in TFP, particularly for major crops, has generated debates on "technology fatigue" and the effectiveness of agricultural research and extension. On the other hand, especially in the context of the growth spurt since 2003, it is not clear if the main drivers are indeed technology or diversification.

An analysis of the determinants of TFP (Kumar, Gautam, and Joshi 2013), using state-level TFP indices for traditional crops and controlling for some of the confounding factors, provides important insights with significant policy implications.[83] The main findings are summarized here.[84]

State-specific (fixed) effects explain nearly half of the observed variation in TFP, clearly demonstrating the important role of state-specific factors, including policies, institutions, governance, and public investments. *Annual shocks (annual fixed effects) by themselves explain only a small part of the variation but are nevertheless significant.* Rainfall has the expected large impact. Together, these "control" factors explain over half of the observed variation in TFP. The inclusion of policy variables captures a substantial part of the state effects, but their continued significance over and above the included factors indicates the presence of other possibly important factors.[85]

Land that is multicropped will have higher TFP—a tautology. The estimates confirm this association, highlighting the role of irrigation, as cropping intensity is almost directly correlated with irrigation. An increase of 1 percent in cropping intensity is associated with 0.6–0.7 percent higher TFP (depending on the specification used), which is substantial but also indicates that irrigation expansion does not lead to a 1:1 increase in area.

As discussed, productivity can change because of a shift from low- to high-productivity crops or through the introduction of new or better technology. To capture the crop-mix effect, crop diversification (index) is included as a control variable. There is almost a one-to-one correspondence between diversification and TFP growth, clearly demonstrating that *diversification is a powerful driver of productivity growth, even within the more restricted group of traditional crops.*

Beyond these "control" variables, technology is perhaps the most well-established driver of productivity growth, and its contribution has not diminished over time. Two dimensions of technology that are operationally relevant are captured through "stock" variables to proxy technology generation (agricultural research output) and technology/knowledge dissemination (the impact of agricultural extension).[86] Research

83 A similar analysis using the broader, sector-wide TFP estimates of Rada (2013) has not been undertaken.

84 See Kumar, Gautam, and Joshi (2013) for a more detailed description of the results of the econometric analysis, including a description of the data, variable definitions, and methodology. Briefly, the results are based on panel regressions of TFP on explanatory factors, with state and year fixed effects to control for unobservable factors. The panel data comprise TFP estimates from 1981 to 2008 for the 15 major states for which crop sector TFP estimates can be calculated using the CoC database.

85 All regressions included state and annual dummy variables to capture the two dimensions of fixed effects and help focus on key policy variables. All regressions control for state clustering effects to get robust standard errors for inference.

86 Both research and extension efforts (using annual expenditures as proxies) have strong lagged effects to capture the lagged effects of research investment, research stock is approximated as a weighted sum of research expenditures per hectare over the previous six-year period. Similarly, extension stock is approximated as a weighted sum of extension expenditures per hectare over the past three years. The weights assume a lagged effect that rises with time and then tapers off (following Evenson, Pray, and Rosegrant 1999).

stock emerges as a consistent and important driver across the various specifications estimated. An increase in research stock (that is, in expenditures) of 1 percent is estimated to increase TFP growth by about 0.2 percent. In addition, tests to see if the impact of research stock has declined over time (that is, if the impact in the second half of the sample period—post-1995—is different from that in the first half) show that is has not. The impact of research in the post-1995 period is not found to be statistically different than before, implying that once other factors (particularly rainfall) are accounted for, the contribution of technology has not diminished over time.[87] This result strongly supports the priority placed by the Twelfth Five Year Plan on public expenditures on research.

In contrast, the impact of agricultural extension is considerably lower and less statistically significant.[88] This low impact is particularly striking, given that traditional crops traditionally have been a priority for public extension. The remaining large yield gaps (discussed in the next chapter), even for the main staples (rice and wheat), suggest that extension's impact is not low because the current technological possibilities have been fully exploited—on the contrary, much remains to be done. Extension's low impact also explains the results from the DEA decomposition showing stagnant or falling technical efficiency, implying a widening gap between available technology and average practice. To enhance productivity quickly, increasing the effectiveness of extension is the low-hanging fruit and warrants serious policy attention.

87 An interaction term between a dummy variable for post-1995 and research stock is very small in magnitude and highly insignificant.

88 Extension stock is significant at the 93 percent level, just below the standard 95 percent level of significance.

Another important finding—and cause for concern from the perspective of environmental, productivity, and growth sustainability—is the excessive or imbalanced use of inputs, which is arguably driven by input subsidies. Two variables to capture these effects (following Chand et al. 2010) are (i) the share of area irrigated by groundwater and (ii) the share of nitrogen in the nutrient mix. Expanding groundwater use is closely associated with electricity subsidies and has proved to be a double-edged sword. It has contributed to the rapid expansion of irrigation and had a large impact on growth, helping to improve food security and reducing poverty. Yet it has also substantially mined groundwater and led to deterioration in the productive resource base (with associated problems of water and soil degradation), especially in the original green revolution areas. Given these opposing effects, it is not surprising to find that groundwater irrigated area has a statistically insignificant impact on TFP. A telling result, however, is that rural electrification (captured as the number of villages electrified in a state, normalized by net sown area to remove the scale effects) has a large, highly significant negative impact. Normally one would expect electricity to have a positive impact as the use of electrically powered irrigation equipment expands, food processing increases, and so on. Given that most rural electricity is consumed for agriculture and used to power the electrical pumps that have grown rapidly in number in most states, the marked negative impact of electricity is surprising and strongly suggests that electricity policies may now be restricting rather than contributing to productivity growth through an adverse environmental (groundwater) impact.

Similarly, lopsided subsidies for fertilizer, which substantially lower the price of urea relative to other nutrients and promote its indiscriminate use, have been argued to create nutrient imbalances with negative impacts on soil health. *The empirical results, showing a negative and statistically significant impact of fertilizer on TFP, strongly support this assertion.*

To test for the impact of nonagricultural investments through output (food processing) or factor markets (labor)—in other words, to test for the effects of backward linkages on agricultural productivity—real wages paid by agro-industry in the state were included as a potential factor driving TFP. *No association was established between industrial wages and TFP for traditional crops.*[89]

Additional hypotheses tested proved to be inconclusive or, in one case, counterintuitive. Road density is found to be insignificant, as is an index for infrastructure (a weighted combination of road density, rail density, and electricity consumption in agriculture per hectare). This result may reflect the finding (described in Chapter 2) that road infrastructure even in laggard districts has improved to a level at which it may no longer be a binding constraint. An even more counterintuitive result is the negative and significant effect of rural literacy. This result is consistent with the Bosworth and Collins (2008) growth decomposition, also discussed earlier, which shows that literacy (basic education level) has a limited contribution to sector growth. Another plausible reason for these results (both for roads and literacy) is that these variables are highly correlated with other indicators included in the analysis, so while they are important, their effects are captured in the other indicators.[90]

Implications: Compromising Sustainability

TFP growth since 2003 has been robust, reversing the worrisome slowdown since about the mid-1990s. The main driver of past TFP growth has been technical change. Efficiency has stagnated over the long run and shown a declining trend in recent years. An important point is that TFP for traditional crops has shown little improvement, implying that the overall sectoral TFP is being driven by high-valued horticulture and livestock subsectors. The stark difference in the performance of traditional and high-value crops is all the more striking given that policy and public expenditures continue to be heavily focused on the traditional crops. Within traditional crops, the major share of output growth has occurred because of increased use of inputs. More detailed analysis shows that subsidy-driven input use now negatively affects TFP, indicating that ironically, instead of boosting productivity, subsidies might now be contributing to lower productivity, compromising sustainability and future productivity growth.

89 Agro-industry wages and industrial capital stock (to reflect past investments) also had no significant impact.

90 Both variables, when included by themselves with only state-fixed effects, show positive, substantial, and significant positive effects (with elasticities of 9 percent and 4 percent, respectively), but these effects vanish when other variables are included. Additional tests show road density to have significant nonlinear (quadratic) effects, suggesting positive impacts at low levels of investment that diminish with additional investment. The estimated results show a maximum impact is reached at about 500 kilometers per square kilometer of surface area.

8 PRODUCTIVITY AND EFFICIENCY AT THE HOUSEHOLD (MICRO) LEVEL

Detailed panel data from the NCAER-REDS household surveys provide a rare view of changes in agricultural inputs and outputs among farm households between 1999 and 2007 and help to ground the understanding of absolute levels and sources of inefficiency in Indian agricultural production. The analysis in this chapter uses nonparametric as well as parametric approaches to gain additional perspective on trends in agricultural productivity at the farm level.

Drivers of Changes in Productivity: Nonparametric Analysis

The change in productivity at the farm level between 1999 and 2007 is measured by Nin-Pratt and Gautam (2013) using Data Envelopment Analysis (DEA) to derive the Malmquist index.[91] The advantage of the methodology is that it does not entail assumptions about economic behavior (profit maximization or cost minimization) and does not require prices for estimating productivity change. The methodology also makes it possible to separate the change in productivity into two mutually exclusive and exhaustive components: Efficiency Change (EC) and Technical Change (TC).

Absolute levels of efficiency for each year are estimated as well. Two measures of efficiency, with different policy implications, are calculated—technical and economic efficiency.[92] The former is a pure input-output based (technical) measure indicating whether farmers are using the available technology efficiently. The latter is a measure of economic performance, indicating whether the inputs used and outputs produced are economically optimal.[93] The analysis also estimates the cost of inefficiency in terms of profits lost owing to different types of inefficiencies.

The analysis is done at the whole farm level. As such, the observed technical change may

91 The Malmquist index measures the TFP change between two data points (such as data for a farmer at two points of time) by calculating the ratio of the distance of each data point relative to a common technological frontier. The Malmquist index, pioneered by Caves, Christensen, and Diewert (1982), has been extensively used to measure and analyze productivity since Färe et al. (1994) showed that the index could be estimated using DEA.

92 To define the input-based Malmquist index, production technology and production efficiency must be characterized. Griliches (1964) defined technology as "the currently known ways of converting resources into outputs." Farrel (1957) introduced the concept of efficiency, which is defined as the ability to produce "the maximum amount of output that is physically achievable with current technology."

93 Technical efficiency measures the distance at which each farmer is operating from the technical frontier (determined as the maximum output obtained by any farmer from within the sample). Economic efficiency is measured as short-run profit (revenue minus variable costs) for each household, which is then compared to the maximum profit that could be achieved with the given factor endowments of the household (land, family labor, and assets).

reflect changes in the output mix or the input mix, perhaps as households shift to crops that are more productive or intensify the use of inputs that are more productive. Change may also arise from a purely technological advance that is neutral across outputs and inputs. To identify the source of technical change, it is decomposed into three components: (i) output-biased technical change (OBTC); (ii) input-biased technical change (IBTC); and (iii) a magnitude or neutral component (MTC). Efficiency is decomposed into two components: (i) pure technical efficiency (PEC) and (ii) scale efficiency (SEC). Scale efficiency is measured relative to the "optimal scale," which is associated with the farm having the highest output to input ratio (average product), assuming "constant returns to scale" (CRS).

To account for India's agro-ecological heterogeneity, productivity changes are estimated by agro-ecological regions, based on the ICRISAT classification of districts across India into four zones (Table 13). A regional Malmquist index measures productivity change with respect to the regional frontier (M^r), and a national Malmquist index measures it with respect to the country-wide frontier or meta-frontier. The differential change in the two frontiers shows how much each region

Table 13: Regional classification

Region	Agro-ecological classification	Characteristics
1	Humid	LGP: >180 days
2	Semi-arid temperate	LGP: 75–179 days; temperature <18° C
3	Semi-arid tropic	LGP: 75–179 days; temperature >18° C
4	Arid	LGP: 0–74 days

Source: ICRISAT 2005.
Note: LGP = length of growing period.

Table 14: Average technical efficiency at the regional and country level

Region	Regional efficiency		Country-wide (meta) efficiency	
	1999	2007	1999	2007
Humid	0.552	0.500	0.463	0.418
Semi-arid temperate	0.523	0.544	0.456	0.469
Semi-arid tropical	0.552	0.541	0.411	0.451
Arid	0.753	0.650	0.436	0.386

Source: Nin-Pratt and Gautam 2013.

needs to "catch up" to the meta-frontier.[94] The Technology Gap Ratio reflects the difference between the regional and meta-frontiers and indicates the state of technology in each region relative the rest of India at a point in time.

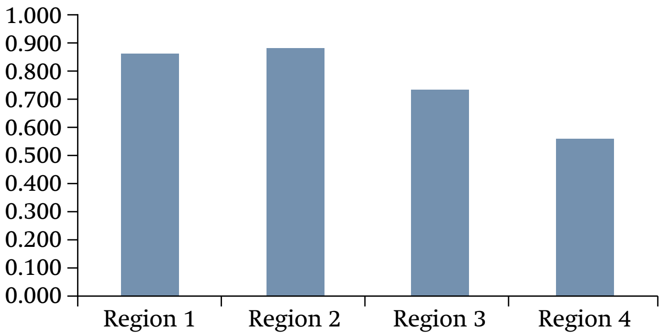
Results

The technical efficiency levels for each year are given in Table 14, which shows the averages for the four major agro-ecological zones with respect to both the regional and the meta-frontiers.[95] The average farmer's level of technical efficiency is estimated at 50 percent with respect to the meta-frontier. The arid zone seems more homogenous; most farmers are closer to the regional frontier (average regional efficiency is high at 75 percent). The efficiency relative to the meta-frontier is significantly lower, indicating that the regional frontier itself reflects lower productivity compared to the other regions (or the meta-frontier). This is

94 The catch-up term is a combination (product) of (i) the movement of the regional frontier (TCr) relative to that of the meta-frontier and (ii) regional efficiency growth relative to the meta-frontier.

95 The results are from the analysis of a panel of 1,971 households between 1999 and 2007. Observations that were either outliers or had missing data were eliminated. Results presented are averages across the sample households.

Figure 45: Technology gap ratio



Source: Nin-Pratt and Gautam 2013.

not surprising for the water-stressed arid zone. The relative regional performance is more accurately reflected in the larger technology gap for Region 4 relative to the meta-frontier (Figure 45).

The technical efficiency measures in Table 14 are static measures (at a point of time) of relative performance and do not convey how performance has changed over time. While the low levels of relative technical efficiency indicate significant potential for improvement, they do not indicate if any improvement in productivity occurred between the two years. Table 15 presents a dynamic picture of productivity change, providing productivity or TFP growth rates for each region as well as the decompositions discussed previously.

The two main components of TFP are technical change (TC) and efficiency change (EC). Average TFP growth for India during 1999–2007 was 1.73 percent, with an even higher growth rate for technical change (2.12 percent). The striking result is the negative growth in efficiency, which compromised the growth in technical change and reduced growth in TFP. These findings are qualitatively similar to the results discussed in Chapter 7, in which technical change was found to be the main driver of productivity growth. Technical change was fastest in Regions 3 and 4, which have traditionally lagged in performance. Technical change has also been output neutral, with some minor input bias, especially in Region 3 (the semi-arid tropics).

The poor performance in efficiency is the result of pure inefficiency, as scale efficiency shows a slight improvement of 0.44 percent annually. Regions 1 and 4 appear to have experienced a significant fall in average efficiency, implying

Table 15: TFP growth decomposition (average growth rate, 1999–2007)

	Region 1	Region 2	Region 3	Region 4	India
TFP	0.75	1.17	3.16	-0.36	1.73
TC	1.89	1.06	2.87	2.79	2.12
MAGTC	1.30	0.63	1.96	2.40	1.47
OBTC	0.06	0.13	0.07	0.09	0.08
IBTC	0.53	0.30	0.92	0.29	0.51
EC	-1.12	0.11	0.29	-3.06	-0.38
SEC	1.03	-0.22	0.93	-1.77	0.44
PEC	-2.13	0.34	-0.63	-1.31	-0.82

Source: Nin-Pratt and Gautam 2013.

Note: Decomposition is exact for multiplicative indices; growth rates do not add up exactly. TC = technical change; MAGTC = magnitude of technical change; OBTC = output-biased technical change; IBTC = input-biased technical change; EC = efficiency change; SEC = scale efficiency; and PEC = pure technical efficiency.

that the average farmer is moving farther from the frontier. The rising disparity in productivity across households is most significant in the arid areas (Region 4). Given the strong growth in technical change, this result suggests that some farmers gained access to irrigation (the share of irrigated area has risen in this region) and hence to a new production frontier, while the remaining (rainfed) farmers reflect lower relative efficiency with respect to this new frontier. Regions 2 and 3 maintained the average distance from the frontier, which is a relatively better performance, considering that the frontier was moving outward as well.

Region 3 (the semi-arid tropical zone) shows by far the best TFP performance—TFP grew at 3.16 percent per year—with the fastest growth in technical change among regions and a modest improvement in efficiency, mostly explained by scale efficiency. This region also had the highest input-biased technical change. In Region 4, the technological frontier is moving fast, but most producers are falling behind. Growth in Regions 1 and 2 involved less technical change.

The dynamics of regional and country-wide frontiers show that Region 4 was the most vibrant region, catching up with the meta-frontier at a very rapid rate (1.97 percent). Region 1 fell modestly behind the country-wide frontier (-0.14 percent). Some of these dynamics are explained by looking at the technology gap ratio, which shows that Region 4 has historically lagged behind the other regions in terms of technology (Figure 45).

The high cost of inefficiency in agricultural production

The analysis of productivity growth and its components is based on physical inputs and outputs and gives a picture of the technical changes taking place at the farm level. What do those technical changes mean to the welfare of the farmer in terms of net returns or profits from farming? Estimates of economic efficiency provide an answer to this question and indicate the extent of losses associated with two types of inefficiencies: technical inefficiency and allocative inefficiency.

Table 16 shows results from the NCAER-REDS household panel survey for 1999 and 2007. It is important to note that the figures presented in the table are percentages of profits *lost* relative

Table 16: Proportion of profit lost in relation to short-run potential profit

Farm size quintile	1999			2007			Change (%)		
	Total profit loss	Profits lost due to technical inefficiency	Profits lost due to allocative inefficiency	Total profit loss	Profits lost due to technical inefficiency	Profits lost due to allocative inefficiency	Total profit loss	Profits lost due to technical inefficiency	Profits lost due to allocative inefficiency
1st	0.59	0.51	0.08	0.59	0.46	0.13	0.25	-10.49	72.80
2nd	0.71	0.51	0.20	0.72	0.45	0.27	1.30	-11.73	35.47
3rd	0.73	0.47	0.25	0.68	0.46	0.22	-6.24	-3.20	-11.93
4th	0.71	0.39	0.31	0.74	0.42	0.32	4.84	6.99	2.15
5th	0.75	0.31	0.44	0.66	0.34	0.33	-11.60	7.55	-25.36
India	0.73	0.36	0.37	0.68	0.38	0.31	-7.05	3.95	-17.75

Source: Nin-Pratt and Gautam 2013.

to the optimal economic profit that is feasible. Results are grouped by quintile of farm size (measured as total cropped area) to assess how inefficiencies change with changes in the size of farm operations.

On average, sample households lost a huge 73 percent of potential short-run profits in 1999; they lost somewhat less (68 percent) in 2007. Losses owing to technical and allocative inefficiencies are about the same (37 percent and 36 percent, respectively). Between 1999 and 2007, inefficiency was reduced marginally by 7.05 percent, mostly because of improved allocative efficiency (17.75 percent). Technical inefficiency worsened marginally (as indicated by the earlier decomposition of TFP).

Small and large farms (the 1st and 5th quintiles) have very different sources of inefficiency. Smaller producers are more efficient than large producers (in other words, their foregone profits were smaller) because their allocative efficiency was significantly higher (with an associated profit loss of only 8 percent in 1999). Larger producers showed high allocative inefficiency but were relatively more technically efficient than smallholders. The change in efficiency between 1999 and 2007 is explained by improvements in efficiency among the group of large producers (5th quintile). Smaller producers did not improve overall efficiency, and their allocative inefficiency worsened even as they improved their technical efficiency.

Major findings

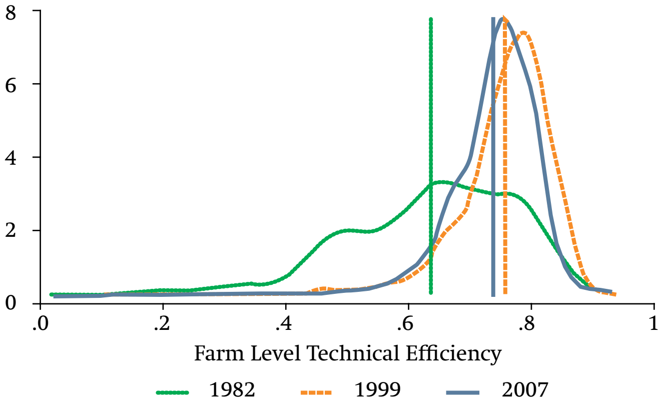
Four major findings emerge from the DEA (nonparametric) analysis. First, technical change made a strong contribution to growth, reflecting the impact of technological advances. Second, the analysis found a low level of average technical efficiency as well as a negative trend between the two survey years, driven largely by rising disparities in growth within the humid and arid agro-ecological zones (the former concentrated in Eastern India and the latter in the Western part of the country). Third, current levels of efficiency are associated with very high economic costs, as indicated by 68 percent of potential profits *lost* due to technical and economic inefficiencies (down from 73 percent in 1999). Finally, small farmers exhibit higher technical inefficiency than large farmers, perhaps reflecting patterns in access to extension or technology services, but they also show lower allocative inefficiency, reflecting more rational economic decisions.

Changes in Efficiency over Time: Parametric Analysis

The econometric analysis uses a stochastic frontier approach to statistically derive the results on technical and allocative efficiency for each household in the same NCAER-REDS sample. This analysis is done for several reasons. First, it helps to verify the main findings of the nonparametric analysis by moving beyond the whole-farm level and to the crop level. Second, the analysis can be extended to a longer timeframe by using the 1982 survey, providing insight into farmers' performance over 25 years and overcoming the potential limitations associated with the 1997–2003 period (the slowdown in growth caused by vagaries of weather, discussed in Chapters 2 and 3).[96] A third advantage of this approach is that it can take advantage of the flexibility of statistical

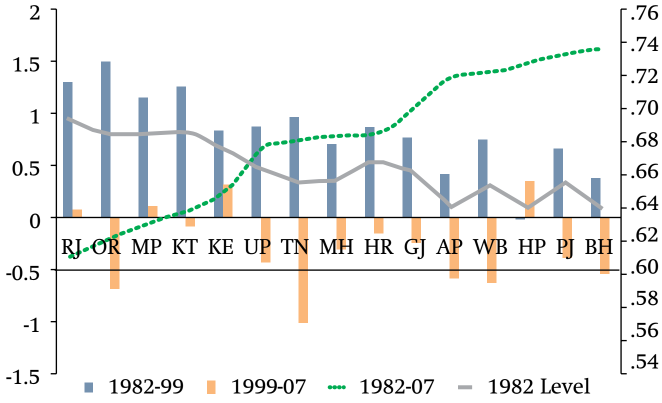
96 The 1982 survey was more limited and the 2007 was the most detailed in terms of data collected (and available). Making the best use of available and comparable data, basic results are estimated for all three years, with deeper analysis restricted to the more comprehensive 2007 data.

Figure 46: Technical efficiency distributions: 1982, 1999, 2007



Source: Authors, using NCAER-REDS Household panel data.

Figure 47: Changes in farm-level technical efficiency by state



Source: Authors, using NCAER-REDS Household Panel data.

analysis and extend the analysis to identify potential determinants of inefficiency. Finally, it is useful for triangulation and for overcoming methodological issues associated with DEA (sensitivity to outliers and measurement errors).

Technical efficiency at the household (whole-farm) level

Parametric estimates of technical efficiency at the household (whole-farm) level are generally higher than those estimated by the DEA method for 1999 and 2007 (Figure 46). The average level of technical efficiency, shown by the vertical lines corresponding to each survey year in Figure 46, increased from 68 percent in 1982 to 78 percent in 1999, indicating that on average households moved significantly closer to the (respective) frontier. The changes in the distribution of efficiency also show convergence among households over the long term. The findings mirror the DEA finding that technical efficiency fell modestly between 1999 and 2007. The decline in efficiency in 2007 is across the board—the entire distribution shifts to lower levels.

Changes in farm-level technical efficiency vary significantly across states. Figure 47 presents the states by increasing level of average baseline (1982) technical efficiency (dotted line, right axis). Farmers in Bihar represent the case of the "poor but efficient" producer, in that they operate at low input-output levels, but their input use was efficient in 1982.[97] Punjabi farmers are equally efficient—but represent the high input-output case.

Figure 47 also shows annual growth in technical efficiency for the entire period (1982–2007), as well as changes between the three survey rounds (1982–1999 and 1999–2007). Most states show an improvement in technical efficiency in the first period (with the sole exception of Himachal Pradesh), but a majority show a decline in efficiency in the second period. The decline from 1999 to 2007 is pronounced for Andhra Pradesh, Bihar, Odisha, Punjab, Tamil Nadu, and West Bengal. The absence of any obvious agro-ecological or geographical correlation in terms of performance suggests that policies and the

97 Recall that technical efficiency measures the distance of each farm from the frontier for the level of inputs being used. A farmer using low levels of inputs may be operating at the low end of the production possibility frontier but may still be relatively efficient (in terms of the distance to the frontier corresponding to that level of inputs).

enabling environment at the state level may play a strong role in determining efficiency levels. For the full period (1982–2007), efficiency growth is positive for all states, although it varies inversely with the base year (1982) levels of efficiency.

Technical efficiency at the crop level

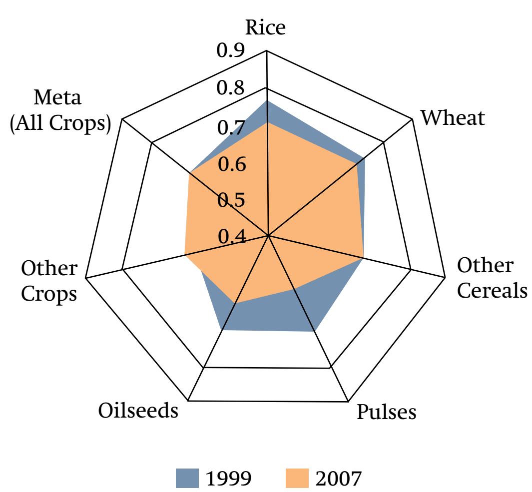
The data also allow more in-depth assessment at the crop level. Crops are classified into broad groups with the exception of wheat and rice, the most widely grown crops. An estimate across all crops/plots is also derived, showing the average (meta) efficiency across crops. The average efficiency levels are plotted in Figure 48 (left panel) and with their distribution across all households (right panel). As expected, the meta-efficiency is representative of individual crop efficiencies, showing on average a lower level of efficiency than the main staples (rice and wheat).

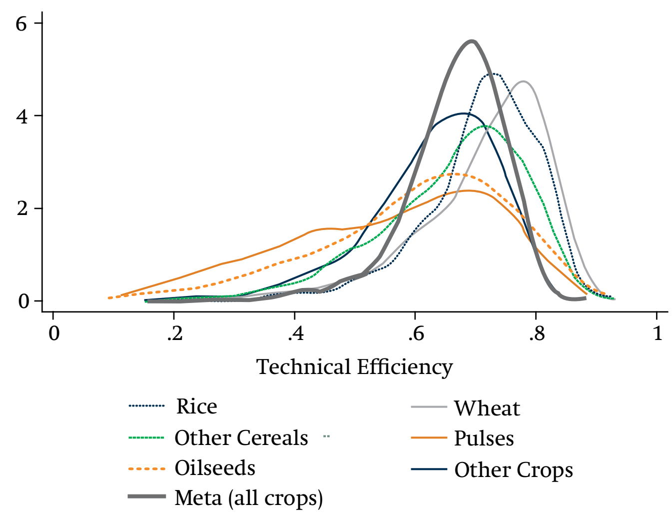
The only group that shows a marginal improvement in technical efficiency between 1999 and 2007 is the group of "other crops" (all crops other than the cereals, pulses, and oilseeds). For all other groups, efficiency is lower or the same. Notably, efficiency is lessening in the most widely grown crops (rice and wheat) and declining significantly for pulses and oilseeds. Across households there is significant dispersion in efficiency levels for all crops, but particularly pulses, oilseeds, and "other" crops.

Regional differences in efficiency

The wide dispersion across households may reflect variation in geographical or agro-ecological conditions. The distribution of efficiency levels by broad geographical classification (North, South, East, and West) shows that farmers in northern India are performing much better than those in the South (Figure 49). The East and West are in between, with western India performing relatively better than eastern India. The distribution of efficiency levels by the four major agro-ecological zones shows the expected patterns, with the arid

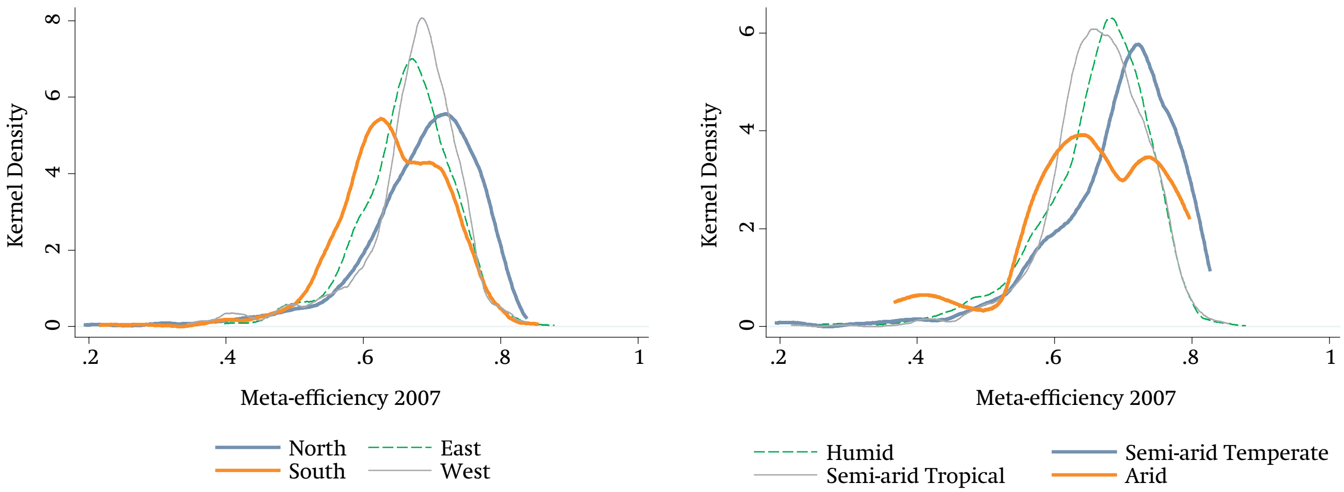
Figure 48: Crop-level efficiency estimates: 1999–2007





Source: Authors, using NCAER-REDS Household Panel data.

Figure 49: Regional differences in efficiency by geographical and agro-ecological zone



Source: Authors, using NCAER-REDS Household Panel data.

zone (mostly the extreme western part of the country) at the lowest levels and the semi-arid temperate zone at the highest levels (mostly the northern part of the country). The semi-arid tropics (much of western, central, and southern India) perform less well than the humid zone (on the eastern and western coasts).

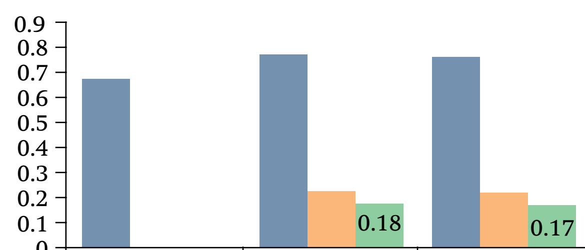
Concerns with economic and allocative efficiency at the farm and crop level

The striking finding from the DEA analysis was the extremely low levels of economic efficiency, which translated to huge profit losses. Using the estimated frontier cost function for the years 1999 and 2007 (no price data are available for 1982), the economic efficiency estimated from the parametric approach provides qualitatively similar results to the DEA analysis. Figure 50 summarizes the household-level estimates. Estimated economic efficiency was extremely low (23 percent) in 1999 and declined further (to 22 percent) in 2007. The relatively high technical efficiency levels imply that allocative efficiency on average is only 17 percent in 2007.

These telling results suggest that the meager resources at the disposal of the primarily small farmers in the sample (the median farming household has 2.75 acres of owned land and 3.75 acres of operated land) are not being used efficiently, despite relatively high levels of technical efficiency.

Another important finding is the difference in efficiency levels at the crop level compared to

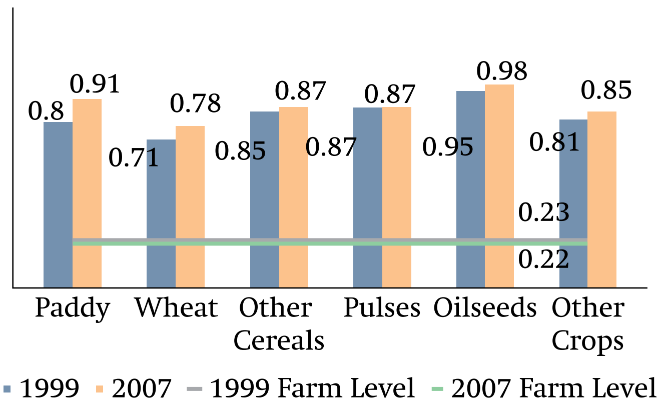
Figure 50: Farm economic and allocative efficiency



	1982	1999	2007
Technical	0.68	0.78	0.77
Allocative		0.23	0.22
Economic		0.18	0.17

Source: Authors, using NCAER-REDS Household Panel data.

Figure 51: Allocative efficiency at the crop and farm levels



Source: Authors, using NCAER-REDS Household Panel data.

the whole-farm level (Figure 51). Estimates of allocative efficiency show that at the individual crop level, households appear to be using resources (inputs) reasonably efficiently, given the output and input prices they face. At the whole-farm level, however, economic (and allocative) efficiency falls sharply, suggesting that that the major source of inefficiency seems to be farmers' crop choices. Household decisions to allocate resources such as land to different crops may be an outcome of the policy environment (distorted prices, for example), the higher risks associated with growing the more profitable crops, or household preferences (to ensure food security, for example). It is important that further research clarify these issues.

These findings have direct implications for policy makers and researchers. Much of the debate on Indian agricultural productivity has focused on technical or production issues, perhaps reflecting the "tonnage" problem—the overriding concern with meeting quantitative production targets, especially for food grains (cereals, but lately also pulses) (Sen 2011). Accordingly, the focus on solving the productivity problem has been very much on the technical side—either on research to raise yields or extension to deliver research findings to farmers.

Without a doubt, technical issues are, and will remain, very important to increase and sustain growth. Yet the findings suggest that it is also critically important to address issues affecting the economic rationality of farmers' decisions. In other words, the potential role of policies, institutions, and the enabling environment needs be brought to the front and center of the productivity debate if India's farmers are to move to more profitable agriculture.

Determinants of Productivity and Technical Efficiency

What is driving inefficiency at the farm level? Analysis of the factors influencing land productivity (defined as value of crop production per hectare) and the simultaneous estimation of technical efficiency in the stochastic production function frameworks can identify some of the drivers/correlates of the observed inefficiency among farmers.[98] The main inferences for policy are summarized here; for details see Gautam, Pradhan, and Nagarajan (2013).[99]

98 The stochastic production function is estimated using a Cobb-Douglas functional form and includes regional and agro-ecological dummy variables. The specification includes nonlinear rainfall effects to adequately control for too much or too little rainfall, proportion of area irrigated, and standard inputs such as seed, fertilizer, pesticide, fixed farm capital, and labor (both human and bullock labor). All dependent and independent variables are in value per acre terms. The efficiency function is estimated simultaneously using a number of household, farm, and village or regional characteristics.

99 The results discussed here are based on crop-level estimation, focusing mainly on the meta-production function at the plot level. The individual results vary by crop to some degree, but the main implications and conclusions are consistent.

Major factors influencing crop productivity

At the *plot level*, yields are inversely correlated with plot size for all crops except minor cereals and oilseeds. This finding is consistent with the long-held technical finding of an inverse land-productivity relationship.

Family labor is *less* productive (at the margin) relative to total labor used, implying overuse or suboptimal use of family labor compared to hired labor. The lower marginal labor productivity of family labor is consistent with the hypothesis that too many people (family members) remain on the farm because of the sluggish structural transformation.

Finally, for several crops and in the aggregate, manure is less productive than inorganic fertilizers. Long-term and other benefits may be associated with organic fertilizers such as manure, but in the short run there is a trade-off in terms of lower productivity.

Major factors affecting technical efficiency

The analysis of demographic variables shows households with older heads to be generally less efficient (with the exception of wheat and pulse producers, who are more efficient). The more educated households tend to be more efficient. The implication is that a younger, better-educated generation will be an important driver of growth in productivity—if they ever gain access to land to put their energy and skills to work.

Another important result is the positive relationship between farm size (total land owned by the household) and technical efficiency, which is statistically significant for rice, wheat, and oilseed crops and in the meta-estimation (across all plots). This relationship is not found for other cereals, pulses, or the broad category of "other" crops. So for the major crops, and overall, even though larger plots are less productive, larger farms are more technically efficient. For that reason, it is important to distinguish the size of individual plots from farm size, which may reflect other advantages that larger farmers may have.

The analysis provides robust evidence that the subdivision of plots is already reducing productivity. The share of each fragment devoted to a particular crop (except for pulses) is positively associated with technical efficiency. This result is statistically significant for all crops.

Infrastructure, as may be expected, has a strong impact, with a consistent finding that the distance of the farm to a *pucca* (paved) road is negatively associated with efficiency. With infrastructure accounted for, distance to market has no further impact.[100]

Considering the importance of extension services to technical efficiency, the analysis provides interesting results. Two variables are used—one is distance to a public extension worker, and the other is the number of times the farmer has participated in extension activities, such as a demonstration, *mela* (fair), or other event. Of the two, public events like demonstrations have a very strong and consistent impact on improving efficiency, indicating the importance of information and practical demonstrations of technology. Distance to extension worker has a mixed impact. Proximity to an extension workers is

100 It is statistically significant only for two crops, but with mixed influence.

negatively associated with efficiency for wheat, but positively associated with efficiency for minor cereals, oilseeds, and "other" crops. The impact on wheat may be associated with the de facto role of public extension in the green revolution areas, where extension has been associated with distributing subsidized inputs and possibly overuse of inputs to the detriment of technical efficiency.

Villages that are more technologically advanced (using the proportion of area planted to HYVs as a proxy) are strongly and significantly more efficient. The importance of technology in all crops and overall is amply clear.

Tubewells, which allow much better control of irrigation water, contribute to efficiency. Access to canal water is less consistent: It contributes to efficiency in rice and minor cereals, and across all crops, but it is not significant for "other" crops.

Governance indicators provide additional important insights. A strong and consistent result across all crops is the strong impact on efficiency of women's reservation (assured participation) in Gram Sabha meetings. A clear message is that involvement of women in local governance is good for productivity growth (and hence prosperity). The proportion of local government expenditures on agriculture has a positive impact for the meta-function and for rice and "other" crops, but it is not significant for "other" crops.

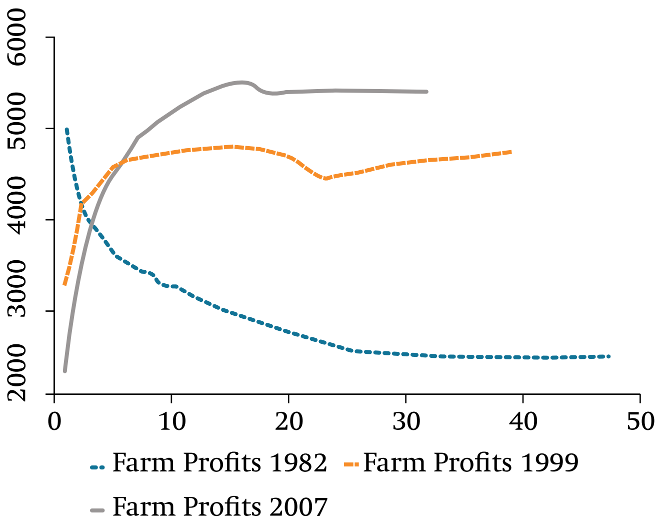
The findings on social inclusion highlight some limited impacts but are not significant for most crops. Female-headed households are more efficient producers of oilseeds only and are not more or less efficient for other crops. In terms of social classes, the results suggest that SC farmers are less efficient in rice and wheat, and ST farmers are less efficient in wheat production. This continued inefficiency for the two crops that receive the most public attention is surprising and calls for a focus on the inclusiveness agenda for extension services. The lack of significance in "other" crops could mean either insufficient statistical power (due to a small number of observations or wide variation in performance), or it could mean that the "other" (relatively minor) crops are part of the traditional portfolio of disadvantaged groups, who may be more proficient in growing them.

Changes in Agricultural Relations: Are Smaller Farms Still Efficient and Viable?

Before concluding the discussion on productivity and efficiency, it is vital to understand how the underlying economic relationships are changing and affecting farmers' incomes and well-being. The variables of interest are farm size, in particular land owned by households, and the returns to farming. Three levels of farming returns are used: gross value of output per hectare, gross-margins per hectare (revenues less paid out costs, so in essence returns to family labor and land), and profits (revenues less all costs, that is paid costs and imputed costs of family labor). Once again, this analysis takes advantage of the household panel data from the NCAER surveys spanning 25 years from 1982, 1999 and 2007. The main findings are presented using simple graphics of nonparametric trends to highlight the key messages.[101]

101 To focus on the main trends and avoid the noise that may be associated with extreme values, the sample is trimmed by deleting the top and bottom 1 percent of the land (farm-size) distribution.

Figure 52: Changing farm size and profitability relationship, 1982–2007



Source: Authors, using NCAER-REDS Household Panel data.

There has been a significant change in the structure of agriculture over the 25 years between 1982 and 2007. Figures A.8.1 and A.8.2 (Annex 8) confirm two main findings. One is the inverse relationship of yields (calculated as gross revenue per acre) and farm size. This relationship has held over the years. Using the "Situation Assessment Survey of Farmers, 2003," Chand, Prasanna and Singh (2011) also confirm the inverse relationship between farm size and productivity (using value of crop output per hectare as the indicator of productivity). But the relationship of technical efficiency with farm size has changed. For 2006 (the last year of the survey), the trend confirms the econometric finding presented earlier that efficiency increases with farm size. For the previous years, however, the relationship was nonlinear—rising slightly from very small farm sizes but then eventually falling.

The most significant and dramatic shift has taken place in the relationship between farm size and net revenues or profits per acre (Figure 52). The figure clearly illustrates a progressive change in agrarian relations over time, from a strong inverse relationship between profits (net income earned from crop farming) and farm size to an increasingly positive relationship in 1999 and 2007.[102]

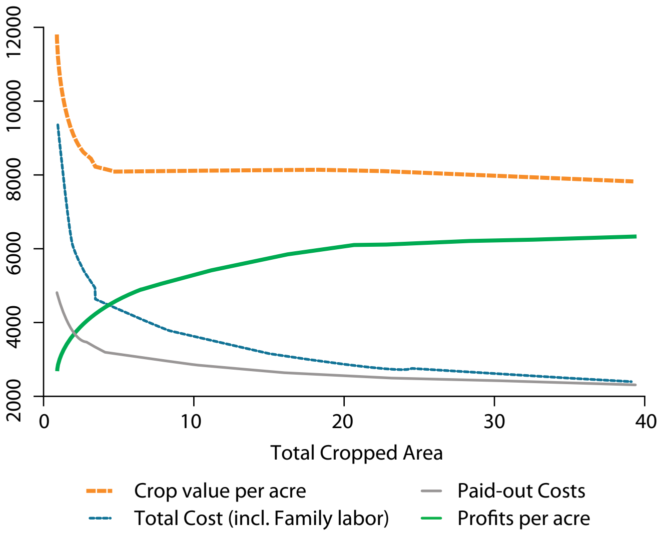
Given that the majority of farms in India are less than 1 hectare (roughly 2.5 acres), these findings are significant—politically as well as economically—for growth and poverty reduction. The argument of "small and efficient (in terms of productivity)" still applies from a technical perspective of higher yields (gross output or value of output per acre), but the changing economic relationship indicates that "small and efficient" does not necessarily translate to economic well-being in terms of more income (profits). The reasons behind the shift in the profit and farm-size relationship are clearly seen in Figures 53 and 54.

Figure 54 shows that while paid out costs rise with farm size, the relationship changes completely with total costs (that is, when family labor is included), which fall with farm size. The trends in the components of production costs in Figure 53 depict this point more clearly. In effect, the higher revenues (at the small-farm level, which turn to almost constant returns to scale beyond about 5 acres) are neutralized by very high family labor costs.[103] These trends

102 Rawal and Swaminathan (2012), based on a study of seven villages in three states (Andhra Pradesh, Maharashtra, and Uttar Pradesh), find a positive relationship between gross as well as net incomes from farming and the scale of operation defined as the "value of means of production," but no clear-cut patterns emerge between farm size and net income per hectare.

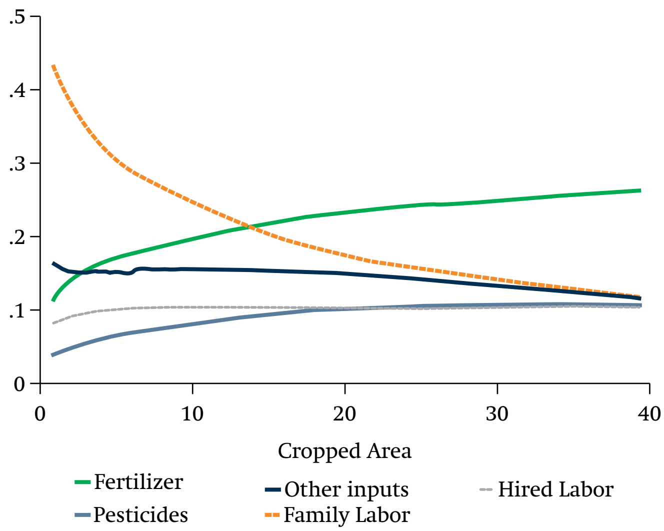
103 A similar conclusion is reached by Chand et al. (2011), who consider output value per capita and find it to be positively correlated with farm size—an alternative way of looking at returns to family labor using family size as a proxy for family labor.

Figure 53: Revenue and costs per acre by farm size



Source: Authors, using NCAER-REDS Household Panel data.

Figure 54: Cost structure by farm size



Source: Authors, using NCAER-REDS Household Panel data.

reinforce the econometric finding that family labor use appears to be less productive on farm, suggesting that labor is overused on the farm. Small farmers use less fertilizer and pesticides than other farmers, but the intensity of use for other inputs is more or less constant across farm sizes.[104]

Summary and Implications: High Cost of Inefficiency

At the household level, the finding of very low economic efficiency implies a very high cost to farmers in terms of foregone farm income. The higher technical inefficiency among small farmers suggests potentially high returns to extension services, whereas the higher allocative inefficiency at the farm level among large farmers indicates economically suboptimal crop choice.

Past (and present) debates on agricultural productivity have centered primarily on technical or production issues, reflecting the policy focus on quantitative cereal output growth. Promoting diversification toward a more economically profitable crop mix would achieve significant gains through improved economic efficiency in production. To achieve this goal, the role of policies, institutions, and the enabling environment needs to be brought to the front and center of the discussions on achieving faster productivity growth.

Along these lines, the findings on land fragmentation, efficiency of younger and more educated households, and the association of profitability with farm size are very important. They suggest that some small farms may be getting too small to remain efficient or viable, despite the inverse technical relationship between farm size and yield.

The findings lend new urgency to land market reforms and efforts to move labor off the farm. The

104 The share of fertilizers in total as well as paid out costs also rises with farm size, indicating that small farmers are using less fertilizer in both absolute and relative terms.

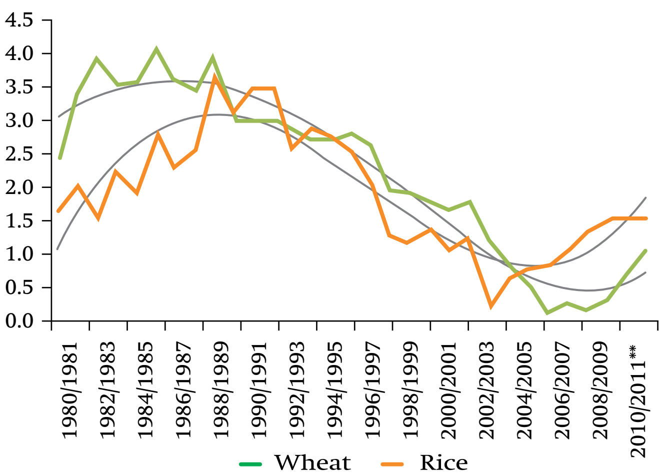
issues concerning land markets in India are not analyzed in depth in this study. They are already well analyzed, and the need to reform tenancy laws as well as legalize or otherwise loosen restrictions on land lease markets is widely acknowledged (for example, see discussions in GOI 2008a, 2011b, 2012; Haque 2012, 2013).

This long-standing issue of reforming the policy and regulatory framework governing land and rental markets is a high priority to sustain productivity and growth in farm incomes. More efficient land markets can help to consolidate land in the hands of the more productive farmers, perhaps by improving access to land for younger and more educated farmers. Perhaps even more important is the potential interaction with the dynamics of structural transformation. The need to attract agricultural workers to productive jobs off of the farm is well recognized, and the findings in this report suggest that it is even more urgent than anticipated. Better-functioning land markets would permit the inefficient or unviable farmers to seek off-farm work without fear of losing their primary asset or being bogged down in debilitating litigation.

9 TECHNOLOGY: YIELD GAPS AND PROSPECTS FOR GROWTH

Many factors drive growth in agricultural productivity, such as investments in infrastructure, education, and market access. Among these, the central role of "technology capital" is well documented for India and globally (Evenson and Fuglie 2010; Chand, Kumar, and Kumar 2011; Fuglie 2012; Fan, Hazell and Thorat 1999; Fan, Gulati and Thorat 2008). The previous chapters provide a somewhat mixed picture of technology's role in Indian agriculture. The estimates of extension stock and research stock suggest that slow growth in productivity may be related more to deficiencies in extension than in research.

Figure 55: Growth in India's rice and wheat yields has slowed (10-year trend rates)

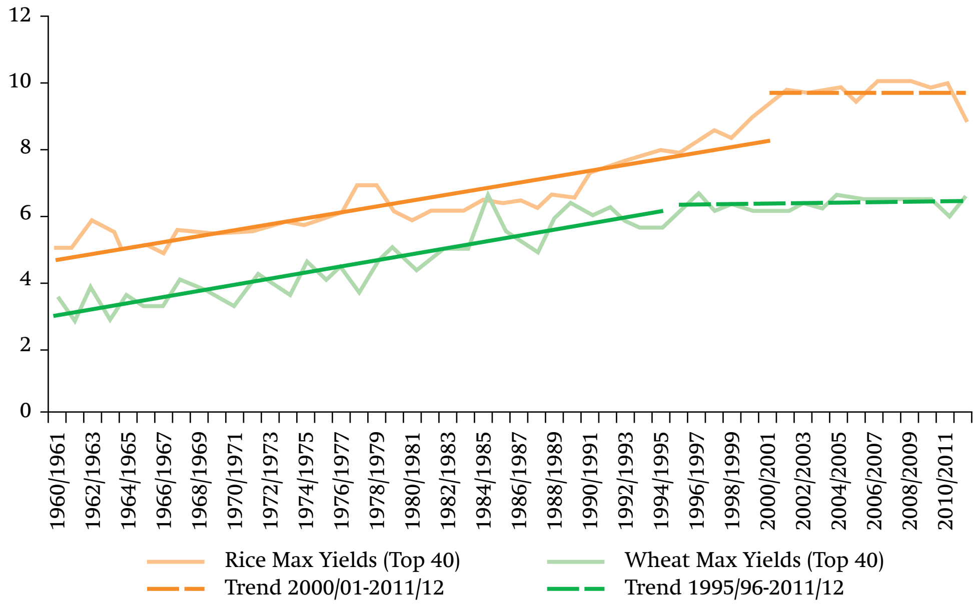


Source: Authors, using data from DES, MOA.

Past investments in technology appear to have made a significant impact, with technical change being the primary driver of TFP. Yet the green revolution technology may be reaching its limits and beginning to show diminishing returns with progressively slower growth in the green revolution stronghold states. The arguments for this "technology fatigue" are grounded in the yield trends of India's major crops, which show decreasing growth rates since the 1980s (wheat) and early 1990s (rice) (Figure 55). Growth rates for both crops have picked up in recent years, but it may be too soon to draw robust conclusions, as weather clouds a clear assessment.

What do these long-term trends mean? They may reflect insufficient generation of new technology. They may reflect farmers' failure to use the newest technology available. Alternatively, farmers may be using the best technology but failing to realize the yields that the technology is capable of delivering. The most alarming prospect is that the technology has reached its genetic limits—not only in India, but globally. In fact, global yields appear to have plateaued since the mid-1990s for wheat and late 1990s for rice, as seen in Figure 56, which plots the highest rice and wheat yields attained in each year since 1960 by any of the world's top 40 producers of rice and wheat.

Figure 56: Global rice and wheat yields have plateaued



Source: Authors, using FAOSTAT.

The food security implications of slow global growth in cereal yields have raised concern for some time (World Bank 2007b, Cassman 2011; Ray et al. 2013). For a country the size of India, food security is a high priority, especially given the projected volatility in global markets and the sheer influence of India on those markets. If past trends continue, demand-supply projection models show that India's food security situation probably will not be dire (Joshi and Kumar 2011; GOI 2012; Ganesh-Kumar et al. 2012). If productivity remains sluggish, however, India might have to rely on imports (Parikh et al. 2011), with a significant impact on global markets. The slowing growth in yields is thus worrisome, regardless of whether the objective is to maintain yield trends for food security or to improve productivity for growth.

To assess the prospects for yield growth, this chapter looks at two aspects of the issue. First, it looks at the "research problem" (the generation of new technology) by assessing how the production frontier has moved over time and examining prospects for progress. Second, it focuses on the "extension problem" through yield gap analysis, in which the differences between yields and agronomic potential are estimated to clarify prospects for improving yields with the technology that is available now.

Current Yield Gaps and Progress in Closing Gaps over Time

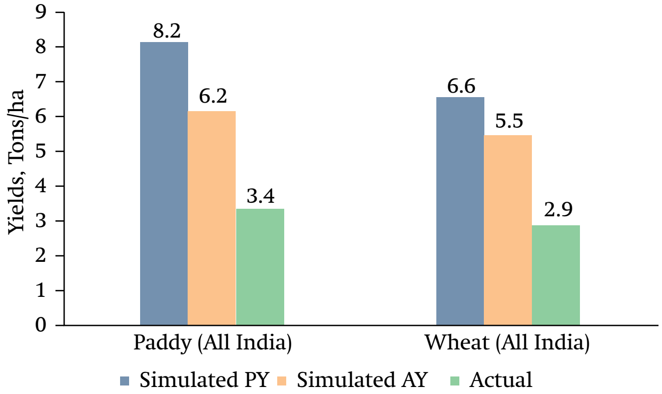
Yield gaps are variously defined based on the benchmark selected for "potential" yields (Fischer, Byerlee and Edmeades 2009; Lobell, Cassman and Fields 2009). While it is tempting to use yields achieved in other countries or certain regions within India as the benchmark, such comparisons may not be valid.[105] Another approach (adopted here) is to use a bio-physical crop model to simulate the potential for popular and established rice and wheat cultivars in different parts of India.

Two benchmark levels are generated for each state: One is a biological potential yield (PY) based only on varietal characteristics without any constraints in the growing environment, and the other is attainable yield (AY), which introduces water management as a constraint, using the current level of irrigation development in each state to simulate attainable yield.[106] A final benchmark is "realizable" yield (RY), which is the research station or experimental yield. Experimental yields (RY) should be close to the AY, with the difference reflecting soil problems, pests, other management problems, and localized variation in weather, as some biotic and abiotic stresses cannot be controlled even on an experiment station. All of these yields can then be compared to observed actual or farm yields (FY) to establish the size of the yield gaps.

105 Agro-ecological conditions (temperature, sunlight, water stress, and so on), soil type, and various other biotic and abiotic factors make such comparisons difficult or meaningless. For example, it is commonplace to compare rice yields in India (typically Punjab) with China (typically Jilin or Jiangsu, provinces with highest yields), despite marked differences in soil conditions (such as soil carbon, micronutrients), temperature, and growing duration (length of growing period or exposure to sunlight), all of which make a significant difference to yields. Farming systems differ as well. Rice is typically monocropped in China, and the length of the growing period is significantly longer than in India's Punjab, where farmers grow rice and wheat in rotation. Their priority is to shorten the growing period for rice to make way for wheat planting, even though rice yields are compromised as a result.

106 The biological potential reflects purely exogenous climate factors and varietal characteristics, but no other biotic or abiotic stresses (considered manageable), and hence represents a theoretical physical optimum. Attainable yield incorporates local soil factors and water control (area irrigated) to identify what is attainable given the current level of water management but assuming that all other factors can be (at least theoretically) controlled.

Figure 57: Yield gaps, all India



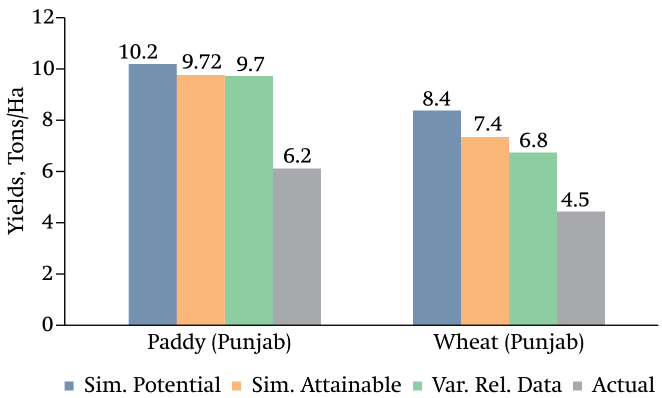
Source: Authors and DES, MOA.

Figure 57 shows the all-India weighted averages for RY, AY, and FY, giving an aggregate picture of yield gaps for rice and wheat. Given India's heterogeneity, yields and yield gaps vary by location, making it difficult to arrive at an aggregate RY estimate (RY data are classified only by broad agricultural domains). The importance of this limitation is clearly shown for rice and wheat in Annex 9, Figures A.9.1–A.9.2. Even theoretical potential yields vary considerably by state, with greater differences for wheat than for rice. The variation in AY is larger, indicating that even within India, a simple comparison of rice yields observed in, for example, Punjab with Madhya Pradesh or Jharkhand may not be useful.

Although RY would be the ideal comparator, AY is used as a proxy, as they are expected to be close. As shown in Figure 58, RY and AY are very similar for Punjab (where RY is more easily compiled based on available data). Assuming this relationship holds for other states, Figure 59 shows the current yield gap[107] for the

107 The yield gap is defined as the difference between FY and AY as a percentage of AY, where FY is a five-year average actual or observed farmer yield at the state level, and AY represents the current simulated potential, with the crop model parameterized using a recently released, widely used variety for each crop.

Figure 58: Yield gaps, Punjab



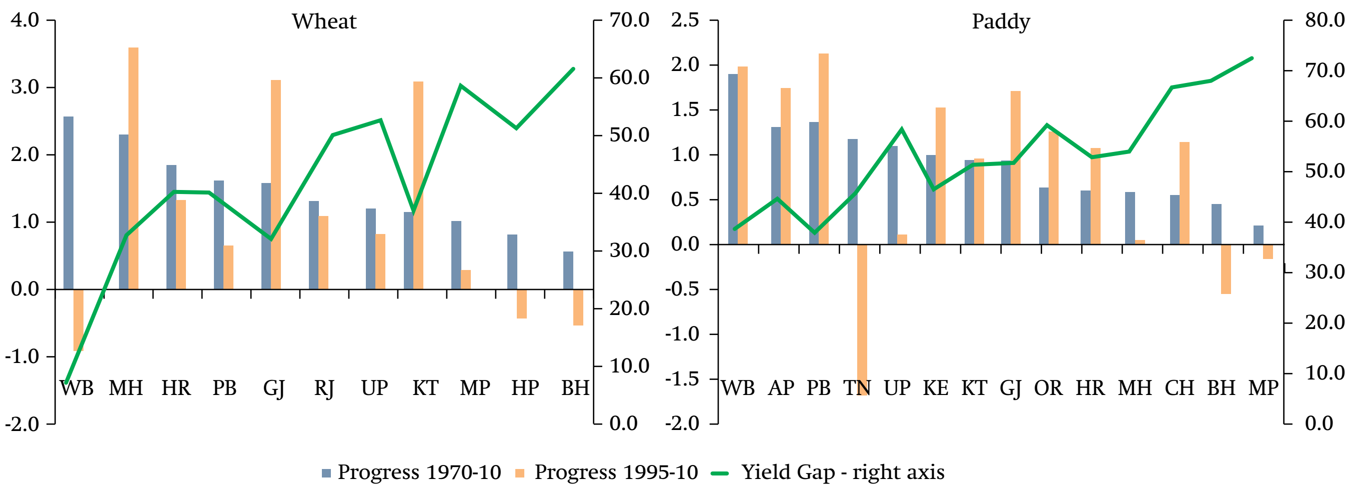
Source: Authors and DES,MOA.

major producing states. It also shows the rate at which the yield gap has reduced over the long run (1970-2010) and in recent years (1995–2010).

Most states have made more rapid progress in closing the yield gap for rice in the last 15 years relative to the earlier period (reflected in the lower long-run growth rate). The notable exceptions are Bihar, Madhya Pradesh, Tamil Nadu, and Uttar Pradesh, which have regressed in the more recent period. In wheat most states show a slowing in yield growth, with the exception of Gujarat, Karnataka, and Maharashtra, all of which have substantially narrowed their yield gaps.

As a point of reference, it is instructive to note that globally no country has been able to reduce its yield gap below 20 percent, suggesting that 30 percent may be a realistic target (Lobell, Cassman and Fields 2009). The reasons behind this phenomenon are not fully understood but probably result from management and variation in field conditions. Yield gaps vary considerably across states, but some approach 30 percent of their potential with current technology and so have little scope for further improvement. West Bengal—not a traditional wheat-growing area—is an outlier that has exceeded its expected performance. Maharashtra and Gujarat seem to have exhausted their potential with the current wheat technology, whereas Punjab and Haryana still have some limited room to increase yields. West Bengal and Punjab are also close to their potential for paddy, but most other states have significant potential yield advances to exploit.

Figure 59: Current yield gaps and progress in reducing yield gap



Source: Authors, derived using DES, MOA, data.

In interpreting these findings, two important caveats need to be kept in mind. One is that AY, used here as the benchmark for the yield gap, assumes no biotic or abiotic stress is present, which may not hold in practice—see the discussion on Bihar and Odisha in Chapter 14, for example. Second, these are physical or output maximum potentials, not economically optimal potentials. So depending on the local policy and institutional environment, reducing the physical yield gaps may not be economically viable (as possibly reflected in the actual or observed farm yields).

Technological Progress: Evolution of Realizable Yields

Using data on India's varietal releases,[108] it is possible to chart the technological progress made for these crops from the 1960s. The database includes varieties released for 6 agro-ecological zones for wheat and 12 agro-ecologies/production systems for rice. It provides information on varieties released in every year, including the experiment station yields that are the basis for varietal release decisions. Several varieties are usually recommended for multiple domains, and multiple varieties are released in most years. To simplify the depiction of the long-term trends, Figure 60 and Figure 61 show the maximum experimental rice and wheat yields across all varieties released in a given year across all domains for irrigated and rainfed conditions.[109] The figures also include current farm yields as an all-India average.

The figures show that while wheat potential continues to rise (after stagnating in the early 1990s), yields in rice have not improved significantly in recent years. Longer trends from 1965 onward (depicted in Annex 9, Figures A.9.3–A.9.6) reveal that growth in RY has slowed in recent years. After the initial sharp growth in the late 1960s with the introduction of HYVs, since 1980 rainfed rice yields have changed little. For irrigated rice, RY grew fastest in the 1980s and early 1990s and then stagnated from 1995. Trends in realizable wheat yields show a more optimistic picture. Growth increased in the latest period (1995–2010) after steady albeit relatively slower growth from 1965 to 1995. For rainfed wheat, RY increased most sharply in the 1980s; it has slowed since then but continues to grow. Almost 90 percent of India's current wheat area is irrigated, however, and after modest but steady growth from the 1960s through the 1980s, potential irrigated wheat yields have been on the upswing since 1995.

Figures 60 and 61 also show what is happening with yield gaps in rice and wheat at the aggregate level. Wheat has seen a recent (1995–2010) widening of the yield gap, whereas the rice gap has been narrowing. Farm Yields (FY) are rising each year by 21 kilograms per hectare (0.74 percent) for wheat and 26 kilograms per hectare (1.2 percent) for rice. The widening yield gap for wheat arises from the much faster rise in RY (36 kilograms per hectare per year for rainfed wheat and 54 for irrigated wheat), while for rice RY has stagnated since 1995, rising at only 6 kilograms per hectare per year.[110]

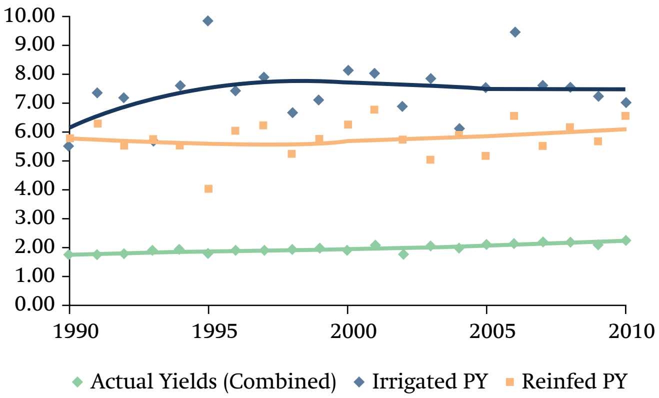
How does India compare to other countries with respect to yield gaps for rice and wheat, and progress in closing those gaps? A study of major grain-growing areas around the world ("global

108 Provided by DWR and DRR and facilitated by ICAR.

109 For some years, recorded yields are very low, because of special traits in the varieties released. These observations are dropped to keep the trends from getting too distorted.

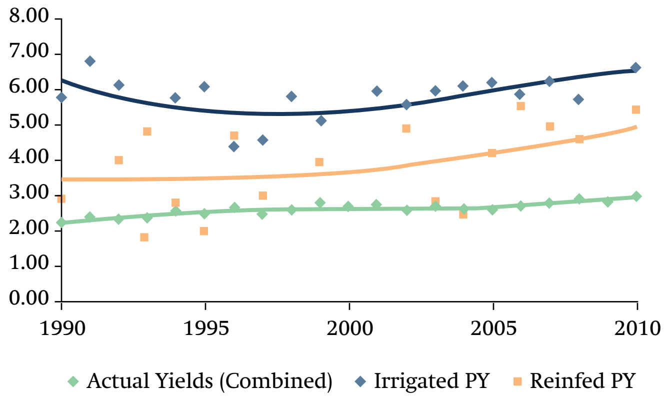
110 Part of the observed growth in FY for each crop is explained by irrigation expansion. Between 1995 and 2008 (years for which data are available), the share of irrigated area grew at 0.5 percent for wheat and 1.04 percent for rice.

Figure 60: Experimental rice yields for released varieties, 1990–2010



Source: Authors, using DRR database.

Figure 61: Experimental wheat yields for released varieties, 1990–2010



Source: Authors, using DWR database.

breadbaskets") analyzes progress in farm yields, potential yields, and yield gaps for rice and wheat (Fischer, Byerlee, and Edmeades 2013). The study sites include Punjab for irrigated wheat and rice and Madhya Pradesh for rainfed rice. The findings are summarized in Annex 9, Tables A.9.1–A.9.2. The yield gap in Punjab is similar to the average across the other sites, with scope for doubling current yield levels relative to Punjab's potential yield. Progress (rate of change) in both FY and PY is also comparable to other sites. Notably, the progress in wheat RY, estimated from the more complete data above, appears to be better than for most other countries (sites) in the study.

The yield gap for irrigated rice in Punjab, however, is larger than the global average. Current yields in Punjab need to rise by 75 percent to close the gap, whereas on average global yields need to double. Although Madhya Pradesh performs as well as the only other rainfed rice site, the scope for improvement is remains substantial—current rainfed rice yields in Madhya Pradesh need to increase by 150 percent to close the gap. Progress with yields at the farm level in India is the same as the average for other sites, but with almost no growth in RY, India is lagging.

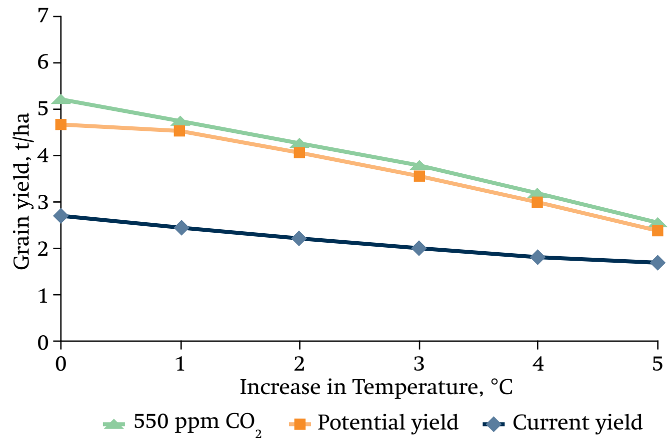
Metrics of Research Achievement Other than Yield

Yield is an important metric of research achievements, but it is not the only one. Research also has to focus on developing varieties that may not necessarily advance the yield frontier but can cope better with particular stresses in specific environments. Developing such varieties is an important part of the work undertaken in India's research system, given India's vast agro-ecological diversity (Annex 9, Figures A.9.7 and A.9.8 show rice and wheat varieties released by decade for specific production domains). Often researchers develop varieties that are adapted to emerging conditions (evolving pests and diseases, for example) or to other local priorities or agro-ecologies, such as resilience to drought, saline soils, waterlogged soils, and so on.

This full set of research priorities and achievements is not captured through yield increases alone. For example, Dar et al. (2012) report that a flood-tolerant rice variety had a significant positive impact (45 percent higher yields) under prolonged flooding (6–14 days) compared to a popular variety in a randomized trial in 128 villages in Odisha. Research on such varieties is a high priority, considering that 25 percent of India's rice area is affected by prolonged flooding and that Odisha's low-lying, flood-prone areas are heavily populated by disadvantaged groups. In Bihar, another randomized evaluation of traits in rice varieties (Ward et al. 2013) finds that farmers value drought-tolerant cultivars and are willing to pay more for them. The high risk of abiotic stresses (such as drought) in Bihar warrants additional research on varieties that can surmount these local problems. At the same time, farmers' willingness to pay for the traits they demand in a variety signals that India should encourage greater investment by the private sector in research on such cultivars.

Another major historical priority of research in India has been to reduce the length of the growing period. As noted, this trait is particularly important in the Indo-Gangetic plains, where farmers growing rice and wheat in rotation place a premium on rice that matures early and wheat that can be planted late. Short-duration varieties are also an important mechanism for managing drought, because they enable farmers to adjust their planting dates and reduce their exposure to risk. An even more important potential benefit from varieties that mature early is that they can help farmers adapt to the rising temperatures that accompany climate change. Higher temperatures are expected to reduce yields significantly (Aggarwal and Rani 2009; Jacoby 2013). Figure 62 shows the results from recent research using a crop simulation model (the

Figure 62: Simulated impact of temperatures on grain yields



Source: Aggarwal and Rani 2009.

same model used to estimate yield potential previously), which clearly demonstrates how rising temperatures might affect grain yields in India.

Technology Capital: Investing for the Future

The evidence on the role of innovation in India's structural transformation—specifically the need to accelerate growth in TFP—heightens the importance of investing in technology capital. Developing countries now account for almost half of all global spending on agricultural R&D (Beintema et al. 2012), recognizing the need for science and innovation to drive their development. China, Brazil, and India are the major powerhouses, together contributing about a one-quarter of the global R&D investment (Beintema et al. 2012).

The recent surge in investment comes in response to many emerging trends. They include the slowdown in productivity growth globally and in individual countries—an outcome of faltering R&D investments and complacency after the success of the green revolution in most countries, as well as shifting R&D priorities in the developed countries where most technological advances once originated. Investment is also increasing to cope with greater volatility in global food markets, the prospective impact of climate change on agriculture and food production, and the imperative to ensure future food and nutrition security in the face of severe natural resource (land and water) constraints.

But success depends on more than the allocation of public funds, as the comparative performance of Brazil, China, and India demonstrates. Brazil spends significantly less than the others but is still widely recognized as the most innovative and successful research system among developing countries (Beintema et al. 2012). China's experience shows the importance of focusing on the quality and not just the quantity of innovation effort (Jin et al. 2010). Successful agricultural innovation systems are built upon strong, interdependent efforts in research, education, and extension. All three countries have a long and notable history of achievements in all three components of the innovation system.

The continuous challenge facing research, education, and extension is to remain relevant, effective, and efficient. Brazil and China have undertaken periodic reforms to reorient and redesign their agricultural innovation systems to meet growing and emerging national challenges (Huang, Hu and Rozelle 2004; Contini et al. 2010). By comparison, research, education, and extension have lagged in India in recent years (Lele et al. 2013). The impressive institutions established at the time of the green revolution have become less effective and relevant in stimulating transformative change in Indian agriculture. Going forward, these institutions must internalize the complexities of the new and emerging food and agricultural systems, respond to local demands from smallholders as well as the broad imperatives of food and nutritional security, feed into the rapidly changing and increasingly knowledge-intensive agriculture practiced today, and provide the high-quality human resources essential for any technology and innovation system to succeed.

Agricultural research

India's large, well-established agricultural research system (Box 2) operates largely in the public domain at both the central and state levels. Public research still accounts for the bulk of current investment in agricultural R&D. Rapidly emerging private research operations now account for almost one-third of total R&D investment but need to be nurtured through an appropriate enabling environment (Pray and Nagarajan 2012). The high returns to investments in agricultural R&D are well documented worldwide (Alston et al. 2000) and in India (Rosegrant and Evenson 1992, 1995). Agricultural research gives higher returns on investment than other public expenditures, even rural roads and education (Annex 11, Figure A.11.3) (Fan et al. 2012). The evidence on productivity growth presented in previous chapters underscores this point at the national, subnational, and farm levels.

Recognizing the long-term repercussions of underinvestment in agricultural R&D in the 1990s, since 2004/05 the government has rapidly increased public expenditures on agricultural research (including education) at about 15 percent per year (Singh 2012). Despite the increase in expenditure, agricultural research intensity—the ratio of agricultural research

Box 2: Agricultural research organization, investment, and capacity in India

The Indian Council of Agricultural Research (ICAR), an autonomous organization under the Department of Agricultural Research and Education, Ministry of Agriculture, is the apex body for coordinating, guiding, and managing research and education in agriculture (including horticulture, fisheries, and animal sciences) throughout India. With 99 ICAR institutes and 60 agricultural universities spread across the country, this national agricultural research system is one of the world's largest.

Public spending on agricultural research and education averaged 0.7 percent of agricultural GDP over the Eleventh Plan period (2007/08–2011/12), compared to an end-of-plan target of 1 percent of agricultural GDP. Public spending in India is relatively low compared to other developed (2.35 percent) and developing countries (Brazil spends 1.04 percent).[a]

The bulk of research capacity, in full-time staff equivalents, is in the state agricultural universities, accounting for about 56 percent of staff, with the rest in ICAR institutes.[b] Research resources continue to be concentrated in the western and southern states (60 percent), with the hill and eastern states receiving less attention. Research focuses more on crop husbandry (85 percent) than animal husbandry (7 percent) or soil and water conservation, dairy development, and fisheries (less than 5 percent each).

Private investment in R&D has grown rapidly in the past couple of decades, and in 2008/09 was estimated to account for 26–30 percent of all spending (public and private) on R&D, compared to about 17 percent in 1994/95.[c] The most dynamic sectors for private innovation over the last decade have been the seed industry, the pesticide industry, and the farm machinery industry. The major remaining constraints noted by the private sector include regulations and price controls on new technology, enforcement of intellectual property rights, and limited availability of scientists.

Source: Authors

[a] GOI 2011c. [b] Beintema et al. 2013. [c] Pray and Nagarajan 2012.

expenditure to agricultural GDP—remains very low (under 0.6) (GOI 2012), well below India's comparators and developed countries, where agriculture's contribution to GDP and employment is much less than in India.

Concerns have grown about the relevance, efficiency, and effectiveness of the national agricultural research system, especially its inability to adapt to changing needs and challenges (Evenson and Jha 1973, Jha and Kumar 2006; Singh 2011; Lele et al. 2013).[111]

111 Key issues include the system's traditional organizational and institutional structure, which is unable to meet the challenges and demands of globalization, privatization, and liberalization; its technology generation paradigm, which is top-down, supply-driven, public-sector-oriented, and linear; high transaction costs; deteriorating human capacity; duplication; bureaucratic rigidities; inadequate incentives to respond to emerging demands; and poor monitoring and evaluation.

Despite increased spending and rapid growth in the number of universities and research institutions, the capacity for research in terms of staff strength is falling (Benteima et al. 2012). State agricultural universities are a critical component of the research system, but they suffer from a number of problems (discussed later in detail), including rapid drop in the number of occupied faculty positions in several state universities and a decline in staff quality arising from insularity, ageing, and a general decline in skills (Singh 2011).

Extensive analysis and two high-powered committees headed by eminent scientists—the Swaminathan Committee (2005) and Mashelkar Committee (2005)—have promoted reforms, but the general consensus is that the research system has seen no real reform in how it functions (Ferroni 2013; Ramasamy 2012; Lele et al. 2013). A review of contemporary institutional and implementation arrangements for agricultural research highlights India's need for a strategy to improve the efficiency of resource use, increase dissemination of known technologies, enhance the quality of human resources, and commercialize technologies (Babu et al. 2012).

Agricultural education

The state agricultural universities not only have a mandate to build the much-needed human capacity for the research system but undertake their own research (particularly adaptive research) and extension. India's once-impressive university system (Lele and Goldsmith 1989), patterned after the United States Land Grant Universities, is in disarray and declining in quality. The system faces multiple crises of governance, resources, effectiveness, and ethics—even as more universities are being created, without attention to quality (Nene and Tamboli 2011). These issues are familiar to the key policy-making institutions and decision makers (the Planning Commission, ICAR, and Vice-Chancellors and Deans of Universities). Under the auspices of the National Academy of Agricultural Sciences and ICAR, the XI Agriculture Science Congress focused on agricultural education, drawing upon best practices across India and from around the world to chart a way forward for

Box 3: Resolutions from the Bhubaneswar Declaration on higher agricultural education in India

The entire community of research, education, and extension professionals, managers, and policy makers at the XI Agricultural Science Congress (Bhubaneswar, February 2013) unanimously endorsed the following resolutions from the Bhubaneswar Declaration:

- Embrace agricultural education and AREE4D [agricultural research, education, and extension for development] as an integral component of the national agricultural policy to ensure adequate, consistent and predictable investments in agriculture, especially education, research, and extension in creating a world-class agricultural university system attuned to face challenges and opportunities over short, medium and long term.
- Ensure and institutionalize transparent governance, autonomy, meritocracy, dynamic assessment of human resource requirement, judicious allocation of resources, effective implementation, monitoring, evaluation, accountability and responsibility based system, and to minimize splitting and inbreeding.
- Pay focused attention to the standards, norms, and accreditation in quality agricultural education, create centres of excellence and institutes for agricultural education, science, knowledge, research, technology, and innovation in an interdisciplinary and multifaculty mode.
- Identify national- and state- level public and private sector leaders with differentiated but reiterative responsibilities to work on the design and implementation of reforms and to develop a strong inter-ministerial and inter-departmental cooperation mechanism.
- Revamp teaching/learning processes and methodologies to attract best of talents and blooming young minds for nurturing them leading to a nation-wide programme on "Youth for Leadership in Farming."
- Support India's proposed development of an active and continuous long-term relationship-based international cooperation, rejuvenate and dynamically strengthen initial very successful collaboration between Indian State Agricultural Universities and United States Land Grant Universities, and launch need-based South-South and South-North collaborations such as the Brazilian LABEX programme of scientific exchange.

Source: NAAS and ICAR 2013.

India. The Bhubaneswar Declaration (NAAS and ICAR 2013) outlines a road map for improving India's higher education system (Box 3). The road map calls for fundamental changes, which will require political will and commitment to implement and overcome the resistance to change.

Agricultural extension

The primary organizational reform of India's agricultural extension services was the gradual implementation of the Agricultural Technology Management Agency (ATMA) model over the past 15 years. ATMA was designed as a decentralized, demand-driven approach to extension that could respond to local demands, priorities, and constraints. Beginning with a pilot (Phase I, 1998–2004), ATMA was implemented in 28 districts of 7 states and later scaled up (Phase II, 2005–10) to 262 districts and then (2007) to all 591 districts.[112] The expansion raised design and implementation concerns, which were eventually addressed in the revised guidelines in 2010 (Annex 9, Box A.9.3) and Phase III of the program (2010 to the present).

Phase I won high marks for innovation (Singh and Swanson 2006; Anderson 2007; Swanson, Hall, and Reddy 2008). Independent evaluations by the Indian Institute of Management showed that the pilot mobilized farming communities, developed public-private partnerships, improved interaction among farmers and extension workers, increased productivity and farm incomes (compared to control groups), and facilitated the development of supply chains for a number of commodities.[113] The problems in Phase II largely resulted from the program's rapid expansion and inability to attract human resources with the appropriate skills, resulting in a lack of skilled, dedicated personnel, weak research-extension links, limited outreach to farmers, limited operational flexibility (compared to the pilot phase), poor organization, and disappointing outcomes (Raabe 2008; Sulaiman and Hall 2008). Despite the revision of ATMA's guidelines in 2010, a vacuum remains in the delivery of technical advisory services (Ferroni and Zhou 2012). To assess ATMA's progress since 2010, Babu et al. (2012) undertook a detailed field assessment based on case studies of seven districts in four states (Bihar, Himachal Pradesh, Maharashtra, and Tamil Nadu).[114] The study highlighted positive achievements resulting from ATMA's demand-driven, multi-agency approach but noted persistent issues with reaching communities, achieving organizational autonomy, and improving staff quality (Box 4).

Conclusions and Implications

Substantial yield gaps remain in large parts of rainfed and irrigated areas, indicating significant potential for further gains. While a number of factors influence yield gaps, from the technology perspective, the immediate priority for addressing "technology fatigue" is to resolve the "extension problem." Research also has significant challenges to confront, such as dedicating more effort to crops other than rice and wheat and leveraging the rapidly emerging private sector to tackle important outstanding and emerging challenges. These research challenges include the multiple biotic and abiotic stresses prevalent in the LIS, a transforming agriculture and food sector, and the potential impacts of a changing climate.

112 ATMA was scaled up under the government's Support to State Extension Programs for Extension Reforms.

113 Participatory planning, operational flexibility, smooth and timely flows of funds, training and capacity building support, and independent monitoring and evaluation were some of the reasons for the pilot's success. See World Bank (2007c).

114 See Babu et al. (2012).

Technology capital is a critical input to accelerate agricultural productivity. Global experience amply demonstrates that success is more than the sum of public funding. The quality of innovation and the capacity of institutions to reconfigure and reorient themselves to a rapidly transforming and increasingly knowledge-intensive agriculture are critical elements of success. In this regard, priorities for research are to implement the reforms proposed by panels led by eminent scientists within India and to remove the remaining constraints to private sector research. Human capacity for technological innovation is needed in both the private and public sectors. The urgency need to resolve the crises in the State Agricultural University System is laid out in the Bhubaneswar Declaration. Similarly, the actions needed to improve agricultural extension are well known but need to be put into practice. These institutional changes require fundamental reforms, and implementing them requires the same unwavering political will and commitment that ushered in the green revolution.

Box 4: ATMA—Steps toward demand-driven, pluralistic extension

On the positive side, IFPRI's study of India's agricultural extension program concluded that ATMA had widened the range of extension activities and modalities that could be funded, enabling extension to respond better to the demands of different stakeholders, although performance varied widely across states, districts, and blocks. Convergence across programs (such as the National Food Security Mission, National Horticulture Mission) had improved, although again it varied by state, with good examples emerging from Maharashtra. Regular meetings at the district and block level between different line departments (agriculture, animal husbandry, fisheries, and so on) improved working relationships across departments. Additional funding from ATMA helped some departments to implement their extension activities. ATMA's association with Commodity Interest Groups (CIGs) helps them to access commercial bank finance, knowledge, and other services such as marketing and inputs—all important elements of success in extension. ATMA has created a constituency for its support at the ground level through Farmer Advisory Committees (FACs) and CIGs and to some extent expanded the reach of public extension agencies to rural communities.

On the less positive side, although ATMA is increasingly recognized as a new demand-driven, multi-agency approach to extension at the district level, that role is not so well articulated at the block and village levels. The lack of skilled staff at the right time remains a constraint. Like other government agencies, ATMA experiences funding delays, but agricultural programs must meet seasonal needs, and delays seriously affect agricultural productivity and incomes. Set up as an independent agency, ATMA was not administratively linked to any particular department, which was instrumental to its success in Phase I. Subsequently the Department of Agriculture became the lead department for ATMA, causing other line departments to perceive ATMA as a Department of Agriculture scheme rather than an equal partner. It may be time to explore more neutral organizational options. At the very least, other departments could take the lead role where warranted (for example, Horticulture or Animal Husbandry in districts where they represent the primary source of agricultural livelihoods). Links with agricultural research must be institutionalized rather than left to personal initiative, interest, and contacts, especially at the block level. Partnerships in delivering extension services should be encouraged with NGOs and the private sector, to add to the plurality of service providers and encourage specialization based on comparative advantages (for example, in areas such as agricultural marketing, where extension staff may not be the best equipped for the job). Finally, monitoring and evaluation must be extended to monitor outputs, outcomes, and impacts, which will require careful selection of performance indicators and systems to ensure that data are collected, verified, and analyzed at regular intervals.

Source: Adapted from Babu et al. 2012.

10 LIVESTOCK SUBSECTOR: OPPORTUNITIES FOR ACTION TO IMPROVE PERFORMANCE[115]

Introduction

Rising income levels, population growth, and urbanization are shifting India's dietary patterns away from carbohydrate-rich cereals to foods richer in proteins and micronutrients, as noted in Chapter 1. Consumption of food from animal sources has increased steadily in rural and urban areas (the shift in favor of fruits and vegetables is even stronger). Interestingly, these shifts are more pronounced in rural than in urban areas and among the urban and rural poor (Table 17). Despite past growth, consumption levels remain substantially below those in developed countries.[116] Considerable inter-state variation in consumption prevails as well (Gandhi and Zhou 2010).[117]

Supply has not kept pace with demand. India has some of the largest animal populations but lower per capita availability of milk and meat than all other regions of the world. Consumption of eggs is much lower than the Asian average on account of low productivity. Looking to the future, continued income growth and demographic changes in India are expected to propel strong growth in demand for livestock products, presenting huge potential for production growth. The

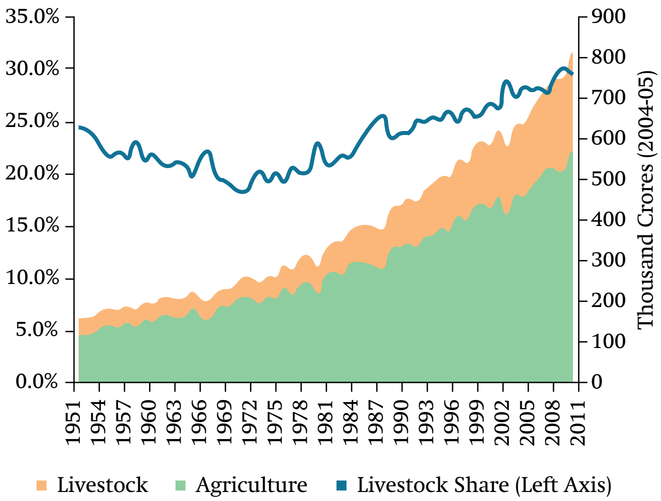
Table 17: Rural and urban household expenditure patterns have shifted away from cereals

	Rural expenditure (%)		Urban expenditure (%)	
	1993–94	2009–10	1993–94	2009–10
Share of food in total household expenditure	63.2	53.6	54.7	40.7
Allocation of food budget:				
Cereals	36.6	28.2	24.7	21.7
Milk and milk products	14.3	15.5	17.2	18.5
Meat, eggs, and fish	5.0	6.2	5.9	6.4
Total animal products	**19.3**	**21.7**	**23.1**	**24.9**
Other foods	44.1	50.1	52.3	53.4
All foods	**100.0**	**100.0**	**100.0**	**100.0**

Source: Birthal 2008 and NSSO survey, 2009–10.

115 This chapter is based on Leitch, Ahuja, and Jabbar (2013).
116 In India, only about 10 grams of protein is derived daily per capita from livestock products, compared to 16.6 grams in Asia, 45.3 grams in the Americas, 47.7 grams in the European Union, and 56.8 grams in Oceania (FAO 2011).
117 Milk consumption in Haryana, Punjab, and Rajasthan (at 146, 134, and 108 liters per capita annually, respectively) is way above that of states like Manipur and West Bengal (2.5 and 20.8 liters, respectively). Per capita meat consumption is highest among the northeastern states but still relatively low at 10.4–19.4 kilograms.

Figure 63: Agricultural GDP: Share of livestock, 1950/51–20110/11 (in 2004–05 prices)



Source: Authors, using CSO National Accounts Data.

livestock subsector has grown at twice the rate of the food grain subsector, raising the share of livestock in agricultural GDP from 20 percent in TE 1981 to about 30 percent in TE 2010 (Figure 63). Livestock's contribution to agricultural growth increased from 31 percent in 1992/93 to 36 percent in 2008/09. Milk accounted for two-thirds of the total value of output in livestock, owing to past and continuing public investment in the dairy sector (see Annex 10, Table A.10.1).

Livestock income contributes significantly to both poverty reduction and economic growth. Using the nationally representative survey data on farm households in 2002/03 (NSSO 2005), Birthal and Negi (2012) find that the probability of a household being poor decreases more with the rising proportion of per capita household income derived from livestock and crops. Over and above the negative effect of log per capita income, the marginal effect on poverty is –0.36 for the share of income from livestock and –0.25 for the share of income from crops.

Other estimates suggest that livestock production has large multiplier effects in India. An additional US$ 1 spent on primary livestock production generates US$ 4.7 in national household income (through demand and nonfarm linkages), compared to US$ 4.3 in fruits and vegetables, US$ 3.6 in crops, and US$ 2.9 each in manufacturing and services (FAO 2011). Importantly, most of the livestock in India is owned by marginal and small farmers, indicating that livestock ownership is more equitable than land ownership. About 65 percent of India's rural farm households have marginal land holdings of less than 1 hectare. These same households own 20 percent of all land but more than 50 percent of all cattle, small ruminants, pigs, and poultry and about 45 percent of India's buffaloes (Table 18).

Livestock is an important source of employment for rural households and especially for women. Mixed crop-livestock farming systems predominate in India, although some scaling up is starting to occur in the leading dairy states. Livestock are labor intensive, providing an opportunity for unskilled labor in rural areas. Crop agriculture is seasonal and risky; adding livestock production helps to reduce rural underemployment, particularly of family labor, and provides more stable income throughout the year. A recent study estimated that the production of 1,000 liters of milk alone on a daily basis by small, medium, and large producers, respectively, creates 230, 97, and 25 jobs in India (Staal, Nin-Pratt, and Jabbar 2008). The livestock subsector engaged 8.8 percent of the agricultural labor force in 2005 (Table 19), with women comprising between 70 and 80 percent of the workforce. While 90 percent of employment in primary production is in rural areas, a sizeable number of jobs in marketing and processing are in the urban areas. Animal

Table 18: **Distribution of land and livestock holding by land holding size**

	Marginal (<1ha)	Small (1–2 ha)	Semi-medium (2–4 ha)	Medium (4–10 ha)	Large (>10 ha)	All
Percent households	64.8	18.5	10.9	4.9	0.9	100
Average land holding size (ha)	0.38	1.38	2.68	5.74	17.08	1.23
Proportion of land owned (%)	20.2	20.9	23.9	23.1	11.8	100
Proportion of livestock ownership (%)						
Cattle	50.4	22.2	16.1	9.1	2.2	100
Buffalo	44.8	21.5	18.3	12.5	2.9	100
Small ruminants	52.4	21.3	14.6	8.4	3.3	100
Pig	55.6	22.6	13.6	6.5	1.7	100
Poultry	64.2	18.7	11.2	4.1	1.8	100

Source: www.indiastat.com.

Note: Land ownership is for 2005–06 and livestock ownership is for 2006–07.

Table 19: **Employment in the livestock subsector by farm size category**

	Agricultural employment in rural employment (percent)		Share of livestock in agricultural employment (%)		Share of women in livestock employment (%)	
Farm category	1993–94	2004–05	1993–94	2004–05	1993–94	2004–05
Landless	62.8	62.5	5.5	2.3	68.0	97.2
Marginal	73.0	65.2	7.1	9.2	69.4	73.4
Small	89.4	88.2	6.1	7.4	72.1	82.1
Medium	92.2	90.8	6.8	7.8	72.8	83.1
Large	93.1	91.4	7.7	8.6	76.7	82.0
All	**78.4**	**72.7**	**6.8**	**8.8**	**70.5**	**76.6**

Source: NSSO 2006 data.

husbandry is also more inclusive, with 69 percent of the persons employed belonging to SC, ST, and OBC.

Finally, improving productivity in the livestock subsector is also important for mitigating greenhouse gas emissions.[118] With the exception of dairy, past growth in the sector has been driven more by expanding numbers of animals than by improved animal productivity (output per unit of livestock or yields). Even in dairy, India's productivity is well below the world average. Given the importance of livestock among poor households (for income and for coping with risk), growth in the subsector is likely to continue.[119] To avoid the tradeoff with environmental impacts, it is critical to focus on livestock management and productivity. Growth in greenhouse gas emissions is closely related to the nature of the livestock production system. Emissions per head of cattle are

118 FAO (2006) estimates that about 18 percent of global greenhouse gas emissions are from livestock.

119 Livestock growth is much less volatile than crop growth, and livestock have been a key part of household risk management and food security strategies to cushion weather and other shocks (Annex 10, Figure A.10.1).

strongly dependent on diet quality (Harper et al. 1999; FAO 2006). The following sections discuss more specific opportunities, constraints to growth, and areas for action to improve the performance of the livestock subsector.

Opportunities for the Livestock Subsector

India is a global leader for livestock production, although production per animal remains low by world standards.[120] The average milk yield of Indian cows is about 3.4 kilograms per day, compared to the world average of 6.3 kilograms per day. Unlike other countries, in India buffaloes are a significant source of milk, accounting for over half of national milk production. Average milk productivity per animal grew at a respectable pace from 1980 to 2000 but has slowed considerably since (Annex 10, Table A.10.2). Reasons for slower growth in milk production include indiscriminate crossbreeding, the failure to respond to growing feed scarcity, underinvestment in systematic disease prevention and control programs, and inadequate services and advice to farmers (Leitch, Ahuja, and Jabbar 2013).

The formal processing sector expanded rapidly, driven by the private sector after the deregulation of the dairy industry in the early 1990s, but it remains small. Currently the formal sector handles less than 20 percent of India's milk output. More than half of the registered milk-processing capacity is in the private sector (in relation to the cooperative sector). Small producers are particularly affected by the lack of formal marketing channels, as profit margins are lower for milk sold through informal markets. During the flush production season, informal traders often offer less than market prices or even decline to procure some of the output.

Historically, the increase in average milk yields was driven by better market access, the growing population of crossbred animals as artificial insemination (AI) services expanded, and the replacement of draft breeds with dairy animals (as mechanization spread). Growth in meat output has mainly come at the extensive margin—that is, from growth in livestock numbers. All types of meat output increased (at varying rates) except for pig meat. Precise and systematic data on measures of meat productivity in India are scarce, but the limited data available suggest a near stagnation of productivity (measured crudely as carcass weight per animal) over the last four to five decades. The only segments that have perhaps shown modest growth in productivity (measured by feed conversion ratios) are the commercial broiler and egg segments.

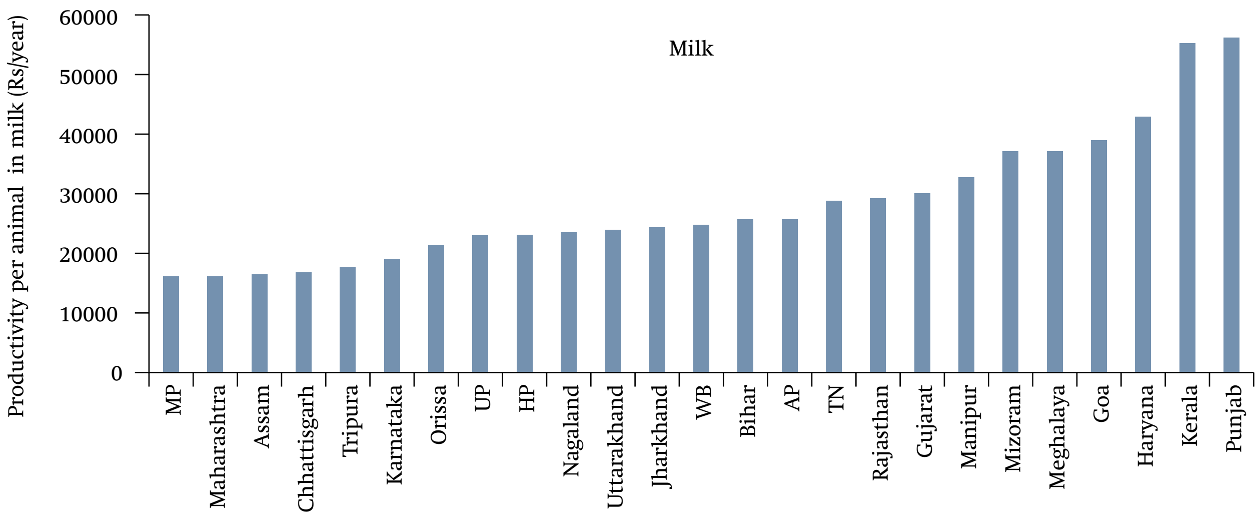
India has substantial room to increase output of milk and meat at the intensive margin. The potential for milk production is demonstrated in Figure 64, which shows the large variation in milk productivity across states.[121]

Crossbred cattle are an important contributor to yield differentials, which in turn reflect the wide variability in AI dissemination rates across states. States with high rate of AI dissemination and other policy measures (such as the

120 India has more than half the world's buffalos, one-fifth of the world's small ruminants, and more than 10 percent of the cattle population. With an estimated 127 million tonnes of milk in 2011-12, India leads the world in milk production and has emerged as a leading meat exporter.

121 Since animal productivity is relatively less subject to agro-climatic conditions, the differences across states suggest the presence of substantial "yield gaps" and scope for improvement in many, especially the lower-income, states.

Figure 64: Milk yield variability by state



Source: Chand and Parappurathu 2011.

development of market infrastructure and promotion of milk procurement) experienced high productivity gains. Feed constraints and a high morbidity/disease burden also contribute to lower yields in some states. Given their low initial productivity, LIS can effectively exploit the livestock subsector's potential for growth. For example, Bihar and Odisha have recently shown high growth rates, supported by policy initiatives and the expansion of dairy cooperatives.

New opportunities for income growth are emerging in export markets. India has already become one of the world's leading exporters of bovine (buffalo) meat. India is unlikely to have a substantial dairy surplus for export, but meat exports have significant potential to grow. India is not a competitive exporter of chicken and goat meat but is highly competitive in buffalo meat, mutton, and pork. Expanding markets for processed meat and halal-certified products provide additional opportunities for export growth. Meat exports can be a means of increasing the offtake rate to improve productivity. Expanding the value of meat and live animal exports requires that India address the pressing feed problem, improve the sanitary quality of finished output, invest in controlling foot and mouth disease (FMD), and implement an identification and traceability system.

Constraints and Challenges

For India's livestock subsector to fulfill its potential, a series of specific constraints and challenges require attention. They range from the need to improve public spending on livestock to particular concerns surrounding animal breeding and genetics, feeding and nutrition, the environmental impacts of the subsector, animal health, markets and value chains, and financial and advisory services related to livestock production.

Public expenditure is low, and priority setting is needed

National expenditure on livestock is low, declining, and insufficient to exploit the

Table 20: Public spending in the livestock subsector in India, selected years

	TE 1992-93	TE 2000-01	TE 2008-09
Public spending as % of total agriculture spending	13.6	9.9	4.6
Public spending as % of livestock output value	3.6	2.8	2.3
Composition of public spending (%)			
Dairy development	41.5	38.6	25.0
Veterinary services and animal health	23.7	24.1	29.1
Cattle and buffalo development	14.0	11.7	10.5
Sheep and wool development	2.7	2.4	2.0
Piggery development	1.8	0.5	0.4
Poultry development	3.1	2.4	2.4
Fodder development	0.9	1.0	1.0
Direction and administration	4.2	8.7	19.1
Research, education, and extension	2.2	3.0	3.0
Others	5.8	7.6	7.5

Source: Birthal and Negi 2012.
Note: TE = triennium ending.

sector's contribution and potential. India's public expenditure on livestock as a percentage of total expenditure in agriculture declined from 13.6 percent in 1992/93 to 4.6 percent in 2008/09, even as the subsector's contribution increased from 22.8 percent of agricultural GDP to 24.8 percent. Spending as a percentage of livestock GDP has declined steadily from 3.6 to 2.3 percent over the same period (Birthal and Negi 2012). The composition of the expenditure is also shifting toward "direction and administration" at the expense of productivity-enhancing activities, with the bulk of expenditures going to the salaries and administration (Table 20). Notably, allocations for the smaller species—small ruminants, poultry, and pigs—that yield more benefits for smallholders remain low and have declined over time.

The National Dairy Plan has a long-term breeding policy and strategy in place, but other segments of the subsector still have no apparent policy or strategy. The scarcity and poor quality of feed is a major constraint for productivity growth and has implications for the environment, but feed is a very low priority in budget allocations, along with research, education, and extension. The importance of extension cannot be overemphasized; inadequate knowledge and management practices directly affect animal health and productivity.

It is critical to prioritize and rationalize public expenditures, especially in the provision of public versus private goods. Monitoring, evaluation, and impact assessment of all government livestock programs is urgently needed to inform future programs, rationalize resource allocations, and enhance the delivery of services.

Breeding and genetics: Room for improvement

Breed improvement programs have generally been overlooked. India has a wide range of animal genetic resources, but only 20 percent are defined breeds. Productivity increases in advanced dairy countries are mostly attributed to genetic improvement (70–75 percent), with the rest attributed to improvements in animals' environment (USDA 2012; F. Miglior, Canadian Dairy Network, 2012, personal communication). India embarked on breed improvement programs in the late 1990s, but less than 10 percent of bulls used for AI have come through any sort of genetic improvement program. The lack of good breeding stock is a major obstacle for cattle but even more so for small ruminants and pigs. Breeding strategies and plans need to be developed at the state level. Breed improvement schemes can be implemented and show results quite rapidly, given the short-cycle nature of small ruminants, the relatively high heritability of key performance traits such as average daily weight gain, and the ability to select animals based on their performance.

India has largely relied on crossbreeding[122] to combine the adaptation of indigenous breeds with the yield capacity possessed by exotic breeds, but upgrading beyond 50–75 percent generally is impractical given India's environmental and resource constraints. Even when practical, there are few examples of sustained genetic improvement with crossbreeds. Nimbkar and Kandasamy's (2012) review finds stagnating performance of crossbred cattle in farmers' and institutional herds. Probable reasons for stagnation include the absence of progeny testing programs for crossbred males and the use of unselected crossbred males (in fact, crossbreeding tends to be indiscriminate, with little attention to breeding policy). The review finds mixed results for other species.

Quality breeding stock is limited, but constraints related to the available technologies (such as AI) lead to generally poor results. Some success has been achieved through AI in the leading dairy states (Andhra Pradesh, Karnataka, Kerala, Punjab, and Tamil Nadu). Problems included low conception rates (35–40 percent on average), with NGOs and private AI centers achieving higher rates than government-run centers because the cows need to be brought to the government location for breeding. Studies have shown that farmers are willing to pay for better conception results, since the overall cost per calf decreases with higher conception rates. Low conception rates are a key factor in reducing productivity, as they result in longer inter-calving periods and less milk production. High levels of infertility mean that many cows do not produce milk at all, as they never get bred. India has more than 6 million infertile cows.

For small ruminants, a recent review by the South Asia Pro-Poor Livestock Policy Programme, (SAPPLPP 2012a, 2012b) highlights that the best-performing animals among local breeds can have great productive potential. The screening and systematic selection of livestock populations could rapidly yield results to benefit the poorer livestock-keepers who rely on low-input systems.

Feeding and nutrition: Issues of scarcity and quality

Poor nutrition is a leading production constraint, and all projections indicate severe shortages of feed and fodder in the future

122 Crossbreds, with varying level of exotic inheritance, accounted for 24 percent of dairy cattle in 2007, but the proportion of crossbred small ruminants and pigs is negligible (GOI 2008b).

(Ramachandra et al. 2007, Herrero et al. 2009).[123] Feed costs are already rising as the costs of crop production increase and the available land decreases. For commercial poultry and dairy producers, prices of feed such as sorghum and maize have increased faster in recent years than the prices of milk, eggs, or meat. Between 1990–91 and 2005–06, the chicken to maize price ratio declined to half, and the egg to maize price ratio fell from 0.33 to 0.26 (Blümmel and Rao 2008).

Access to quality seed of fodder crops remains a constraint: Only about 7 percent of the estimated 10.5 million hectares of fodder grown in India is planted with improved seed. Commercially processed feed of assured quality, accessibly priced and accurately labeled, is in short supply. For that reason, a large proportion of feed concentrates are home-made, often with limited or no understanding of the nutritive value of the components or the nutritional requirements of the animals. This practice increases wastage as well as producers' costs.[124]

Smallholders use crops for food and feed. In maize, sorghum, millet, and groundnut, for example, crop breeding can improve the quality of stover and other crop by-products for livestock in addition to increasing grain yield, but such opportunities are often overlooked. Given the likely increase in reliance on crop residues for feed (Ramachandra et al. 2007) and the reduced availability of high-quality residues like sorghum and millet, the need for better integration of crop and livestock production systems is apparent.[125] Feed storage receives little attention, despite the routine occurrence of feed shortages during the summer months.

Poor integration of crop and livestock production also has consequences for crops and the environment. Manure is the second most valuable livestock product, yet improper storage and application limit its contribution to soil fertility or as an economic option for energy and biofuels. A considerable proportion of crop residue is burned in Punjab and Haryana—squandering an otherwise useful feed resource.

Common property resources are diminishing and their quality is declining. Pastoralists and the landless rely heavily on public grazing land and common property to sustain their animals, but both poor and rich producers relied equally on common property for feed (GOI 1999; Narain, Gupta, and Veld 2005). Communal land declined by an estimated 14 percent between 1980/81 and 2008/09 and now accounts for a mere 3 percent of India's geographical area (Birthal and Negi 2012). These lands are degraded through overstocking and poor management or are increasingly lost to encroachment. The management of common property requires alternative institutional arrangements to reconcile administrative and legal procedures and alternative management practices to reduce the stocking rate, increase offtake through culling, and improve the land's silvopasture potential through regrowth and management.

123 Dikshit and Birthal (2010) predict that by 2020 India will need an additional 100 million tons of green fodder, 60 million tons of dry matter, and 9 million tons of concentrates for feeding its livestock population, excluding poultry. Poultry production would demand an additional 27 million tons of feed (Robinson and Makkar 2012), which translates into an additional protein requirement of approximately 6 million tons (equivalent to 60 million tons of cereals or 2.4 million tons of soybean; see Makkar 2012).

124 Garg, Biradar, and Kannan (2009) find that nearly 90 percent of cows in Gujarat were overfed, but with balanced rations, costs decreased by 10 percent and production increased by 10 percent.

125 Lower-quality residues such as rice and wheat, unless inexpensively treated with urea, have little nutritive value, yet they are the main feed source for most livestock.

Environmental aspects of increasing livestock productivity

As pressure on water and land resources rises throughout India, it will not be sustainable to meet the increased demand for livestock products by expanding animal numbers. To produce one liter of milk in Gujarat requires 2,000–4,600 liters of water, mainly to grow feed (Singh 2004), against the world average of about 900 liters of water per liter of milk. India's water use per liter of milk exceeds the world average in most intensive and semi-intensive systems. For example, using several field locations in the Indo-Ganga Basin, Haileslassie et al. (2011) find that the water used to produce a liter of milk ranged between 1,300 and more than 3,000 liters. Smallholder production systems based on crop residues make more efficient use of water (Peden, Tadesse, and Misra 2007), but continuing pressures for intensification are likely to exacerbate the pressure on water resources unless specific ways to increase livestock water productivity are encouraged. Potential strategies include increased use of crop residues and by-products, managing the spatial distribution of feed resources in ways that match availability more closely with demand, and enhancing animal productivity (Peden, Tadesse, and Misra 2007).

India is already witnessing the pressures on land from its growing human population and increasing demands for alternative uses. Livestock stocking rates are nearly 5–10 times the recommended levels in many areas.[126] Livestock need to be managed in ways that maintain vegetative groundcover to avoid increased soil erosion, down-slope sedimentation, reduced water infiltration and groundwater recharge, and ultimately reduced pasture production (Sheehy et al. 1996).

Climate change and increased weather variability will also affect livestock development and require adaptation strategies. India's production environment is characterized by heat stress, drought, and flooding, all of which are likely to become more frequent. A large number of adaptation strategies exist, but greater implementation is needed. Kurukulasuriya and Rosenthal (2003) provide a useful framework to consider several adaptation options. *Micro-level adaptation options* include diversification and intensification of crop and livestock production, pasture management, irrigation of fodder crops, planning breeding seasons to coincide with resources, fodder storage, and better timing and management of disease prevention efforts, given that climate accounts for 52–84 percent of the variation in FMD incidence. *Innovative mechanisms* include weather-indexed insurance schemes to better manage weather risks and support increased technology adoption, remote banking to promote savings instead of overstocking, and marketing livestock to limit risk. *Institutional changes* include support for producer organizations (for inputs and markets), management of common property, and the development of fodder markets. *Technological developments* include dual-purpose varieties suitable for feed and fodder, varieties bred for better-quality crop residue, agroforestry varieties, improved animal health, low-cost animal shelters, and better-adapted species and breeds, among many others. FAO is currently mobilizing a major global initiative on sustainable livestock development, initially focusing on enhancing resource-use efficiency

126 In rainfed areas, the present stocking rate is 1–5 tropical livestock units (1 TLU = 250 kilograms, or roughly the size of one indigenous cow) per hectare against a recommended 1 TLU, whereas in arid zones the stocking rates are 1–4 TLU per hectare against a recommendation of 0.2–0.4.

in livestock production, reducing pollution, and restoring grazing and pasture lands. India can benefit significantly by partnering in this global initiative through impact assessments, trade-off analyses, and networking in search of appropriate technologies and institutional models.

Deficiencies in animal health services and disease control

Animal health and veterinary services account for the highest share of public expenditure in the livestock sector, but service provision is not very effective. Disease prevention and control are the shared responsibility of central and state governments. Despite increased public expenditures and an expansion in the number of veterinarians and paravets, disease prevention and control remain inadequate. Weak capacity for diagnosis and insufficient drugs for treatment undermine the quality and efficiency of the services provided. Disease surveillance suffers from underreporting, untimely reporting, or failure to report important diseases. The reporting hierarchy, complex reporting forms, and lack of facilities for quick communication are additional constraints (Ahuja et al. 2008; WGAHD 2012).

Increased public expenditures on animal health must be accompanied by reforms in animal health services.[127] The high incidence of some major diseases inflicts substantial and increasing economic losses on all livestock-owning households, particularly poor and marginal households. India has been declared free of rinderpest, but a number of other diseases persist.[128] No accurate data are available on the total financial and economic losses caused by animal diseases. Various estimates put the losses between Rs. 50 billion and Rs. 132 billion annually (Chawla et al. 2004; Ahuja et al. 2008). More recent estimates (Indian Immunologicals 2012) are several times higher.

To be effective, national programs for priority diseases need to be more systematic and targeted. The government has identified FMD as the highest-priority disease and launched a national program. This is a very good step, and similar programs could be undertaken for control of PPR,[129] brucellosis, and other diseases. The FMD program is not without formidable challenges. It has seen a dramatic increase in coverage, yet it falls considerably short of the target of 85 percent needed for effective control. Additionally, FMD control is complicated by factors such as the many serotypes of the virus, the lack of sufficient vaccine and systematic vaccination, unrestricted movements of livestock across state and national borders, and symptom-free small ruminants with the disease, which often goes undetected. Infrastructure for disease surveillance and reporting needs to be expanded as well as consolidated for functionality and efficiency to provide the foundation for a needs-based system to deliver animal health services. Legislation related to the control of infectious and contagious animal diseases should be updated and enforced effectively, making disease reporting mandatory.

As with FMD, classical swine fever, and many other priority diseases, vaccine supplies are

127 Reformed health and extension delivery system are reviewed in greater detail in Ahuja (2004); Ahuja, Morrenhof, and Sen (2003); Ahuja, Umali-Deininger, and de Haan (2003); Ahuja et al. (2003).

128 Such as FMD, black quarter, haemorrhagic septicemia, blue tongue, PPR, sheep and goat pox, and classic swine fever. Poultry are affected by Newcastle disease, infectious bursal disease, chronic respiratory diseases, and H5N1 (highly pathogenic avian influenza).

129 Peste des petits ruminants (ovine rinderpest).

inadequate. Problems in ensuring a cold chain heighten the need to develop heat-stable vaccines. Except for the FMD vaccine, most other vaccines are produced by the obsolete state biological units, which do not have the modern infrastructure or qualified staff to operate effectively or comply with Government Minimum Standards.

Distribution of curative healthcare facilities and human resources across states is not always congruent with distribution of livestock, and these facilities are inadequately funded to deliver effective services of adequate quality. Only 28 percent of livestock producers currently use veterinary services (World Bank 2009). Government services are often overloaded, and the ratio of livestock to veterinarian is among the highest in some of the poorest states, such as Bihar, Chhattisgarh, Jharkhand, Madhya Pradesh, and Rajasthan. The distribution of veterinary institutions also reflects a bias toward large animals, as states with larger small ruminant populations have fewer veterinary institutions. State livestock departments are overstretched, with responsibilities for a number of services (many of which would ideally be privatized). NGOs and the private sector are active in service provision in advanced dairy states where the public sector also has a strong presence—perhaps because emerging commercial livestock producers are more able and willing to pay for private services. The ratio of veterinarians to animals could be improved by employing more paravets, who could handle general clinical services and enable vets to concentrate on more complicated problems of diagnosis and treatment.

Veterinary services provided in dispensaries and other centers are supposed to include prescription and basic drugs and vaccines free of charge or at nominal or subsidized cost, yet most of this subsidy does not reach the intended beneficiaries. Often, dispensaries and service centers lack the budget to stock drugs. Centers may also charge a nominal fee for home visits, especially to cover transport costs. In such cases, the basic drugs are still supposed to be provided free or at a nominal cost. In reality, the free services provided by the veterinary centers are limited to prescriptions issued by veterinarians. In the case of home visits, in addition to the cost of medicine and the transport fee, government veterinarians charge visit fees, which are not substantially different from those charged by private veterinarians (Ahuja et al. 2003; Ahuja, Rajasekhar and Raju 2008). There is a wide variation between states in terms of fees charged for home visits. In some of the leading dairy states like Punjab and Haryana, over 70 percent of farm-gate services are provided by public sector veterinarians on a "private contract" basis, at commercial rates—which the larger commercial producers are willing to pay, as they get satisfactory service.

Rapidly growing markets and value chains require better organization and attention to quality standards

Markets for all product groups are by and large unorganized, traditional, and fragmented, except for some portion of the dairy, poultry, and egg markets. Marketed surplus of livestock and livestock products, and producers' participation in product and input markets, vary considerably between the main product groups.

Dairy marketing. Traditional dairy marketing systems have been complemented by cooperatives since the early 1970s, and the private sector has been playing an increasingly important role since the market liberalization of the early 1990s. Cooperatives dominated the dairy processing industry due to regulatory restrictions on private processing firms. With the removal of those restrictions, the structure of dairy markets changed significantly. The private sector quickly overtook the cooperatives in numbers of processing plants and installed capacity. Between 1996 and 2010, the share of the private sector in the number of plants increased from 49 to 67 percent and in installed capacity from 44 to 58 percent.

Wide differences are seen between states in processing capacity, the market shares held by private, cooperative, and traditional processors, and the disposal pattern of marketed milk. Shares of national milk output and shares of national processing capacity are converging in the leading dairy states, although not in the lagging states. Uttar Pradesh and Maharashtra have the highest concentration of processing capacity (each state has 20 percent of national capacity); Gujarat has 11.2 percent; Tamil Nadu, 7.2 percent; and Haryana, 6.4 percent. Average plant size is fairly small in Uttar Pradesh (83,000 liters per day) compared to Gujarat (1,667,000 liters per day), Tamil Nadu (184,000 liters per day), and Haryana (168, 000 liters per day) (Ahuja and Sharma 2005).

Meat marketing. The Indian meat industry is highly fragmented and unorganized. Offtake rates of live animals are low, and domestic markets for live animals and meat are few and unorganized. Generally, market chains for cattle and small ruminants are fairly similar, and each involves a number of intermediaries.

Modern, sanitary slaughtering and optimum utilization of by-products are the most important issues to be addressed by the meat industry, especially as demands for quality and safety are increasing in urban areas and meat exports are growing as well. The total meat-processing capacity in India is over 1 million tonnes per year, of which about 40–50 percent is utilized. Meat-processing infrastructure is inadequate and of poor quality. In 2007–08, only 29 percent of meat was produced in registered slaughterhouses, with the rest coming from unregistered slaughter slabs/points and markets (GOI 2008b; Birthal 2008). Adequate, standard slaughter facilities are not available to provide proper sanitary conditions. Slaughterhouses also lack facilities for processing wastage and by-products, leading to a large loss of value. Quality and hygiene levels in the wet markets are low because of improper handling and the lack of water, electricity, and facilities for hanging carcasses/flaying. These problems add to wastage and the deterioration of meat quality.

India has fast emerged as a leading exporter of buffalo meat, accounting for nearly one-quarter of the world's beef trade, compared to just 8 percent in 2009. Lower prices, the ability to provide halal products, and robust demand (largely from the Middle East, Africa, and southern Asia) have contributed to the rapid rise of exports. In response to this rapid growth, new slaughterhouses are emerging, providing farmers with new outlets for nonproductive buffalo heifers, bulls, and bull calves. India is cost competitive in the export markets, but poor quality and food safety standards could block it from capitalizing on this potential. As discussed in greater detail later, there is a critical need to invest in upgrading food safety and quality standards throughout the value chain, implement risk assessment mechanisms and infrastructure, and set up a nationwide animal identification and traceability system.

In the commercial poultry industry, the dominant mode of production and marketing in the broiler industry is contract farming, while independent enterprises remain dominant in the layer industry. Like dairy production, commercial poultry production is also concentrated in a few states. For example, in 2004–05, Tamil Nadu, Karnataka, Maharashtra, and Andhra Pradesh produced 41 percent of total broiler output in the country, and 78 percent of it was under contracts (Annex 10, Table A.10.3). Both the broiler and layer industries have scaled up significantly, including contract production units. The benefits to smallholders from the growth of the sector, with its increased specialization and economies of scale, have been limited to the few states where the industry is concentrated.

The market is large and growing, offering significant scope for other states, especially the lagging states, to participate. Creating the enabling environment to establish such value chains or to create links to already functioning value chains in other states would benefit smallholders in the lagging states. Backyard poultry is still a major source of poultry meat and eggs in India, but little support is available from the public or private sector to address the production and marketing problems of such small-scale producers.

Quality and safety standards. Quality and safety standards in all value chains for livestock products are poor. As incomes and urbanization increase, so do concerns about food standards, quality, safety, variety, and convenience (Grace, Baker, and Randolph 2010). To address problems such as adulteration; improper or overuse of antibiotics, hormones, and additives; unhygienic handling of products; and inappropriate transportation and storage, the Food Safety and Standards Act 2006 was promulgated. The Act consolidated previous regulations and went into effect from August 2011. The implementation of the law remains very poor because laboratories are few in number and lack trained personnel and infrastructure (WGAHD 2012). Quality and safety standards in domestic and export value chains are managed through a number of regulations and implementing authorities with little coordination. The main challenge here is to ensure the coordination and enforcement of quality and safety standards along the value chain, as effectiveness in individual nodes will have a limited impact.

Very limited access to credit and insurance

Access to credit and insurance coverage are limited, declining, and biased toward dairy and the leading states. Livestock's share in agricultural output is consistently increasing, yet its share in agricultural credit has dwindled over time (Annex 10 Table A.10.4). The preference for lending to dairy and large animal producers reduces the chances for producers in lagging states to access credit. The institutional response for smallholders has been the microcredit industry, with a growing number of schemes linking banks with Self Help Groups and private banks entering the microcredit sector.

Livestock insurance coverage has increased from a relatively low base, but only 6 percent of animals, mainly dairy animals, are covered. The figures are slightly higher for poultry because of the Poultry Venture Capital scheme, in which credit for commercial poultry production is linked with insurance (WGAHD 2012). New insurance products generally target high-yielding animals and commercial production systems. Private insurance providers are working with pro-poor development agencies in several states and have a sizeable number of clients, but they are encountering problems of high transaction costs, improper selection of clients, and moral hazard in settlement of claims (Sirohi et al. 2008).

Livestock advisory and extension services are negligible

Access to advisory and extension services remains negligible for livestock keepers. Health service providers are also responsible for providing extension services, but nationally only about 4 percent of households claim to have access to livestock-related information.[130] In contrast, 28 percent of farmers said they had advisory support for crop production. Livestock producers tend to rely on the more progressive local livestock farmers and the media (TV, radio, newspapers) as their main source of livestock production information. In designing the content of extension packages and institutional arrangements for delivering extension services, it is important to respond to market demands so livestock producers can link to existing or emerging value chains (Sirohi et al. 2008).

Conclusions and Implications

Policy interventions to raise productivity in the livestock sector need to target service delivery and institutions for technology, marketing, and animal health. The National Dairy Plan provides an example of this kind of multi-pronged approach. It is a multi-state initiative to improve animal productivity, strengthen/expand infrastructure for milk procurement at the village level, and enhance milk processing capacity and marketing, backed with appropriate policy and regulatory measures. The program emphasizes enhancing productivity and strengthening village-level institutions and milk collection systems. Investments in breeding and feeding, as well as in strengthening and expanding infrastructure for the production, processing, and marketing of milk products, are targeted. It proposes to develop new business models to link the unorganized sector to value chains by establishing new producer companies alongside cooperatives to provide viable alternative forms of dairy marketing (GOI 2012).

Lack of timely, accurate information on the livestock population is a fundamental problem. Accurate population data and data at the animal production level are lacking. The National Dairy Plan aims to set up an information network for animal productivity and health, and the country's first unique identification and information database for dairy, called the Information Network for Animal Production and Health.

A similar approach would benefit the meat and other livestock subsectors, such as poultry and pigs. With a dual production structure emerging in the country, in addition to encouraging commercial and large-scale operations, special attention must be given to technology, institutional, and policy measures that can support the development of smallholder systems to produce animals more efficiently and sustainably, and compete profitably in a price- and quality-conscious market.

Potential gains from genetic improvement will be squandered if feed constraints persist. The manufacture of concentrates is expected to increase as livestock production scales up and becomes increasingly commercial, but

130 The rates are slightly higher in leading dairy states.

other avenues for improved feed supply will require attention. These include green fodder production, dual-purpose food and feed crops in farming systems, dual-purpose varieties for grain and stover, the treatment of crop residues, facilitating feed market development, trade policy to guide domestic production versus imports of maize and soybeans, and better management of common property resources. The priority given to these issues will vary depending on their relative importance in different states.

Animals' productive potential depends crucially on the animal health system, which has a poor performance record. The quality of livestock support services remains inadequate and poor, and disease surveillance, control, diagnostics, and reporting continue to be weak. Serious steps are required to improve animal health and extension support systems (including identification and traceability), identify areas of public and private investment, institute policies attractive for the private sector, and reform public service delivery systems to become more efficient and responsive. To ease funding constraints, subsidies on drugs should be phased out, with government clinics either charging the full cost for essential drugs or not stocking them (Ahuja 2004).

Investments in market infrastructure are important for the efficient distribution of livestock products. A large proportion of the investment will necessarily come from the private sector. In addition, the public sector needs to pay attention to measures that will help smallholders improve their bargaining power and build their capacity to absorb production and market risks. Options include policy and public support for producer organizations, risk mitigation, reputation-building through labeling or branding programs, and improving access to information with respect to pricing and product quality.

Improvements in extension services will be critical to promote modern practices to produce products that meet the quality requirements of domestic and international markets. An important part of these advisory services will be monitoring and evaluating the activities of animal health extension services provided by ATMA and KVKs.[131] A strategy to develop the capacity of livestock extension staff is needed. Programs to improve access to credit and insurance services for smallholders, and for animals other than the high-yielding larger animals (cattle), need to be developed and piloted.

131 Krishi Vigyan Kendras (Agricultural Science Centres) are extension outreach programs.

D. Moving Beyond the Farm: Investments, Markets and Food Processing

India's agricultural markets have long a long history of active government intervention. The overall regulatory framework was initially established to prevent market failures (as in the Bengal Famine) resulting from inadequate state intervention (Acharya 2006). From the 1960s, various instruments were introduced to support the green revolution and achieve food security (Chand 2003b; Acharya 2004). The instruments introduced in the 1960s and 1970s are now widely viewed as being outdated and unproductive, to the extent that the current situation is characterized a market failure "due to excessive state intervention" (Acharya 2006).

Agricultural markets in India have been studied extensively.[132] The consensus from these analyses is that India's agricultural markets are inefficient and fragmented, lacking integration across parts of the country (Gulati, Landes, and Ganguly 2009; Reardon and Minten 2013; Sekhar 2012).

Some regulations have eased over time, especially since the 1990s, but reform has been slow, uneven, and often marked with reversals. By and large, the perception is that the reforms have been insufficiently deep or broad to promote the level of marketing, trade, value addition, and food processing needed for the modern, diversified, and vibrant agriculture that India has tremendous potential to realize (Acharya et al. 2012; Ganesh-Kumar et al. 2012; GOI 2013b).

It is noteworthy that when and where reforms are introduced, even if partially, the private sector response is swift and dynamic, as witnessed by the emergence of contract farming, electronic exchanges, ICT-based market information systems and kiosks, and myriad value chain improvements (Birthal et al. 2006, 2012, Joshi; Gulati, and Cummings 2007; Gulati and Ganguly 2010; FICCI 2010; Readon and Minten 2013) and the recent rapid growth in exports (Gulati, Jain, and Hoda 2013).

Given the importance of marketing and other post-farm elements of agricultural value chains, this section builds on the large knowledge base to focus on three themes. The first is a brief review of the current situation with agricultural markets, especially the current status of the two main regulatory reforms—the APMC Act and ECA (arguably the two most binding constraints for the proper functioning of agricultural markets). The second theme is a review of the efficacy of alternative marketing arrangements in reaching small-scale farmers. The third theme is the key issues associated with food processing, an understudied and underexploited avenue for diversifying agriculture and increasing off-farm employment, particularly in the poorer and more agriculturally dominated states.

132 For an overview, see GOI (2007, 2012) and Reardon and Minten (2013); see also Rashid, Gulati, and Cummings (2008); Ganesh-Kumar, Gulati, and Cummings (2007); Mattoo, Mishra, and Narain (2007); Joshi, Gulati, and Cummings (2007); Landes and Burfisher (2009); Gulati, Ganguly, and Shreedhar (2011); and World Bank (1999, 2005, 2007d, 2008b).

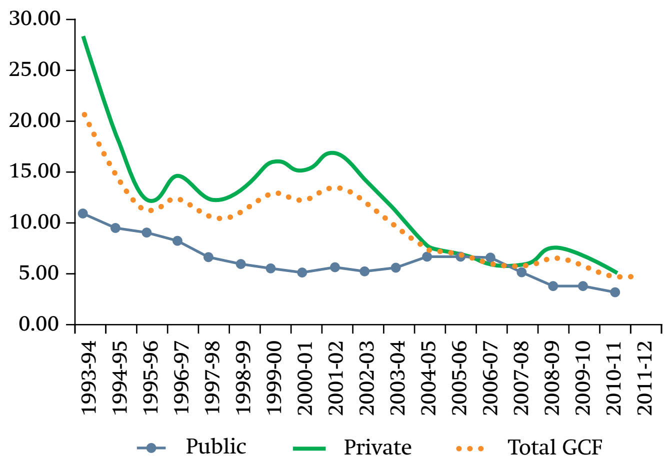
11 INVESTMENTS FOR GROWTH AND SUSTAINABILITY

The importance of investment for productivity and growth cannot be understated. The relationships between capital formation and agricultural growth and labor productivity, as well as the "crowding in" effects of public investment on private investments, are well established (Larson et al. 2000; Stephan et al. 2009; FAO 2011; Bisaliah and Dev 2012; Chand and Parappurathu 2012). Not surprisingly, the "neglect" of agriculture (GOI 2007) sparked serious concerns, given the lengthy decline in public investment from levels that were already low—it peaked in the 1970s at about 4 percent of agricultural GDP (Chand and Parappurathu 2012).

As shown in Figure 10 earlier, public investments increased after 2003/04. This major reversal from the negative growth rates in the 1980s and 1990s (Bisaliah and Dev 2012) was the outcome of a concerted effort through several major programs (some in national "mission" modes) during the Eleventh Five Year Plan, with substantial budgetary resources allocated to boost agricultural growth. Since 2006/07, the trend has been relatively flat, however. Private investment has consistently increased since the mid-1990s, reaching about 20 percent of agricultural GDP, and now accounts for over 80 percent of total investment in the sector. This development is positive. Agriculture is private enterprise, and increased private participation is the way to the future. Yet both public as well as private investments are needed—they are not substitutes.

As a share of total capital formation in the economy, however, the trends continue to decline for both public and private investments (Figure 65). For the private sector, the trend reflects a revealed preference for investment outside the sector, perhaps driven by higher returns or by an inadequate enabling environment for investment in agriculture. Public investment is slipping once again after its brief increase in the mid-2000s.

Figure 65: Share of agriculture in gross capital formation



Source: Authors, using CSO statistics.

Table 21: Government expenditures on agriculture and allied sectors (all India, 2004/05 prices)

Particulars	TE 1995	TE 2009
Government expenditure for agriculture (Rs billions)	827	2,202
Share of capital expenditure in total agriicultural expenditure (%)	17	23
Share of union government in total agricultural expenditure (%)	26	49
Share of agricultural expenditure in AgGDP (%)	20	35
Share of agriculture in developmental expenditure (%)	23	33
Agricultural expenditure per capita of rural population (Rs)	1,316	2,966
Agricultural expenditure per ha (NSA) (Rs)	5,794	15,645
Share of agricultural research and education in AgGDP (%)	0.45	0.58
Share of agricultural extension in AgGDP (%)	0.14	0.15

Source: Singh 2011, using Combined Finance and Revenue Accounts, GOI (various issues).

Trends in Public Expenditure

For a sector deemed to be a priority, agriculture's continued diminishing share of public investment would seem to indicate otherwise. That assessment may not be accurate, however. Using a broader definition of public expenditure that includes expenditures *in* the sector (directly though agriculture programs and institutions) and expenditures *for* the sector (for complementary public investments in other sectors like rural roads and electricity, which also show the priority that the government assigns to promoting agricultural growth), Singh (2011) finds that public spending to support agriculture is substantially higher, in real absolute and relative terms, in 2009 (13 percent) than it was in the mid-1990s (2.5 percent) (Table 21).[133]

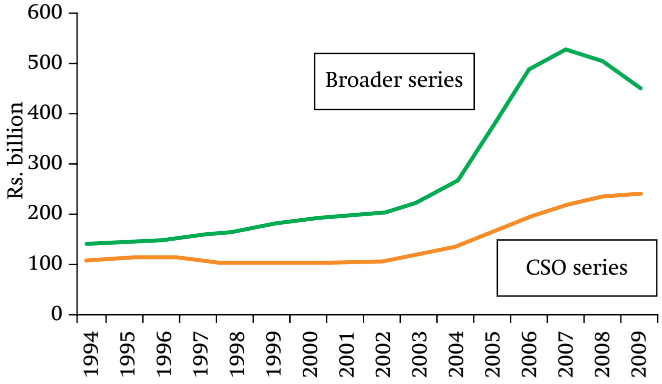
133 Singh (2011) includes a comprehensive assessment of total central and state expenditures covering both the capital account (investment) and revenue account (noninvestment or recurrent) expenditures incurred on rural infrastructure (rural roads and electricity), irrigation (major and medium, minor and command area development), rural development and rural employment programs (including land reforms), expenditures on crop husbandry, soil and water conservation, animal and dairy husbandry, fisheries, agricultural research and education, extension, and training.

Clearly, agricultural expenditures are substantial, now equivalent to *one-third of agricultural GDP*. The rising trends in intensity (as a share of sector GDP) and allocation (as a share of development expenditures) suggest that agriculture is indeed receiving higher priority. Another change over time is the significantly larger role of the central (union) government in funding the sector, financing almost half of total spending in 2009.

There is nevertheless an important distinction to be made between public expenditures and public investments. Of total expenditures, capital expenditures reflect the expansion of productive capacity or public investment, and these have also risen, indicating a rising priority for capital formation (Figure 66). The broader measure of investment (capital expenditures directly in agriculture and indirectly for agriculture through other sectors) is significantly higher than the CSO estimate.[134] The broader series also shows significantly faster growth than the CSO series, being

134 The CSO data include largely major and minor irrigation capital expenditures, which is a much narrower definition than that used by Singh (2011).

Figure 66: Trends in public investment (2004/05 prices)



Source: Singh 2011.

Figure 67: Subsidies and public investment as a share of agricultural GDP

Source: Based on data from Hoda and Gulati 2013 and the Planning Commission website.

particularly high in the 2000s (15 percent).[135] In totality, however, investments still constitute less than 23 percent of public expenditures, indicating that the vast majority of public spending is not directed at increased public investments.

In addition to levels of expenditure, the composition of expenditures is an important indicator of the relative priority placed on different components of public expenditures. A breakdown shows the largest share going to rural infrastructure (34 percent), followed by input support services (26 percent), rural development (23 percent), irrigation (15 percent) and agricultural research, education, and extension (at under 2 percent). Among these items, expenditures on input and support services grew the fastest (at 22 percent annually), which includes the provision of private goods (including subsidies), followed by infrastructure (13 percent), consisting mainly of rural roads and rural electrification, rural development (13 percent), and major and medium irrigation facilities (11 percent).

Singh's analysis shows increasing investments as well as increasing concentration in delivery of private goods or subsidies. But it does not fully account for the substantial public expenditures on subsidies in various forms. Given the many concerns about the composition of public expenditures and the need to boost investments in agriculture (Gulati and Narayanan 2003; Chand and Kumar 2004; GOI 2007), a brief update on these other budgetary expenditures is useful.

In a separate detailed study, Hoda and Gulati (2013) estimate current (and recent) levels of the major categories of subsidies supporting agriculture. These estimates also do not capture the totality of subsidies to agriculture, such as subsidized credit or subsidies provided through various rural development or other programs that may be reflected in Singh's analysis, but which likely account for some of the largest elements in the total.

135 Singh (2011) includes agricultural input supply and services as part of the broader series to capture the expenditures that "influence agricultural growth." Earlier analysts have made similar arguments in analyzing public expenditures, using varying definitions and time periods (for example, see Fan et al. 1997; Chand 2000; Roy and Pal 2002). How much of the capital expenditures estimated by Singh fall under the category of inputs and services is not specified in the paper.

Comparing the findings of Hoda and Gulati with the data on gross capital formation (CSO estimates) in Figure 67 shows that the share of five major subsidies in public expenditures continues to far outweigh public investments. As noted, the CSO data are more limited, but even when using an approximation of the broader public investments from Singh's (2011) estimates, which is roughly double the CSO estimate, subsidies still dwarf public investments.[136]

As discussed, to kick-start agricultural growth, the government initiated a number of programs or "missions" targeting substantial resources to raise agricultural productivity or reduce poverty, which may also be contributing to capital formation in agriculture (Dev 2013a). Among these, the two largest schemes are the National Food Security Mission (NFSM) (2007) and Rashtriya Krishi Vikas Yojana (RKVY) (2007), providing funds equivalent to about US$ 2 billion per year to state governments toward agricultural development.[137] A review of their implementation in three states (Andhra Pradesh, Bihar, and Gujarat, chosen to represent different levels of development) for 2013/14 shows subsidies rather than capital formation to be the preferred mode to stimulate agriculture. Depending on the state, 88–98 percent of the NFSM funds were allocated to the distribution of subsidies for purchasing various inputs (see Annex 11, Table A.11.1).

136 This approximation overstates the share of pure public investments, as Singh's (2011) analysis does not look at the composition of sectoral expenditures—for example, how much of the expenditures on power are for subsidies or how much of the rural development expenditures are in the form of subsidized private goods.

137 See http://rkvymis.dacnet.nic.in/(S(aqx2bynqxqv2ctrtauu2gjt2))/Reports/SectorWiseApprovedCost.aspx, http://www.nfsm.gov.in/ReleasedApproval.aspx.

The second program, RKVY,[138] is the government's flagship effort to consolidate various programs and provide essentially unconditional transfers to states to flexibly align public expenditures to their priorities. The review of RKVY for the same states also shows a clear preference for distributing inputs in Bihar (87 percent). The extent of subsidy provision is less in Andhra Pradesh (69 percent) and Gujarat (42 percent) but still substantial (Annex 11, Table A.11.2). Gujarat has paid relatively more attention to delivering services and building institutions and capacity, showing selectivity in targeting key constraints (Raturi 2011; Feroni and Zhou 2012). The other two states have focused primarily on input distribution to drive production. Overall, both the assessments indicate the pervasiveness of subsidies in various programs and schemes designed to promote agriculture.

Trends in Private Investment

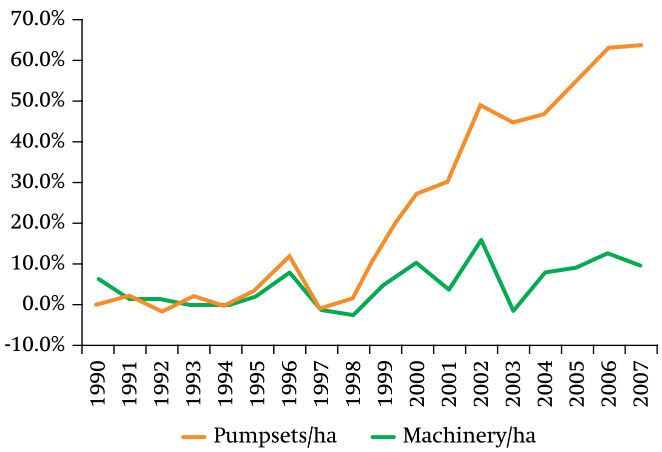
The aggregate CSO data show that private investment has increased significantly since about 2000 (Figure 10).[139] The vast majority (90 percent) of these investments are estimated to be made by farmers for on-farm production (HLC 2009). Data from the district-level database show trends in farm equipment that are consistent with the CSO investment trends (Figure 68), with remarkable growth in irrigation pumps per hectare since about 1998. Machinery per hectare (defined as tractors and power tillers) also shows sustained growth at an impressive but relatively lower rate.

Evidence on farm investments at the household level is limited and somewhat mixed. Using

138 See http://rkvy.nic.in/.

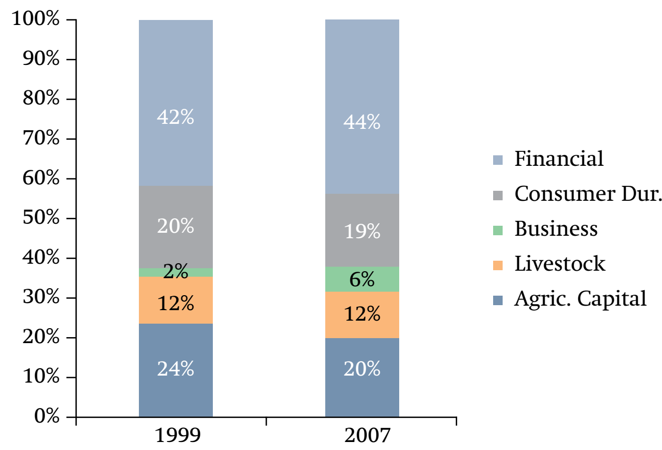
139 The CSO data are based on assumptions regarding credit growth that raise doubts about the actual magnitudes of investment in agriculture (Dev 2013a).

Figure 68: Annual growth in farm equipment



Source: Authors, using ICRISAT-NCAP district database.

Figure 69: Composition of household assets (other than real estate), real 1999 prices



Source: NCAER-REDS survey data.

the CoC data from the Ministry of Agriculture, Bisaliah and Dev (2012) suggest that nonland capital stock per hectare declined on average between 1994–95 and 2007–08. The data are limited and may not represent all forms of farm capital. Bisaliah and Dev do find, however, that irrigation capital showed positive growth, whereas livestock (animal capital) had a negative growth rate. Within the limited accounting for capital, they identify a shift in the composition of nonland capital, with an increase in the share of irrigation capital. They also find an increase in factor productivity for land, labor, and capital, suggesting that perhaps the estimates of capital (excluding animals and irrigation capital) may be not be accurate.

A more complete accounting for household assets, including farm capital, is available in the NCAER-REDS household survey data for 1999 and 2007. Land constitutes an overwhelming 77 percent of all assets owned by households, and buildings (residential or business) account for another 10 percent. Total assets grew by a little over 5 percent per year over the period, but the shares of real estate (land and buildings) remained the same. Among other assets, the share of farm assets (including livestock and physical agricultural capital) declined, while business capital expanded (Figure 69). Households are also saving more, increasing their financial assets.

While the average value of land owned by households increased (5 percent) between the two years, average farm size declined from 5.61 acres to 4.46 acres (about 3 percent per year). Assessing trends in investment (change in capital stock) is thus more appropriately done on a per acre basis (capital–land ratio) to account for changes in farm sizes. Table 22 shows the levels and growth in the value per acre of different types of farm assets that households possessed in 1999 and 2007. The growth in mechanized assets (which includes irrigation equipment) and livestock capital is lower than nonmechanized capital. Nevertheless, the data suggest robust annual growth in all forms of farm capital, with the most rapid growth in nonmechanized capital.

Table 22: On-farm investment (capital per acre), real Rs. 1999

	1999	2007	Annual growth rate
a. Farm (mechanized)	2,771.48	5,552.91	9.1%
b. Farm (nonmechanized)	489.72	2,152.73	20.3%
c. Farm (other)	555.94	1,121.46	9.2%
d. Livestock	4,289.62	9,784.51	10.9%
Agricultural capital (a–c)	3,817.14	8,827.10	11.0%
All farm assets (a–d)	8,106.76	18,611.62	10.9%

Source: NCAER-REDS survey data.

These trends also suggest that although the CSO data on private investments may not reflect a complete picture, their underlying rising trend is corroborated by micro-level estimates. The divergent trend in the CoC data is a bit worrisome, though it should be reiterated that they do not represent the totality of farm investments and hence may not capture some of the dynamic shifts taking place. Both data sets indicate that the level of irrigation has gone up. The REDS survey data show that irrigated area saw strong growth (as a share of overall area owned by households) and unirrigated area contracted.

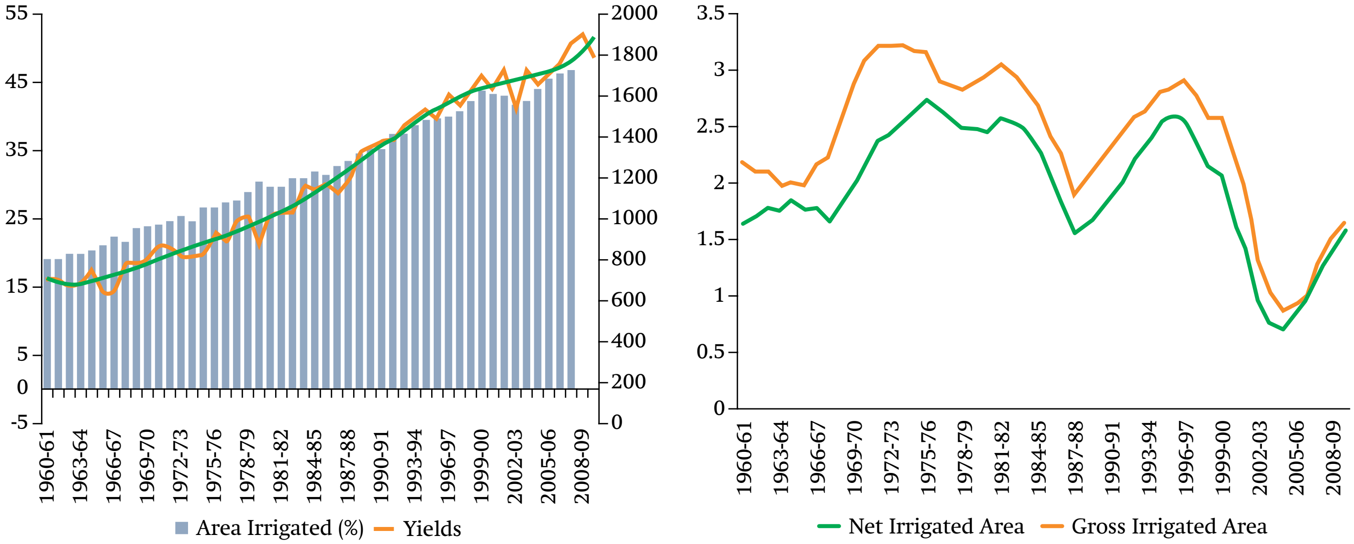
Impact of Expenditure Patterns: Sustaining Productivity

Two major trends identified in this review of public and private investments are the rapid growth in irrigation and the large and growing volume of subsidies in public expenditures. The importance of irrigation in India's agricultural growth is clear from previous chapters and encapsulated in the close relationship between irrigation and yields (at the aggregate level) shown in Figure 70 (left panel). The analysis in this chapter indicates that public expenditures on irrigation have grown rapidly, but their impact on irrigated area is not evident. In fact, growth in irrigated area slowed in the mid-1990s and recovered only slightly after 2004/05. This limited expansion may reflect the constraints on expanding groundwater irrigation (Shah 2007), but most public expenditures on irrigation go to major and medium-scale surface water irrigation facilities (Singh 2011). Despite the substantial potential for surface water expansion (GOI 2013a), this potential does not appear to be translating into additional irrigated area.

In this context, it is important to note that the geographical targeting of public expenditures remains skewed. Singh (2011) analyzes geographical distribution of public expenditures (broadly defined); Annex 11, Figure A.11.1 summarizes the results. Over 2000–09, relative to other parts of India, the eastern states (excluding the northeastern region) received the lowest level of public spending for irrigation as well as infrastructure, both on a per capita and per hectare basis—a continuation of historically skewed public expenditure patterns. This low level of expenditure persists even though eastern India has significantly less irrigation coverage (with the notable exception of Bihar) than the average for all India (45 percent) (Annex 11, Figure A.11.2).

The main driver of irrigation in India over the past three decades has been private investment

Figure 70: Trends in share of irrigated area and yields (left panel) and decadal trend growth rates in share of irrigated area (right panel)

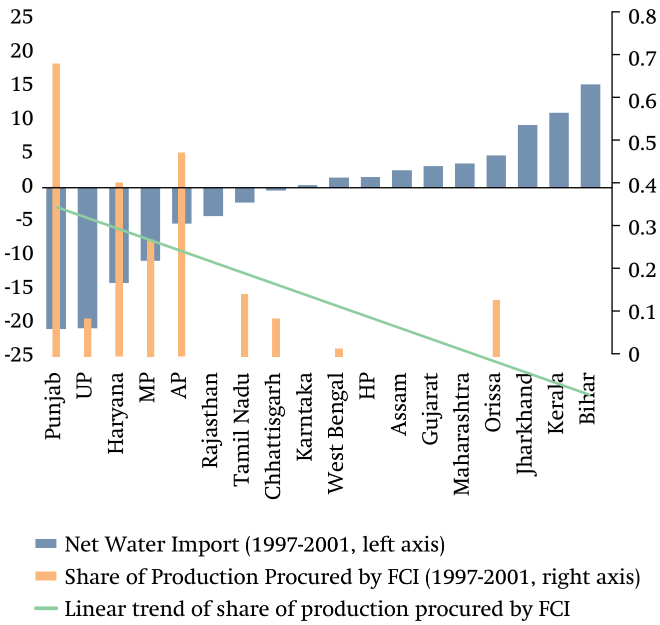


Source: Authors, using DES, MOA data.

in pumps. The International Water Management Institute estimates that almost 62 percent of irrigated area is under groundwater irrigation. Power and credit subsidies, combined with heavy investment for rural electrification, have led to a proliferation of electric pumps for groundwater irrigation. Irrigation has been and will remain an important driver of agricultural productivity—but the main concern is its sustainability. It is widely recognized that the distorted incentives created by subsidized pricing of electricity and credit have encouraged the excessive extraction and highly inefficient use of water. On the benefits side, as shown by Fan, Gulati, and Thorat. (2008) and summarized in Annex 11, Figure A.11.3, power and credit subsidies had large marginal returns in terms of improved productivity and poverty reduction in the 1960s and 1970s. The marginal returns are now greatly diminished and are significantly less than returns to investments in roads, research, and education. The returns to other subsidies are also marginal.

Not only are the marginal returns to subsidies significantly lower than those for other investments—particularly rural roads, research, extension, and education—but they are also likely to be negative when the impacts of subsidies on environmental degradation are considered. This negative impact may already be reflected in slowing productivity and yield growth despite farmers' increasing use of inputs. Specifically, the sustainability of agricultural production itself is threatened as excessive extraction of groundwater makes less water available for future use and water levels fall below a critical threshold from which they may not be able to recover. The political economy of subsidies in India is complex (Birner, Gupta, and Sharma 2011). The public expenditure efficiency as well as budgetary implications have been relegated to the extreme margins of public decision making. Yet the more concrete evidence that is presently emerging on the outsized impacts that current policies will have over the long run calls for

Figure 71: Virtual water imports and public procurement of rice



Source: Kampman 2007 and Authors using DES, MOA data.

urgent attention—not only in the interest of sustainability but in the interest of responding to the serious risks imposed by climate change. The emerging trends and risks are discussed next in greater detail.

The energy-water-agriculture nexus

The negative impacts of free or highly subsidized power supply, including falling groundwater levels and problems with soil and water quality resulting from overuse of groundwater, have long been debated. Badiani and Jessoe (2011) provide rigorous evidence on the impact of electricity subsidies on agriculture as well as the extraction and overexploitation of groundwater.[140] They find that a 10 percent reduction in the average subsidy leads to a 6.7 percent reduction in groundwater extraction. A 10 percent reduction in subsidy also leads to a reduction in the value of water-intensive agricultural output by 3 percent, largely due to the change in the value of rice. These analysts also formally show that electricity subsidies cause an increase in the area planted to water-intensive crops such as rice.

The long-term environmental cost and potential threat to the sustainability of food production can be derived from the findings of a separate study on the impact of groundwater depletion on agriculture. Sekhri (2013) estimates, also using district groundwater panel data combined with production data, that a fall in groundwater level by 1 meter reduces food grain production by 8 percent, water-intensive crops by 9 percent, and cash crops by 5 percent.

Together with MSPs, these policies have driven the changes in crop composition evident in several parts of the country, particularly in the Northwest and Mid-West, where farmers have concentrated on water-intensive crops such as rice and sugarcane. These areas are experiencing the most severe groundwater crises. As shown in Annex 11, Figure A.11.4, the most irrigated crops are cereals and sugarcane, and not surprisingly they are cultivated in the areas with critical groundwater levels.[141] This correlation is shown more clearly in Figure 71, which summarizes virtual water flows across states in India. The figure also shows the strong correlation between

140 They use district groundwater data along with electricity prices and generation data and agricultural production data from the respective government ministries/agencies.

141 Less than 60 percent of the area under rice is irrigated, largely because agro-climatic conditions favor rice in most parts of the country with less access to irrigation. Consequently, wheat has performed significantly better in terms of productivity growth. Sugarcane, on the other hand, has not done so well. Considering that sugarcane had among the highest rates of area expansion in the recovery phase, and that virtually all of that area was irrigated (especially in the major growing states of Uttar Pradesh and Maharashtra), the low improvement in yields may reflect increasing water stress with excess groundwater extraction.

water "export," essentially groundwater in the Northwest, and public procurement of rice. The virtual flow of water from the water-scarce Northwest to the water-surplus East goes against the intent of current development strategy, which is to promote the reverse flow.

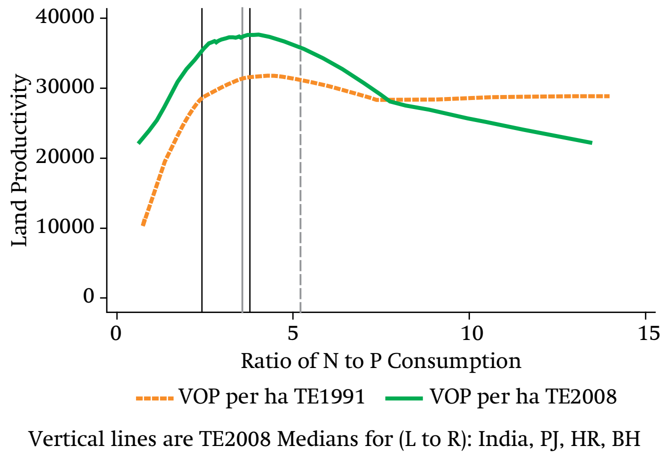
Electricity is an important input to productivity growth, but the new, concrete findings highlight the unsustainability of its current pricing policies: Electricity subsidies drive over-exploitation of groundwater, resulting in a rapid fall in groundwater levels, which in turn drives down agricultural production and productivity. Given the fact that water levels have already fallen rapidly, it is likely that recent growth in agricultural productivity has been lower than it could have been otherwise.

Consequences of imbalanced nutrient use

Another potential policy-driven factor suppressing productivity is the nutrient imbalance resulting from current patterns of fertilizer use. The environmental impacts of imbalanced soil nutrients are widely recognized (see, for example, GOI 2007). When farmers apply significantly more urea than the other major nutrients (potassium and phosphorous), let alone micronutrients, they inadvertently create soil and water problems and contribute to greenhouse gas emissions. Again, the major factor behind this practice is the price distortions created by substantial subsidies that alter the relative price of domestically produced urea relative to the other nutrients.

The direct impact of the imbalanced use of fertilizers on productivity—that is, the current as well as the long-term cost—is less well appreciated. The econometric analysis in Chapter 7 provided evidence of the negative

Figure 72: Impact of nutrient imbalance on land productivity



Source: Authors, using ICRISAT-NCAP district database.

impact of the ratio of nitrogen to other fertilizers on TFP. Using district-level data, a simple nonparametric relationship between land productivity (defined as value of total output per hectare) and the ratio of nitrogen to other nutrients provides a clearer visualization of the likely magnitude of this impact. Figure 72 shows the change in land productivity as the ratio of nitrogen to other nutrients rises. The response initially rises and then falls as the ratio increases.

The drop is quite significant at high levels, indicating a substantial cost in terms of lower productivity. More importantly, the figure shows how the response function has changed between 1991 and 2008. The response at lower levels is higher, showing productivity growth (due to technical change and irrigation expansion), but at higher levels, the decline is sharper and eventually becomes lower, indicating a long-term deterioration of productivity.[142]

142 The response in rice and wheat yields is very similar, with the main difference being a sharper fall at a higher nitrogen ratio.

The figure also shows the all-India median of the nitrogen ratio, which is still below the turning point. For Punjab and Haryana, however, the median is now at the peak response level, indicating that half of the districts are operating on the declining returns part of the response curve. This is not surprising, given the long history of fertilizer use in these states. The surprising result shown in the figure is the average for districts in Bihar: Even in this state, where productivity is relatively low, more than half of the districts operate on the decreasing returns part of the response curve. In other words, the overuse of nitrogen is hurting rather than helping Bihar's farmers, whose productivity is already very low.

These results clearly indicate that policies intended to help increase production and productivity are in fact imposing substantial costs. More importantly, the costs are being borne right now. If they are not checked, they are only likely to rise, resulting in lower productivity and returns to farmers.

Conclusions and Implications

Public spending has grown rapidly since the early 2000s and now equals one-third of agricultural value added, reflecting the priority placed on agriculture by the government. But only a small fraction of this public expenditure goes toward expanding the productive capacity of agriculture (that is, toward capital investments). Subsidies dwarf public investments. The debate on striking a better balance between the much higher return investments and subsidies is not a new one (see GOI 2012). The challenge has been the political economy of subsidies, which has made their budgetary implications seemingly inconsequential in public policy decisions. But evidence is starting to show that these policies are now imposing substantial costs. If public policies are not rationalized, they will further reduce productivity, compromise sustainability and lower the returns to farmers—outcomes that are diametrically opposite to their intent.

12 CURRENT STATE OF AGRICULTURAL MARKETS IN INDIA

Virtually all agricultural produce is bought and sold within India's vast network of market yards, subyards, and Rural Periodic Markets.[143] The traditional marketing chain, passing through agricultural wholesale markets and traditional urban retail, remains dominant for agricultural commodities. Four alternatives have emerged over time, based on distinct types of midstream or downstream buyers: modern retail/cooperatives, the processing sector, the food service sector, and parastatal marketing (Reardon and Minten 2013).

Research on India's traditional markets indicates that they are inefficient;[144] lack integration;[145] are plagued by trader collusion;[146] and are characterized by a high level of physical wastage.[147] Wholesale market infrastructure for staple as well as nonstaple crops is not very developed.[148] Agricultural markets suffer from significant policy distortions, and progress in implementing reforms has been slow and uneven (Chand 2012).

Despite these problems, with rapidly rising incomes and urbanization changing the patterns of demand, all "modern" market channels—private (modern retail, food processing, the food service industry) as well as public (parastatals)—show high annual growth rates. Modern retail is growing the fastest at 50 percent annually, although it has started from a very low base. Modern retail is estimated to account for about 3–5 percent of the produce (nonstaple) market (Readon and Minten 2013). The expansion of modern retail could have several important effects on the rural-urban food supply chain as experienced in many other countries (Reardon, Timmer and Minten 2010). It could change the processing sector and the way it does business. It could reduce transaction costs, make pricing more transparent, introduce economies of scale in transport, and enhance food safety and quality. Urban consumers could benefit from lower prices and lower transaction costs.

Even the traditional value chains for staples are seeing important changes (Reardon and Minten 2013). Upstream, farming technologies and farmers' factor markets are quickly changing, while in output markets, the majority of farmers are empowered by access to mobile phones. Midstream, fewer intermediaries seem to be involved in operations (a process described as dis-intermediation) that are growing in scale.

143 There were 7,246 regulated markets at the end of 2011 and 21,238 recognized Rural Periodic Markets, about 20 percent of which worked under the ambit of market regulations (Patnaik and Sharma, 2013).

144 Umali-Deininger and Deininger (2001); Ramaswami and Balakrishnan 2002; Thomas (2003); Matoo, Mishra, and Narain (2007); Gulati, Landes, and Ganguly (2009).

145 Palaskas and Harriss-White (1996); Sekhar (2012).

146 Banerji and Meenakshi (2004).

147 Matoo, Mishra, and Narain (2007).

148 Fafchamps, Vargas-Hill, and Minten (2008).

Downstream, large price variation is driven by increasing quality and brand differentiation in staples. Wastage in value chains is lower than the level found in previous studies (Das Gupta et al. 2010a, 2010b; Minten, Reardon, and Sutradhar 2010; Reardon and Minten 2013).

Parastatals dominate food grain marketing, accounting for over 40 percent of the rice and wheat marketed surplus. The government's role goes far beyond its direct involvement in trade, however. It heavily regulates private agricultural trade for staples as well as nonstaples. The main rationale of government intervention, starting from the 1940s when markets were disorganized and very poorly developed, has been to protect both farmers and consumers from exploitative or unscrupulous traders (Shiva 2007; Acharya 2004). Now the focus seems to have shifted considerably to address market distortions created by the same instruments, effectively segmenting markets (typically across states), creating disincentives to diversify, and prompting calls for action to "get the markets right" (GOI 2013b).

Markets within India appear to be relatively more integrated in the post-reform period (Ghosh 2011), yet recent studies of market integration—which is a reflection of market efficiency—provide a very mixed picture (Bathla 2008, 2009; Bathla and Srinivaslu 2011; Dasgupta et al. 2011; Acharya et al. 2012; Sekhar 2012). For a range of crops and markets, the picture that emerges is that internal markets are "co-integrated"—that is, they exhibit a long-term relationship. This is not a surprise, considering that these markets belong to the subnational markets within India. A more important test is how well they function in terms of transmitting price signals across space, and studies consistently find that this key function of markets is weak and that policies and regulations strongly influence market performance.

For instance, Sekhar (2012) finds the extent and degree of market integration is lower for rice than for gram or edible oils, and that the extent and degree of integration varies by region. Sekhar contends that this outcome results from the substantial regulation and policy intervention in rice compared to other commodities. Using a wider range of commodities and markets, Bathla (2009) finds evidence of only partial integration in wholesale markets across states. While markets for some horticultural crops and oilseeds are well integrated, most other markets do not demonstrate a consistent, long-term relationship across states. Factors influencing these outcomes include proximity to large metropolitan areas, poor infrastructure, and other risks in some states that lead to high price volatility (as in the eastern states). A major source of market fragmentation, however, is regulations, which remain in place despite being relaxed over time. The controls and regulations (including movement restrictions and stock limits) under the ECA, which covers all commodities except fruits and vegetables, are identified as potential impediments to efficient marketing, including for the major staples (rice and wheat). The stability imparted by MSPs, however, clouds the interpretation of results on market integration, especially for states where procurement is concentrated. This is consistent with the lack of convergence of prices within certain states that are subject to the forces of demand and supply even for cereals (Bathla 2008).

The degree of market inefficiency and segmentation, even in rice and wheat markets, is highlighted by other recent studies of market integration. Analyzing markets at different levels—retail, wholesale, primary wholesale, and farmgate—Acharya et al. (2012), using bilateral market pairs, find that price signals are transmitted at varying speeds across markets. The transmission from wholesale to farmgate prices (typically within states) is relatively quick, but integration across major markets varies widely for both commodities. Despite the influence of policy (MSP) on prices (which is most evident at the farmgate level), empirical estimates find the highest degree of integration between the Chennai and Hyderabad rice markets. Other markets show significantly less integration.

Perhaps the most telling statistic is that even in the most integrated market pairing (rice between Chennai and Hyderabad), only 22 percent of the price divergence from the long-run equilibrium is adjusted each month, suggesting that it would take over 10 months for about 90 percent of the price shock to be transmitted from one market to another. Most other markets would take longer. Price signals thus are not transmitted efficiently across states, suggesting significant impediments to internal trade.

Alternative Marketing Arrangements: Linking Smallholders to Markets

Access to markets, especially for small and marginal farmers—more than 80 percent of India's farmers—is critical to provide appropriate incentives for productivity to grow. Despite the isolated pockets of dynamism noted here, markets remain relatively weak and inefficient. A number of institutional innovations have the potential for overcoming some of the well-known constraints to marketing efficiency and integrating smallholders to value chains. Yet after several years of implementation, the scale of these innovative initiatives remains limited and their replicability open to question. To better understand their performance and draw lessons from their experience, some of the promising initiatives are reviewed here and in the remainder of this chapter. The specific models studied include contract farming, cooperatives, producer companies, and rural business hubs (RBH).

Contract farming

In anticipation of improved agricultural market performance following the reforms and liberalization of the 1990s, the corporate sector has shown increased interest in processing, exports, and retailing/marketing of agricultural products. A general expectation was that contract farming (CF) would rapidly expand to better integrate small farmers into agricultural value chains, and in general bring about much-needed efficiency and growth in the sector. Several corporate initiatives in the retail and perishable produce sectors launched CF in the last decade.[149] Singh (2012) reviews the experience with CF and domestic supermarket retail chain linkages, with a focus on smallholders' participation and on managing production and market risk.

Diversification into high-value agriculture is particularly important for the overwhelming

149 Foreign investors (such as Metro, Wal-Mart, Tesco, Carrefour) have stayed in the wholesale cash and carry business (permitted since 1997) as FDI in retail has been restricted to 51 percent of the total equity and in single brand retail only (permitted only since 2010). The recent changes allowing multi-brand retail address some of these issues.

majority of marginal and small farmers in India, and significant numbers of small farmers have indeed diversified into horticultural crops in irrigated and nonirrigated areas (Gaurav and Mishra 2011; Birthal et al. 2012).[150] The main problem facing these farmers is the inherently higher production and market risk associated with such crops. They lack the economies of scale that could give them an advantage in bargaining power, and they face higher transaction costs to access inputs or market output, as well as basic agricultural services such as credit, extension, and market information. CF is often viewed as an appropriate response to these circumstances, benefiting not only farmers, but also intermediaries in the value chains and consumers.

India's experience with CF has been mixed, however. Singh (2012) notes that alternative modalities have been practiced by different players in India.[151] Yields are generally higher among contract farmers (relative to those not under contract)—but so are costs. Nevertheless, with generally more stable prices, net income tends to be higher. Birthal and Kumar (2009) document a number of studies showing several successful CF arrangements (for milk, poultry, spinach, grapes, and gherkins, for example) alongside instances in which CF has been less successful or less inclusive of smallholders.

In practice, the main problems faced in CF include default by companies and farmers, which highlights challenges in enforcing contracts; undue discounts on value for quality (as perceived by famers); delayed deliveries and payments; mixed experience with the provision of extension services, including competitive pricing and the poor quality of seed or inputs provided; unequal or unshared production risk; an insufficient premium relative to open market prices or for quality, including for organic produce; and a lack of attention to social impacts (inadequate safeguards against child labor and gender-related issues).

The impact of CF practices on natural resource management has also been mixed. In several instances, CF has promoted more water-intensive cultivation, even in water-stressed areas. For example, the irrigation intensity of tomatoes, basmati, and maize grown under CF is greater than that of wheat in Punjab. Monocultures to ensure year-round supplies can dominate CF and deplete soil quality. Insufficient attention to the safe, sustainable use of fertilizers and pesticides has potentially adverse impacts on natural resources, the wider environment, humans, and animals. Given the short-term nature of CF, issues related to sustainability, particularly land and water quality, are rarely factored into the business model.

Notable exceptions include CF for potatoes in Gujarat, where McCain Food has promoted the use of sprinklers without subsidy by all contract farmers. Unilever's integrated pest management package in gherkin production resulted in lower fungicide/insecticide use and reduced residues. Some CF arrangements for organic basmati rice, cotton, and fruits and vegetables have sought to reduce environmental pollution and resource depletion (Singh 2012).

150 Vegetable crops are the most favored crops on small farms, whereas fruits, condiments, and spices are favored on large farms, owing to the availability of surplus labor, liquidity constraints, and a good market price for vegetables.

151 They include a centralized model (company and farmers); joint venture with the public sector (NDDB, Markfed); multi-partite model (Punjab in many years); nucleus grower model (Namdharis); and the intermediate/facilitator model (several examples).

Perhaps the most significant issue is whether CF is inclusive of small farmers. The evidence so far appears mixed. Singh (2012) summarizes studies in India showing that contracting firms or entities, mostly private but some public, tend to prefer large and medium farmers for CF. The average size of contract growers is significantly higher than the average holdings in several states (see Annex 12, Table A.12.1). Some exceptions exist. Firms in Karnataka, Tamil Nadu, and Andhra Pradesh work with marginal and small farmers but tend to focus on specific labor-intensive crops like gherkins. With a few exceptions, in the emerging fresh fruit and vegetable retail chain it is also medium and large growers who are the "contact" (not "contract") growers (Annex 12, Table A.12.2). The established or corporate retail chains prefer the more advanced agricultural states as opposed to the states where the majority of the poor smallholders reside.

The main reasons for CF to exclude small holdings reflect some of the problems with CF mentioned earlier: difficulties in enforcing contracts, challenges in meeting quality standards (and a high rate of product rejection), high transaction costs, and smallholders' weak bargaining power. Consistent with these findings, Birthal and Kumar (2009) note that successful CF cases involved market-linked prices to avoid opportunistic behavior, providing essential services like insurance and banking (interest-free advances, capital for start-up costs, and so on), operating through farmer groups or intermediate contracts to overcome the high costs of transacting with individual farmers producing small volumes, and nonprice factors (such as the regularity of off-take and payments, on time delivery of inputs, and technical advice). These relationships are established to exploit long-term mutual benefits by both the agri-business and the farmer.

Pro-poor agricultural value chains

A number of innovations in marketing promote higher-value crops. To review some of these approaches, especially their ability to link smallholders to value chains, Ganguly (2012) analyzes four value chains in Maharashtra: cashew, pomegranate, vegetables, and cotton. The four chains include a producer company (for cashew) and three farmer cooperatives.[152]

Cashew producer company. Promoted by BAIF, a national NGO, a multi-state producer marketing company in Maharashtra links farmer cooperatives (largely established by small and marginal tribal households) to organized markets. BAIF's introduction of cashews among tribal farmers generated modest improvements in income for poor households, but even that small income brought underused land into production and triggered socioeconomic change as farmers increasingly ventured into intercropping other cash crops like flowers and vegetables. In addition to the gains in income and diversification, many farmers retain some of the raw cashews and cashew apples for their own consumption, which adds to nutritional security. The initiative has also generated downstream employment in primary processing facilities, benefiting both the member households and landless households.

Pomegranate cooperative. The producer-led Krishi Vikas Cooperative (KVC) was registered in 1989 and later federated with five

152 The case studies included in the study are cashew—Vasundhara Producer Company Limited (VAPCOL) in Pune, promoted by BAIF, a national NGO; pomegranate—Krishi Vikas Cooperative, Sangola, Solapur, promoted by farmers; vegetables—Nandini Vegetable Producer Cooperative, Nandni, Kolhapur, promoted by farmers; and cotton—Indira Gandhi Sut Girini Cooperative, Wardha, promoted by farmers.

other cooperatives to form Maha Anar. The cooperative successfully created backward and forward linkages for its member growers but failed to retain the trust of its members and expand business. Membership declined, and members started selling their produce through other channels. Focus group discussions revealed that small farmers participated little in pomegranate cultivation throughout the area owing to irrigation problems and the riskiness of the crop. When small and marginal farmers take up pomegranate cultivation, however, their incomes improve significantly. KVC is a partial success as a pro-poor value chain. The cooperative provided initial access to domestic and international markets for farmers in the area and expanded cash cropping among smallholders. As for many cooperatives, the challenge for KVC appears to be weak governance. The priority now is to regain members' confidence.

Vegetable cooperative. The Nandini cooperative in Kolhapur was formed to organize small-scale vegetable growers and link them to national markets. The cooperative started procuring vegetables directly from farmers in 1986. By 1993, instead of having to transport their produce by truck, farmers benefited from collection centers developed by the cooperative (1 center for every 10 villages). The cooperative successfully linked vegetable growers to various national markets, especially in the first two decades of its existence. It created the required infrastructure and demonstrated a proven mechanism to market vegetables in distant markets. Over time it failed to sustain the system, however, and its business declined drastically. The lack of skills and capacity to manage the business under a viable business plan is a critical constraint on the cooperative's ability to sustain its growth.

Cotton cooperative. Indira Cooperative Sut Girni Limited at Wardha was one of many yarn-manufacturing units promoted by the Government of Maharashtra under the Fifth Five Year Plan to integrate producers in value chains. The major objectives were to purchase member's produce, provide extension services, and establish research and development activities. Ginning and pressing activities started in 1985. With a huge capital investment in ginning and yarn-making and with very low operating margins, the business became unsustainable and prone to high market risks. To become sustainable, the business requires professional management along the components of the value chain and diversification into higher-value products such as dyed yarns and textiles.

Lessons. A number of lessons emerge from these experiences. In all of the value chains, at least initially, small farmers benefited from gaining access to markets, information on better production techniques and markets, and higher returns. The value chains introduced new crops, and farmers overcame barriers to entry such as the need for irrigation and other investments to diversify. Crop diversification is an important foundation for building pro-poor value chains—farmers will take risks for profitable and sustainable activities. Farmer initiative also matters. For example, cashew farmers intercropped to generate additional income, whereas pomegranate farmers did not. All four value chains, however, failed to introduce or adapt appropriate technology over time. Finally, producer companies seem to offer a better organizational framework than the cooperative model for linking small-scale producers to markets.[153]

153 For example, the producer company (VAPCOL) fared better compared to the cooperative (KVC) venture as far as forward linkages are concerned. VAPCOL engaged professional managers for marketing activities.

Efficacy of Market Channels in Improving Access

The structure and functioning of markets at the village level is important for promoting technology and productivity. A survey-based study of three alternative market channels—traditional private sector traders, state-sponsored cooperatives, and Rural Business Hubs (RBHs)—a modern private sector innovation)—by Reardon et al. (2012) provides a descriptive and statistical analysis of the performance of these channels. The study specifically investigates the outreach and incidence of services and proximate impacts on technology use and productivity at the farm level. The study involved three states (Andhra Pradesh, Madhya Pradesh, and Uttar Pradesh) to capture different agro-ecological, economic, and institutional environments.[154] The RBHs included are Hariyali Kisaan Bazar (HKB) in Uttar Pradesh, ITC's Choupal Saagar in Madhya Pradesh, and Viswas in Andhra Pradesh. These firms entered the scene around the mid-2000s. The major findings and conclusions concerned seed and input markets, input and output prices for small and marginal farmers, and the determinants of purchases and prices in different market channels.

Seed, fertilizer, and farm chemical markets: Subsidized outlets sell subsidized inputs mostly to medium-scale farmers

The findings for seed markets are similar across all three states, so the case of Uttar Pradesh and the most popular crop there—wheat—is highlighted here. Farmers have several options to purchase seed: traditional input dealers, PACS (primary agricultural credit society, a state organization of farmers), state seed stores (located mainly at the district level), agricultural universities (offering direct retail of breeder and foundation seed to selected farmers), RBH outlets, and *mandi* (wholesale market) traders. The major share (over 80 percent) of the seed market is supplied by the private sector (56 percent through traditional retail and 24 percent by RBHs). Marginal farmers who bought wheat seed in Uttar Pradesh purchased 12 percent of it from state/cooperative stores and 4 percent from other farmers; the overwhelming majority bought it through private channels (21 percent from HKBs and 63 percent from small traditional shops). Clearly a minority of poor and marginal farmers purchase seed from state/cooperative outlets.

Viewed from a sales perspective, the findings are similar. State/cooperative outlets sold 16 percent of wheat seed to marginal farmers and 22 percent to small farmers; 62 percent of sales were to medium farmers. This finding sharply contradicts the conventional view that the (subsidized) state/cooperative outlets focus on selling to the poor. Although to some extent this sales pattern reflects the land distribution, which is dominated by medium farmers, the targeting of the seed subsidy does not appear to be pro-poor.

Similar conclusions emerge for fertilizer and farm chemical markets, with a few exceptions. In Uttar Pradesh, the major share of sales from state/cooperatives of the heavily subsidized fertilizers (73 percent) and chemicals (83 percent) are to medium farmers (73 percent). One exception in Uttar Pradesh is RBH sales

154 The study chose six zones by reasoned sampling around nodes (RBH centers). The survey sample is therefore not random and may not represent markets more generally (for example, markets where RBHs are not located). Nevertheless a comparison of the three channels provides important and interesting insights. For each state, household surveys were conducted in 30 villages within and just beyond the catchment areas of six RBHs equally distributed over western, central, and eastern study zones in each state.

of urea, two-thirds (67 percent) of which are to marginal/small farmers. In general, RBH sales follow the pattern of land distribution, with their main client (by volume share) being medium and large farmers.

Input and output prices do not place small and marginal farmers at a disadvantage

Input prices are consistent across farm-size groups, so marginal and small farmers do not pay more than larger farmers for inputs—another finding that is contrary to expectations. Similarly, output prices show no systematic variation across farm size groups. The *mandi* wholesaler, RBHs, and brokers paid close to the same price for wheat and soybeans (net of transaction costs) irrespective of farm size. Although small and marginal farmers are presumed to dominate rural food markets, such farmers account for only a small volume of output handled by those markets. *Mandis* and RBHs thus rely little on output supplied by small and marginal farmers.

Determinants of purchases and prices in different market channels

Choice of market channels for inputs. The choice to purchase inputs from a particular market channel is influenced by proximity (distance to the respective outlet for the market channel) as well as nonfarm income (off-farm employment). For example, the likelihood of a farmer choosing an RBH outlet for paddy seed in Uttar Pradesh increases with off-farm employment, distance to traditional stores, and proximity of the RBH. But marginal farmers are significantly less likely to be RBH customers, suggesting an "asset bias" in the modern market. Again, there are some exceptions, as in the case of poorer Eastern Uttar Pradesh, where the probability of using state sources increases. For other parts of Uttar Pradesh, as well as in Madhya Pradesh and Andhra Pradesh, however, the likelihood of purchase from a state/cooperative outlet falls sharply for marginal farmers but rises with education, being a cooperative member, having wealth through livestock, and the distance to traditional stores.

Two other notable results are the greater likelihood that minorities ("non-Hindus") will purchase fertilizers from state/cooperative stores, suggesting that they tend to be more socially inclusive, perhaps reflecting the location effects of alternative channels. For pesticides, the probability of purchase from a modern outlet (RBH) is positively correlated with farm size, but there is a distinct U-shaped probability curve for herbicides, with both marginal and medium farmers more likely to buy from RBHs.

Price formation. In Uttar Pradesh, paddy seed prices paid by farmers decline with greater education, the age of the household head, nonfarm income, farm machinery, greater distance from the district town, and being in the favorable western and central areas. These factors may suggest greater bargaining power among farmers, but they could also reflect the size and level of development of the market. By contrast, worse prices are paid by scheduled castes and tribes and by farmers in the eastern zone. In Madhya Pradesh, there is a strong negative association of RBH with fertilizer and pesticide prices, again likely reflecting the effects of modernization and larger transaction volumes.

In general, farmers in eastern zones do not benefit from modern market channels as much as the other groups studied. For example, farmers in the poorer eastern zone pay more for their pesticides (as in Uttar Pradesh), and the likelihood of output purchases by RBH falls with being located in the east or belonging to SC/ST social classes. The relatively better-off farmers (in terms of assets and livestock) are better connected and more likely to participate in modern output markets, while "poorer" farmers rely on selling primarily to the traditional sector.

Implied quality of inputs. Since quality cannot be determined from sales data, an indirect assessment is to infer quality using partial factor productivity measures. The results do not suggest any obvious discrimination against smallholders in terms of quality. For example, for paddy and wheat in Andhra Pradesh, seed purchased from the traditional market is associated with higher output than the same seed purchased through state market channels. In Madhya Pradesh, farmers buying inputs within traditional markets show lower but comparable returns to increases in farm operations, which likely reflect other attributes, but no obvious association suggests comparable quality across farm-size groups. In Andhra Pradesh, farmers' main problem appears to be a labor shortage rather than any problems directly associated with other inputs.

Status of Agricultural Marketing Reforms

Among the controls that have "stifled" agriculture (GOI 2013b), two pervasive regulations are the Agricultural Produce Markets (Development and Regulation) Act—APM (D&R) Act—and the Essential Commodities Act (ECA) (see Annex 12 for a brief description). The zoning and storage restrictions under the ECA, and the requirement that all produce be sold at a limited number of licensed and regulated markets under the purview of the committees set up under the APM(D&R) Act, referred to as APM Committees (APMCs), have created significant disincentives for private investment in storage, handling, and marketing infrastructure. They have also promoted the fragmentation of markets (by restricting movement and through cess/tax implications) and made market transactions and price discovery less transparent.

These regulations constrain direct marketing arrangements such as CF or direct purchases by food-processers from farmers, and they prevent improvements in value chain efficiencies. Thus the very considerable potential for food processing remains largely untapped, dominated by low-level processing by informal enterprises (Bhavani, Gulati, and Roy 2006; Morisset and Kumar 2008a, 2008b). Farmers as well as consumers bear the brunt of these regulations, which have fostered uncompetitive market structures at the *mandi* level, depressing farmer prices and raising final consumer prices.

The issues related to the ECA and APMCs are well recognized and widely acknowledged. To address the major problems, the government introduced a "Model Act" in 2003 and urged state governments to amend their respective legislation and regulations accordingly.[155] Most states have amended their legislation to reflect the recommendations of the Model Act, but the nature and extent of reforms (and more importantly, their implementation) by

155 The APMC is a "State Subject," so the central government's role in implementation legislation and regulations relating to the APMC (as with other agricultural regulations) is limited, with responsibility resting squarely with the states.

individual states is not known. Similarly, the government has periodically modified the ECA provisions to ostensibly pare down the list of "essential commodities." Again, with limited central government control over implementation and authority for each state to establish its own regulations and controls, progress on removing the ECA's restrictions on domestic markets and trade is not known.

To address this knowledge gap, Patnaik and Sharma (2013) conducted a study that also included detailed field assessments in five states. The main findings are not very encouraging. Although a few states moved well ahead in implementing both the letter and spirit of the APMC reforms, implementation is generally uneven and inconsistent across states. The net result is that despite some progress, significant impediments still constrain the performance of markets and internal trade. The major findings from the study are reported in the sections that follow.

Current provisions of the ECA. The list of essential commodities has changed over the years, with the latest list, issued in 2006, pruned down (in principle) to only seven items (Box A.12.1). Qualitatively, the coverage of agricultural commodities has changed little, as the key provision of the broadly defined "foodstuffs" essentially covers all food commodities, whether processed or unprocessed. The act also covers key inputs, fertilizers, and seeds for most major crops (certainly all food crops). Equally important, the list of commodities can be amended by executive orders from the central and state governments. The result is a multiplicity of Control Orders and frequent changes of rules and restrictions (see Patnaik and Sharma 2013 for recent examples).

Despite the central government's 1993 decision to treat the entire country as a single food zone, markets remain segmented. The issues that continue to constrain markets and trade, by raising transaction costs and creating disincentives for private investment in marketing and trade infrastructure, are many. Even though ECA currently has no movement and stock restrictions, several states have established ad-hoc stock restrictions, with frequent changes, creating uncertainty and raising transaction costs. A lack of transparency prevails: Orders can be issued independently by state governments and sometimes by different departments within the same state. Because no compilation exists of all orders in effect at any time, it is extremely difficult to get a sense of what is happening on the ground. Despite their best efforts, Patnaik and Sharma (2013) could not obtain or compile a comprehensive list of all orders currently in effect.[156] Multiple and ad hoc taxes are another problem. Several statutory, fiscal, and administrative barriers hamper the free movement of agricultural products between and within states. They include border check gates (entailing avoidable delays that are costly for products that are perishable or have a short shelf-life); "entry" and "export" taxes in some states; other state-specific taxes; multiple taxation (taxes levied by different markets within each state); and a lack uniformity in fiscal measures across states.[157]

156 As statutes and regulations in India generally do not have a "sunset clause" and continue to be in force until their repeal, it is likely that most of these orders remain in force.

157 For example, in Punjab the total market charges on food grain transactions are around 15.50 percent (a market fee of 2 percent, development cess of 2 percent, purchase tax of 4 percent, commission charge of 2 percent, infrastructure cost of 1.5 percent, and VAT of 4 percent) ad valorem, apart from the charges for weighing-(Rs. 0.55), loading (Rs. 0.40), brokerage (Rs. 0.16), *hamali* (labor in the market area) (Rs. 1), and cleaning (Rs. 0.65 per bag per quintal).

APM (D&R) Act reforms as per the Model Act (2003). Of the 35 states and union territories, 6 had never adopted the Act and required no reforms (see Annex 12, Table A.12.3). Of the remaining states and territories, 18 formally amended their Acts, and 1 (Bihar) completely repealed it in 2006. The remaining 11, including some major agricultural states (Punjab, Uttar Pradesh, West Bengal) have not adopted the Amendment. The Model Act contains five critical provisions for liberalizing trade:

1. Direct marketing (purchase by the buyers outside market yards).
2. Contract farming.
3. Entry of private sector (to establish wholesale markets).
4. Single license (for operating in more than one APMC jurisdiction).
5. Single levy of market fee (irrespective of the times produce is sold and purchased).

On paper, progress toward the much-anticipated market reforms appears to be good—most states have amended the APM(D&R) Act—but real progress remains much more modest. First, the states have not adopted all provisions of the Model Act (Annex 12, Table A.12.3). Only 6 of the 18 amending states adopted all 5 key provisions, while others adopted the amendments only partially. The uneven implementation of specific provisions gives mixed and unclear picture.

Some states have not formally adopted the amendments but have made specific provisions through executive orders on a case-by-case basis. For example, both Uttar Pradesh and Punjab have provisions for a single-point levy of the market fee. Both have also adopted other provisions, such as bulk purchases (Uttar Pradesh) and contract farming (Punjab), but these are on an exceptional basis through executive orders. On the other hand, Maharashtra is the most progressive state in terms of market reforms, and it has amended the APM Act but does not provide for single point levy of the market fee due to opposition by the APMCs.

Special provisions (such as market fee exemptions in Punjab) exist for particular businesses, often business that have promised to make large investments in the state. Case-by-case exemptions through executive orders may be expedient compared to enshrining the provisions in the statute itself, but they do not allow robust market development. Such exemptions are surrounded by uncertainty because the orders can be rescinded at any time—often for political reasons. For example, the Government of Punjab allowed Cargill to make direct purchases of food grains from the *mandis*, but the order was withdrawn within a year following opposition by commission agents.

Finally, for actual implementation, the amendments to the Act need to be formulated as rules and notified. In this regard, progress is even weaker. Annex 12, Table A.12.4 shows that only 10 of the 18 adopting states have formulated and notified the rules for implementation. Again, the actual provisions and rules vary across states. Maharashtra and Karnataka have detailed rules in place for implementation. In Andhra Pradesh, rules for direct marketing have not been covered in the notification. Because Madhya Pradesh has exempted sales of fruits and vegetables (except bananas) from the provisions of the Act, it needs no rules, since the provisions of the Act are not now applicable to fruits and vegetables. Himachal Pradesh has no restriction for setting up private markets; licenses for private markets and direct marketing are issued on a case-by-case basis. Rules framed by Odisha for private markets specify no restrictions on setting up private markets, except to state that the location for the private market will be specified by the state government and will not be permitted within one kilometer from an existing APMC. Such restrictions are not conducive to the spirit of the reforms, which is to increase effective competition.

Impact of reforms. As indicated, whenever the opportunity has arisen—either through formal reforms or through special provisions—the private sector's response has been swift and at times revolutionary. The improvements in potato and rice supply chains are examples (Reardon and Minten 2013). Reforms have spurred other innovations such as the emergence of virtual markets (including futures markets, spot exchanges, warehouse receipt systems, ICT-based market information, and web marketing), electronic spot exchanges, and significant private sector response in terms of initiatives involving contract farming, direct purchase, and the establishment of mega-food parks (Patnaik and Sharma 2013). Some of the private sector initiatives in different states are summarized in Annex 12, Table A.12.5. Note that investment and corporate activities have been more common in states where reforms were more significant.

Among the states, Maharashtra has been the front-runner in market reforms and has seen significant new initiatives and impacts (Box 5), yet even in Maharashtra challenges remain in implementing the provisions of the amendments. For instance, despite several government initiatives, contract farming remains informal. Maharashtra is at the forefront in establishing private markets but faces a number of problems. On the one hand, farmers do not perceive the benefits of selling their fruits and vegetables to the dedicated private market set up for them, as there are no additional facilities or services. On the other hand, the private market has run into several problems with the local APMC, restraining its

Box 5: Progress in market reforms in Maharashtra

- The Maharashtra State Agricultural Marketing Board actively promotes public-private partnerships in setting up markets and infrastructure.
- A total of 23 private markets are functional, of which the first private market for fruits and vegetables has been set up by Premium Farm Fresh.
- Maharashtra issued 47 licenses for direct marketing to companies/traders.
- Licensed E-markets under APMC Act, Maharashtra have led to the establishment of spot exchanges by MCX, NCDEX, and Reliance Spot.
- Trade in fruits and vegetables has been deregulated and exempted from market fees.
- Paithan Mega Food Park has been given special status for sourcing raw materials.
- A total of 10 contract farming sponsors have been registered.
- Major private companies are involved in contract farming, such as Marico (Saffola), ITC and Pepsico (potatoes), More, Reliance, Big Bazaar (fruits and vegetables), and KB Export (vegetables for export).

Source: Patnaik and Sharma 2013.

ability to provide comparable services. APMC contends that any produce in its jurisdiction, even if traded in the private market, needs to pay APMC market fees. APMCs have opposed the implementation of a single-point levy for market fees, and the private market is not allowed by the APMC to procure produce at collection centers. All of these stipulations reduce the revenues or raise costs to the private operator, restricting the viability of the business.

In contrast, Tamil Nadu has not amended its Act but already had a provision for setting up private markets and for direct marketing. The Agricultural Products Producers and Traders Association Market, a modern fruit and vegetable market, is performing well (in strong contrast to Maharashtra's experience), providing good services, infrastructure, and public utilities.

More tangible benefits of reforms are demonstrated by the specific impacts on the benefits to producers as well as consumers from better-functioning markets, indicating the large potential impact such reforms can have. Table 23 presents an example of the benefits of competition gained by allowing private *mandis* to operate. Competition has driven down the market and other fees charged for the same transactions, as APMC is now forced to compete for customers. Another specific example is the reduction in marketing margins through direct marketing, which benefits farmers (receiving a higher output price) and consumers (paying a lower retail price), shown in Table 24.

Table 23: Comparison of charges in private and APMC markets

Charge	APMC Pimpalgaon	Private mandi (Santosh Pvt.Ltd Bagulgaon Yeola)
Market fees/charges	1%	0.75 %
Supervision charges to GOM	0.05%	0.05%
Commission charges	4%	4%
Weighing	Rs. 1 per 100 kg	Rs. 1 per 100 kg
Hamali	Rs. 4 per 100 kg	Rs. 2.50 per 100 kg
Sorting/grading	Rs. 20 per 100 kg	Rs. 6 per 100 kg
Loading charges	Rs. 4 per 100 kg	Rs. 7 per 100 kg

Source: Patnaik and Sharma 2013.
Note: GOM = Government of Maharashtra.

Table 24: Price build-up in tomato value chain (Salarpur, Uttar Pradesh)

Particulars	Traditional marketing		Direct marketing (Vista Foods)	
	Rs/q	%	Rs/q	%
Producer share	800.00	43.24	900.00	53.42
Market fee	11.50	0.62	9.00	0.53
Commission charge	102.36	5.53	0.00	0.00
Logistic and OH cost	290.00	15.68	387.00	22.97
Retailer/processor margin	646.14	34.93	388.8	23.08
Consumers price	1850.00	100.00	1684.80	100.00

Source: Patnaik and Sharma 2013, based on key informant interviews in UP case study.

Conclusions and Implications

In most cases, market reforms have not been implemented in full or in earnest and are instead hampered by provisions and omissions that have effectively retained the status quo. The APMCs continue to exert strong control and have been a key obstacle to reform, even where states have amended their respective Acts.

A key message emerging from the analysis is that India remains a segmented agricultural market, with high transaction costs that hurt both producers and consumers, hinder the smooth internal flow of trade, and restrict productivity growth. Removal of movement, stock, and trade restrictions for smoother internal trade remains a very high priority.

The experience with different states interpreting and implementing reforms and regulations in different ways suggests a need to rethink market governance. For example, differential and multiple taxation, different and frequently changing stock limits, and movement restrictions create problems in marketing across state borders. Agriculture is a State Subject, but Inter-State Trade and Commerce is under the Union List. It may be advisable to consider putting agricultural marketing on the Concurrent List and establishing common norms for taxation and other charges/fees to make the system more transparent and predictable. This approach will facilitate smoother movement of agricultural products across states, foster more efficient modes of marketing through electronic trading and virtual markets, and help achieve the objectives of the Model Act. Reform of fiscal policies will obviously have revenue implications, and how these costs are to be shared will be an area for policy attention.

Overregulation is clearly demonstrated to restrict private investment and trade, as seen from the experiences of Maharashtra compared to Uttar Pradesh and Punjab. Even initiatives to promote private investments, such as the schemes for "Modern Terminal Markets" and "Wholesale Markets," have not been successful. The subsidies offered in these instances are clearly not attractive enough to overcome the unattractive restrictions these schemes place on private sector activities.

An important problem is the conflict of interest for state governments. The current markets and APMCs generate revenue. Any change in market regulations will have resource implications for state governments, which must be dealt with in terms of sharing the costs of reforms. Another important conflict of interest is the state departments or marketing boards responsible for both running and regulating the markets. It is important to ensure an independent market regulator to create a level playing field between the APMCs and private markets.

Finally, while the overregulation inherent in the current APM(D&R) Act is clearly a hindrance, the absence of all market regulation would not be desirable. An important role of the government is oversight and regulation, and the complete abdication of this role may not lead to a better outcome. For example, since Bihar completely repealed the APM(D&R) Act, its markets have been completely unregulated. Bihar sought to promote free, competitive transactions, but the state's public facilities are public goods; if no entity is responsible for them, there will be no investment in infrastructure or maintenance to improve market conditions. Most importantly, governance of the markets has become a critical issue, as the markets allegedly have been taken over by a few traders and cartels.

To create a healthy environment for transactions, it is important for markets to be orderly and governed well. The private sector would invest in market infrastructure, given reasonable assurances that such investments would be secure and generate returns. An independent market regulator is clearly needed, with the primary objective of promoting competition and creating an orderly environment for price discovery and physical transactions, and with the capacity to provide basic services as needed (perhaps until the private sector steps in), including dispute resolution services.

13 AGRO-INDUSTRY: THE FOOD-PROCESSING SECTOR

As the structural transformation of the economy accelerates in India, the nature of agriculture and the food industry will change dramatically. With inevitable urbanization, the shift to nonfarm activities, rising incomes, women's increasing participation in the labor force, and changing consumption habits, an outpouring of demand for processed (including prepared and packaged) foods will occur. For India, food processing provides a natural entry point for the sluggish "manufacturing" sector to enter agricultural areas, exploit their present comparative advantage, and create much-needed off-farm employment.

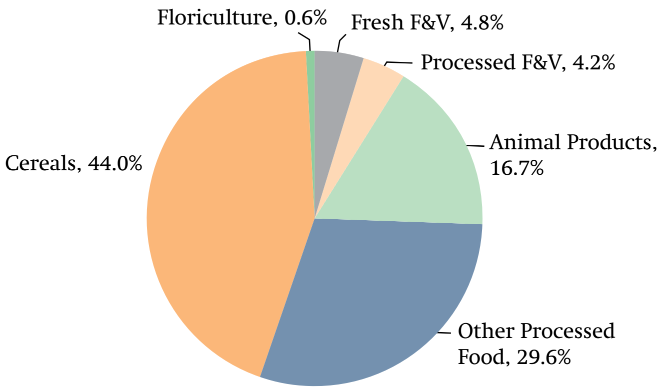
A well-developed food processing industry can also stimulate higher agricultural productivity and growth through several channels. Examples include better and more stable farm prices; reduced wastage as produce unsuitable for wet markets is processed into more value-added consumables, increasing returns to farmers; and diversification into crops needed for processing, potentially transforming traditional "food" crops into "cash" enterprises.

The importance of food processing for stimulating growth and employment stems from its high backward linkages. Of all activities in the economy-wide activity matrix, food processing has the highest estimated backward multipliers (both output and income multipliers) based on the national Input-Output tables constructed by CSO (Ganesh-Kumar and Panda 2013). The employment multiplier effects from investments in the food-processing industry are also high—about 2.5 times that of other industries (Bhavani, Gulati, and Roy 2006). Finally, processed exports are an important outlet for agricultural output. Exports of processed foods now constitute almost 48 percent of rapidly expanding agricultural exports, almost doubling in (real) value over the past three years (Figure 73).

To capture these benefits, the central government has made concerted efforts since the mid-1990s to attract private investment in the food-processing industry by giving it priority sector status, providing fiscal incentives,[158] and initiating other reform measures. The proposed National Mission on Food Processing will scale up these efforts at the state level, with technological and logistical support from the center. The food-processing sector has grown rapidly in the past five years, with investments growing at 20 percent per year. Foreign direct

158 Some of these include a five-year tax holiday and 35 percent tax deduction for the same period for setting up new agro-processing industries; reduced import duty on processing machinery; no corporate taxes on profits from export sales; and automatic approval for 100 percent FDI in most items. Exemptions from excise duty have been given to encourage capital investment in large projects and processing firms.

Figure 73: Composition of food exports, 2012/13



Source: Authors, using APEDA data.

investment (FDI) is still relatively small (US$ 2 billion cumulative investment between April 2000 and August 2013) compared to the overall investment in food processing of about US$ 24 billion, but it is expected to grow more rapidly with the expansion of organized food retail.[159]

The literature on agro- and food processing in India is limited and mostly outdated. Given the importance of food processing in promoting agricultural productivity and generating employment, this chapter analyzes the food-processing sector—its structure, evolution, and the interplay of factors and policies that influence its performance.[160] To place India's food-processing industry in the context of other industries, the analysis will rely on indicators such as the number of units (factories), employment, investment, capital stock, and gross value added (GVA).[161]

Food Industry Structure and Investment

Like all manufacturing in India, the food-processing sector has a dualistic structure: A relatively small (in number of units) but capital-intensive organized segment coexists with a pervasive, mostly rural, and relatively labor-intensive unorganized segment. Organized and unorganized food-processing operations employed nearly 8 million people in 2008–09 (the latest year for which survey data are available)[162] and contributed over Rs. 500 billion (about US$ 10 billion) to the economy (valued added in 2004/05 prices).[163] In 2008/09, the organized segment provided 1.56 million jobs in a little over 27,000 units, producing an average of Rs. 13 million of output per unit (in real 2004/05 rupees). In the unorganized segment, about 2.6 million enterprises employing 6.3 million people producing Rs. 0.054 million of output per enterprise in 2005/06.

Figure 74 shows the dualistic structure of the food-processing sector in 2005/06. The unorganized segment dominates in numbers of (small) enterprises and workers, but the organized segment dominates in terms of the value of output and investment. The average scale of operations is much smaller in the

159 FDI estimates from the website of the Department of Industrial Policy and Promotion, Ministry of Commerce and Industry, GOI. Growth estimates from India Brand Equity Foundation.

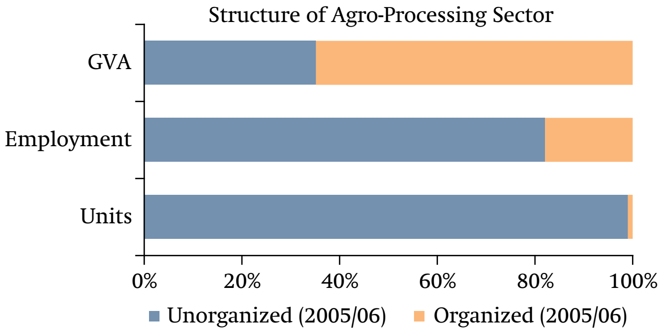
160 This chapter is based on a background paper by Bathla and Gautam (2013).

161 All values are converted to real terms with the base year 2004–05. Investment is taken to be the difference in fixed capital in two periods plus depreciation in year t. Capital stock is estimated using the Perpetual Inventory Method.

162 The analysis of organized manufacturing is based on state-level data from the Annual Survey of Industries (ASI) from 1980–81 to 2008–09. Data used are for the food and beverage industry (National Industrial Classification code 15) for 17 major states of India. The analysis of the unorganized segment uses the 2000–01 and 2005–06 quinquennial NSS data (the 56th and 62nd rounds). The analysis for organized food manufacturing is confined to 17 major states and that for unorganized manufacturing to 20 major states at 2004–05 prices. Of 24 groups of industries at the two-digit level as per the National Industrial Classification (NIC) 2004, unit-level data on food products and beverages (NIC 15) are extracted for selected states. For additional detail on the data and variables used in the analysis, see the background paper.

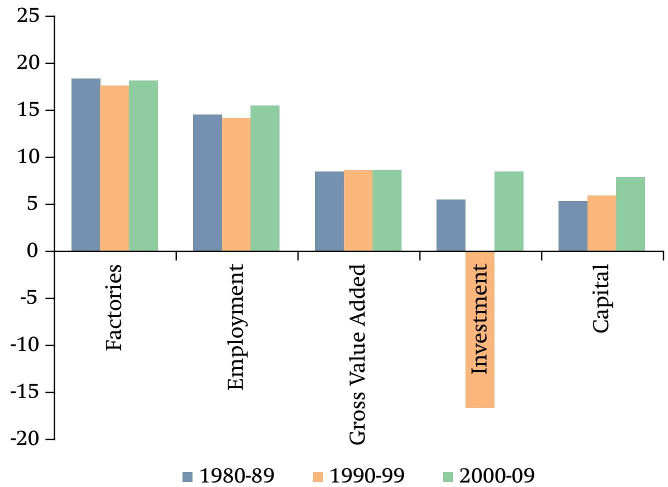
163 The size of the organized segment was Rs. 352.5 billion in 2008/09, and the size of unorganized segment was Rs. 142.5 billion in 2004/05 real rupees.

Figure 74: Dualistic structure of the agro-processing sector



Source: Bathla and Gautam 2013.

Figure 75: Share of agro-processing in organized manufacturing



Source: Bathla and Gautam 2013.

unorganized segment, with fixed assets per enterprise of Rs. 0.096 million employing an average of 2.4 persons, compared to Rs. 25.6 million and 57.4 persons per enterprise in the organized segment.

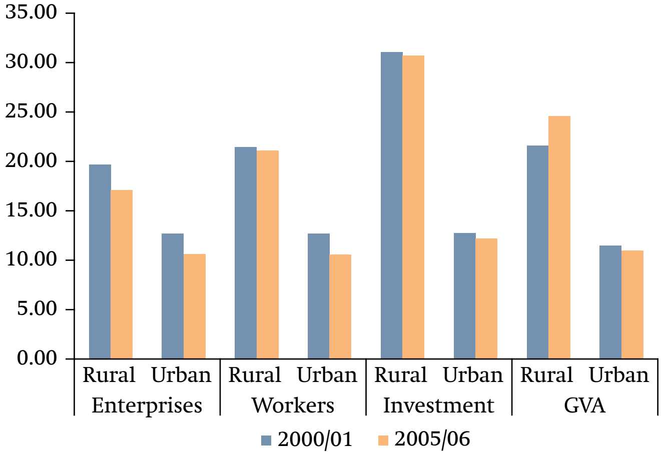
The structure of unorganized manufacturing is changing among the three types of enterprises defined by NSS: Own Account Manufacturing Enterprises (OAMEs), Non-Directory Manufacturing Establishments (NDMEs), and Directory Manufacturing Establishments (DMEs) (defined in Annex 13). Small, family-run OAMEs dominate the unorganized segment (81 percent of enterprises) and are located primarily in rural areas (the share of NDMEs is 13 percent and that of DMEs 6 percent). OAMEs also had the largest share of output (42 percent) in 2005–06, compared to NDMEs and DMEs (25 and 33 percent). Over time, OAMEs have gradually declined, and the share of DMEs in almost all the key indicators has expanded.

Spatial and temporal trends

Food processing provides significant employment in both the organized and unorganized segments. It accounted for about 18 percent of factories and 16 percent of employment in organized manufacturing on average between 2000 and 2008, with a steady share in output of 8–9 percent over time (Figure 75). The shares in investment and capital stock are lower but grew from 5.5 percent in the 1980s to 8 percent in the 2000s. The relative size of food processing varies by state (Annex 13, Table A.13.1a), with few changes over time. The share of food processing in investment and output in lagging states (Bihar, Madhya Pradesh, and Rajasthan) as well as some advanced states (Punjab and Andhra Pradesh) has increased. Most states show no discernible trends, however.

In the unorganized segment, food processing has a slightly higher share of the industry (17 percent of employment and value added in 2005/06). Of the 82,897 unorganized enterprises surveyed in 2005/06, a little over 15 percent of all enterprises (rural and urban) were in food processing, accounting for 18 percent of investment in the sector (Figure 76). Rural unorganized food-processing accounts for

Figure 76: Share of agro-processing in unorganized manufacturing



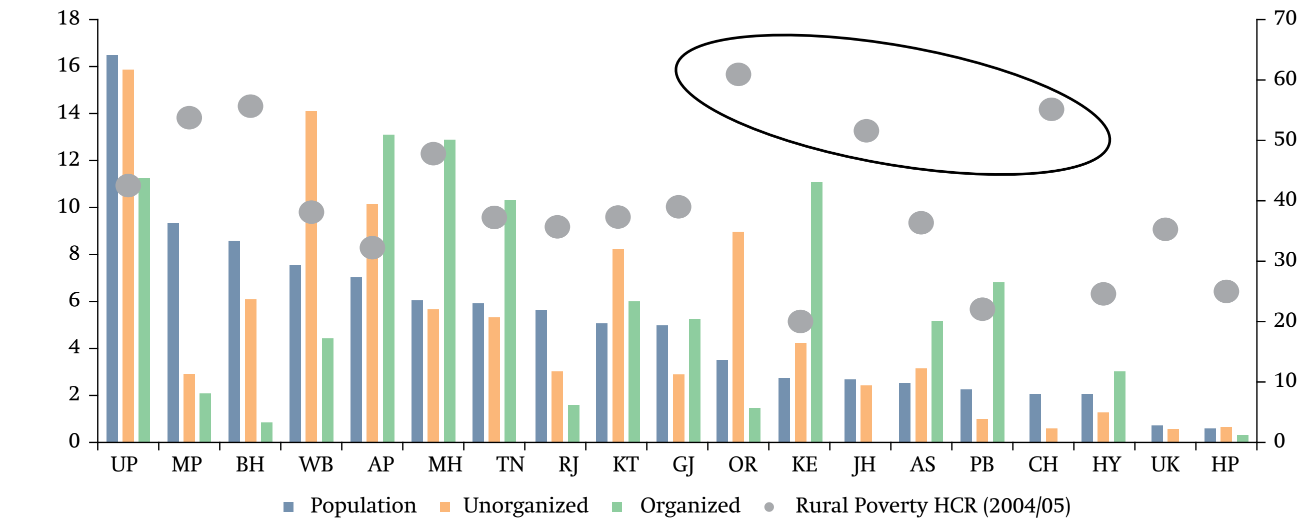
Source: Bathla and Gautam 2013.

significantly higher shares of investment (about 31 percent), output (25 percent), and employment (21 percent). As with the organized segment, significant change has occurred across states over time (Annex 13, Table A.13.1b).

The diversity of the organized and unorganized food-processing segments across states is evident in Table A.13.2. While the shares of employment and numbers of units and enterprises have been relatively stable over time across states, some states have become more productive, with growing shares in GVA for food processing—notably Andhra Pradesh, Karnataka, Punjab, and Rajasthan.

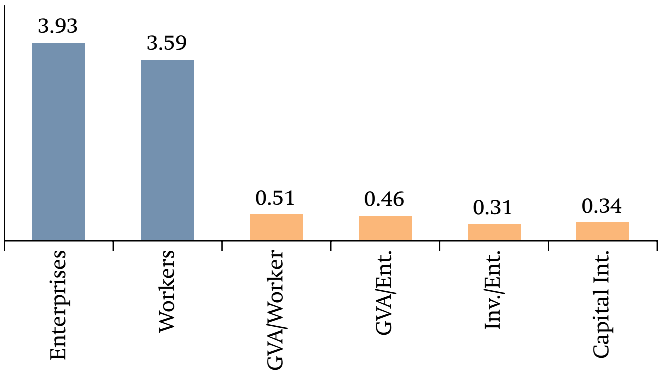
The differences in shares across states, especially for employment, may simply reflect differences in the size of each state's population. Figure 77 shows that with the exception of a few "outliers" (circled in the figure), the more populous states are also generally poorer. Organized employment is clearly concentrated in a few states, but the trends in unorganized employment broadly track the size of the state. The exceptions are Bihar, Madhya Pradesh, and Rajasthan, where both organized and unorganized food processing is underrepresented. On the other hand, informality is the preferred mode of manufacturing in Karnataka, Odisha, and West Bengal. The broad correlation between unorganized food processing and poverty likely

Figure 77: State poverty rates and shares in population, employment



Source: Bathla and Gautam 2013.

Figure 78: Rural-urban ratios in the unorganized sector



Source: Bathla and Gautam 2013.

reflects a combination of "pull" and "push" factors, which call for deeper analysis.

The final aspect of the sector's structure is the rural-urban dispersion of unorganized enterprises (data to make this distinction are not available for the organized segment). Food-processing enterprises and employment are almost four times more common in rural than in urban areas (Figure 78). The rural firms are much less capital intensive, and also less productive both in output per enterprise and per labor. Apart from the greater dominance of OAMEs in rural areas, these ratios likely reflect inadequate access to infrastructure, technology, skills, and capital.

Scale, factor intensity, and employment creation in the food industry

Organized food processing has grown rapidly since 1980 (Table 25), with capital deepening in both the organized and unorganized segments. Capital stock grew at 8 percent annually between 1980 and 2008 in the organized segment, primarily due to an increase in the scale of operation (output per factory); the number of factories grew at a much slower pace. Employment per factory declined, but total employment increased with the increase in the number of factories. Between 1980 and 2008, the sector generated jobs at a rate of 1 percent a year, with the fastest pace between 2000 and 2008 at 2.3 percent per year. In the unorganized segment, the number of enterprises has declined over time (Table 26), but the remaining enterprises are operating at a larger scale, with rapidly growing output per unit and slower but still growing employment per enterprise. Overall employment in the unorganized segment fell due to the high exit rate of enterprises.

The rapid increase in the average scale of operation, visible in several states, was realized mostly in the post-reform period and is consistent with the significant increase in investment in the organized and unorganized

Table 25: Organized food-processing segment: Size and growth

Size	Factories (units)	Employment (millions)	GVA (Rs billion, 2004/05)	Capital stock (Rs billion, 2004/05)
2008-09	27,218	1.56	352.5	11,363
Growth (%/yr)	**Factories**	**Employment/factory**	**GVA/factory**	**Capital stock/factory**
1980-1989	0.8%	-3.5%	8.3%	12.7%
1990-1999	2.1%	-0.1%	5.1%	8.6%
2000-2008	1.8%	0.5%	6.4%	5.4%
1980-2008	1.6%	-0.6%	4.2%	8.3%

Source: Bathla and Gautam 2013.

Table 26: Unorganized food-processing segment: Size and growth

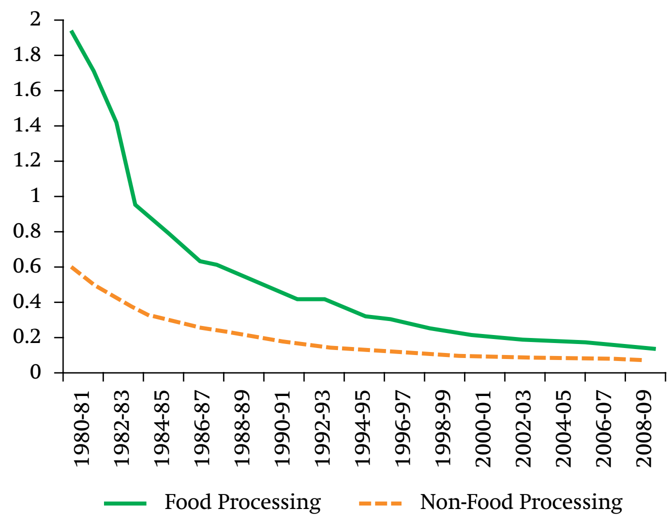
Size	Factories (units)	Employment (millions)	GVA (Rs billion, 2004/05)	Capital stock (Rs billion, 2004/05)
2005/06	2.6	6.35	142.5	11,363
Growth (%/yr)	**Enterprises**	**Employment/ enterprise**	**GVA/enterprise**	**Capital stock/ enterprise**
2000/01–2005/06	-2.87%	1.38%	7.25%	3.85%

Source: Bathla and Gautam 2013.

segments. In the organized segment, for which the temporal data are available, investments increased substantially in the post-reform period. Capital invested per factory grew more than fourfold after 2000/02, when investment grew by almost 20 percent per year. Employment grew more slowly, although some states saw a rapid expansion of employment in the latest period (2000–08), including Gujarat, Himachal Pradesh, Madhya Pradesh, and Rajasthan. Employment per enterprise increased slightly in the unorganized segment, but the decline in the number of enterprises, particularly in urban areas, caused employment in the unorganized food-processing segment overall to decline—a trend consistent with the rising capital intensity in the urban unorganized food-processing segment. Employment grew in only four states (Assam, Gujarat, Haryana, and Madhya Pradesh).

Underlying these trends is a rapid decline in labor intensity, with food processing experiencing a more rapid decline than non-food industries (Figure 79). Consistent with this trend, labor productivity has risen, as have wages, while capital productivity has declined. Labor productivity has risen faster in the non-food-processing sector, but wages have increased more rapidly in the food sector. Figure 80 shows indicators for the food-processing industry as a ratio of the indicators for the non-food industry. Capital productivity

Figure 79: Trends in labor intensity



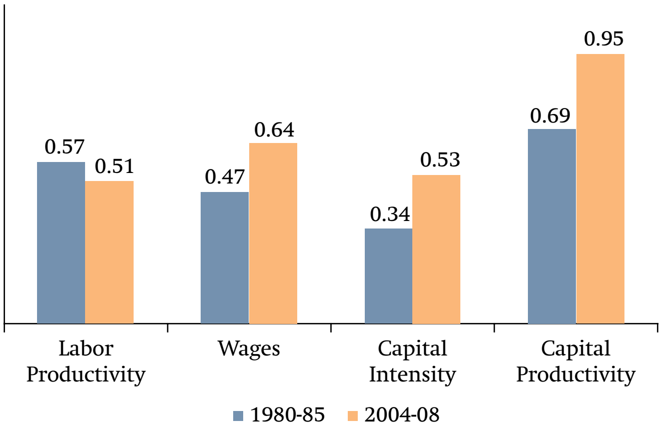
Source: Bathla and Gautam 2013.

has almost converged, but significant gaps remain in wage rates and labor productivity in favor of the non-food-processing industry.

Factors determining employment (labor demand) in food manufacturing

A statistical analysis of labor demand confirms that increasing capital (and capital intensity) and scale of operation are associated with positive but low growth in employment (Bathla and Gautam 2013). The elasticity of employment per factory with respect to scale (output per factory) is estimated to be 0.47, indicating that employment grows half as fast

Figure 80: Ratios of indicators in food to non-food-processing industry



Source: Bathla and Gautam 2013.

as output per factory in the organized segment. The elasticity for the unorganized segment is also positive but lower at 0.17. As expected, wage rate has a strong negative impact on labor demand, but that impact is much higher in the organized segment than in the unorganized segment (–0.47 versus –0.07). Rising wages induce substitution of capital for labor, as confirmed through an alternative specification with capital intensity, which shows a negative and significant impact on employment in both segments.

The unorganized food segment has lower employment elasticity but is also becoming more capital intensive (albeit at a much slower pace than organized processing). Labor productivity has accordingly risen (with a high correlation between capital intensity and labor productivity of 0.78 for 2005/06). Wages have not risen as fast, probably because of the large labor pool in rural areas where most unorganized food processing is located. Large variations across states prevail, however. Capital intensity declined in some states, such as Gujarat, Himachal Pradesh, and Odisha, whereas most others showed varying degrees of increase. The overall trend in employment shows no consistent relationship, suggesting that a mix of "pull" and "push" factors is at work across states. A deeper analysis of the dynamics of the rural informal sector is needed to disentangle the factors driving employment there.

In sum, although the Indian food-processing industry is more labor intensive than other industries, labor intensity has declined significantly as the industry has shifted toward more capital-intensive (labor-saving) technology. The good news is that labor productivity has risen fast, keeping pace with labor productivity in the non-food industry. The more rapid rise in wages (relative to the non-food sector) has had a dampening effect on employment, however, encouraging further capital intensity and scale of operating units. Rising profits are inducing additional investment and the adoption of better technology, as expected, but enterprises clearly prefer to move toward higher capital intensity and labor-saving technology. This preference reflects the perpetuation of informality in the manufacturing sector and a reluctance to hire labor, given labor laws and other factors in the enabling environment.[164]

The significance of these trends for employment and transformation, even in the more rural food-based industry and in the more populous and poorer states, cannot be overstated. Encouraging new businesses to enter and existing businesses to expand employment more rapidly than in the past will create employment, but only with greater attention to the enabling environment and barriers to entry for smaller firms, especially in the lagging states.

164 See the extensive discussion in the Economic Survey (GOI 2013a) and World Bank (2012).

Patterns and Drivers of Private Investment in Food Manufacturing

Given the significant variation across states in employment and private investment in the food industry, it is important to understand the patterns and drivers of investment. Based on standard metrics, this section assesses the concentration and determinants of investment across states. Investment by a firm is based on many factors, such as profit (rate of return), sales, liquidity, cost, and infrastructure. Agglomeration economies, captured mainly through location and urbanization effects, may loom large in firms' investment decisions. At the same time, higher productivity may also be achieved by greater diversity economies in locations having favorable policies for private investment (World Bank 2003).

Regional specialization and concentration/diversification in private investment

Two widely used two indices for specialization and concentration are the Location Quotient (LQ) and Relative Diversity Index (RDI). LQ shows the degree of representation of an industry in a particular region/state relative to other regions/states, with an LQ greater than 1 (less than 1) indicating higher representation (dispersion) of an industry in the state relative to the national average.[165] RDI measures the degree of industrial concentration within individual states.[166] As RDI increases, the regional distribution approaches that of the national economy. An RDI that is greater (less) than the national average indicates greater diversity (concentration).

The LQ and RDI results show significant variation across states, summarized in Table 27 (for detailed state estimates, see Annex 13, Table A.13.3a–b).[167] Food processing has a greater presence (higher share) in the organized segment of the industry in about half (8 of 17) states in the 2000s, with some changes over time. The most significant shifts have been a large decline in concentration in Assam and a large increase in Uttar Pradesh in the 2000s. Most states have remained either stable or increased, with consistent and notable increases in Bihar, Kerala, and Madhya Pradesh. In the unorganized segment, the share of food processing is high across a much larger number of states (13). The level of representation is *higher* in urban areas, both in terms of a higher number of states (15) and a higher LQ in most states relative to rural enterprises. The states with higher shares of investment (representation) in the food industry also have a relatively higher share of output of the food industry in total manufacturing.

The RDI estimates indicate that very few states have diversified their organized industrial base over time. Even in the 2000s, only four states (Haryana, Karnataka, Maharashtra, and West Bengal) have a high level of diversification (RDI greater than the national average at 0.95), with a very high degree of concentration in

165 LQ_ir is defined as LQ_ir = (Investment_is/Investment_s)/Investment_in/Investment_n), where Inv_is= Investment in industry i in state s; Inv_s= Investment in state s; Inv_in= Investment in industry i in country n; and Inv_n = Investment in country n.

166 RDI is the inverse of the summed difference between the regional and national industrial shares, i.e., RDI_s =1/Σi|(Investment_is/Investment_s) – (Investment_in/)Investment_n|.

167 LQ and RDI are calculated using average investment in the food industry drawn from ASI data at the two-digit level classification for the organized segment in each decade from 1980–81 to 1989–90, 1990–91 to 1999–2000, and 2000–01 to 2008–09. For the unorganized segment, the data are from the two NSS rounds (2000–01 and 2005–06).

Table 27: Classification of states as per LQ and RDI estimates based on investment

States with LQ > 1 (representation/concentration)	States with RDI > national average (diversity)
Organized segment, 1980–1989	
Andhra Pradesh, Assam, Karnataka, Maharashtra, Punjab, Tamil Nadu, Uttar Pradesh,	Andhra Pradesh, Gujarat, Maharashtra, Tamil Nadu
Organized segment, 1990–1999	
Andhra Pradesh, Assam, Bihar, Karnataka, Kerala, Maharashtra, Punjab, Tamil Nadu, Uttar Pradesh	Haryana, Madhya Pradesh, Maharashtra, Tamil Nadu
Organized segment, 2000–2009	
Andhra Pradesh, Assam, Bihar, Kerala, Madhya Pradesh, Punjab, Uttar Pradesh,	Haryana, Karnataka, Maharashtra, West Bengal
Unorganized segment, 2000–2001	
Andhra Pradesh, Assam, Bihar, Chhattisgarh, Haryana, Himachal Pradesh, Jharkhand, Kerala, Madhya Pradesh, Odisha, Rajasthan, Uttaranchal, Uttar Pradesh, West Bengal	Haryana, Karnataka, Kerala, Punjab, Rajasthan
Unorganized segment, 2005–2006	
Andhra Pradesh, Assam, Bihar, Himachal Pradesh, Jharkhand, Karnataka, Kerala, Madhya Pradesh, Odisha, Uttar Pradesh, Uttaranchal, West Bengal	Haryana, Karnataka, Madhya Pradesh, Punjab, Rajasthan, Tamil Nadu, West Bengal

Source: Bathla and Gautam 2013.

most states. In the unorganized segment, overall diversification is low (with a national average of only 0.22). Urban enterprises are significantly more diversified, but with the majority of food enterprises located in rural areas, the total RDI reflects the concentration of rural enterprises. Relative to the national average, about half of the states are more diversified (8) in the unorganized segment.

Three main findings emerge from the analysis. *First*, in the organized segment, the food and beverage industry has relatively higher representation (based on LQ) in states that are less industrially developed and have a relatively higher share of income from agriculture. In contrast, the spatial distribution and locational representation of the food and beverage industry in the unorganized segment is dominant in every state, whether industrially advanced or less developed.

Second, food manufacturing is more dominant in states with a higher percentage of poor people. Individuals in the agricultural sector apparently diversify out of agriculture by starting small nonagricultural enterprises or operating such enterprises alongside their agricultural ventures to supplement their incomes.

Third, industrial investments are highly concentrated in specific sectors, with the majority of states having an RDI less than the national average. The weak link between diversity and performance (growth in output per enterprise) suggests that beyond the benefits of competition, other factors, including agglomeration economies (specialization in certain subsectors or industries) and especially linkages back to agriculture (for access to raw materials and cost considerations), may be important reasons for the private sector to invest in food processing in certain states.

Patterns of private investment

The role of different factors in explaining inter-state variations in the pattern of investment in food manufacturing is assessed using a flexible accelerator model (see Bathla and Gautam 2013). In addition to the economic variables and industry characteristics common to such investment functions, key variables of interest are the policy variables, namely infrastructure, agricultural linkage, and investor friendliness. Given India's diverse agro-climatic conditions, which favor the cultivation of many different crops, agricultural linkages are likely to be important for locating investments. Two alternative variables, size of the agricultural economy (share of agricultural state GDP in total state GDP) and land productivity (defined as agricultural state domestic product per unit of net sown area) are used to test this linkage. Capital expenditures by state governments to build roads and bridges are used to test the "crowding in" effect of infrastructure investments on private investment in food processing.[168] The proxy for an investor-friendly environment is the number of industrial strikes and lockouts in a state.[169] To capture any other location effects (broad agglomeration economies such as skilled labor force, size of urban demand, and others), the LQ for factories is used as a proxy.

The descriptive statistics for the data used in the analysis are given in Annex 13, Table A.13.4. Investment rate (investment per capital stock) varies between 10 and 17 percent across states, but investment rate as a ratio of value added is significantly higher and also considerably more variable. Most states also show a high rate of return on capital. As noted, capital output ratios are low across the states, as is capacity utilization. It is also clear that the food industry depends heavily on borrowed capital, with a high ratio of indebtedness (outstanding loan to capital) in most states. Across states, the rate of investment in food processing is relatively higher in agriculturally dominant states and states with relatively lower per capita incomes. The exceptions are Punjab and Haryana, which have a higher share of agricultural income and higher annual per capita income.

Results of the econometric analysis of the determinants of investment show significant impacts of internal industry factors as well as external (that is, state-specific) factors (see Annex 13, Table A.13.5). As expected, investment responds to profits and sales (accelerator). Borrowing as a ratio of capital is negative, suggesting possible credit constraints to expansion, but it is only weakly significant and is sensitive to specification.

Private investment is also influenced by other factors. Infrastructure development is an important determinant of investment. Clearly, higher public investment in roads and bridges has a strong "crowding-in" effect on private investment. Backward linkage of the food industry to agriculture, captured through the share of agricultural income in total state

168 A weighted average of public capital expenditures on roads and bridges, on a per capita basis, for the previous four years is used to assess the crowding-in effect. This approach makes it possible to capture the lags in the likely impact of infrastructure development on investors' expectations and response.

169 The impact of market reforms as initiated under the APMC Model Act could not be gauged because most states implemented the reforms only recently (Chapter 11).

income, is positive and significant, suggesting potential economies of scale and accessibility to raw material as strong determinants. Further, an alternative specification using agricultural productivity also shows a strong positive impact, indicating that not only size but also higher agricultural productivity can stimulate investment in food processing.[170] The estimated elasticity for public infrastructure is substantial at 0.24, but the elasticity for linkage to agriculture is even higher at 0.99. Agricultural productivity shows an elasticity of 0.74. Finally, investor friendliness has an expected negative sign but is not statistically significant, although this result is likely clouded by the state fixed and lagged investment effects.

The key results from a policy perspective are the backward linkages to agriculture, the importance of infrastructure, and the role of credit. Backward linkages to agriculture are clearly important for increasing private investment (and thus employment) through food processing. The food industry's concentration in agricultural states and relatively lesser presence in the more industrial states such as Gujarat and Maharashtra is consistent with this result and clearly suggests that "location" matters.

Encouraging private investment in food processing in the relatively more agricultural states such as Bihar, Himachal Pradesh, Madhya Pradesh, and Uttarakhand could contribute significantly to poverty reduction. Recently several states have sought to attract private investment through incentives including subsidies, single-window clearance mechanisms, tax holidays, and the mobilization of required resources. To complement these initiatives, creating the enabling environment for private investment by removing the regulatory and institutional constraints (such as the marketing issues discussed in the previous chapter) needs to be a high priority. The recent opening up of FDI in retail is likely to yield significant benefits for those states that move most rapidly to initiate and implement investor-friendly reforms in the agricultural sector.

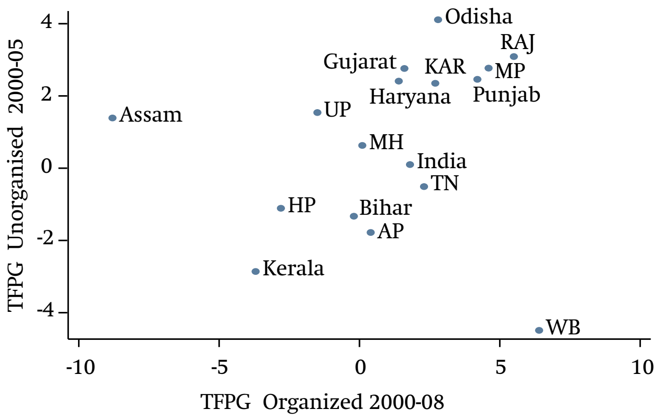
Productivity Growth, Technical Change, and Technical Efficiency in the Food-processing Industry

Trends in partial factor productivities show that labor productivity has grown consistently in the organized segment of the food-processing industry since the 1980s, while capital intensity increased rapidly (though both have slowed from their very high rates of growth in the 1980s) (Annex 13, Table A.13.6). Capital productivity has declined for the most part, although modest growth began in the 2000s. The unorganized segment shows similar trends, despite the relatively short time between the two surveys in the 2000s, with a slightly higher annual growth rate in capital productivity than in the organized segment. Interestingly, the fairly high correlation between capital intensity and labor productivity across states in the 1980s (0.78) declined in subsequent decades (to 0.22 in the 2000s), showing no clear pattern in any state except Maharashtra (especially in the 2000s).

Given these divergent trends, assessing the performance of the food-processing industry using total factor productivity (TFP) gives a better picture of how well the industry is performing. Estimates of the annual TFP growth

170 The specification uses agricultural productivity from the previous year (in other words, a one-year lag) to avoid the problem of potential endogeneity with current investment. The impact of infrastructure becomes insignificant in the specification with agricultural productivity as the two variables are correlated.

Figure 81: TFPG in organized and unorganized food manufacturing, 2000–09 and 2000–05



Source: Bathla and Gautam 2013.

(TFPG) are given in Annex 13, Table A.13.7. Figure 81 gives the scatter plot of TFPG in both the segments during 2000–08.

For all of India, TFPG was positive in the pre-reform period (1.28 percent), declined in the immediate post-reform period of the 1990s (–0.45 percent), and picked up in the 2000s to attain its highest level (1.76 percent). The decline in the 1990s possibly reflects the increased investments in capital, while labor growth continued at a steady but lower rate. This pattern is consistent with lags in the benefits from capital investment, which perhaps started to be realized in the 2000s. Like the other indicators, TFPG varies across states. A majority of states saw a rise in TFPG after 2000, except for Assam, Bihar, Himachal Pradesh, Kerala, and Uttar Pradesh.

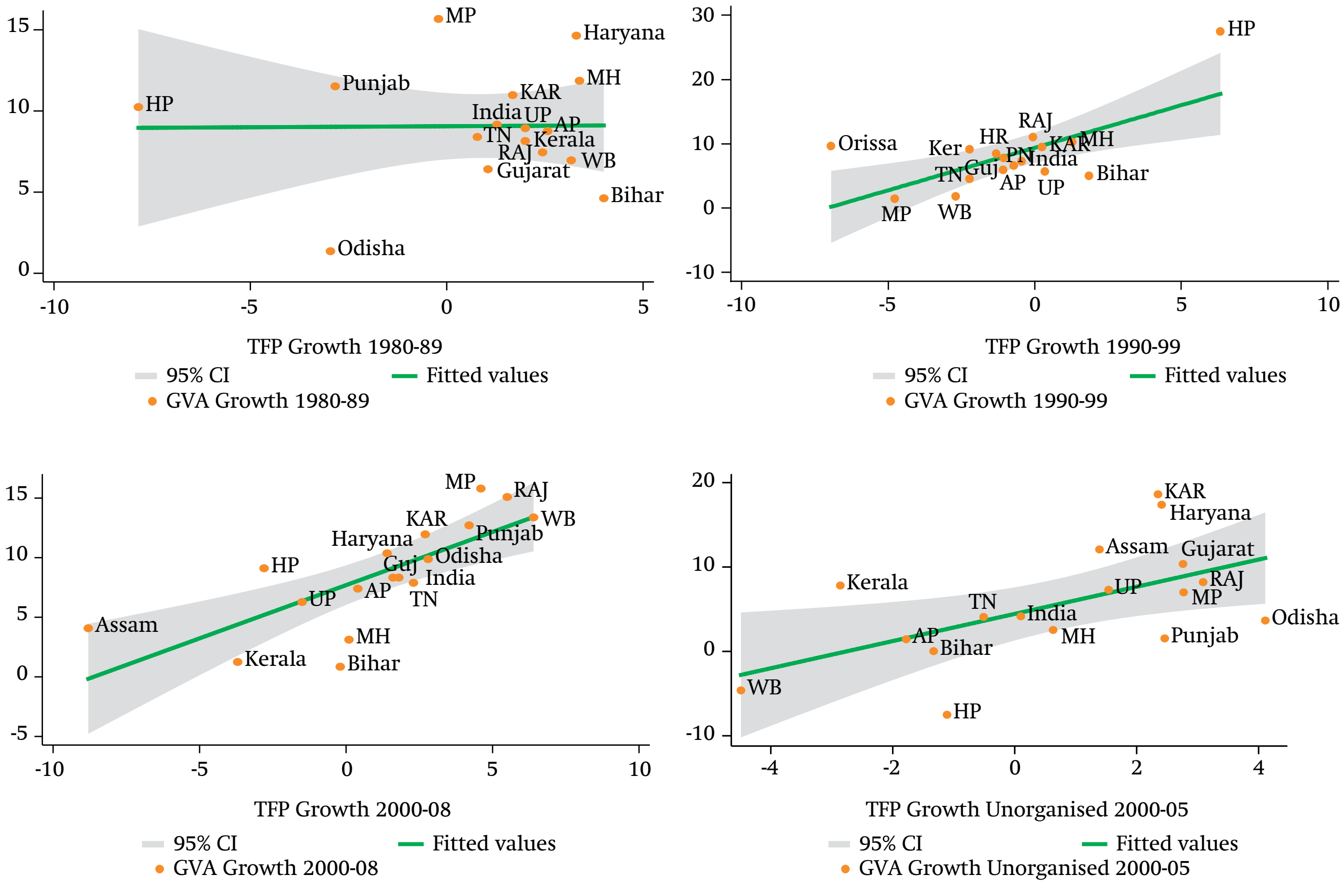
The data make it possible to estimate TFP for the unorganized segment only for the post-reform period. TFPG is estimated separately for rural, urban, and all areas. At the aggregate level, TFPG for the unorganized segment was positive but much lower than in the organized segment. Across states there is considerable variability, but on average TFPG is estimated to be higher for rural enterprises. The correlation between TFPG for the organized and unorganized segment across states is strong and positive (Figure 81), indicating that states doing better in one segment also do better in the other, though at very different rates of growth. The implication is that some states may have a better overall investment climate for food processing.

The better growth in TFP for the organized food industry may be attributed to the acquisition of better technology, driven by the growing demand for processed food and a policy change in favor of this segment. The low growth in TFP in unorganized food processing is consistent with the weak position of many micro-enterprises, reflected in their high exit rates, low capacity utilization, and inadequate resources and/or skills. These problems are particularly acute among the OAMEs that represent a large share of the enterprises in the unorganized segment.

The unorganized segment might grow through a complementary relationship with organized food manufacturing, yet while TPFG is positively correlated between the two segments, in the 2000s the correlation was low and statistically insignificant (0.28). The correlation between TFPG in the organized food segment and growth in GVA in the unorganized segment is also low, indicating weak complementarity (for example, through outsourcing or subcontracting) between the two segments.

Another important finding is the growing relationship between TFPG and growth in output (GVA) in both the organized (correlation of 0.63) and unorganized (correlation of 0.77) segments, indicating growing efficiency in the

Figure 82: Relationship between growth in GVA and TFP



Source: Bathla and Gautam 2013.

use of inputs. This relationship has evolved over time. Figure 82 plots GVA and TFP growth in food processing in major states for each of the three decades from 1980–81 onward. No relationship existed in the 1980s, but a positive relationship developed in the 1990s and remained positive in the 2000s. The same relationship holds for the unorganized segment in the 2000s.

Explaining TFP and technical efficiency in food processing

What explains changes in productivity growth in food manufacturing? This analysis estimates the relative technical efficiency in food manufacturing to assess the extent of inefficiency in the industry—either because subsidies and other incentives drive inefficient input use or because of other factors. Technical efficiency is a key component of TFP and provides an assessment of the relative performance of individual states.[171]

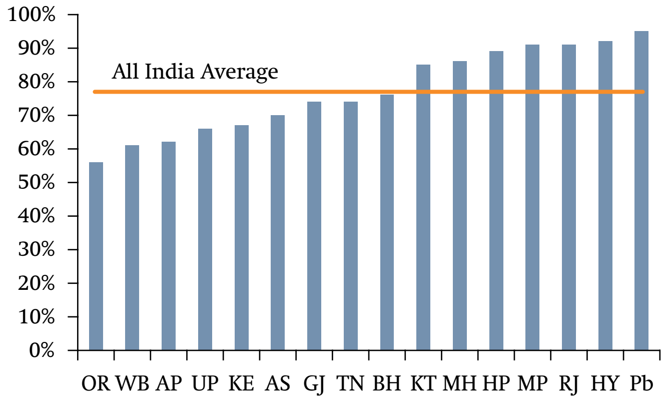
171 The analysis uses stochastic frontier analysis based on time invariant and time varying decay inefficiency models. The estimates are based on an estimated standard Cobb-Douglas production function with labor and capital (fixed capital stock from ASI data and value of fixed assets from the NSS data for the unorganized segment). See Bathla and Gautam (2013) for details.

The estimated factor elasticities indicate scope for additional labor absorption through expansion, with significantly higher potential in the unorganized segment.[172] In the unorganized segment, rural enterprises tend to be more productive than others. Finally, both the organized and unorganized segments seem to be operating below optimal scales—both exhibit increasing returns to scale. The fact that enterprises in the unorganized segment operate well below optimal levels highlighted throughout India, as labor laws and other regulatory constraints create strong disincentives for enterprises to expand (GOI 2013a).

In terms of technical efficiency, the average firm appears to operate at about 77 percent efficiency, although levels vary widely across states, from 56 percent in Odisha to 95 percent in Punjab. Several states are at the high end of the efficiency scale, including Haryana, Madhya Pradesh, and Rajasthan in addition to Punjab, implying that the potential for easier gains through pure technical efficiency appears to be lower than in other states. At the other end of the scale, Andhra Pradesh, Kerala, Odisha, Uttar Pradesh, and West Bengal are operating at low levels of efficiency, suggesting significant scope for improvement.

Figure 83 shows average efficiency levels for the entire period (1980–2009), but efficiency levels have varied in most states over time.[173] Haryana, Himachal Pradesh, Karnataka, Madhya Pradesh, Punjab, and Rajasthan had high levels of

Figure 83: Technical efficiency across states



Source: Bathla and Gautam 2013.

efficiency in the 1980s, which they maintained in subsequent decades (Annex 13, Table A.13.8), whereas other states started at relatively lower levels and have fallen further behind, with consistent declines over the decades.

These results demonstrate the considerable scope to improve productivity in the organized food industry in most states. This goal could be achieved in agriculturally dominant states through appropriate measures to exploit their comparative advantage in offering lower transaction and transport costs (for raw materials), better economies of scale, and cheap labor. A favorable policy of appropriate incentives and enabling environment offers promise, as shown by the examples of Himachal Pradesh and Madhya Pradesh (and lately Uttarakhand), which offered incentives for private investment. Himachal Pradesh has a small share in the food industry in terms of factories, workers, investment, and output, but efficiency and productivity are much higher there than in other states.

What explains the variation in the food industry's productivity from one state to the next? This question has received less

172 The coefficient of labor, estimated at 0.61, is slightly higher than the coefficient for capital at 0.48 in the organized food industry. In contrast, the value of coefficients of labor in NDME-DME is much higher at 1.56 and lower for capital at 0.37.

173 Decadal estimates are derived from a time varying decay inefficiency model.

attention than warranted by India's spatial heterogeneity. It can be examined by estimating the effects of the following factors on TFP (subject to the availability of data): infrastructural development, of which two particularly important public investments are roads (represented by road density) and power (measured as electricity consumption per capita). With respect to power, an equally important dimension for investing in processing plants (as in manufacturing more broadly) is access to power, which may be limited given the share of electricity used by agriculture (often heavily subsidized). Other factors include investor friendliness (numbers of strikes and lockouts as a proxy for the investment environment); localization index (measured as the LQ for factories to test for agglomeration economies); agricultural linkages (size of agriculture in the state economy to capture the importance of backward linkages in determining the productivity of the food industry); and urbanization (to proxy market or demand side factors).

The results (Annex 13, Table A.13.9) confirm the earlier finding of strong cross-state differences as captured by the state fixed effects, clearly showing that the broader policy and institutional environment matters significantly for productivity. These strong state-specific effects, which reflect public investment decisions, appear to cloud the effect of roads. Controlling for state fixed effects, the results suggest that improvements in road density over time within a state (the "within" state effect) have a positive impact, although it is not as strong statistically as other results. The agricultural linkages again have a high and significant impact, showing that the relative size of the agricultural economy helps improve the productivity of food processing. A 1 percent increase in share of agriculture in the state economy is associated with an increase in the productivity of the food processing sector by about 0.3 percent. As expected, investor friendliness is important, with strikes and lockouts having a significant negative impact on productivity. Urbanization is another significant determinant of productivity in food processing, reinforcing the importance of access to markets and consumer demand. The LQ for the industry is positive but not statistically significant, suggesting that agglomeration economies appear to be adequately captured through backward linkages, urbanization, and institutional environment.

Summary and Implications

Geographical and agricultural conditions heavily influence an environment's favorability for improving productivity in food manufacturing, encouraging additional investment in the industry, and creating much-needed jobs of good quality off of the farm. This result is understandable, given the benefits to be had from good access to raw materials with fewer transaction and transport costs. It is consistent with and helps provide a rationale for the earlier findings that private investment in food processing tends to be concentrated in more agricultural states.

In addition to the agro-ecological endowments and structural factors, the results show that state-specific factors such as the policy and institutional environment play a very large role in explaining TFP and productivity growth. These factors are not fully understood, and they could not be captured in the analysis above using the data in hand. Further research will be critical to expand the understanding of the role of policies that can support growth in productivity in food processing and agriculture more generally.

The findings highlighted here point to the significant potential for agriculturally dominant states to attract private investment in the food industry. Rapid expansion of this relatively more labor-intensive industry in laggard states with low per capita income, high dependence on agriculture, and high incidence of poverty will help to absorb more people from agriculture. These arguments are even more relevant with respect to the unorganized segment of the industry, which is more widespread, has higher potential to absorb labor, but has low productivity. Public policy thus needs to focus on promoting growth in agricultural productivity and increasing investments in supportive infrastructure such as irrigation, roads, and marketing facilities, within a climate that will attract private investment. The high levels of (technical) efficiency within the food-processing sector in many states suggests that the food industry is well placed to compete in a more liberalized marketplace, suggesting potential scope for FDI as well as exports.

E. Transforming Agriculture in East India

Geographical diversification of the production base from the traditional grain basket (the irrigated upper Gangetic plains) is a high priority for the government. An important element of the broader strategy is to promote growth in agricultural productivity in the eastern states, given the sustainability concerns and diminishing returns in cereals in northwestern India. With substantial water, a suitable climate for cereals (especially rice), and significant room to improve yields, the underdeveloped eastern states are an attractive alternative for sustaining national food security. The focus on catalyzing the transformation process in the LIS and rainfed areas—which occupy 60 percent of the country's area—is also driven by their potential to produce high-value commodities such as oilseeds, pulses, horticultural crops, and livestock.[174]

Eastern and Central India (comprising Bihar, Uttar Pradesh, Jharkhand, Madhya Pradesh, Odisha, and Chhattisgarh) are well endowed with natural resources for agriculture,[175] yet they are food-deficit areas with very low agricultural productivity. At the same time, they house the largest number of undernourished and poor people in India (more than 40 percent). Multiple reasons have been forwarded for the poor performance and historically poor agricultural growth of these regions.[176] They have a high risk of concurrent floods and droughts, small and fragmented landholdings, little infrastructure to facilitate agriculture, weak institutions, poor governance, and a poor policy response to the changing needs of agriculture. The general perception is that eastern India presents enormous opportunities if its natural resources can be judiciously managed, appropriate policies and institutions established, and supportive agricultural infrastructure put in place. With the limited resources available, it is important to focus and sequence any reforms and interventions in these areas to ensure that they realize their potential for improved agricultural growth. This chapter conducts an in-depth assessment of two states—Bihar and Odisha—to gain a better understanding of the constraints and opportunities involved in promoting more rapid agricultural growth in eastern India.

174 LIS include Bihar, Chhattisgarh, Jharkhand, Madhya Pradesh, Odisha, Rajasthan, and Uttar Pradesh.

175 Northeastern states, including Assam, are classified as Special Category States, and are not the focus of the analysis here.

176 NAAS (2010, 2011).

14 PRIORITIES FOR AGRICULTURAL GROWTH IN BIHAR AND ODISHA

The Low-income States (LIS)[177] have long lagged behind the other states in overall and agricultural growth. Their GDP growth improved significantly between 2005 and 2012, narrowing the differential with the non-LIS, but still remains lower on average at 7.8 percent per year compared to 8.5 percent all other states (Annex 14, Figure A.14.1). The average for the four eastern states (Bihar, Chhattisgarh, Jharkhand, and Odisha) is about the same as the LIS average. In contrast, agricultural growth in the LIS (4.9 percent) has been higher than the non-LIS (about 3 percent), suggesting convergence, although the LIS started from a very low base. The eastern states' average agricultural growth is close to the overall LIS rate.

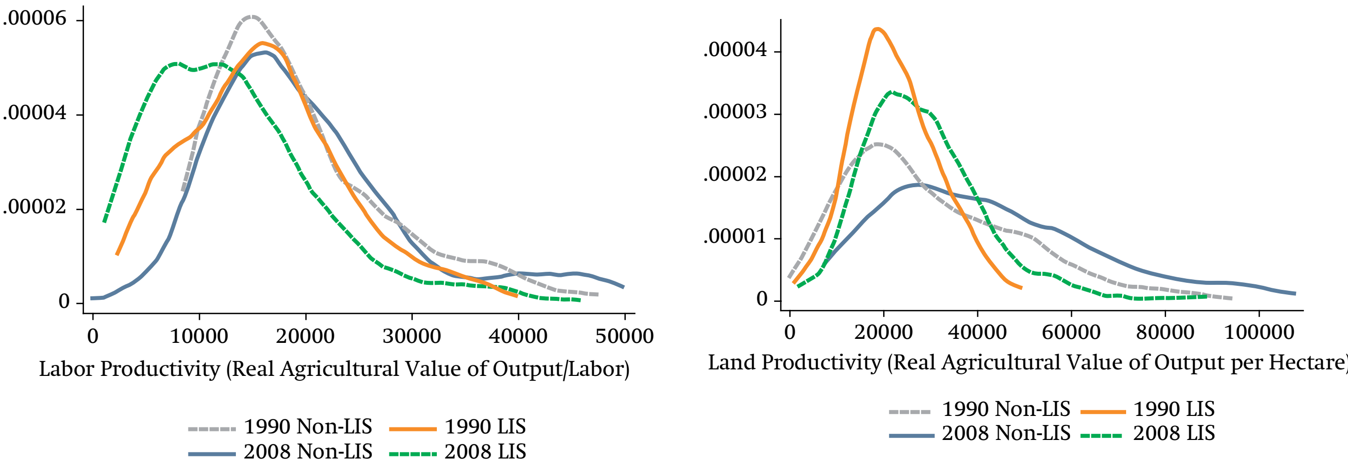
The level of poverty reflects the level of development in each state (Annex 14, Figure A.14.2). The seven LIS states collectively house 62 percent of India's poor and 64 percent of the rural poor.[178] Poverty is overwhelmingly rural, averaging 84 percent across the LIS (the national average for rural areas is about 80 percent), with the highest incidence in Odisha (91 percent) and Bihar (90 percent). With the exception of Rajasthan, all rural poverty rates in LIS are higher than in non-LIS, although both groups experienced a similar reduction in poverty in recent years.[179] Within the LIS and non-LIS, states with a relatively larger share of the economy in agriculture also had a lower head-count ratio of poverty in 2011–12 (Annex 14, Figure A.14.3). Drawing causal inferences from these trends may be misleading (a deeper analysis of the drivers of poverty is required), but they do not prima facie suggest inherent links between poverty and the share of agriculture in the economy.

India's broader development strategies focus on agriculture as an important component of making growth more pro-poor. The RKVY "Bringing Green Revolution to Eastern India" program, for example, focuses explicitly on promoting agricultural production in eastern India, to promote inclusive growth as well as maintain food security in light of the concerns about the sustainability of production in the traditional northwestern breadbasket states.[180] Recent experience from Gujarat shows that appropriate policies and interventions can stimulate agricultural productivity and growth (Shah et al. 2009).[181]

177 Lagging states include Assam, Chhattisgarh, Jharkand, Madhya Pradesh, Odisha, Rajasthan, and Uttar Pradesh.
178 Estimated from Planning Commission (2013) data.

179 Poverty estimates on national poverty line using uniform reference period, for 2004–05 (Planning Commission 2013 data).
180 For details, see http://bgrei-rkvy.nic.in/
181 Gujarat averaged annual agricultural growth of 9.6 percent between 2000 and 2007. Gujarat's growth has slowed since 2007 but remains on par with that of other states.

Figure 84: Change in labor and land productivity for LIS and non-LIS, 1990–2008



Source: Authors' estimates, using district agricultural productivity data from Kumar and Jain 2012.

This chapter examines the barriers to agricultural growth in Bihar and Odisha, two of the poorest and least developed eastern states, and identifies opportunities for faster and more inclusive growth. Given the heterogeneity and potential governance issues (since agriculture is a state responsibility), a case study approach is adopted for this analysis.[182] After characterizing the current status of agriculture in these two states, the following sections discuss the specific challenges to the sector in each state and potential interventions to overcome them.

Agricultural Performance

Agriculture's share in the economies of both Bihar and Odisha has declined quite rapidly; in 2011–12, agriculture and allied sectors accounted for 22 percent and 16 percent of their respective state economies (GSDP), respectively (Table A.14.1). Both states face a significant structural transformation problem: Agriculture's share in economic output is falling much faster than the share of people employed in agriculture, which remains disproportionately large at 63 percent of Bihar's 10.9 million workers and 62 percent of Odisha's 16.2 million workers in 2009.[183] Continued rapid population growth and insufficient exit of labor out of agriculture has resulted in falling labor productivity, even as land productivity improved between 1990 and 2008. This situation contrasts sharply with that of non-LIS (Figure 84).

Recent years show some improvement, with Bihar and Odisha experiencing higher agricultural growth rates than the non-LIS after performing poorly in the 1990s (Bihar grew slower than the national average; Odisha had negative growth). Despite the good performance in the last decade, significant scope for improvement remains in both states, as the following sections indicate.

182 The Bihar- and Odisha-specific details in subsequent sections draw heavily from preliminary drafts of background papers prepared by IFPRI (2012a, 2012b).

183 These shares are estimated from Planning Commission (2013) data and are lower than the shares in 2004. Since then, employment growth has been faster in nonagricultural sectors, such as industry in Bihar.

Low yields and wide yield gaps

Very low yields are typical of agriculture in both states (Figure 85), but large yield differentials for crops and livestock are found across districts within each state (IFPRI 2012a, 2012b). Despite generally favorable growing conditions (plenty of water, sunlight, and good soils), the substantial variation in local agro-ecologies calls for a localized rather than generic approach. For example, the most popular crop in both districts is rice, but yields on nearly half (47 percent) of Bihar's rice area are less than 1.5 tons per hectare. Similarly, yields in one-third of the wheat area are less than 2 tons per hectare. Maize has performed better in Bihar, with relatively fast growth in output, half of it due to improved yields.

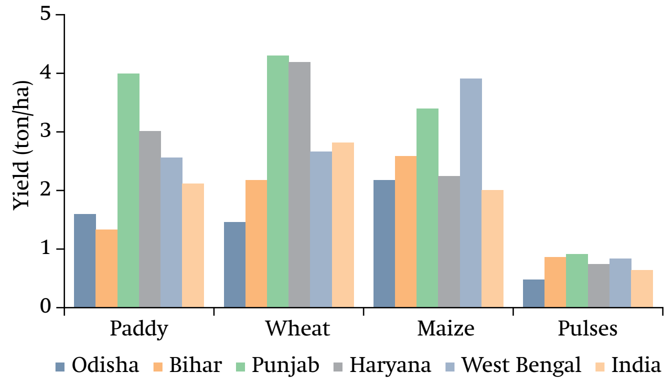
Rice is even more important in Odisha, occupying about half of the gross cropped area. While the area under rice has been steady, its share in gross cropped area has slowly declined.[184] Rice yields grew reasonably well after 2001 (from 1.1 tons per hectare in 2000/01 to 1.6 tons per hectare in 2008/09), for an annual increase in rice production of 6.47 percent. Almost all of this increase (97 percent) was from yield improvements.

Yield gaps are large. In rice, yield gaps for popular varieties are as great as 300 percent in Bihar and 80 percent in Odisha (Figure 86). Substantial yield gaps remain in maize in Bihar, despite rapid recent growth, calling for better management practices.

The LIS generally have significantly lower milk and livestock productivity (Leitch, Ahuja, and Jabbar 2013). For example, milk and overall livestock productivity in Punjab, Kerala, and

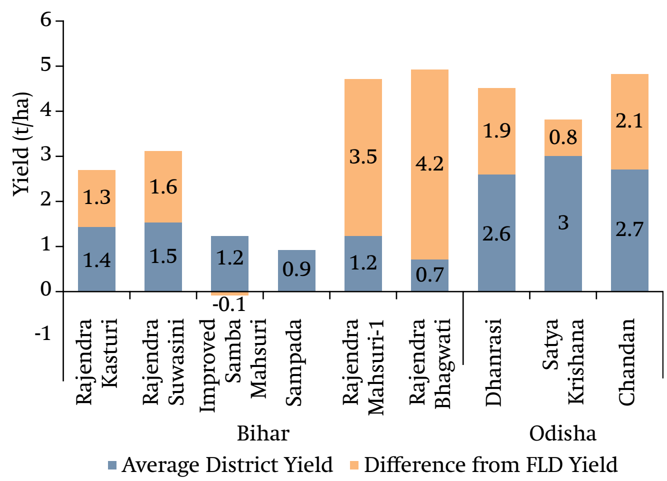
184 Share of area under rice declined from 56 percent in 2000–01 to 48 percent in 2009–10.

Figure 85: Average yields of major crops in selected states (2009/10, MT/ha)



Source: MoA (various), Directorate of Statistics and Evaluation, Department of Agriculture, Government of Bihar.

Figure 86: Rice yield gaps in Bihar and Odisha, 2009 (difference between district average yields and frontline demonstration yields, by variety)



Source: DRR and IFPRI 2012a, 2012b.

Note: Bihar districts are Bhagalpur, Munger, Banka, Nawada, Jahanabad, Patna, Nalanda, Samastipur and Muzaffarpur; Odisha districts are Dhenkanal, Jagatsinghpur, Jajpur and Puri.

Haryana are at least double the levels in Bihar and Odisha. IFPRI (2012a, 2012b) finds substantial gaps in milk yields in Bihar and Odisha (Table 28).

Table 28: Milk yields in Bihar and Odisha (kg/day/per animal) in 2009–10

	Average yield	Yield range under best practice
Bihar		
Crossbred cattle	6.2	9.5–11.1
Indigenous cattle	2.9	4.2–4.9
Buffalo	3.9	5.5–5.9
Odisha		
Crossbred cattle	5.9	10–15
Indigenous cattle	1.2	3.7–5.7
Buffalo	2.9	6–8

Source: Basic Animal Husbandry Statistics 2010, GOI.

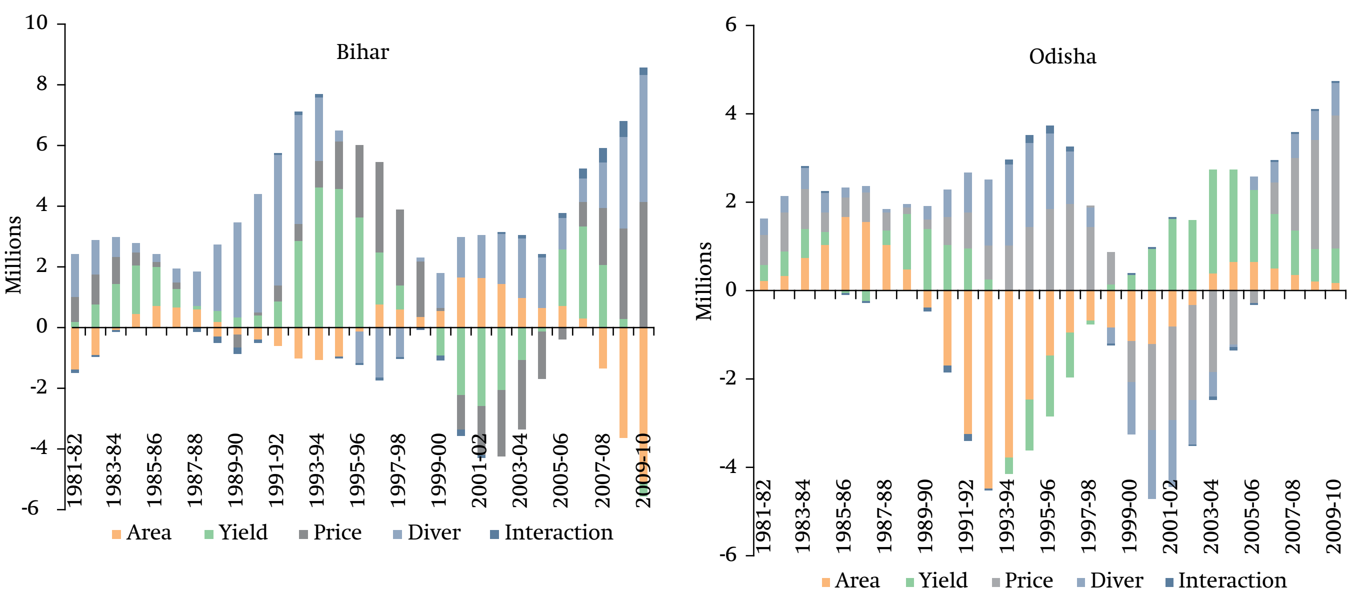
A rapidly diversifying production base

As shown in Chapter 6, diversification drove nearly one-third of the growth in the crop sector in East India between 2004 and 2009. Both Bihar and Odisha are good examples of a rapidly diversifying production base in which the share of food grains has fallen. In Bihar, fruits and vegetables accounted for 14 percent and livestock for 30 percent of the value of agricultural output in 1990–91. By 2008–09, their shares had risen to 23 percent and 40 percent, respectively. In contrast, the share of rice was only 11 percent and wheat was 8 percent in 2008–09.

Similar patterns are observed in Odisha. The share of high-value commodities (fruits, vegetables, livestock, and fisheries) in output has risen rapidly. Fruits and vegetables are the largest share of output, with eggplant, tomato, cabbage, cauliflower, and okra being the most important. They accounted for 65 percent of vegetable production and 56 percent of area under cultivation during 2009–10.

Despite their seeming agro-ecological similarities and increasing agricultural diversification, the two states show distinct patterns and sources of growth (Figure 87), which belie broad conclusions about growth processes across the subregion. For example,

Figure 87: Sources of growth in Bihar and Odisha, 1981–2010



Source: Authors, using data from Birthal et al. 2014.

Bihar has seen strong and consistent diversification, in which prices have played a lesser role. An important finding is that land is increasingly being taken out of production, which is undoubtedly a drag on growth. Improved yield spurred growth in Odisha in the early 2000s, but now growth is led primarily by prices. The rising contribution of prices and declining contribution of yields raises concerns about the sustainability of growth. In comparison, the sources of growth in Bihar appear to be more robust.

Significant diversification has occurred beyond the crop subsector with a rising contribution from the livestock sector over the past two decades, (Annex 14, Table A.14.3) (IFPRI 2012a, 2012b). Leitch, Ahuja, and Jabbar (2013) estimate that in 2008/09, the livestock subsector was responsible for 69 percent of agricultural growth in Bihar and 42 percent in Odisha. These contributions are substantially higher than the 36 percent share of livestock in agricultural growth for all of India, indicating the importance of livestock as part of the growth strategy, given rapidly rising demand for livestock products and the limited land for extensive cultivation of crops.

Challenges

Holdings are small and fragmented

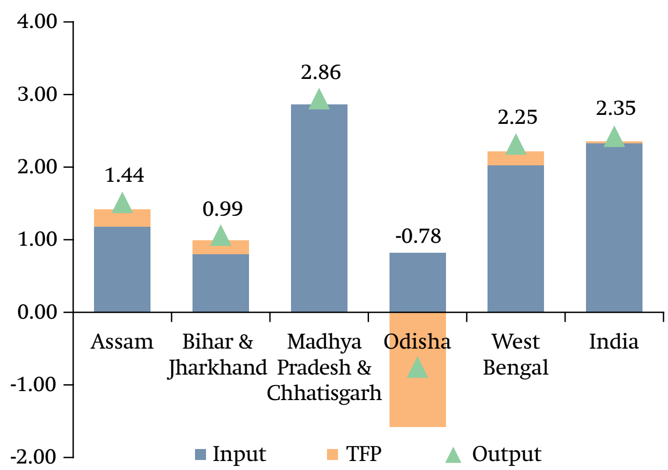
Smallholders predominate in Bihar and Odisha. The fragmentation of land holdings is an additional challenge to efficiency and productivity in Bihar. The "nano" scale of operations is a constraint in marketing output (especially bulky, low-value cereals) and in accessing information on grades and sanitary and phytosanitary standards necessary to move up the value chain (IFPRI 2012b). When the marketable surplus is small, transaction costs and market risks tend to be very high.

About 90 percent of the holdings in Bihar are under 1 hectare (72 percent are under 0.5 hectare). The average land holding is extremely small in Bihar (0.43 hectare in 2005–06) (Annex 14, Table A.14.2). It is higher in Odisha (1.15 hectare in 2006–07), but farm sizes are declining there as well. Already 60 percent of holdings in Odisha are less than 1 hectare. The small size of holdings, absentee landlordism, and tenancy and sharecropping arrangements discourage investments in agriculture, especially for land development and irrigation. Tenancy is pervasive in Odisha, mostly on a sharecropping (cash or kind) basis (IFPRI 2012a).

Growth in productivity is sluggish

As at the national level, over the long run (1980–2008) crop production (excluding horticultural crops) has been heavily input-driven (Figure 88). Bihar and Odisha were

Figure 88: **Sources of output growth in selected states, 1981–2008 (%)**



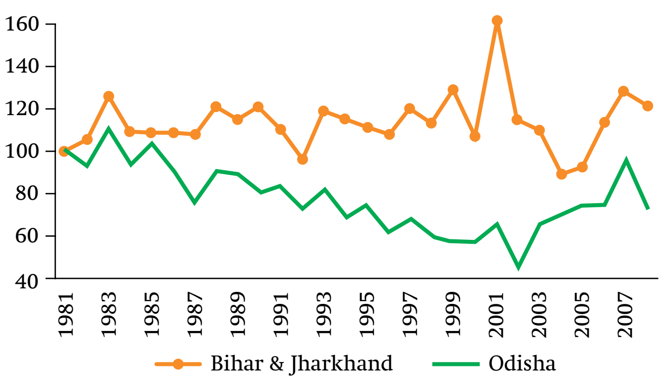
Source: Calculated using estimates of Kumar, Gautam, and Joshi 2013.

among the states with the slowest growth in production; production actually contracted in Odisha in the 1990s. While Bihar's crop sector experienced some TFP growth, Odisha's hemorrhaged as productivity fell throughout the 1980s and 1990s (Figure 89). Odisha's TFP has also been highly erratic over the past two decades. Between 1981 and 1995, TFP declined at an average annual rate of 2.5 percent, but it has since risen faster than in any other state (1.86 percent).

Low input use efficiency is a major contributor to sluggish and negative productivity growth in Bihar and Odisha, partly because seed replacement rates are low and fertilizer use is imbalanced. In Bihar, the seed replacement rate has hardly ever exceeded 15 percent, except for maize, rapeseed-mustard, rice, and wheat; the highest replacement rate is about 30 percent for wheat. In Odisha, the seed replacement rate is less than 14 percent. Seed replacement rates are higher where hybrids are available, such as hybrid sunflower (about 83 percent).

Fertilizer use is more differentiated. Odisha's fertilizer intensity (NPK kg/ha) has consistently

Figure 89: TFP in traditional crops, Bihar and Odisha, 1981–2008



Source: Estimated from CoC data (Kumar, Gautam, and Joshi 2013).

Table 29: Fertilizer use in Bihar and Odisha

	NPK use intensity (kg/ha)		Growth in NPK intensity (% per year)
	2000	2008	2001–08
Bihar	95.76	174.04	10
Odisha	40.49	58.96	6
India	89.73	127.67	5

Source: Estimated from CoC data.

been half of the all-India average (Table 29), though it has been growing in recent years. In contrast, Bihar's fertilizer use is well above the Indian average and grew at an average annual rate of 10 percent in 2001–08, faster than the national average. In 2009, Bihar's fertilizer use intensity was 231 kilograms per hectare, with fertilizer use in some districts rivaling that in Punjab (400 kilograms per hectare) or Haryana (320 kilograms per hectare). As elsewhere in India, in Bihar fertilizer use is imbalanced. More urea (nitrogen) is applied relative to other nutrients (phosphorus and potassium). Fertilizer use in Odisha is within the recommended range.

High risk of biotic and abiotic stress

Multiple biotic and abiotic stresses, often at high levels, add significantly to the risks inherent in agricultural production in both states. They are a critical constraint on the adoption of new technology, the efficiency of input use, and productive investments, limiting potential growth. Quantitative data are not available on the nature and extent of losses from biotic and abiotic stresses, but focus group discussions identified a number of stress factors affecting crops.

In Bihar for example, rice is affected by sheath blight, bacterial leaf blight, and blast. Stem borers can lead to losses ranging from 25–40 percent of the final output of rice, maize and vegetables (IFPRI 2012b). Similar risks were identified for wheat (rust) and pulses (pod borers).

Odisha also faces a number of biotic constraints exacerbated by high rainfall and humidity, which are conducive to a range of crop diseases and pests (see Annex 14, Table A.14.4 for some of the pests and diseases and their associated risks) (IFPRI 2012a). Crop damage from pests and diseases ranges from 20 percent for the most widely grown rice variety to 70 percent in maize. The susceptibility to multiple diseases and pests makes production very risky.

Abiotic stresses are common in both states, including frequent and multiple threats of floods, drought, soil problems (acidity and sodicity),[185] and waterlogging (IFPRI 2012a, 2012b). Floods are a major challenge for Bihar, where nearly 41 percent of cropped area (2.2 million hectares) is prone to flooding. Bihar experienced severe floods in 2004/05, 2007/08, 2008/09, and 2010/11. In the past five years, droughts have also occurred almost every year. Sodicity adversely affects crop yields on about 300,000 hectares, soil acidity affects 236,000 hectares (25.1 percent of cropped area), and waterlogging affects 628,000 hectares. Odisha's abiotic constraints include floods, cyclones, droughts, acidity and water logging (Annex 14, Table A.14.5). Deficiencies of zinc, boron, and sulfur reduce yields, especially in upland areas.

Poorly functioning markets

Marketing remains a challenge in both states, where commodity prices often fall below prices farmers obtain elsewhere in India. A useful benchmark is the government-established MSP, which is often the floor price for areas that are major producers of commodities supported through public procurement. A comparison for Bihar is given in Table 30. Farmers in Odisha similarly receive rice prices that are 10–25 percent lower than the MSP, even though Odisha's rice markets are well integrated (IFPRI 2012a). Odisha's vegetable markets, on the other hand, are not so well integrated, and prices vary significantly across markets.

Markets in Bihar and Odisha tend to be thinly spread and underdeveloped. The low density of markets raises transportation costs from the

Table 30: Farm harvest prices (FHP) of paddy, wheat, and maize in Bihar and their Minimum Support Price (MSP) (Rs/quintal)

	Paddy				Wheat		Maize	
	MSP		FHP					
	Grade A	Common	Winter	Rainy	MSP	FHP	MSP	FHP
2001–02	560	530	418	363	620	517	485	366
2002–03	580	550	411	355	630	539	490	397
2003–04	580	550	410	361	630	566	505	403
2006–07	650	620	497	455	850	817	540	514
2007–08	775	745	633	549	1,000	938	620	575

Source: IFPRI 2012b.

185 Sodium content.

farm to primary or secondary markets. Markets often have insufficient basic infrastructure and facilities. Only a very limited number have invested in more sophisticated infrastructure such as cold storage.

Stakeholders highlighted several constraints in marketing agricultural commodities (IFPRI 2012a, 2012b). With the repeal of the APM(D&R) Act, Bihar has no regulatory framework for markets. Any private player can set up a market without government clearance, but private investments have not taken place due to other constraints, such as the lack of access to land—including the now-defunct APM(D&R) markets. Private traders have taken over the marketplaces amid allegations of collusion and monopolistic/monopsonistic behavior by traders/agents, who exact fees as before but do not invest in market infrastructure or provide any services.[186] The situation is viewed as untenable and unconducive to orderly and transparent marketing or proper price discovery.

In Odisha, the Act is intact, but most markets have no mechanism for price discovery and price determination. Prices are mostly "negotiated" rather than determined by an orderly process. The lack of transparency prompts frequent complaints of farmers being "cheated" by traders.

Despite the range of vegetables grown in Odisha, the market infrastructure is generally negligible. A few markets provide basic infrastructure such as a market yard and cleaning and sanitation facilities. Storage facilities are virtually absent. As markets play no active role in price realization, nonmarket forces determine the eventual prices.

Infrastructure gaps

Infrastructure shortfalls in Bihar and Odisha are clear barriers to growth. Poor infrastructure has far-reaching effects on agricultural productivity by raising input prices, reducing output prices, increasing volatility through limiting market integration, and constraining the development of value chains and value addition. Bihar and Odisha, like other eastern states, face a number problems related to infrastructure, partly because past public investments have been low. As noted in Chapter 11 and Annex 11 (Figure A.11.1), eastern India as a region continued to receive far less capital investment per capita for irrigation and infrastructure (roads and electricity) than other regions (Singh 2012). The various Five Year Plans also show that Bihar and Odisha's allocation of plan resources (in rupees per person) has been consistently lower than the all-India average since the very first plan. In the Eleventh Five Year Plan, Bihar received Rs. 6,576 per capita and Odisha received Rs. 8,205 per capita, versus an all-India average of Rs. 13,187. This under-allocation is at odds with the plan's stated objectives of pro-poor and inclusive growth.

Despite this resource constraint, Odisha and Bihar have narrowed the gap in road density with the rest of India (on average). Odisha's road density is 138 kilometers per thousand square kilometers (km/thousand km^2); it also has a long seacoast (with three ports) and a network of railways. Bihar has more than 1,276 km/thousand km^2—higher than the all-India average (812 km/thousand km^2). Current road density is a significant improvement over

186 These allegations, voiced through stakeholder focus group discussions, need to be investigated formally through a detailed market study on the current (post-repeal) structure, conduct, and performance of agricultural markets in Bihar, including the development of farm and wholesale prices.

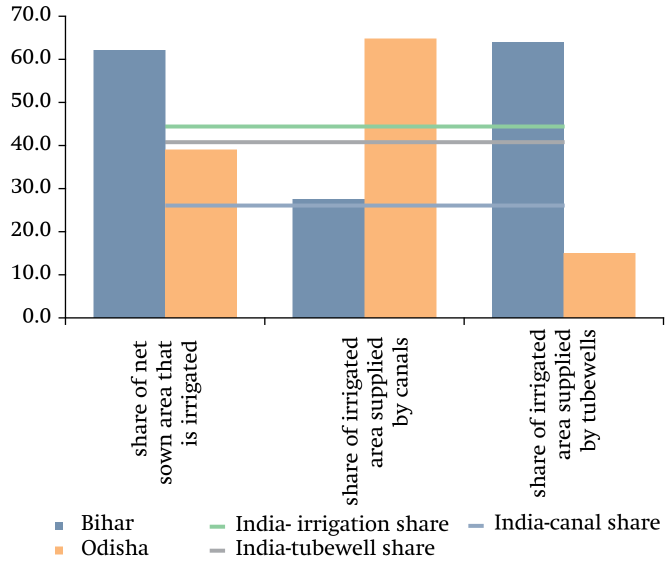
2003, when the state government started to invest heavily in roads. Road density increased at about 9.8 percent per year between 2003 and 2008. On a per capita basis, however, Bihar lags behind the national average. Road density in Bihar is 1.3 km per thousand persons, compared to the all-India average of 3.7 km per thousand persons.

Other infrastructure bottlenecks remain more binding, particularly rural electrification (IFPRI 2012a, 2012b). By 2008, only 52 percent of inhabited villages in Bihar were electrified—60 percent in Odisha—in contrast to 100 percent in Andhra Pradesh, Haryana, and Punjab; 98 percent in Karnataka; and the all-India average of 81 percent. In Odisha, electricity consumption in agriculture is only 1.5 GWh per 100,000 persons, among the lowest in India, where the average is about 45 GWh per 100,000 persons. While electricity consumption in agriculture has increased over the years in other states, in Odisha it declined from 1.7 GWh per 100,000 persons in 2007–08 to 1.5 in 2008–09.

The lack of electricity prevents the LIS in general from increasing irrigation intensity (Annex 14, Figure A.14.4), but Bihar and Odisha appear to be outliers in terms of irrigation development. Bihar, with 62 percent of its net sown area irrigated, *surpasses* the all-India average of 45 percent, while Odisha has 38 percent of its area equipped for irrigation. The nature of irrigation in these two states explains how this development occurred despite severely limited access to electricity.

Groundwater provides 64 percent of irrigation water in Bihar (Figure 90), while 28 percent is sourced from canals, despite access to three major rivers—the Ganges, Kosi, and Gandak. Moreover, 92 percent of the pumps

Figure 90: Extent of irrigation and sources of irrigation water in Bihar and Odisha, 2008 (%)



Source: Authors, using DES, MOA data.

for groundwater are diesel-operated and thus more expensive to operate than electric-powered pumps, but that consideration has not prevented irrigation from spreading (IFPRI 2012a). Bihar could improve its irrigation system by better exploiting its surface water potential.

Odisha's irrigation profile is the opposite of Bihar's, with greater reliance on surface water irrigation: 65 percent of irrigation water is from canals and only 15 percent is sourced from groundwater. This difference is partly a result of Odisha's geological profile, which in many places restricts access to groundwater.

Priority Areas for Growth

Overcoming the challenges to agricultural growth in Bihar and Odisha will require resources and investments—making it necessary to prioritize agricultural investments in overall public expenditures in addition to reorienting current public expenditures to achieve the maximum impact. Historically agricultural investments have been low in both states. Within the existing resource envelope, Bihar's agriculture received about 4 percent of the Tenth Five Year Plan outlay, while irrigation and flood control received about 11 percent. The allocation of these expenditures prioritized infrastructure for food grain storage and crop husbandry, which together accounted for 54 percent of the total expenditure. The livestock sector contributes about 40 percent of agricultural value added but received an allocation of only about 10 percent. An even smaller proportion was spent on dairy development. For Odisha, the share of public expenditure in Agriculture and Allied Activities in total public expenditure was 4 percent in 2009–10, a marked improvement from the 0.8 percent of 2006–07.

The three main areas for intervention to enhance agricultural growth in Bihar and Odisha are improving productivity, marketing, and livestock sector development. These are discussed next.

Strategies and technologies to mitigate risks and increase productivity

Bihar and Odisha have significant opportunities to improve agriculture's performance in ways that maximize its capacity to reduce poverty. The prospects for each state lie along similar but not identical paths. The small size of holdings in Bihar make it more imperative to focus on enabling labor to exit agriculture by developing skills and creating nonfarm jobs. Odisha is not in the same situation but will likely soon face the same problem. In Bihar, the predominance small farms mean that prospects for improving livelihoods and prosperity among those remaining in farming are likely to be enhanced by diversifying into higher-value crops in Bihar. Odisha still has significant potential in traditional crop production, but diversification will remain an integral part of sustainable productivity growth and poverty reduction.

To raise productivity, the high risks from biotic and abiotic stresses need to be mitigated. For both states, better land use through sustainable multiple cropping holds significant promise in this regard. Both have witnessed considerable diversification already, and significant scope remains for further gains. Technology and innovation can enable the current rice-fallow systems to make better use of land and irrigation. Exploiting options other than rice (such as legumes, as in the Barind Tract of Bangladesh), in combination with short-duration rice varieties, will improve the use of soil moisture as well soil fertility and farmers' incomes.[187]

Technological solutions include relatively simple strategies, such as ensuring good quality seed and increasing seed replacement rates. Research and extension can make it easier to cope with abiotic stresses, as in the case of the flood-tolerant rice varieties (like the Swarna-sub1) that are now becoming popular in Odisha and the hybrids being grown in Bihar. Promoting and partnering with private seed

187 Nearly 2 million hectares in Bihar and 1.5 million hectares in Odisha are left fallow during the rainy season to preserve soil moisture for the subsequent rabi (spring) season. New technologies are available to improve the use of land and water resources without compromising soil moisture for rabi crops, and they will significantly improve land productivity and farmers' incomes.

companies to propagate hybrid seed, as for maize in Bihar, is a high priority. Biotechnology is another important and unexploited tool to improve stress resistance and tolerance in new varieties and hybrids, enabling farmers to increase productivity. Improved management practices to mitigate crop risks are equally important.

Input use and efficiency can increase significantly, especially for fertilizer and irrigation. In Odisha the major constraints to using more fertilizer are soil acidity and sodicity. Both have relatively simple technical solutions that can significantly improve crop response to fertilizer and irrigation. Through new programs (or perhaps through reorienting current public programs such as RKVY), acidic and sodic soils could be reclaimed and improved.

Improved management practices have enormous potential, given that the region's abundant water could be better managed to reduces losses and increase production. Surface water management and drainage must receive high priority to direct excess water from flood-prone areas to drought-prone areas. A comprehensive irrigation and drainage program, including hydrological and technical feasibility assessments, needs to evaluate the options for better water management (such as linking rivers with adequate provision of drainage) (IFPRI 2012a).

Finally, agricultural research and development need to be reoriented, in addition to receiving better support from a robust extension program. Spending on agricultural research and extension was low in Bihar and Odisha; extension has been generally low for decades, but spending on research declined to negligible levels in the 1990s (Annex 14, Table A.14.6).[188] Since 2000, research spending has increased at 11 percent and 15 percent per year in Bihar and Odisha, respectively, but spending on extension has stagnated. ATMA and KVKs are the two important channels connecting innovation and farmers, and coordination between these components of the system is necessary to reap the benefits of improved technologies.

A focus on linking smallholders to remunerative markets

Marketing interventions need to focus on smallholders to link them with input and output markets. In this respect, collective action—for example, through producer organizations, cooperatives, farmer associations, or self-help groups, as well as contract farming, farmer companies, and farmer clubs—is important to achieve scale economies. Bihar already has several successful approaches that could be scaled up, such as the Sudha program for dairy production and marketing, and the Samridhi program through the Kaushalya Foundation to integrate vegetable producers and shorten the supply chain in Nalanda District. These innovations offer important lessons on the importance of using sustainable farmer institutions to realize the benefits of new opportunities.

Besides mobilization at the farm level, measures are needed to link farmers with remunerative markets and value chains. Such measures could include evolving special agriculture zones in niche areas such as cereal, fruit, vegetable, poultry, fish, or milk production and processing;

188 In Bihar, 2.7 percent of public expenditure was allocated to agricultural research, compared to 0.1 percent in Odisha (IFPRI 2012a, 2012b). Agricultural research spending was Rs. 6.2 billion in 2007 for India as whole, Rs. 289 million in Bihar, and Rs. 169 million in Odisha.

initiating contract farming; creating an enabling environment and incentives to attract private investment in markets, food processing, and land development; and reforming the policy and regulatory framework to reduce market-related risks, promote transparency, and allow the free movement of goods and services.

An example of a program to link producers with remunerative markets is development of Krushak Bazaars (farmers' markets) in Odisha. To promote direct links between farmers and consumers, the Government of Odisha has established 43 Krushak Bazaars since 2000, through incentives including the provision of land and infrastructure. Wholesale prices in Krushak Bazaars are higher than in the wholesale markets but lower than retail prices (based on primary data collected by IFPRI 2012b), ensuring that farmers and consumers gain. There is scope for improvement: pricing rarely involves farmers, and participating farmers find that the prices do not account for quality differences. There is also evidence that these markets are dominated by nonfarmers. Involving farmers in determining prices, and creating adequate infrastructure, are two areas for improvement.

Another option is to develop horticulture clusters that focus aggressively on horticultural commodities from production to marketing. Initiatives in horticulture have been taken up in an integrated manner by promoting the cultivation of mangoes, bananas, spices, and flowers. With a significant rise in the production of horticultural crops during the last 10 years, the Odisha government has decided to identify clusters by mapping areas producing specific varieties of fruits and vegetables. Along with mapping, the government is creating a policy framework for the private sector to invest in modern market infrastructure, particularly for horticultural crops.

Growth in the livestock subsector—a "quick win"

For both Bihar and Odisha, growth in the livestock subsector represents a relatively "quick win" in terms of poverty impact, empowering women, improving nutritional outcomes, and generating employment for the landless or for marginal farmers. The subsector's strong prospects for growth are seen in its rapid transformation throughout India, with rising demand for higher-value animal products and significant potential for exports (Chapter 10). For example, rapidly expanding exports of buffalo meat constitute an important opportunity for Bihar. Livestock accounts for an increasing share of agricultural output in each state.

Even so, the subsector remains vastly underdeveloped for milk, meat, and other livestock products. Yield levels remain very low, indicating the substantial scope for improvement through better service provision. Veterinary services, breeding facilities, access to good quality feed/fodder, and processing facilities are all in very short supply. Yields of crossbred cows remain very low for several reasons, including indiscriminate breeding, low artificial insemination (AI) rates (Leitch, Ahuja, and Jabbar 2013), limited facilities for AI (IFPRI 2012a), feed constraints, and high morbidity because of the high disease burden. Priority actions to remedy these problems include a reorientation of the agricultural research agenda to focus on major livestock diseases and production constraints, increased policy and public support for small ruminant, pig, and poultry production (with their significant potential for growth), and incentives for private investment in processing, value chains, feed production, and veterinary services.

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ANNEXES

ANNEX 1: POLICY REFORMS AND PRIVATE SECTOR RESPONSE

Table A.1.1 Major agricultural policy reforms since 1990/91

Year	Reform
1991-92	• The new economic policy introduces major economic reforms (including exchange rate deregulation, trade liberalization, export promotion, and decontrol of domestic manufacturing), with significant impact on agriculture, though the sector is not directly affected by the initial reforms
1992/93	• Potassium and phosphate fertilizer production liberalized; nitrogen (urea) pricing remains unchanged due to resistance to reforms • Removal of marketing restrictions in the dairy sector
1994/95	• Agricultural trade liberalization starts after India becomes a signatory to the WTO agreement on agriculture and slowly removes import and export restrictions, with a notable opening up of exports for common rice and subsequently wheat • Trade progressively liberalized but remains heavily regulated, with frequent changes in response to domestic supply situation
1997/98	• Introduction of Targeted Public Distribution System to improve targeting and delivery of the Public Distribution • FDI in wholesale trade opened up • Seed Policy changes allow entry of private sector, including major international firms
1998/99	• Cold Storage Order 1964 repealed
1999/00	• De-licensing of Food Processing Industry to remove the reservation on food processing for small-scale enterprises
2000/01	• Quantitative restrictions on imports eliminated
2001/02	• Restrictions on domestic and foreign investment (FDI) (up to 100%) in bulk handling and storage removed • Inter-Ministerial Task Force and Committee of State Ministers on Agricultural Marketing Reforms implemented
2002/03	• Licensing requirements; stocking limits; movement restrictions on food grains and edible oils removed; and selective credit controls lifted • Milk and Milk Products Control Order (MMPO) amendment removes restrictions on milk processing capacity while continuing to regulate health and safety conditions • Leather and leather and paper products removed from small-scale reservation list • New Pricing Policy Schemes introduced for fertilizers • New Seed Policy introduced

Year	Reform
2003/04	• Ban on futures trading of 54 commodities, including rice, wheat, oilseeds, and pulses, removed • Levy on sugar reduced from 15% to 10% • Model Act for State Agriculture Produce Marketing (Development and Regulation) formulated • Processed food items exempted from licensing under Industries (Development and Regulations) Act 1951, except those reserved for small-scale industries (SSI) and alcoholic beverages • Food processing included in priority list for bank lending • Automatic approval for 100% FDI for most processed foods, except alcohol and beer and those reserved for SSI
2004/05	• Group of Ministers established to formulate modern integrated food law
2005/06	• National Horticulture Mission (NHM) initiated • Negotiable Warehouse Receipt and Warehousing (Development and Regulation) Bill 2005 approved by Cabinet
2006/07	• Food Safety and Standards Act approved • Cess Act repealed • Forward Contracts (Regulation) Amendment Bill submitted to Parliament • Futures trading prohibited for main food grains (rice, wheat, and tur and urad pulses) • Export bans imposed on rice and wheat
2007/08	• National Food Security Mission (NFSM) launched • Rashtriya Krishi Vikas Yojna (RKVY)
2008/09	• Futures trading resumed in some food commodities, including wheat
2010/11	• Nutrient Based fertilizer subsidies introduced
2011/12	• Export bans on wheat and rice lifted
2012/13	• National Food Security Bill (NFS) approved by Parliament

Policy Change and Private Sector Response

The 1990s saw tremendous change in the Indian economy. Agricultural reforms started some years later in the mid-1990s, but the broader economic reforms had already set in motion important changes in the sector. Rapid income growth provided a strong stimulus for agricultural demand, and the change in economic policies (in particular the protection of manufacturing) led to a significant reduction in the domestic distortions in incentives for farmers. Trade liberalization and the prospects of rapid income growth led to private sector investments in consumer products, including for example the entry of PepsiCo (in 1989) and McDonald's (in 1996). These two major investments (the former primarily foreign equity and the latter domestic—through franchising) generated ripple effects with the rapid emergence of snack foods (led by chips) and fast foods through the quick service restaurant (QSR) chains. The ripples backwards were through contract farming and the ancillary industry to supply the raw materials or intermediate prepared food products.

Three key policy changes were the permission of FDI in wholesale trade (1997), de-licensing of Food Processing Industries(1999), and the New Seed Policy (1998). For agriculture, these policies induced a number of potentially transformative private sector initiatives and investments. Several global and domestic corporate investors entered the agro-processing sector (such as PepsiCo, Coca-Cola, Cargill, Hindustan Unilever, Reliance, Tata, Godrej, ITC, and Mahindra's). McCain, the world's largest producer of French fries and potato specialties, started operations in 1998 with a focus on the frozen food market for India and the Indian subcontinent.

McCain's experience highlights the importance of the policy space and gestation period for establishing a viable business. It undertook R&D experiments in five states to grow the "right" quality of potato for its core business and was successful in establishing a reliable supply chain for French fries for the fast-evolving QSR market. Its produce effectively substituted for imports for the highly specific types of French fries demanded by the QSR giant, McDonald's. Similarly, PepsiCo developed the specific variety of potato needed for its Frito Lays chips business, and it now operates a large "contract" farming program for an assured supply for its factories. The demand from the burgeoning snack/fast-food market is one key factor behind the "success" of the potato supply chains (including the wide network of much-needed cold stores for potatoes) despite existing obstacles.

The change in the policy for wholesale trade induced investments such as METRO Cash & Carry in Karnataka (1997). The DCM Shriram (DSCL) group launched its Haryali Kissan Bazaar (rural markets) in north India in 2002, and FieldFresh Foods started to market horticultural products in 2004. The new seed policy attracted a number of multinational companies in the seed sector, like Novartis (later to become Syngenta), Cargill, and Pioneer Seeds. Private sector seeds supply is rapidly growing; it now provides the bulk of improved seed varieties for horticulture and introduced the revolutionary Bt Cotton (in 2002) that has since transformed the Indian cotton sector.

Recognizing the importance of key services—ostensibly to fill the large void in public service delivery in agricultural market information and extension (Ahuja 2014; Ferroni 2013)—two important private initiatives with huge potential for transformative impact are the "e-Choupal" of ITC and the mobile SMS based information service by Reuters Market Light (RML). The "e-choupal" started in 2000 and seeks to connect rural India with data access to market prices, agricultural extension services, and other e-services. The RML (Reuters Market Light) information service, stated in 2007, provides a highly customized and localized agricultural and related information service, primarily aimed at farmers, through mobile phone-based text messages.

The interest of the private sector in the 1990s was triggered by the economic reforms and expectations of rapid increases in consumer income. There was also an expectation that the well-known challenges in making agriculture more competitive (including critical lower-level policy reforms to address the complex and myriad state and central laws on agriculture, taxation, marketing, access to land, roads, power, and water) would be progressively addressed, even if only slowly. Among these, market regulations (such as the APMC Act, ECA, and lack of a uniform national tax code for processed foods) are particularly constraining to the development of efficient agricultural value chains, raising transaction costs and creating uncertainty over whether private investors can sustain their investments and remain viable.

Small and medium businesses are particularly severely affected by these circumstances, as they have much less capacity (either in terms of profit margins or scale of operations) to absorb the costs as the large corporate entities may be able to do.

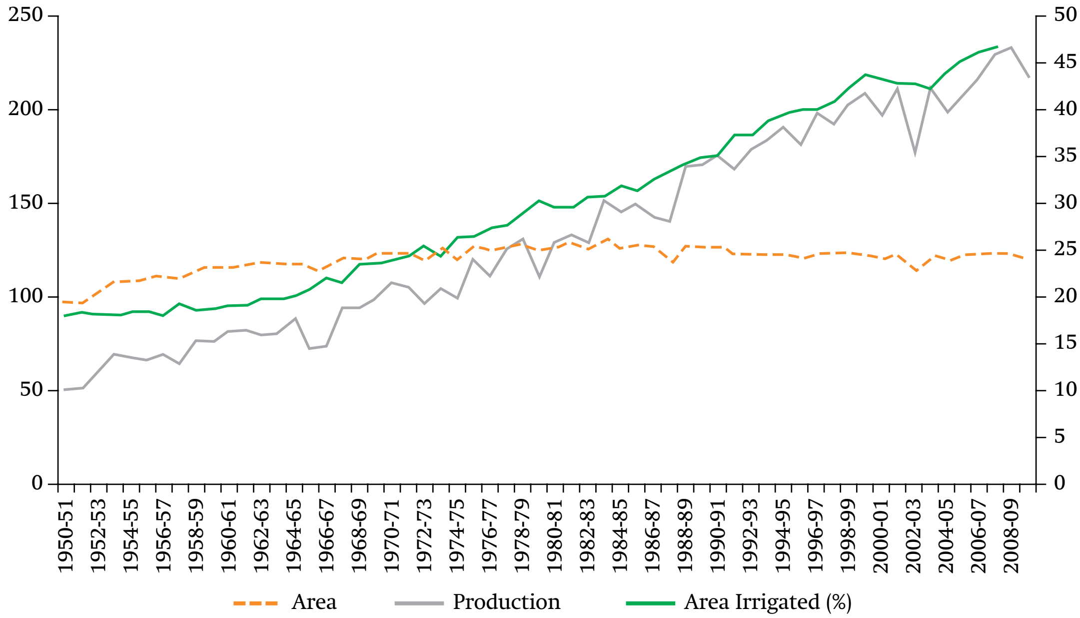
In reality, several large and visible corporate initiatives were rooted in a mix of strategic interests, public relations, or corporate social responsibility activities. Some initiatives have matured into well-integrated and managed supply chains for the investors' main businesses. Others have remained small, reflecting the corporate social responsibility orientation, or have failed to achieve commercial viability. For example, many Indian corporations have attempted chain store grocery retailing but have not seen any significant success. The development of the cold chain infrastructure is a case in point. Cold chains are a priority for moving perishables from their production base to large consumption centers in urban India. Despite government incentives to develop the sector, however, the poor infrastructure (power and roads) and the regulatory framework for agricultural markets have hampered investment and growth in cold chains. Where cold stores have emerged, they have been driven by strong demand (and high margins) for specific commodities such as potatoes, which have made the investment viable despite existing hindrances and transaction costs. They have not emerged as a supply-led solution.

The importance of public support and appropriate policies to promote rapid agri-business growth is demonstrated by the development of horticultural exports (especially grapes) and rapid growth of the poultry and dairy processing industries. On the export front, the government's Agricultural and Processed Food Products Export Development Authority (APEDA), established in 1985 with a mandate to develop and promote exports of agricultural and processed food products from India, has been successful through sustained efforts in improving the transparency of supply, implementing traceability and quality standards, and negotiating entry into the European Union market for Indian grapes, and Japan and the United States for fresh mangoes.

Other successful experiences also point to the important role public policy can play in market development. For example, rapidly rising domestic incomes and urbanization, and the associated growth in demand for animal proteins and milk products, have helped the poultry industry, which has integrated vertically to benefit from economies of scale and value chain integration. The industry has benefited significantly by the absence of any truly inimical regulations to hinder business development, but its growth has been limited by the lack of proper cold chain infrastructure for frozen and processed poultry meat. Similarly, the removal of market restrictions in the dairy industry led to a rapid response by the private sector in creating new value chains in many parts of the country. The projected growth in demand is now attracting large international and domestic investments in the sector.

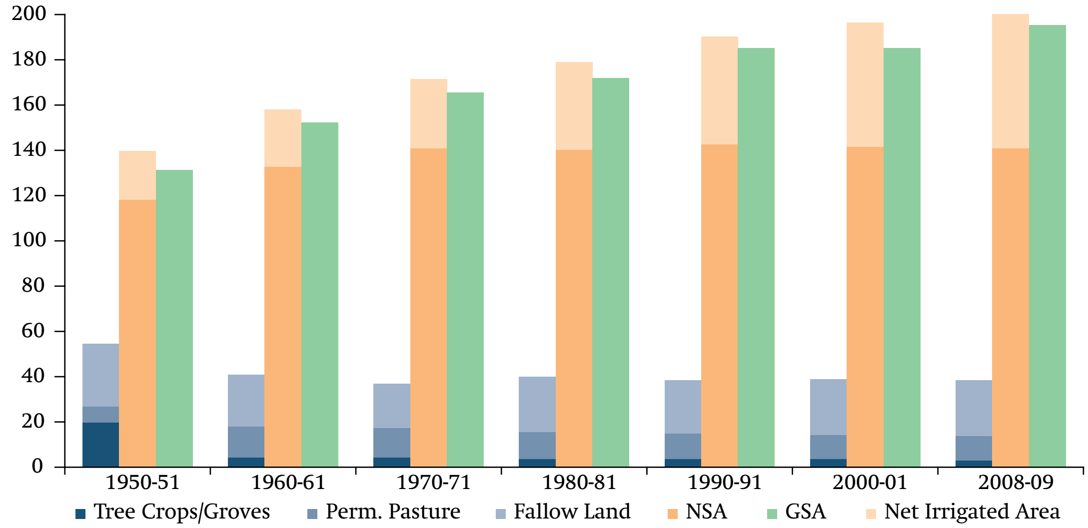
ANNEX 2: LAND USE, GRAIN STOCKS AND THE STRUCTURE OF PRODUCTION

Figure A.2.1: Food grain area, production, and yields and irrigated area



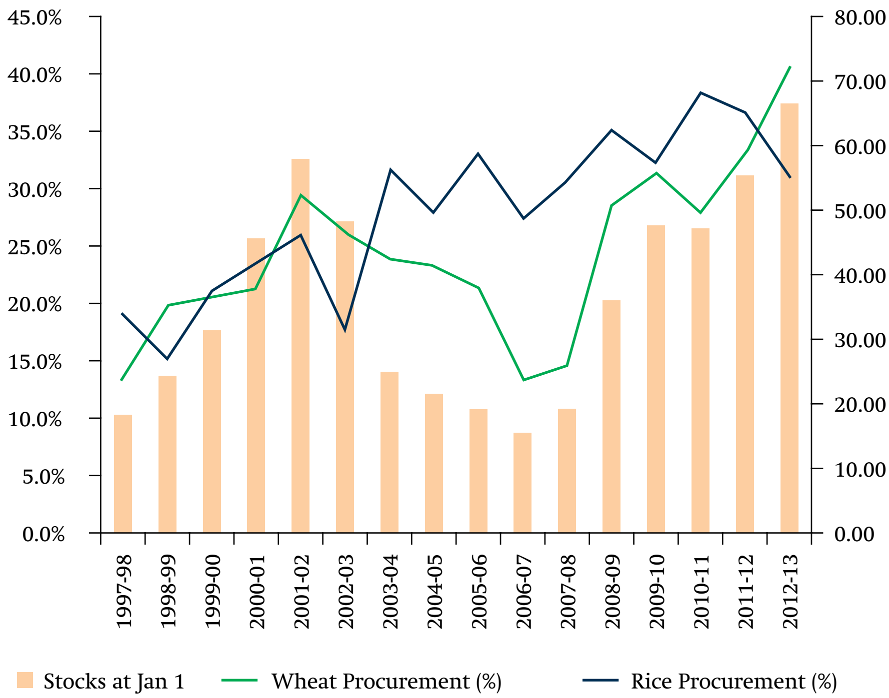
Source: Authors, using CSO data.

Figure A.2.2: Trends in agricultural land use



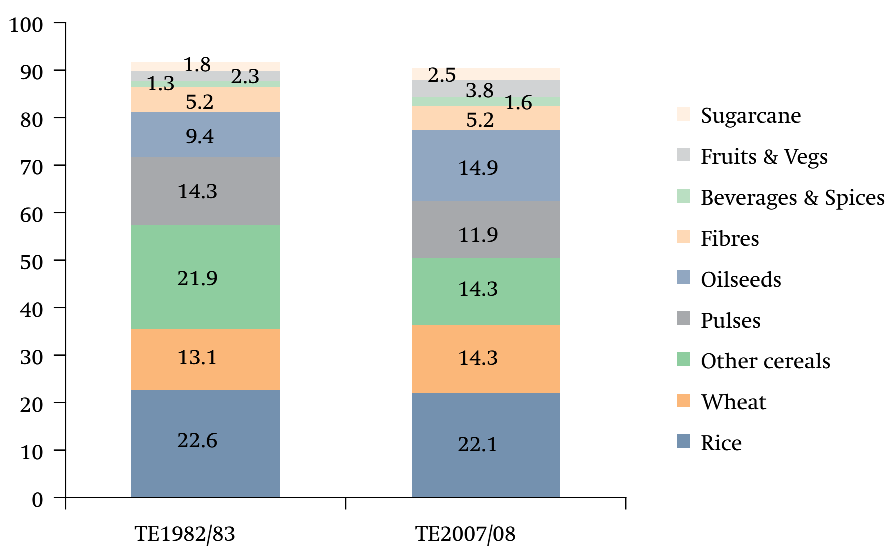
Source: Authors, using CSO data.

Figure A.2.3: Stocks and procurement as percentage of production (right)



Source: Authors, using FCI and CSO data.

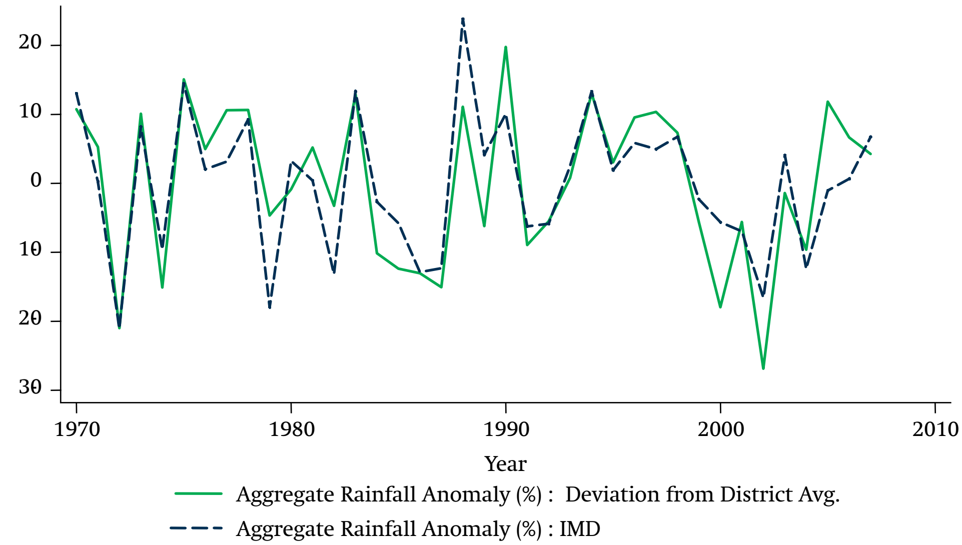
Figure A.2.4: Changes in land allocation, 1982/83–2007/08



Source: Authors, using CSO data.

ANNEX 3: COMPARING THE IMPACT OF ALTERNATIVE RAINFALL ESTIMATES

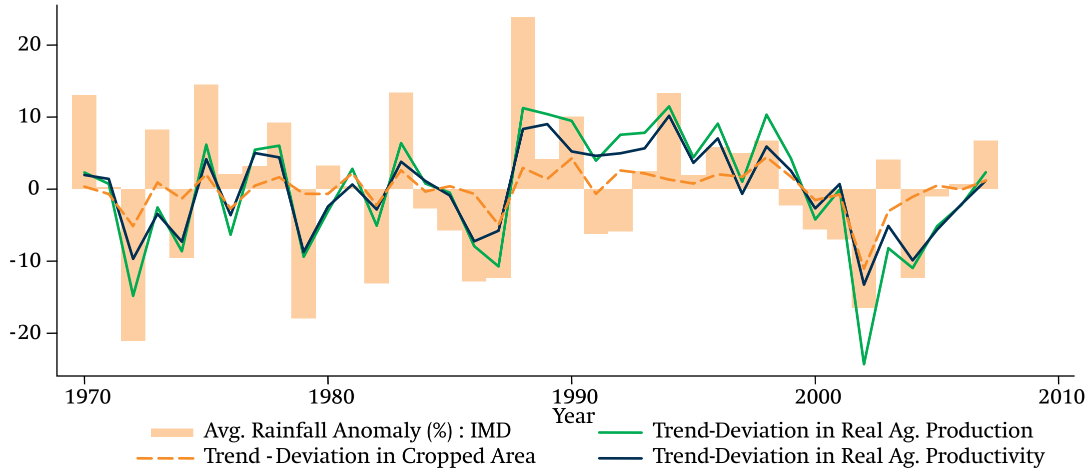
Figure A.3.1: Comparison of rainfall anomalies using IMD and district (ICRISAT/NCAP) data



Source: Kshirsagar and Gautam 2013.

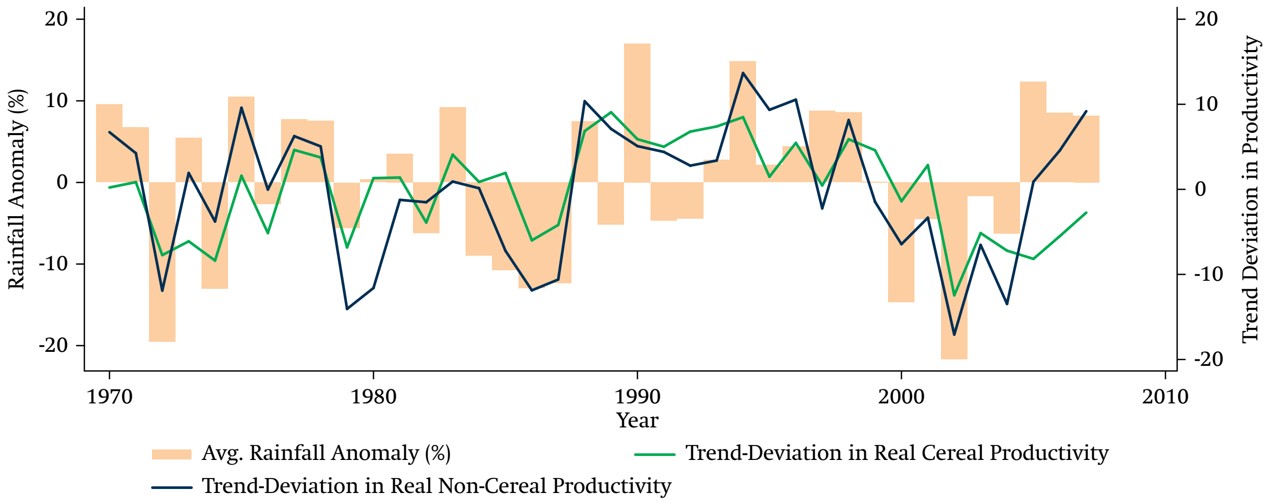
Note: District-level rainfall data are for annual rainfall and IMD rainfall data are for aggregate national-level monsoon rainfall (i.e., for June–September of each year). The observed differences thus are due to differences in the rainfall period and geographical coverage, as the district-level analysis is based on the original (as they existed in 1970) 207 districts with available rainfall data.

Figure A.3.2: Relationship between agricultural productivity and rainfall (using district rainfall data)



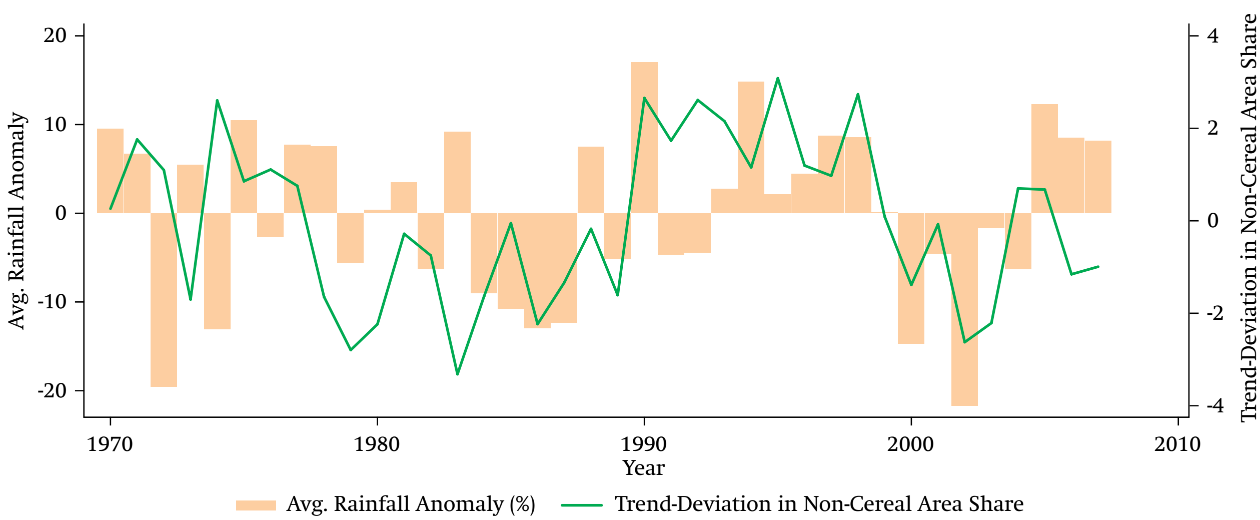
Source: Kshirsagar and Gautam 2013.

Figure A.3.3: Cereal and noncereal productivity deviations and rainfall anomalies



Source: Kshirsagar and Gautam 2013.

Figure A.3.4: Sensitivity of noncereal area share to rainfall



Source: Kshirsagar and Gautam 2013.

ANNEXES

ANNEX 4: SUB-NATIONAL HETEROGENEITY IN AGRICULTURAL PRODUCTIVITY

Table A.4.1: Disparities in productivity within states

State	Coefficient of variation			Gini coefficient		
	TE 1991	TE 2001	TE 2007	TE 1991	TE 2001	TE 2007
Andhra Pradesh	45.97	46.79	40.95	0.25	0.24	0.22
Assam*	21.46	19.66	22.43	0.12	0.11	0.12
Bihar*	19.16	26.23	27.24	0.11	0.14	0.14
Chhattisgarh*	19.00	15.24	27.41	0.09	0.08	0.14
Gujarat	35.98	32.92	29.69	0.19	0.17	0.16
Haryana	45.94	38.95	42.19	0.19	0.17	0.16
Himachal Pradesh	29.06	34.69	35.21	0.15	0.19	0.18
Jharkhand*	45.37	34.3	60.33	0.23	0.18	0.27
Karnataka	60.3	48.88	45.74	0.27	0.23	0.23
Kerala	36.61	29.79	31.87	0.2	0.16	0.17
Madhya Pradesh*	25.18	27.05	28.18	0.14	0.15	0.15
Maharashtra	52.02	52.83	56.56	0.25	0.26	0.26
Odisha*	25.67	26.37	18.26	0.14	0.14	0.1
Punjab	19.98	18.76	19.49	0.11	0.1	0.11
Rajasthan*	53.09	60.77	53.27	0.3	0.34	0.3
Tamil Nadu	47.23	36.58	32.72	0.24	0.2	0.18
Uttar Pradesh*	23.01	23.56	27.47	0.13	0.13	0.15
Uttarakhand*	30.47	52.28	52.7	0.12	0.23	0.24
West Bengal	37.85	37.08	32.72	0.21	0.2	0.17
Overall	58.31	59.79	56.85	0.30	0.33	0.29

Source: Kumar and Jain 2012.
Note: * indicates Low-income States.

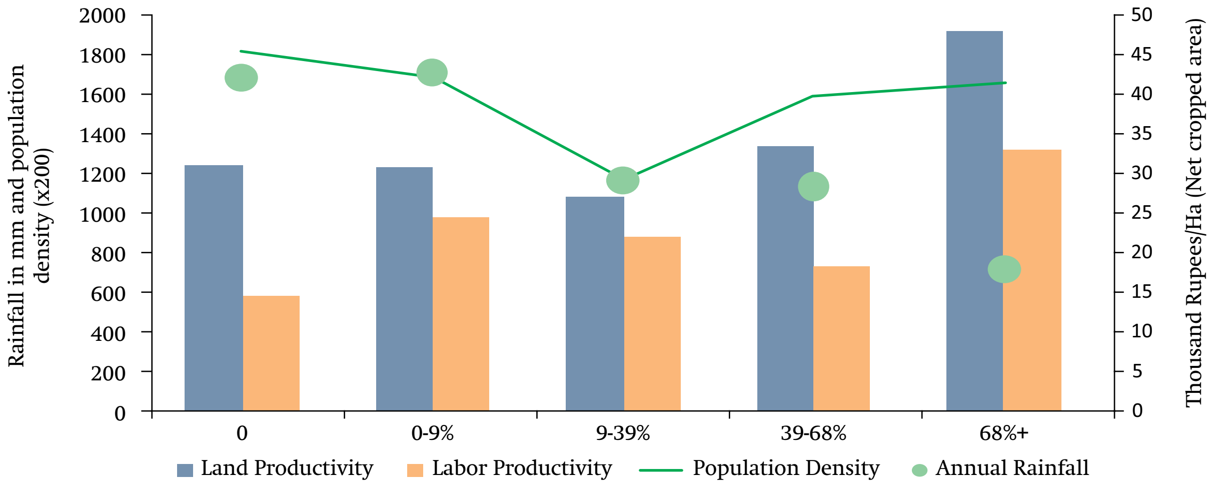
Table A.4.2: Districts' transition using irrigation typology

	2000s			
1970s	<25%	25-50%	>50%	Total
<25%	89 (30)	64 (22)	19 (6)	172 (58)
25-50%	3 (1)	26 (9)	49 (17)	78 (26)
>50%	1 (0)	1 (0)	43 (15)	45 (15)
Total	93 (32)	91 (31)	111 (38)	295 (100)

Source: Authors, using ICRISAT-NCAP district database.

Note: Irrigation typology defined as indicated percentage of net irrigated area in a district.
Parentheses indicate the percentage of all districts in each category.

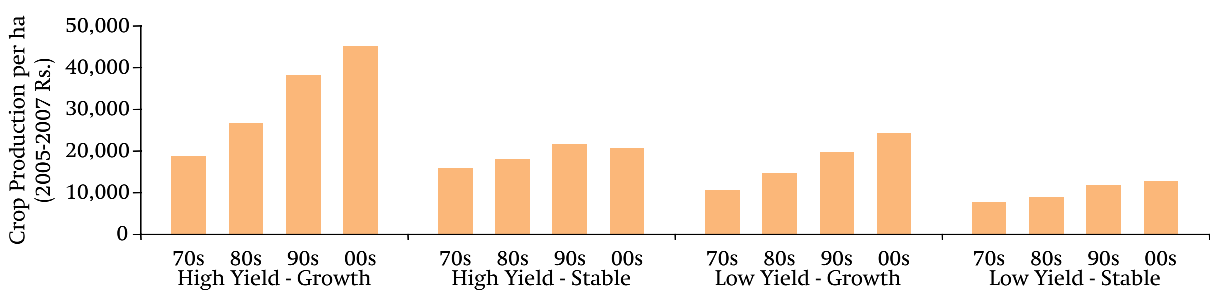
Figure A.4.1: Average level of productivity, rainfall, and population density for districts categorized by level of irrigation intensity for TE 2007



Source: Authors, using ICRISAT-NCAP district database.

Note: Less-irrigated districts are often endowed with higher rainfall and hence may be as or more productive than districts with significantly higher levels of irrigation development.

Figure A.4.2: Real value of crop production across district typologies



Source: Kshirsagar and Gautam 2013.

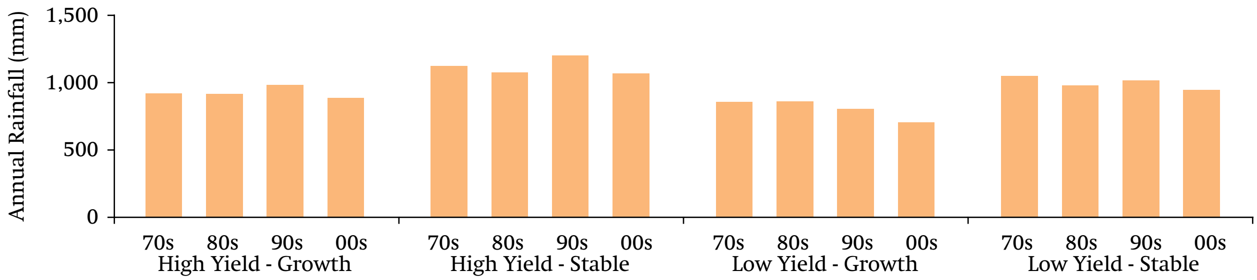
Note: Total value of crop production includes crops other than cereals but not fruits, vegetables, and spices, for which production data are not available.

Table A.4.3: District growth typologies by agro-ecological zone

Agro-ecological zone	High Yield/ Growth	High Yield/ Stable	Low Yield / Growth	Low Yield/ Stable	Total
Humid	3	32	17	39	91
Semi-Arid Temperate	5	12	42	12	71
Semi-Arid Tropical	4	13	34	67	118
Arid	1	2	10	4	17
Total	13	59	103	122	297

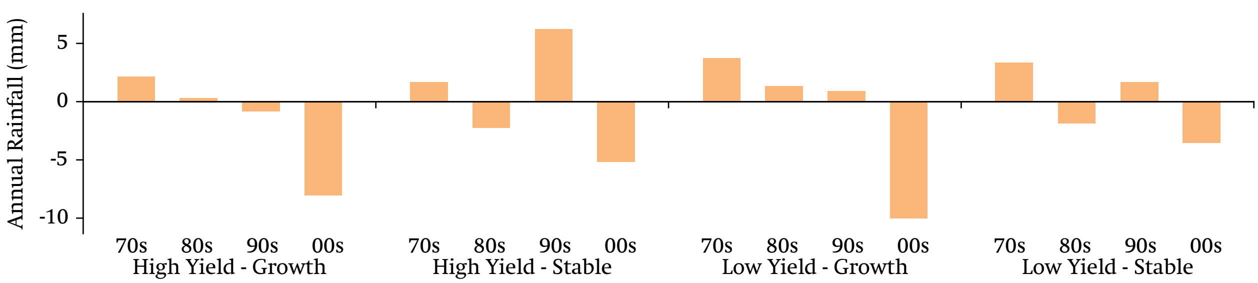
Source: Kshirsagar and Gautam 2013.

Figure A.4.3: Average rainfall across district typologies by decade



Source: Kshirsagar and Gautam 2013.

Figure A.4.4: Average rainfall anomaly across district typologies by decade



Source: Kshirsagar and Gautam 2013.

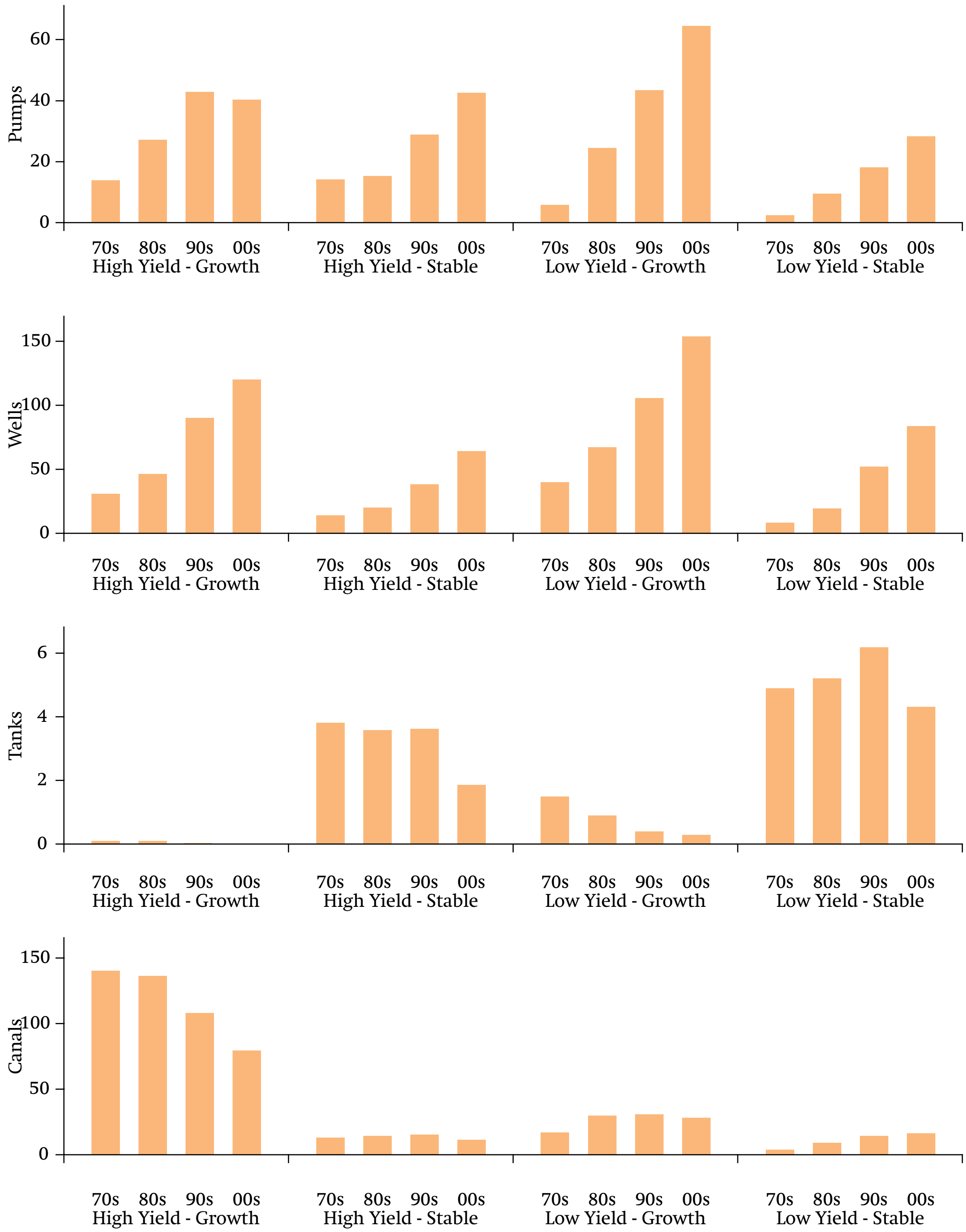
Table A.4.4: District growth typologies by irrigation development

	Dynamic Irrigation Typology			
LR growth typology	Low	Moderate/ growth	High	Total
High yield–growth	1	0	12	13
High yield–stable	20	6	33	59
Low yield–growth	18	35	50	103
Low yield–stable	50	42	28	120
Total	89	83	123	295

Source: Kshirsagar and Gautam 2013.

Note: Category "low" refers to districts with less than 25% irrigated area in both the 1970s and 2000s; "high" refers to districts with more than 50% irrigated area in both the 1970s and 2000s; "moderate/growth" refers to districts that had less than 50% irrigated area in the 1970s but subsequently experienced growth in irrigated area.

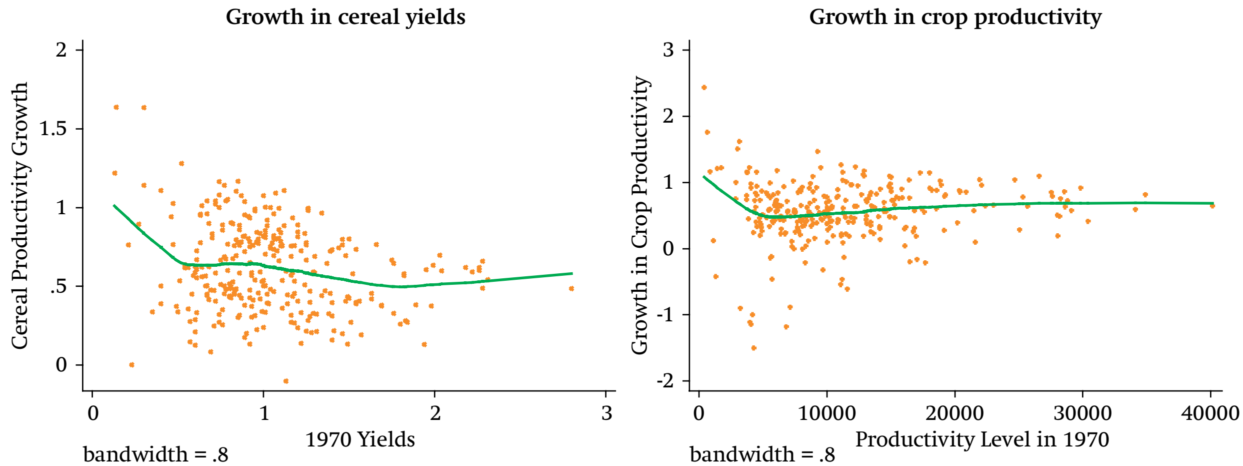
Figure A.4.5: Changing patterns in modes of irrigation across typologies



Source: Kshirsagar and Gautam 2013.

Note: The top panel shows the median number of pumps (diesel and electric) across typologies and decades. The bottom three panels show the median area irrigated using wells, tanks, and canals across typologies and decades.

Figure A.4.6: District productivity growth and convergence



Source: Kshirsagar and Gautam 2013.

Table A.4.5: Breakdown of agro-ecological zones by state

State	Humid	Semi-Arid Temperate	Semi-Arid Tropical	Arid	Total
Andhra Pradesh	5	0	14	1	20
Assam	10	0	0	0	10
Bihar	5	2	4	0	11
Gujarat	0	0	17	1	18
Haryana	0	5	0	2	7
Himachal Pradesh	9	0	0	0	9
Karnataka	6	0	12	1	19
Kerala	10	0	0	0	10
Madhya Pradesh	5	9	29	0	43
Maharashtra	6	0	19	0	25
Odisha	11	0	2	0	13
Punjab	0	8	0	3	11
Rajasthan	0	5	12	9	26
Tamil Nadu	3	0	9	0	12
Uttar Pradesh	7	41	0	0	48
West Bengal	14	1	0	0	15
Total	91	71	118	17	297

Source: Kshirsagar and Gautam 2013.
Note: Own calculations using broad agro-zone classification of districts by ICRISAT.

Table A.4.6: Levels and changes in the composition of crop area allocations

Area share	High Yield/Growth			High Yield/Stable			Low Yield/Growth			Low Yield/Stable		
Decade averages	1970s	2000s	% change	1970s	2000s	% change	1970s	2000s	% change	1970s	2000s	% change
Cereals	0.60	0.55	-8	0.66	0.60	-9	0.61	0.53	-14	0.63	0.56	-11
Pulses	0.11	0.08	-31	0.07	0.05	-25	0.17	0.11	-33	0.15	0.16	8
Oils	0.04	0.03	-18	0.09	0.15	59	0.10	0.19	94	0.09	0.14	53
Sugar	0.07	0.09	36	0.02	0.03	50	0.02	0.03	21	0.01	0.02	98
Cotton	0.03	0.06	86	0.02	0.01	-34	0.03	0.05	37	0.06	0.04	-25
Fruits/veg	0.06	0.10	70	0.09	0.14	44	0.02	0.04	173	0.03	0.06	105
Onions	0.00	0.00	7	0.00	0.00	15	0.00	0.00	120	0.00	0.00	103
Potatoes	0.03	0.02	-32	0.01	0.01	56	0.01	0.01	102	0.00	0.01	101
Fodder	0.06	0.07	4	0.05	0.03	-40	0.05	0.05	-4	0.04	0.03	-11
Total	1.0	1.0	0	1.0	1.0	0	1.0	1.0	0	1.0	1.0	0

Source: Kshirsagar and Gautam 2013.

Table A.4.7: Correlates of real cereal productivity

Dependent Variable : Real Valu of Cereal Production per ha (2005-2007 Rs)					
Sample	Full	High Yield - Growth	High Yield - Stable	Low Yield - Growth	Low Yield - Stable
Lag Dep. Variable	0.221***	0.360***	0.418***	0.145***	0.126***
	0.0449	0.0576	0.0461	0.0316	0.0403
Annual Rainfall	0.185***	0.0322	0.0418	0.212***	0.263***
	0.0314	0.0506	0.0252	0.0596	0.0347
Share Irrigated	0.0745***	0.209	0.0395	0.0731**	0.0348
	0.0227	0.108	0.0322	0.0233	0.025
Share HYV	0.0214***	0.00742***	0.0235**	0.00994	0.0251***
	0.00448	0.00122	0.00763	0.00792	0.00687
Fertilizer Intensity	0.0653***	0.0929*	0.0341*	0.0620***	0.0455*
	0.0126	0.0435	0.0156	0.0162	0.0218
Road Density	0.00394	0.0126	0.0523**	0.0265	0.00997
	0.047	0.0626	0.0203	0.0618	0.0399
Constant	5.984***	6.452***	5.267***	6.706***	6.288***
	0.404	0.25	0.434	0.311	0.486
Observations	7,347	328	1,561	2,435	3,023
R-squared	0.576	0.852	0.686	0,696	0.481
Number of Districts	286	13	58	103	112

Source: Kshirsagar and Gautam 2013.

Note: All variables are in logs (i.e., all the coefficients are elasticities). *All regressions use both district fixed effects and year dummies.* Robust standard errors clustered at the state level: *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Table A.4.8: Correlates of real agricultural productivity

Dependent Variable : Real Value of Agricultural Production per ha (2005–2007 Rs)					
Sample	Full	High Yield - Growth	High Yield - Stable	Low Yield - Growth	Low Yield - Stable
Lag Dep. Variable	0.368***	00351**	0.806***	0.203**	0.254***
	0.098	0.0952	0.0985	0.0689	0.043
Annual Rainfall	0.191***	0.0198	0.0333	0.240***	0.263***
	0.033	0.0429	0.0295	0.0618	0.038
Share Irrigated	0.0856*	0.290*	0.0406	0.126**	0.0633
	0.0399	0.131	0.0317	0.0376	0.0393
Share HYV	0.00315	0.00601	0.00968	0.0143	0.00281
	0.00938	0.00906	0.00621	0.0132	0.00874
Fertilizer Intensity	0.0954***	0.0816**	0.0831***	0.0870**	0.0711***
	0.0219	0.0209	0.0176	0.0306	0.0195
Road Density	0.0449	0.198*	0.0262	0.0415	0.01
	0.0392	0.0781	0.018	0.101	0.0327
Constant	4.341***	5.860***	1.34	5.909***	4.942***
	0.967	0.891	0.876	0.364	0421
Observations	7,333	328	1,561	2,435	3,009
R-squared	0.571	0.816	0.734	0.65	0563
Number of Districts	286	13	58	103	112

Source: Kshirsagar and Gautam 2013.

Note: All variables are in logs (i.e., all the coefficients are elasticities). *All regressions use both district fixed effects and year dummies.* Robust standard errors clustered at the state level: *** p<0.01, ** p<0.05, * p<0.1.

Table A.4.9: Correlates of real non-Cereal productivity

Dependent Variable : Real Value of Non-Cereal Production per HA (2005-2007 Rs)					
Sample	Full	High Yield - Growth	High Yield - Stable	Low Yield - Growth	Low Yield - Stable
Lag Dep. Variable	0.604***	0.522***	0.796***	0.389***	0.471***
	0.0942	0.124	0.0488	0.112	0.0578
Annual Rainfall	0.144***	0.117*	0.0402	0.207***	0.144**
	0.0284	0.048	0.0238	0.0545	0.0509
Share Irrigated	0.0909	0.576**	0.0444	0.183**	0.0831*
	0.057	0.163	0.125	0.0791	0.0428
Share HYV	0.0197	0.0287	0.0536	0.00498	0.0339*
	0.0124	0.0155	0.0364	0.0207	0.0174
Fertilizer Intensity	0.0776***	0.0494	0.0913	0.0880**	0.0318
	0.0246	0.0417	0.058	0.0275	0.0347
Road Density	0.0141	0.369*	0.103**	0.0268	0.00494
	0.0307	0.18	0.0338	0.0988	0.0253
Constant	2.296**	3.720**	1.175*	4.114***	3.487***
	0.943	-1.371	0.632	0.862	0.492
Observations	7.294	316	1.531	2.429	3.018
R-squared	0.488	0.616	0.687	0.459	0.416
Number of Districts	286	13	58	103	112

Source: Kshirsagar and Gautam 2013.

Note: All variables are in logs (i.e., all the coefficients are elasticities). *All regressions use both district fixed effects and year dummies.* Robust standard errors clustered at the state level: *** p<0.01, ** p<0.05, * p<0.1.

Table A.4.10: Cross-sectional correlates of real cereal productivity

Dependent Variable : Real Value of Cereal Production per ha (2005-2007 Rs)				
Sample	Full	Full	Full	Full
Mean Rainfall	0.315***	0.343***	0.325***	0.309***
	0.0698	0.0669	0.0875	0.0763
Norm. Std. Dev of Rainfall	-0.145***	-0.147***	-0.148***	-0.142***
	0.046	0.0399	0.0443	0.0376
Share Irrigated	0.220***	0.0375	0.175***	0.0313
	0.0377	0.0354	0.0373	0.0324
Share HYN	0.0963**	0.245***	0.142***	0.247***
	0.0373	0.0665	0.0393	0.0626
Fertilizer Intensity	0.241***	0.209***	0.244***	0.224***
	0.0399	0.0391	0.0389	0.0405
Markets pc	0.0714**	0.0308	0.0695**	0.0335
	0.0349	0.0332	0.0343	0.0335
Road Density	0.0156	0.0641	0.00746	0.0591
	0.0308	0.0479	0.035	0.0503
Constant	7.911***	7.780***	7.874***	8.008***
	0.645	0.606	0.708	0.626
State Dummies	No	Yes	No	Yes
AEZ Dummies	No	No	Yes	Yes
Observations	275	275	275	275
R-squared	0.723	0.848	0.753	0.855

Source: Kshirsagar and Gautam 2013.

Note: All variables are in logs (i.e., all the coefficients are elasticities). All regressions estimate the (cross-sectional) relationship between mean values across districts. Normalized std. deviation of rainfall measures the standard deviation of rainfall anomalies across the sample period (i.e., 1970–2007). Robust standard errors: *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

ANNEXES

ANNEX 5: CHANGING STRUCTURE OF HOUSEHOLD INCOMES IN BIHAR

Table A.5.1. Distribution of income by source and class, 2011 (%)

Caste/ community	Own production in agriculture	Agricultural wages	All agriculture	Non-agricultural own production	Non-agricultural wages	Regular employment	Other income	Remittances
Agricultural labor	16.4	8.9	25.3	5.4	15.3	3.9	16.1	34.0
Poor peasant	24.3	1.5	25.8	25.4	4.2	5.6	11.2	27.8
Middle peasant	38.4	1.8	40.2	19.5	7.0	1.6	9.8	22.0
Big peasant	34.8	0.1	34.9	9.3	1.5	17.5	18.3	18.5
Landlord/ supervision	11.1	0.0	11.1	0.7	0.0	44.7	20.5	23.0
Nonagricultural wages	10.1	1.2	11.3	4.2	5.2	27.9	16.3	35.0
Nonagricultural self-employment	9.5	0.6	10.1	49.9	1.5	0.2	19.6	18.7
All total	22.3	4.2	26.5	10.7	8.2	10.6	16.0	28.0

Source: IHD Bihar Survey 2011; Rodgers and Sharma 2011.

ANNEXES

ANNEX 6: GROWTH DECOMPOSITION: METHODOLOGY AND SELECTED INDICATORS

Growth decomposition: Data and methodology

Data. Data on major crops grown in 20 major agricultural states[189] and data on area, production, and yield of important crops were compiled from the Indian Agricultural Statistics, Agricultural Statistics at Glance, and Horticultural Database, all published by the Ministry of Agriculture, Government of India: cereals (rice, wheat, maize, sorghum, pearl millet, finger millet, barley, small millets); pulses (chickpea, pigeonpeas, and other pulses); oilseeds (groundnut, sesamum, rapeseed-mustard, soybean, linseed, sunflower, safflower, castor, and niger seed); fibers (cotton, jute, and sunhemp); spices (arecanut, cardamom, chillies, pepper, turmeric, ginger, garlic, and coriander); fruits (bananas, cashewnuts, and other fruits); vegetables (potatoes, sweet potatoes, onions, tapioca, and other vegetables); beverages (tea and coffee); coconut, sugarcane, tobacco, rubber, and cluster bean. These data were supplemented with the data from state-specific Statistical Abstracts published by the state governments. The crops included account for more than 90 percent of the cropped area and the value of the output of the crop sector.

189 Andhra Pradesh, Assam, Bihar, Chhattisgarh, Gujarat, Haryana, Himachal Pradesh, Jharkhand, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Odisha, Punjab, Rajasthan, Tamil Nadu, Uttarakhand, Uttar Pradesh, and West Bengal.

Data on the value of the output of the selected crops (for generating implicit prices of the selected commodities) were obtained from the National Accounts Statistics published by CSO (Ministry of Statistics and Program Implementation, Government of India). The price of a commodity was obtained by dividing its value of output (at current prices) by its level of production. The current prices were deflated by the general WPI to convert these into real prices (at 1993–94 base). The data series on area, production, and prices were smoothened by applying a Hodrick-Prescott (HP) filtering[190] technique with an adjustment factor of 6.25. The HP filtered data series were used for analyzing the patterns and sources of growth.

Methodology. Following Minot et al. (2006), the change in gross revenue from each crop can be decomposed into (i) change in cropped area, (ii) change in yield, (iii) change in real price, and (iv) a residual representing interaction among (i) to (iii). When more than one crop is considered, an additional source of change is the reallocation of area between crops, or (v) diversification. Typically, assuming profit maximization behaviors, farmers are expected

190 The HP filter is a data-smoothening technique commonly applied to remove short-term fluctuations from time-series data. It generates a smoothened nonlinear representation of a time series. The adjustment of the sensitivity of the trend to short-term fluctuations is done by applying a suitable adjustment factor.

to diversify from lower- to higher-value crops. But based on their individual circumstances and in any particular year, farmers may choose to diversify to less risky crops that may be of lower value.

Assuming that farmers behave rationally, the individual farmer maximizes profits from land by choosing a production mix, inputs, and technologies subject to the individual's resource endowments and markets. If A_i is area under crop i, Y_i is its production per unit area, and P_i is the real price per unit of production, then the gross revenue R from n crops can be written as:

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

Expressing A_1 as the share of crop i in the total cropped area, $a_i = \left(\frac{A_i}{\sum_i A_i}\right)$, and substituting in equation (1):

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

Total derivatives of both sides of equation (2) provides absolute contribution of changes in these components to the change in gross revenue:

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

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

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

And, further expansion of the second term of equation (4) results in the following expression:

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

Equation (5) decomposes change in gross revenue due to change (i) in total cropped area, (ii) crop yields or technology, (iii) real prices, and (iv) land reallocation or diversification. The first term on the right-hand side of this equation represents the change in gross revenue due to change in total cropped area. The expression $\sum_{i=1}^{n} a_i Y_i p$ is the weighted average of the gross revenue per hectare, the weights being share of each crop (a_i) in the total cropped area. The second term on the right-hand side captures change in the gross revenue due to a change in the real prices of commodities. The third term measures change in gross revenue due to changes in crop yields or technology. The fourth term represents the change in gross revenue associated with changes in the crop composition. If the fourth term is positive, this indicates a reallocation of land from lower-value to higher-value crops. Dividing both sides of equation (5) by the overall change in gross revenue (dR) gives the proportionate contribution of each source to the overall change in gross revenue or agricultural growth.

Description of the study regions

Northern region, excluding the hill states of Himachal Pradesh, and Uttarakhand, has alluvial soils and a semi-arid to humid climate. Agriculture contributes about one-fifth to GDP in this region. In the plains, irrigation infrastructure is well developed, with more than 80 percent of cropped area under irrigation. The average size of land holding is small. The land is intensively cultivated, with wheat and rice as the main crops in the plains, and maize, wheat, fruits, and vegetables in the hills. Fertilizer consumption per unit of cropped area is one of the highest in this region. Road density and telecommunication density are low.

Eastern region is characterized by relatively high rainfall and widespread cultivation of rice. Rice occupies 56 percent of cropped area. In value terms, fruits and vegetables outweigh the contribution of rice. Average land holding is smaller than in any other region. and the level of irrigation development and technology adoption is also low. The region is heavily populated but is the least urbanized; it has the lowest per capita income of all regions. The region has good road infrastructure. Agriculture accounts for one-fifth of GDP in the region.

Western region has low population density but high levels of urbanization and per capita income. Economic dependence on agriculture is the lowest in this region. The region receives less rainfall than the others, and agriculture is highly diversified, with oil seeds (mainly groundnuts and rapeseed-mustard), wheat, pulses, fruits, and vegetables as important crops. Coarse cereals, such as millets and maize, are also widely grown. The average land holding is larger than in other regions, but irrigation coverage and fertilizer use are less.

Southern region, except Kerala, has a semi-arid climate and almost a uniform rainfall pattern throughout. Agriculture is largely rain-dependent, but irrigation coverage is better than in other regions. Rice is the dominant crop, followed by oil seeds, pulses, fruits, vegetables, and spices. The average landholding is about 1 hectare. The region has relatively low population density and is the most urbanized, with higher incomes than other regions. The region also has the best road infrastructure and telecommunication system.

Table A.6.1: Selected regional development indicators

Indicator	Northern	Eastern	Western	Southern	All India
Population, in millions, 2011	282	301	340	251	1210
Geographical area, 000 km2	667	497	1289	636	3287
Population density, persons/km2, 2011	423	606	263	395	368
Urban population, in %, 2011	25.1	20.0	35.2	40.9	31.2
Per capita GDP, in Rs (at 2004–05 prices), 2008–10	26587	21749	38787	43006	35722
Share of agriculture in GDP (%), 2004–05 prices					
1981–83	43.2	38.0	33.1	33.6	35.1
1991–93	36.1	34.5	25.6	28.3	29.0
1999–01	31.1	28.2	18.8	22.7	24.0
2008–10	22.0	20.8	13.7	15.3	15.7
Gross cropped area, in 000 ha, 2008–10	42765	31968	82940	34476	194301
Gross irrigated area, in %, 2008–10	78.8	43.5	31.0	40.5	45.2
Fertilizer consumption, in kg/ha, 2008–10	173	108	89	180	136
Road density, in km per 000 km^2, 2008–09	689	1601	548	1552	966
Average size of land holding in ha, 2005–06	0.89	0.69	2.02	1.02	1.23
Tele-density, telephones/100 persons					
Urban	86.0	123.9	112.6	151.9	162.1
Rural	23.0	30.1	40.6	46.8	37.9
Total	38.8	48.8	66.0	89.8	76.6

Source: Birthal et al. 2014.

Table A.6.2: Contribution of crops to agricultural growth: National level

Crops	Share in gross cropped area			Share in real value of output*			Annual growth in real value of output			Share in overall growth		
	1980s	1990s	2000s	1980s	1990s	2000s	1980s	1990s	2000s	1980s	1990s	2000s
Rice	24.2	24.1	23.6	22.4	21.7	19	3.3	3.1	–0.2	23.1	20.5	–1.7
Wheat	14.2	14.6	15.1	12	12.7	12.6	2.4	5.5	1.2	10.2	20.7	4.6
Maize	3.5	3.4	4.1	2.1	1.9	2.1	0.5	3.1	5	0.7	1.9	3.2
Other cereals	*20*	*14.6*	*11.6*	*5.8*	*4.1*	*3.2*	*–2.7*	*0.4*	*1.3*	*–3.2*	*–0.2*	*0.9*
Total cereals	*61.9*	*56.7*	*54.5*	*42.4*	*40.4*	*37*	*2*	*3.6*	*0.7*	*30.7*	*43*	*6.9*
Chickpea	4.5	4	3.9	2.8	2.4	2.4	1.2	2.4	5.2	0.7	1.1	3.6
Pigeonpea	1.9	2	2	1.5	1.4	1	3.5	1.7	2.6	1.4	0.1	0.9
Total pulses	*14*	*13*	*12.5*	*7.3*	*6.2*	*5.2*	*2.6*	*1*	*3*	*4.6*	*0.3*	*4.8*
Groundnut	4.5	4.4	3.5	5.2	4.4	3	3.2	–2	2	4.9	–4.2	1.1
Rapeseed and mustard	2	3.3	3.2	2.4	3.1	2.7	9	–1.5	6.1	6.9	–1.7	4.3
Soybean	0.7	2.8	4.3	0.5	2	2.4	30	8.7	9.1	4.2	3.7	6.6
Other oilseeds	4.3	6.6	7.4	4.3	4.8	4.1	8.7	–2.8	5.4	5.4	–0.5	1
Total oilseeds	*10.8*	*14.2*	*14*	*12.4*	*14.1*	*12.1*	*6.9*	*–0.7*	*5.4*	*21.4*	*–2.6*	*13*
Cotton	4.5	4.8	4.9	3.9	5	5	1.4	2.8	10.7	4	1.7	14.5
Other fibers	0.7	0.6	0.6	0.7	0.5	0.4	3.7	1.1	1.4	0.8	0.1	0.2
Total fibers	*5.2*	*5.4*	*5.5*	*4.7*	*5.5*	*5.4*	*1.7*	*2.6*	*9.9*	*4.8*	*1.8*	*14.7*
Plantation crops	1.3	1.6	1.8	1.7	1.8	1.6	5.6	2.7	5	6.8	0	1.1
Spices and condiments	1.1	1.3	1.3	2.8	3.8	3.9	8.5	6.8	3.8	4.8	5.1	5.4
Fruits	1.4	1.9	2.7	9.4	10.6	14.2	4.4	6.2	5.5	11.3	20.4	24.6
Vegetables	2.1	2.9	3.8	9.8	11.5	13.5	3.6	6.8	6.7	11	19.1	28.9
Sugarcane	1.9	2.3	2.5	8.1	8.6	8.8	1.2	5	0	3.8	13.1	–1.3
Other crops	1.6	1.5	1.9	1	0.9	0.9	0.9	1	6.8	0.8	–0.1	2
All crops	*100*	*100*	*100*	*100*	*100*	*100*	*3.1*	*3.7*	*3.3*	*100*	*100*	*100*

Source: Birthal et al. 2014.

ANNEX 7: TFP: METHODOLOGY AND CROP-SPECIFIC ESTIMATES

A Bird's-eye view of TFP literature on India

Since the 1970s, following the Solow (1975) residual, several studies have estimated TFP in Indian agriculture. Most have used the growth accounting method, applied at different levels of aggregation; see Rada (2013), Chand, Kumar and Kumar (2010), and Kumar and Mittal (2006) for reviews of past studies. Because of data constraints, the majority have been at the aggregated sector-wide or national level. Some studies have attempted TFP analysis at the individual crop level to overcome potential problems and complexities associated with aggregation across crops and inputs, but these have primarily been on rice and wheat, with concerns about slowing yield growth rates and their implications for food security. Most analyses were done for the 1980s and 1990s and are now outdated; they are reviewed briefly in Kumar and Mittal (2006). Chand, Kumar and Kumar (2010) offer the most detailed state and crop estimates. They use the CoC data (based on annual surveys) from the Ministry of Agriculture, allowing for better accounting for inputs used by farmers than previous studies. Their analysis stops in 2004/05.

Depending on the level of aggregation, scope of coverage (for example, crops with or without livestock, and types of crops covered), methodology used, and time periods considered, estimates of TFP growth vary considerably. A common thread in these diverse estimates, however, is that growth in TFP slowed after the 1980s. This decline was observed in many regions of the country, with output growth becoming increasingly input-based (Chand et al. 2010). Most studies have found agricultural research to have contributed significantly and substantially to past growth in TFP, with significant inter-state and inter-crop variations in TFP growth.

TFP estimation: Methodology and data

At the sector-wide level, three recent analyses use the growth accounting framework with Tornqvist-Theil input and output indices to measure TFP for a composite output of crops and livestock[191] : Fuglie (2012), Bosworth and Collins (2003), and Rada (2013). Fuglie (2012) uses FAO statistics to compile a carefully reconciled and comparable database for estimating TFP across 173 countries from 1961 to 2009. The study uses an index of real value of crops and livestock production covering the entire agricultural sector in India. Bosworth and Collins (2003) use National Accounts data to estimate TFP in Indian agricultural using official GDP estimates from 1961 to 2004 as part of their analysis of the sources of growth in the Indian economy. These data and TFP estimates

191 The advantages of the Tornqvist-Theil index are discussed in Diewert (1976, 1978).

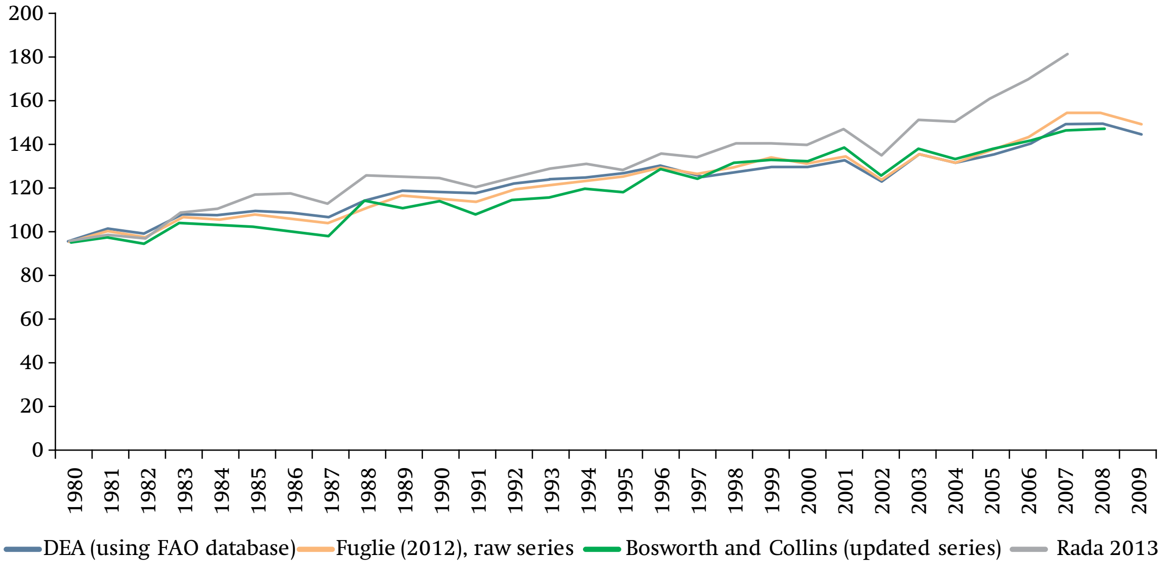
were updated to 2008 as part of the background work for World Bank (2012). These estimates use the same growth accounting framework as Fuglie but with a different model, inputs, parameters, and source of data. A third study by Rada (2013) uses state and national Value of Production data a comprehensive set of crops and livestock outputs and inputs to arrive at an independent estimate of TFP for 1980–2008.

An alternative method of measuring TFP growth is the Data Envelopment Analysis (DEA) nonparametric methodology. The DEA allows the two components of TFP, normally referred to as "technical change" and "technical efficiency," to be separated. This procedure provides insight into whether the observed changes in productivity are a result of a shift in the production frontier or a movement closer to the frontier. A shift in the frontier is normally ascribed to technological progress when using physical outputs in the analysis; however, when a composite index is used to represent the output of the sector as a whole, it more appropriately represents a combination of technological progress and a change in the output mix (which, as noted, has been an important driver of growth in recent years in Indian agriculture). For this study, the DEA was applied to the same dataset used by Fuglie (2012) to provide comparable estimates.

The four TFP estimates provide very similar trends, as shown in Figure A.7.1.

A second level of aggregation is at the state level. Using the National Accounts data on the total value of production, Rada (2013) estimates TFP using the Tornqvist Theil indices for inputs and outputs for the years from 1980 to 2008. This analysis uses data on all crops, including estimated value of output for horticultural crops and livestock, and cost shares for major inputs using aggregated data. A background paper for this study also uses the growth accounting methodology to estimate TFP at the state level but focusses only on major crops for which the data are more reliable. The main difference

Figure A.7.1: TFP Estimates from different methodologies and data sources



Source: Authors

is that it does not include horticultural crops (fruits and vegetables) and livestock products, and hence provides insight into the performance of the more traditional crop sector. Nevertheless these crops cover over half the estimated value of production (aggregated at the national level) and account for nearly 75 percent of the area under cultivation. So while diversification is an important strategy to improve incomes and productivity in a broader sense, the narrower estimates provide an important contrast to how the majority of the sector resources are being used. An important methodological difference between this study and the estimates by Rada is that it uses a more detailed and comprehensive accounting for inputs by using the estimates from the survey-based annual CoC data compiled for the major crops by the Ministry of Agriculture. These data not only allow a more complete accounting for the inputs used by farmers and but permit more accurate estimation of their cost shares, allowing a more precise measurement of TFP.

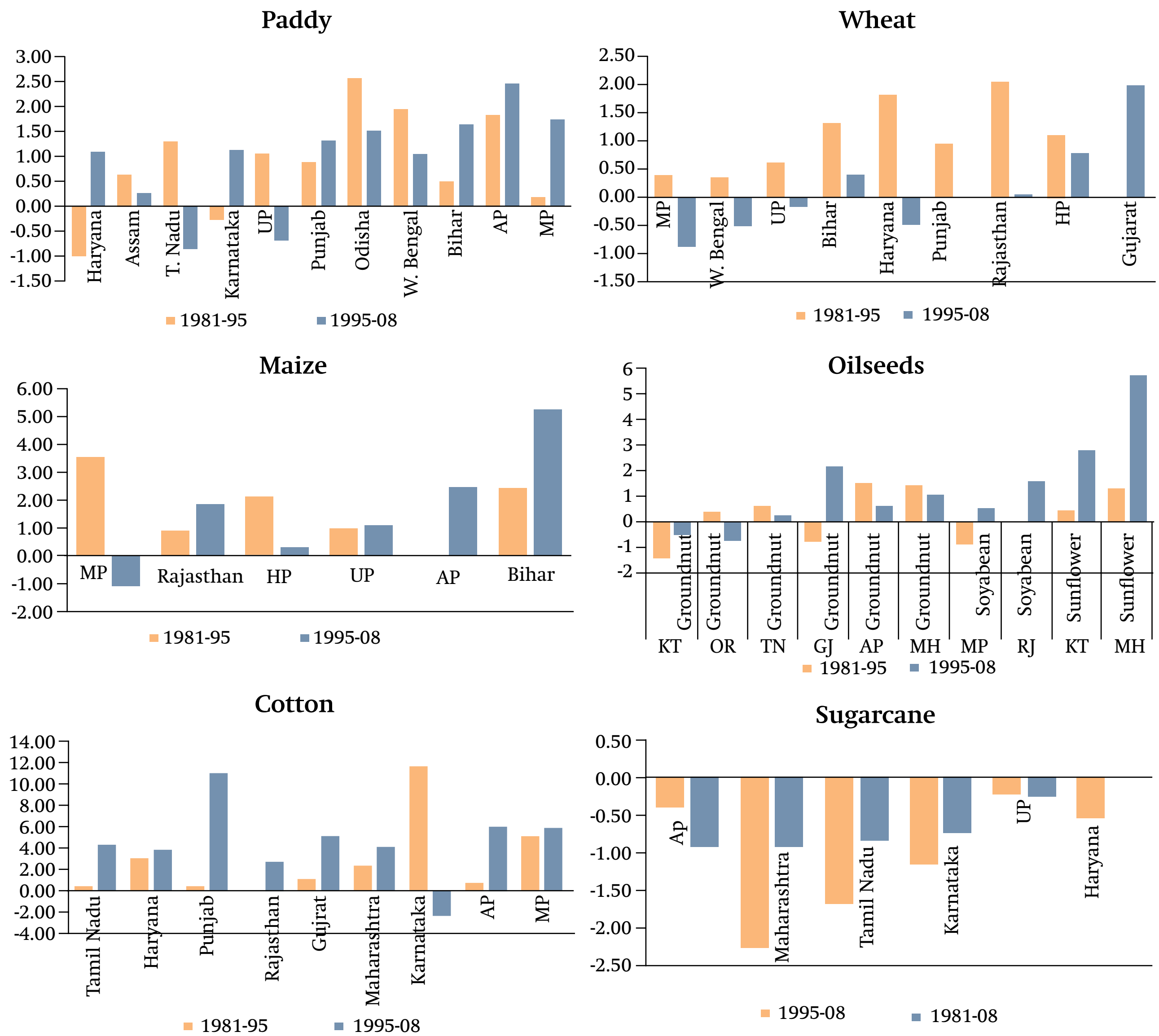
Finally, access to a unique household-level panel dataset allows deeper and more precise insights into the changes occurring at the farm level. Detailed information on agricultural production for 1999 and 2007 for 4,000 households from the NCAER-REDS data are used to estimate productivity changes and various measures of efficiency. The data also allow alternative methodologies to be used to triangulate potential shortcomings associated with particular methodologies. Using the nonparametric DEA methodology, Nin-Pratt and Gautam (2013) provide a detailed breakdown of productivity changes at the farm level as well as estimates of profits lost due to different types of inefficiency at the farm level. Complementing this work, Gautam, Pradhan, and Nagarajan (2013) use econometric methods to estimate the determinants of both technical and economic efficiency across household status levels and determinants of technical as well as allocative efficiency, providing insights into the overall economic efficiency at the household level.

Table A.7.1: Major crops included in estimates of TFP for traditional crops

Crop	State
Cereals	
Paddy	Andhra Pradesh, Assam, Bihar, Haryana, Karnataka, Madhya Pradesh, Odisha, Punjab, Tamil Nadu, Uttar Pradesh, West Bengal
Jowar	Andhra Pradesh, Karnataka, Madhya Pradesh, Maharashtra, Rajasthan, Tamil Nadu
Bajra	Gujarat, Haryana, Maharashtra, Rajasthan, Tamil Nadu, Uttar Pradesh
Maize	Andhra Pradesh, Bihar, Himachal Pradesh, Madhya Pradesh, Rajasthan, Uttar Pradesh
Wheat	Bihar, Haryana, Himachal Pradesh, Madhya Pradesh, Punjab, Rajasthan, Uttar Pradesh, West Bengal
Pulses	
Gram	Haryana, Madhya Pradesh, Rajasthan, Uttar Pradesh
Moong	Andhra Pradesh, Odisha, Rajasthan
Arhar	Gujarat, Karnataka, Madhya Pradesh, Uttar Pradesh
Urad	Andhra Pradesh, Madhya Pradesh, Maharashtra, Odisha, Rajasthan, Tamil Nadu, Uttar Pradesh
Edible oilseeds	
Rapeseed & mustard	Assam, Haryana, Punjab, Rajasthan, Uttar Pradesh
Groundnut	Andhra Pradesh, Gujarat, Karnataka, Odisha, Tamil Nadu
Soybean	Madhya Pradesh
Fibre crops	
Cotton	Andhra Pradesh, Gujarat, Haryana, Karnataka, Madhya Pradesh, Maharashtra, Punjab, Tamil Nadu
Jute	Assam, Bihar, Odisha, West Bengal
Other cash crops	
Sugarcane	Andhra Pradesh, Bihar, Haryana, Karnataka, Maharashtra, Tamil Nadu, Uttar Pradesh

Source: Authors

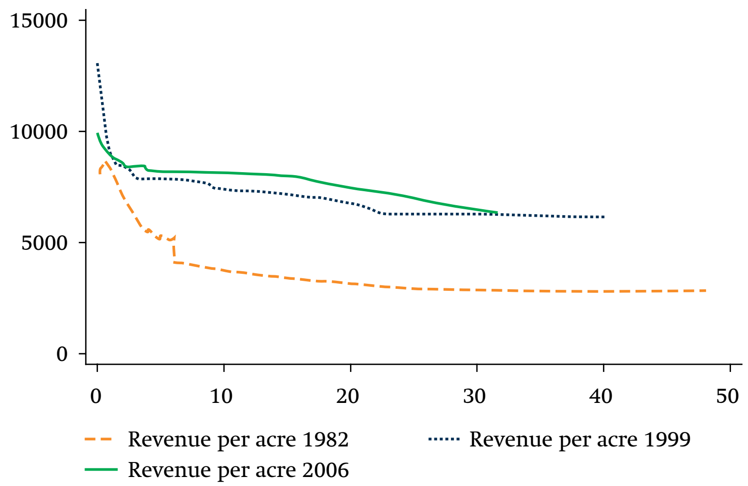
Figure A.7.2: Crop-specific TFP estimates by state



Source: Kumar, Gautam and Joshi 2013.

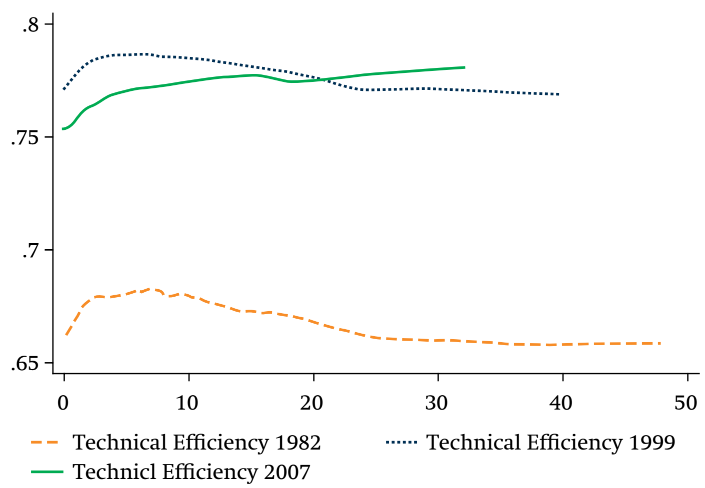
ANNEX 8: CHANGES IN FARM REVENUES AND EFFICIENCY BY LAND SIZE

Figure A.8.1: Gross revenues per acre and by farm size, 1982, 1999, 2007



Source: Authors, using ICRISAT-NCAP district database.

Figure A.8.2: Technical efficiency and farm size, 1982, 1999, 2007



Source: Authors, using ICRISAT-NCAP district database.

ANNEX 9: PROGRESS AND POTENTIAL FOR GAINS THROUGH TECHNOLOGY CAPITAL

Potential and Attainable Yield simulation model

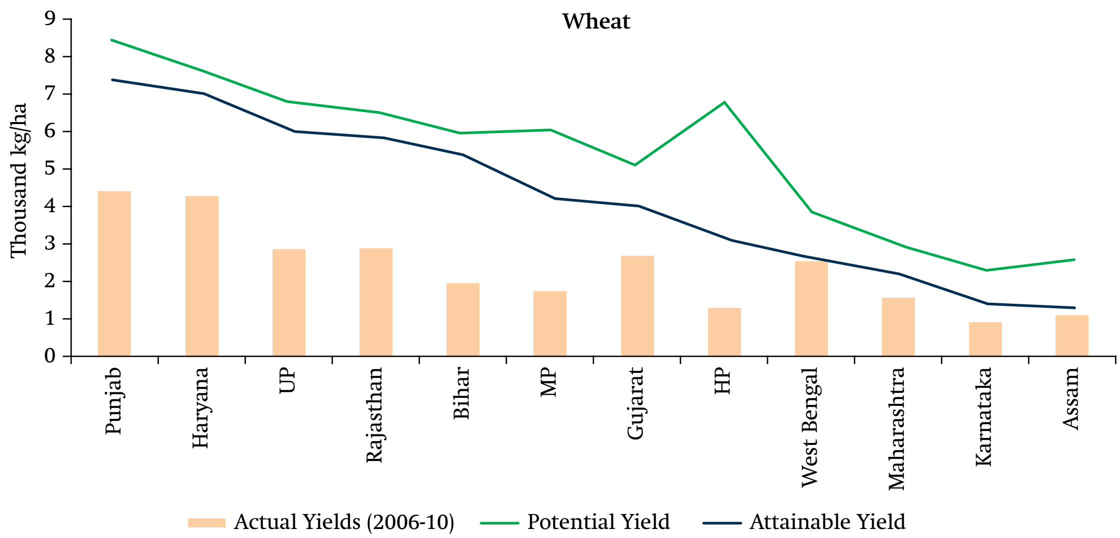
The InfoCrop model (Aggarwal et al. 2006) was used for simulating potential yields. This generic dynamic crop simulation model is sensitive to variety, agronomic management, soil, weather, flooding, frost, and pests. The model simulates all major processes of crop growth, soil water and nutrient balances, greenhouse gas emissions, and crop-pest interactions. It is used for estimates of potential yields and yield gaps, impact assessment of climatic variability and climate change, optimizing management (planting dates, variety, irrigation, and nitrogen fertilizer), genotype by environment by management by pest interactions, yield forecasting, and assessments of yield losses due to pests. The model has been calibrated and validated in typical rainfed and irrigated crop growing areas.

A methodology was developed for estimating regional crop production using a crop simulation model together with databases for soil, management, and weather. The Planning Commission of the Government of India has divided the country into 15 agro-climatic zones and 95 subzones. The latter were used as the primary simulation units. Only those subzones where rice or wheat cultivation is significant were considered for this analysis. Weather data of a representative location in each of these subzones was obtained from the India Meteorology Department. Wherever such climatic data was not available, data of an appropriate location adjacent to the selected zones was utilized. Representative soil profile details for each zone were input in the model for calculation of simulated rainfed potential yields.

Wheat simulations were done for three sowing dates (normal, late, and very late) in line with farmers' practices in different regions. For each sowing date, coefficient of a standard variety, common for that time of sowing, was used. For paddy, it was assumed that the crops were transplanted with the standard onset date of the rainy season. It was assumed that both rice and wheat did not suffer from any deficiency of water or nutrients and that pests and diseases were controlled. Simulations were done using 10–20 years of weather data for each location depending upon its availability. The average of the yields of all years was used as the simulated potential yield for a location. Simulated potential yield was aggregated for each zone considering the weighted distribution of planting times (in the case of wheat).

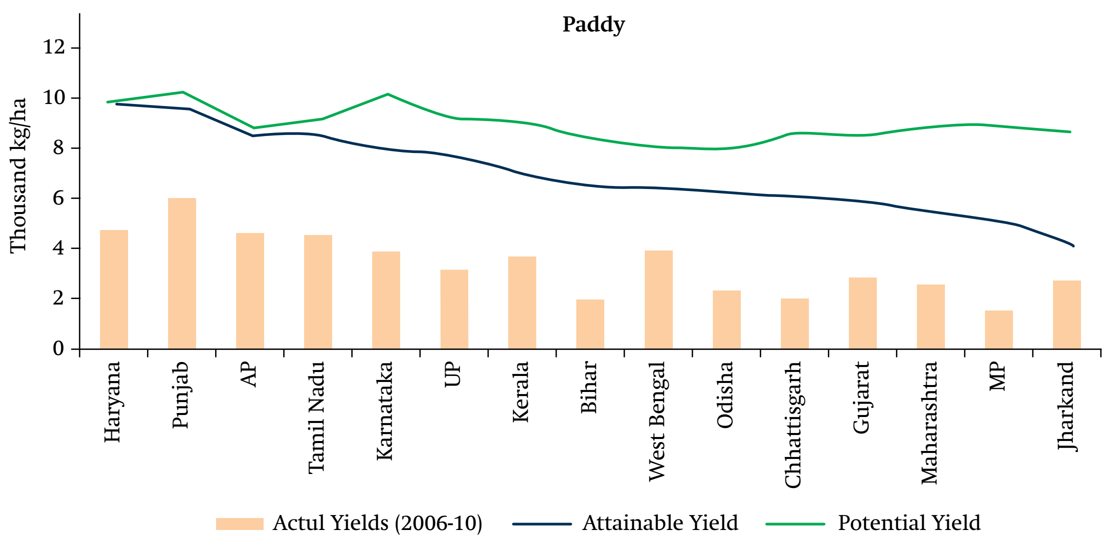
The results from the models for wheat and rice are given in Figures A.9.1 and A.9.2. The figures present simulated potential yields (assuming no constraints to inputs), attainable yields (given the current level of irrigation), and actual yields (average of 2006–10). The states are shown in decreasing order of attainable yield level, which is assessed to be a more realistic assessment of the current yield potential for each state, conditional on the level of irrigation development in the state.

Figure A.9.1: Current yield gaps for wheat by state



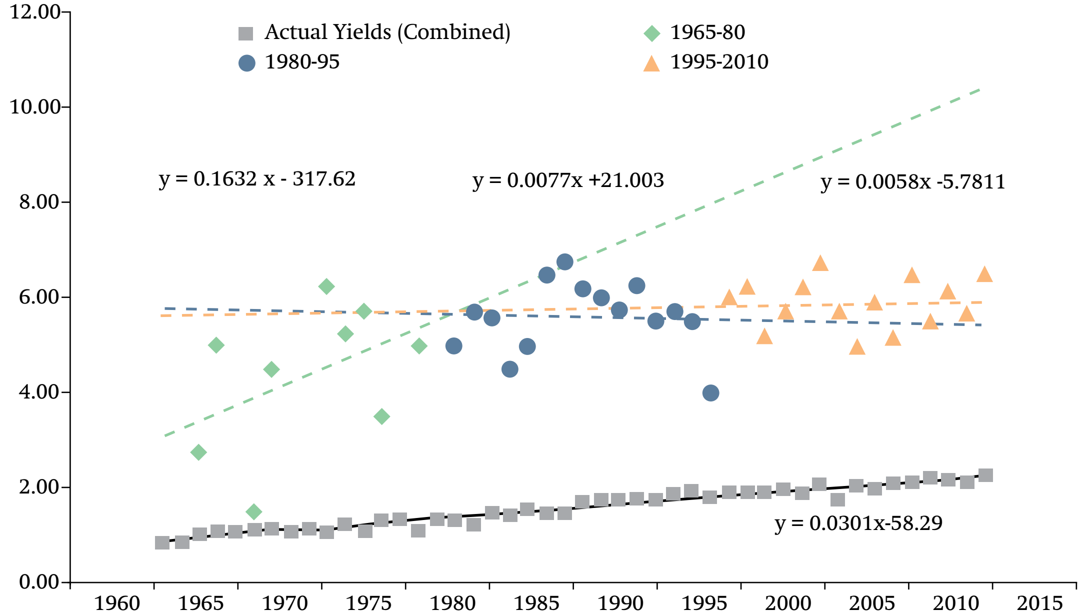
Source: Authors

Figure A.9.2: Current yield gaps for paddy/rice by state



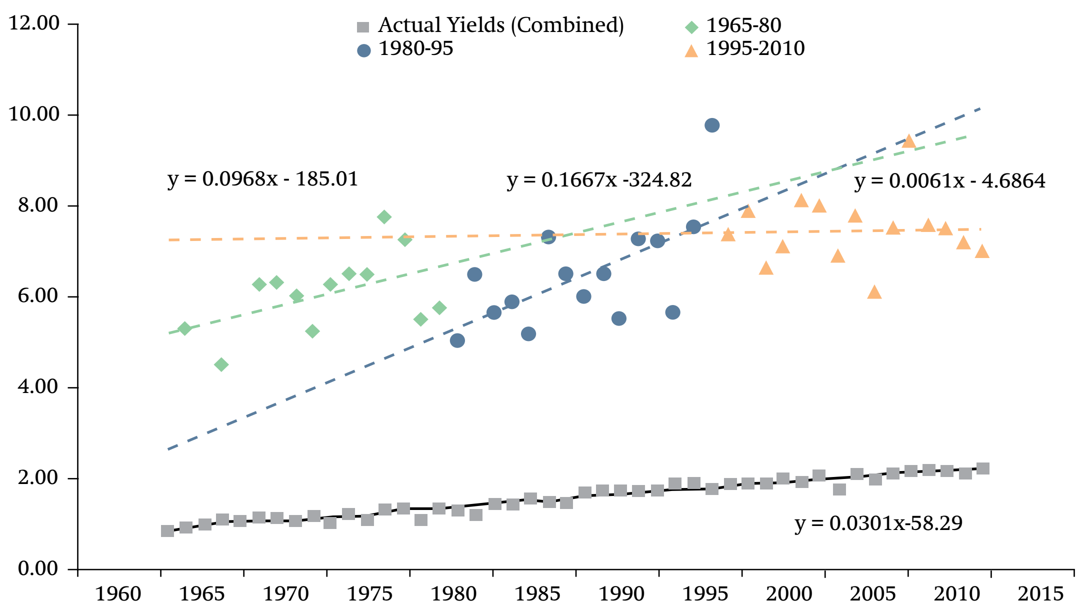
Source: Authors

Figure A.9.3: Yields of released varieties: Rainfed rice, 1965–2010



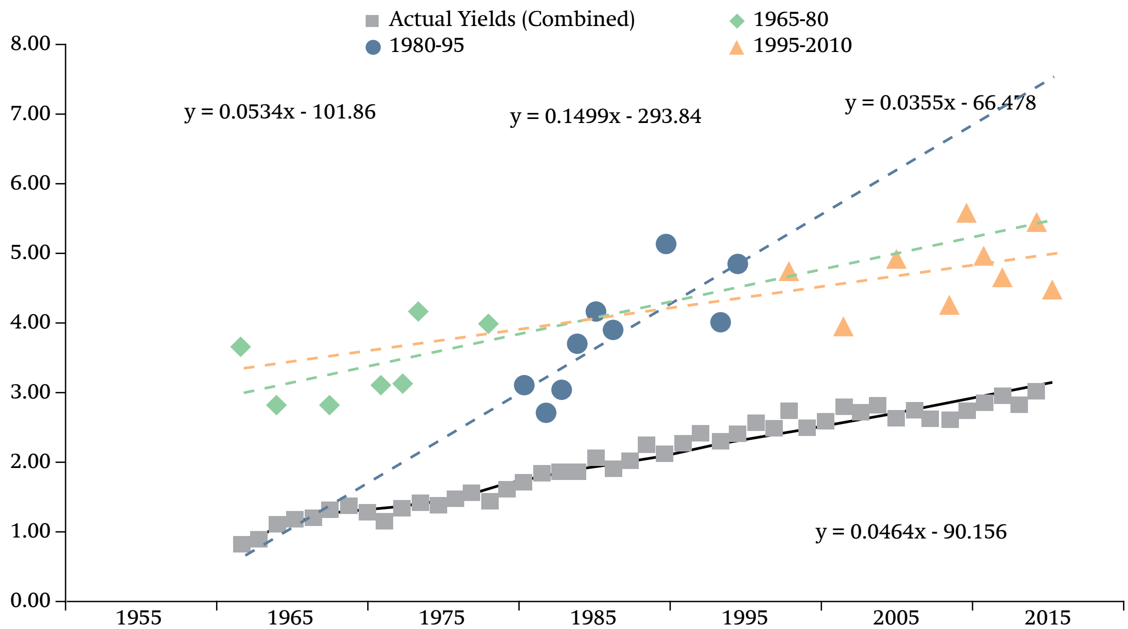
Source: Authors, using DRR database.

Figure A.9.4: Yields of released varieties: Irrigated rice, 1965–2010



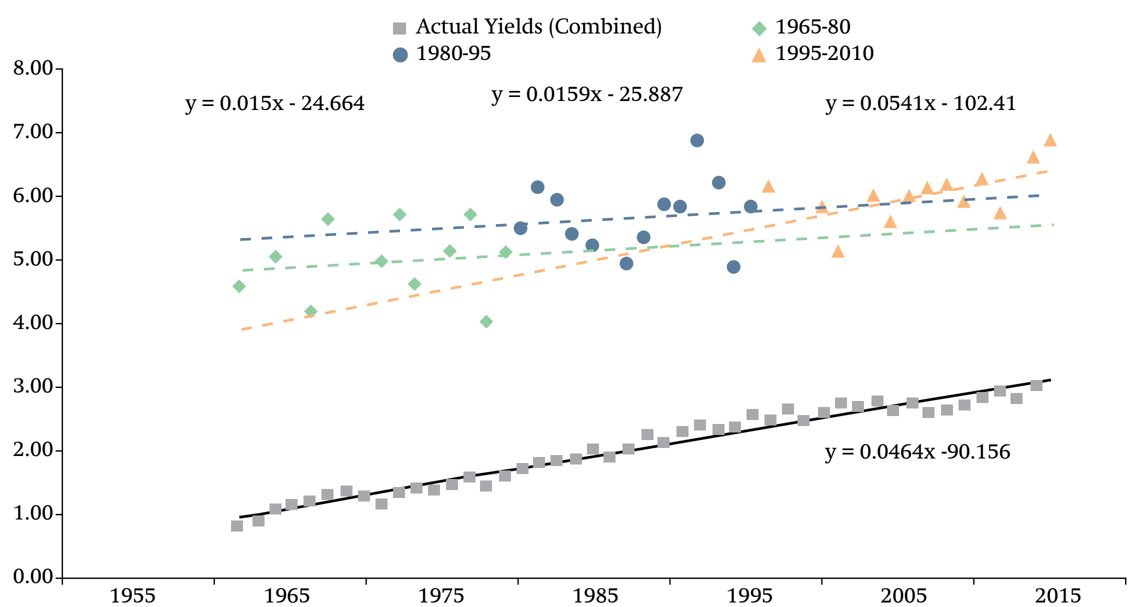
Source: Authors, using DRR database.

Figure A.9.5: Yields of released varieties: Rainfed wheat, 1965–2010



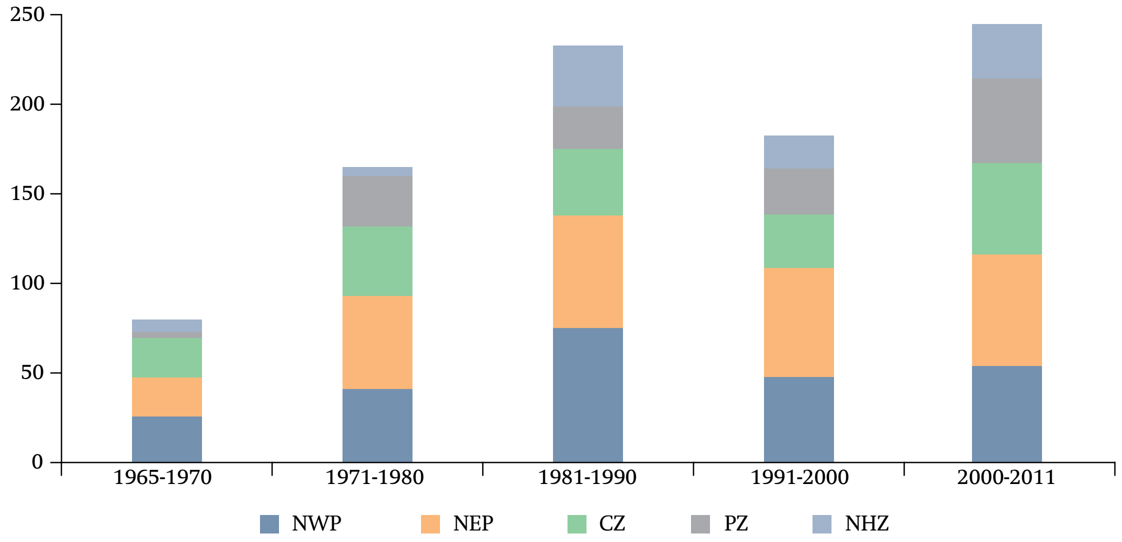
Source: Authors, using DWR database.

Figure A.9.6: Yields of released varieties: Irrigated wheat, 1965–2010



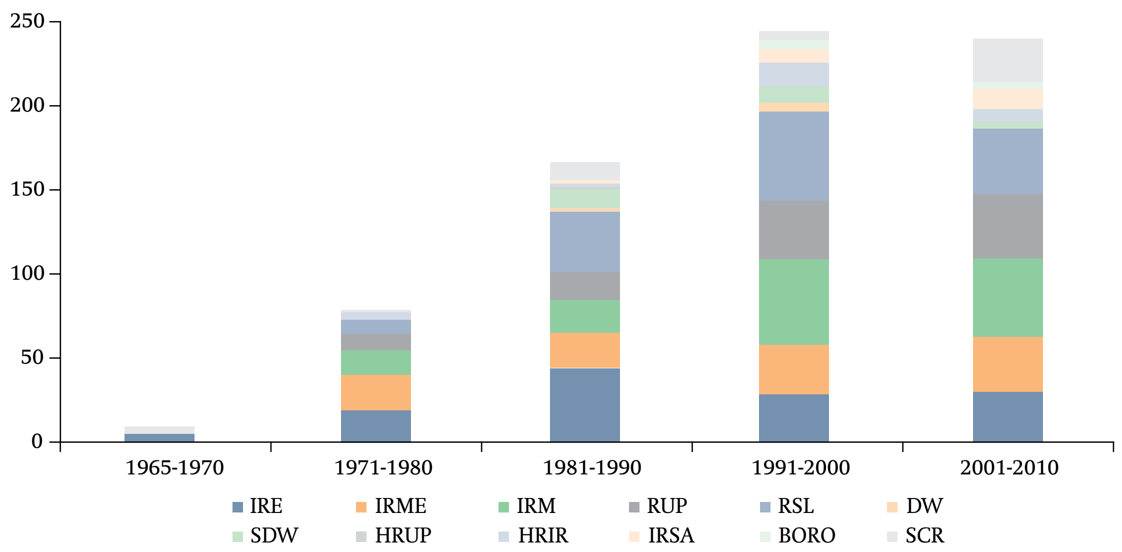
Source: Authors, using DWR database.

Figure A.9.7: Wheat varieties released by decade and zone



Source: Authors, using DWR database.

Figure A.9.8: Rice varieties released by decade and ecosystem



Source: Authors, using DRR database.

Table A.9.1: Farm yields, potential yields, and yield gaps in global rice mega-environments

RME	Region	Estimated yield (t/ha) and gap (%), in 2009 or 2010			Rate of change (%) relative to current values		
		FY	PY	Gap	FY	PY	Gap[b]
1	C. Luzon, the Philippines (wet season)	3.9	7.0	79	0.6	0.7	0.1
1	C. Luzon, the Philippines (dry season)	4.6	9.5	107	0.6	0.7	0.1
1.	The Philippines	3.7	5.6	51	1.6	0.7	−0.9
1.	Indonesia	5.0	6.5	30	0.7	1.3	0.6
1	Southern Vietnam	5.2	na	na	1.9	1.0	−0.9
2	Jiangsu, China	8.0	11.0	38	0.7	1.2	0.5
2	Punjab, India	6.0	10.5	75	1.1	0.3	−0.8
3	Japan	6.6	11.8	80	0.2	0.7	0.3
3	Rio Grande do Sul, Brazil	7.0	10.5	50	2.0	0.7	−1.3
4	Egypt	10.0	12.0[c]	25	1.1	0.6[d]	−0.5
5	Madhya Pradesh, India[b]	1.8	4.5	150	1.2	na	na
5	North-East Thailand[b]	2.1	5.0	140	1.6	na	na
6	Central Brazil[b]	2.0	3.6	80	2.2	0.7	−1.5
	Average (n = 13)	5.2		76	1.19	0.78	−0.39

Source: Fischer, Byerlee, and Edmeades 2013.

Note: RME refers to Rice mega-environment classified by Fischer, Byerlee, and Edmeades (2013) based on climate and hydro-morphology.

a. All PY and FY slopes are significant at $P < 0.10$ or better. Note all rates of FY progress and gap closing contain the direct effect of CO_2 rise (~0.2% p.a., see Section 2.4 of the source text.

b. PYw was estimated for these rainfed cropping regions which commonly experience water shortage.

c. Calculated as the difference between the rates of increase in PY and in FY (see Section 2.3 of the source text).

d. Based on on-farm demonstration yields; includes contributions of management and breeding progress, and ignoring yield stagnation since 2006.

Table A.9.2: Wheat farm yields, potential yields, and yield gaps

WME	Region[a]	Predicted yield (t/ha) and gap (%), in 2009 or 2010			Rate of change (%) relative to current values		
		FY	PY	Gap	FY	PY	Gap
1	Yaqui Valley, Mexico	6.4	9.0	41	0.9[g]	0.3	−0.6
1	Punjab, India	4.5	7.0	56	0.7[g]	0.4	−0.3
1	Jiangsu, China	4.6	7.5	63	0.8	0.7	−0.1
4	Western Australia[b]	1.8	2.6	44	1.0[g]	0.5	−0.5
6	Saskatchewan[b], Canada	2.3	3.8	69	0.8	0.6	−0.2
6	Saskatchewan[b], [c], Canada	2.2	3.6	64	0.7	0.5	−0.2
6	North Dakota[b], USA	2.5	4.0	60	1.0	0.7	−0.3
6	Finland	3.7	4.8	30	1.0	0.8	−0.2
10	Shandong/Henan, China	5.8	8.8	52	1.7	0.7	−1.0
11	United Kingdom	8.0	10.7	34	0.4	0.6	+0.2
	Northern France	8.6	10.8	26	0.3	1.1	+0.8
12	Kansas[b], USA	2.8	3.8	36	0.7	0.4	−0.3
	Average (n = 12)	4.43	na	48	0.83	0.61	−0.23

Source: Fischer, Byerlee, and Edmeades 2013.

Note: WME refers to wheat mega-environment classified by Fischer, Byerlee, and Edmeades (2013) based on growing season, temperature, moisture, and latitude.

a. These are rainfed cropping regions commonly with water shortage so PY_w was estimated
b. Durum wheat.
c. Note all rates of FY progress and gap closing contain the direct effect of CO_2 rise (~0.2% p.a., see Section 2.4 of the source text).
d. All FY and PY slopes are statistically significant at $P < 0.10$ or better, except for the FY slope for Northern France ($P = 0.13$).
e. Calculated as FY rate of change less PY rate of change.
f. The FY rates of change include small but significant weather trends (see text) for which no correction is applied here; two were unfavorable and one favorable.

Box A.9.1: The National Agricultural Innovation Project: Supporting change in India's national agricultural research system

The ongoing World Bank–supported National Agricultural Innovation Project (NAIP), implemented by ICAR since 2006, is piloting a number of change initiatives in the Indian national agricultural research system. The initiatives have the potential to catalyze system-wide efficiency, effectiveness, and productivity, and they include:

- ***Competitive consortia-based funding for agricultural research to introduce pluralism in the national agricultural research system.*** A total of 188 subprojects have been approved under NAIP, involving 844 participating institutions. More than 90 public-private partnerships have been established among 174 private organizations and NGOs. This is the first time that private organizations from outside the ICAR and state agricultural university system have been involved as partners in carrying out publicly funded agricultural research in the country.
- ***Support for system-wide changes to improve efficiency and productivity.*** Particularly noteworthy subprojects seek to establish a financial management/management information system that would connect all ICAR institutions on a real-time basis; establish a National Agricultural Bio-informatics Grid that would provide access for scientists to high-performance computing facilities for research related to biotechnology; and an online examination system for recruitment of agricultural scientists across the country.
- ***Business Planning and Development Units (BPDU) piloted in 10 selected state agricultural universities and ICAR institutions.*** These units have encouraged, nurtured, and supported technologists and scientists to develop their research products into sound commercial ventures. About 31 technologies have already been commercialized through this route, generating revenues surpassing Rs. 10 crores in the process.
- ***Stronger information communication and dissemination systems to provide online information to agricultural scientists.*** These systems include an online e-publishing system for ICAR research journals; operationalization of the Consortium for e-Resources in Agriculture (CeRA) to provide online access to about 3,000 scholarly journals for 142 institutions in the national agricultural research system; development of a knowledge management platform (Agropedia) to aggregate and disseminate information; a knowledge management portal providing complete information on rice; a group catalog (AgriCat, http://www.agricat.worldcat.org) of 12 major libraries for online access by researchers and students; a new platform (KVKnet http://agropedialabs.iitk. ac.in/extension) and knowledge network (vKVK http://www.vkvk.in) for Krishi Vigyan Kendra (Agriculture Science Centre) scientists; e-courses for five Bachelor's degree programs and strengthening of statistical computing in the national agricultural research system (http://www.iasri.res.in/sscnars).

Encouraged by the initial success, ICAR plans to further scale up and mainstream initiatives such as competitive research funding and BPDUs during the 12th Plan (2012–17) using its own funds.

Source: Authors

Box A.9.2: The Agricultural Technology Management Agency Model of extension

The Agricultural Technology Management Agency (ATMA) is a quasi-governmental organization registered under the Societies Registration Act of 1860. It operates under the direction and guidance of a Governing Board (GB) that determines program priorities, allocates funds, and assesses program impact. The composition of the GB provides a balance between the heads of the line departments and research units within the district and the stakeholder representatives—farmers, women, disadvantaged groups, and private firms within the district. The GB, chaired by the District Magistrate/Collector, reviews and approves the Strategic Research and Extension Plan and annual work plans, and sets policies and procedures for ATMA operations.

ATMA Management Committee (AMC) serves as the Secretariat of the GB and is responsible for coordinating and integrating extension and research activities within the district. The Project Director (PD), ATMA chairs the AMC, which includes the district heads of line departments, zonal research station, Krishi Vigyan Kendra (KVK, Agriculture Science Centre), NGO representatives, and two representatives from farmers' organizations.

ATMA Personnel include the PD, supported by a Deputy PD and other staff. The PD and DPD are taken on deputation, and the support staff is hired on a contract basis. To facilitate research and extension linkages within the district, if the PD is from the research system, then the DPD is from the extension system and vice-versa. Actual implementation of ATMA activities is done by the line departments.

The Block Technology Team (BTT) consists of block-level line department (agriculture, horticulture, animal husbandry, dairy, fisheries, forestry, and sericulture) officers and subject matter specialists, and it is headed by a Block Technology Manager. A designated scientist from the local KVK also attends the BTT meetings and provides a link with the agricultural research system. The BTT consults with the Farmer Advisory Committee (FAC) and develops a comprehensive extension program called the Block Action Plan (BAP), consistent with farmers' needs.

The Farmer Advisory Committee (FAC) is composed of farmers who represent different disciplines (agriculture, horticulture, livestock, and so on) and socioeconomic groups. Following the 2010 revised ATMA guidelines, FACs are now established at State, District, and Block levels; previously there was only a block FAC (BFAC). The BFAC advises the BTT on extension priorities for the block. It also reviews and approves the annual BAP prepared by the BTT before its submission to ATMA for funding. Then, the BFAC monitors and provides feedback to BTT on BAP implementation.

The Farm Information and Advisory Center (FIAC) is a block-level facility which includes an office for the BTT convener, a meeting room, and office space for the operator of the FIAC computer, with internet connectivity. It has become the single-window delivery mechanism for extension programs within the block. The internet access serves as an important information resource for all participants.

Farmer Organizations (FOs) are a key element of the group approach and focus on diversification into high-value crops and products. The farmers are organized into farmer interest groups around specific crops or products for which there is a market demand and that are appropriate for the agro-ecological conditions and resources of each group. To successfully supply different markets, achieve economies of scale, and create an efficient supply chain, these groups are organized along crop or product lines as block- and district-level farmer federations.

Source: Authors

Box A.9.3: Changes introduced in ATMA through the 2010 revised guidelines

- Provides for dedicated manpower at various levels. In 2005 when the pilot phase was scaled up, the scheme did not provide for dedicated manpower support at the different organizational levels. Work pertaining to ATMA was mostly looked after by staff of line departments in addition to their other duties, leading to the neglect of ATMA work. The revised guidelines provide for a State Coordinator, faculty, and support staff at the State Agricultural Management and Training Institute (SAMETI); a Project Director, Deputy Project Director, and support staff at the district level; and a Block Technology Manager and Subject Matter Specialist at the block level.
- During Phase II of the program, the extension system below the block level was weak, with inadequate links to the levels above. The revised guidelines seek to address this weakness by providing for a "farmer friend" for every two villages.
- Additional activities have been added to the "ATMA cafeteria" (the list of extension activities that can be funded), such as farmer schools. Unit costs have been enhanced for some of the activities.
- Farmers Advisory Committees (FACs) at the state, district, and block levels comprise farmer representatives. The earlier guidelines provided for FAC at the block level only.
- Support to SAMETIs for essential infrastructure.
- Delegation of powers to State Level Sanctioning Committees (SLSCs) set up under RKVY, to approve the State Extension Work Plan (SEWP) prepared under the Extension Reforms Scheme.

Source: Adapted from ATMA Guidelines 2010, available at http://Agricoop.nic.in/

ANNEXES

ANNEX 10: LIVESTOCK SECTOR: STATUS AND PERFORMANCE

Table A.10.1: Share of livestock in gross value of output and growth of the agricultural sector, TE 1992-93 and TE 2008-09, at 2004-05 prices (%)

State	Livestock share in agricultural VOP		Annual livestock sector growth		Annual agric. sector growth		Livestock share in agric. growth	
	1992-93	2008-09	1992-93	2008-09	1992-93	2008-09	1992-93	2008-09
Haryana	27.8	32.0	3.6	3.8	2.9	2.9	34.9	41.1
Punjab	26.2	33.1	4.1	2.5	2.0	1.7	57.8	47.2
Rajasthan	33.9	38.5	5.2	1.7	3.3	2.3	53.2	29.3
Himachal Pradesh	27.3	28.3	3.7	3.3	3.3	3.5	30.3	26.2
Gujarat	19.6	25.4	5.3	6.2	3.4	5.0	30.0	31.4
Uttar Pradesh	21.0	28.2	4.5	3.6	3.0	1.5	31.8	69.7
Madhya Pradesh	26.8	27.0	3.1	3.2	3.3	2.9	25.5	29.9
Tamil Nadu	27.4	29.0	1.9	3.5	2.4	1.8	21.6	57.4
Maharashtra	22.1	20.1	4.0	3.1	3.9	4.1	22.9	15.0
Andhra Pradesh	22.5	30.2	6.3	5.3	3.0	4.6	46.7	35.4
Bihar	28.7	36.8	6.2	7.4	6.6	3.9	27.3	69.1
Kerala	19.5	21.0	2.9	0.7	2.5	0.6	23.2	25.8
West Bengal	21.6	20.9	2.5	2.1	3.5	1.5	15.4	29.4
Assam	10.6	13.0	1.2	3.5	1.9	0.1	6.7	-
Odisha	10.2	18.6	4.2	7.7	0.4	3.4	104.3	42.3
Northeastern states	22.3	23.1	4.5	4.5	3.9	2.7	25.5	38.3
India	23.3	26.8	3.9	3.6	2.9	2.7	31.1	36.3

Source: Birthal and Negi 2012.

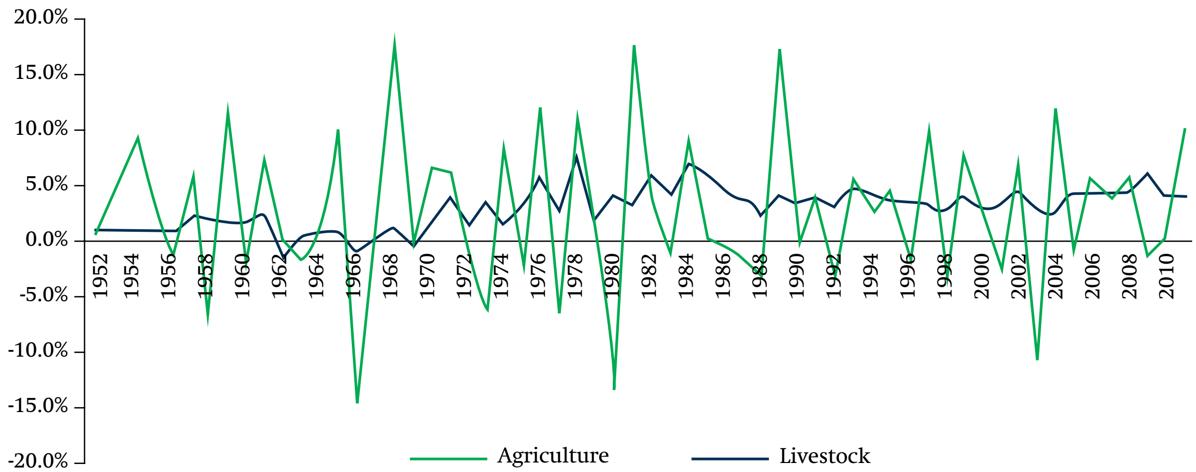
Note: Bihar includes Jharkhand; Madhya Pradesh includes Chhattisgarh; Northeastern states excludes Assam; Uttar Pradesh includes Uttarakhand.

Table A.10.2: Livestock population, output, and yield, 1990, 2000, and 2010

	Year			% change		
	1990	2000	2010	2000 over 1990	2010 over 2000	2010 over 1990
Milk output, million MT						
Cow milk	22.2	33	54.9	48.6	66.4	147.3
Buffalo milk	29.1	43.4	62.4	49.1	43.8	114.4
Goat milk	2.4	3.3	4.6	37.5	39.4	91.7
Total	**53.7**	**79.7**	**121.9**	**48.4**	**52.9**	**127.0**
Milk yield, kg/in-milk animal/year						
Cow	732	1003	1284	37	28	75.4
Buffalo	1122	1479	1679	31.5	13.5	49.6
Goat	100	122	151	22	23.8	51.0
Population , million head						
Cattle	202.5	191.9	210.2	-5.2	9.5	3.8
Buffaloes	80.6	93.8	111.3	16.4	18.7	38.1
Dairy cows	30.4	32.9	42.8	8.2	30	40.7
Dairy buffaloes	25.9	29.7	37.1	14.8	24.9	43.4
Goats	113.2	123.5	154	9.1	24.7	36.0
Dairy goats	23.8	26.7	30.5	12.2	14.2	28.2
Sheep	48.7	59.4	74	22	24.6	52
Pigs	11.9	13.4	9.6	12.6	-28.4	-19.4
Chickens	268	374	773.8	39.6	106.8	188.7
Ducks	22.6	30.4	26	34.5	-14.5	15.0
Slaughter animals, million head						
Cattle	10.3	9.6	10.6	-6.8	10.4	2.9
Buffalo	7.8	9.1	10.8	16.7	12.5	38.5
Goat	43.0	46.9	58.7	9.1	25.2	36.5
Sheep	15.1	18.4	24.1	21.8	31.0	59.6
Meat and eggs, million MT						
Cattle meat	1.036	0.981	1.087	-5.4	10.8	4.9
Buffalo meat	1.078	1.256	1.489	16.5	18.6	38.1
Total	2.114	2.237	2.576	5.8	15.2	21.9
Goat meat	0.43	0.469	0.587	9.1	25.2	36.5
Sheep meat	0.181	0.221	0.289	22.1	30.8	59.7
Pig meat	0.413	0.466	0.333	12.8	28.6	-19.4
Chicken meat	0.362	0.864	2.193	138.7	153.8	505.8
Duck meat	0.03	0.04	0.038	33.3	-5	26.7
Hen eggs	1.161	2.035	3.378	75.3	66	191.0

Source: Estimated from http://faostat.fao.org/site/603/default.aspx#ancor accessed 22/11/2012.

Figure A.10.1: Agriculture (crops) and livestock GDP annual growth rates



Source: Authors, using CSO National Accounts data.

Table A.10.3: Extent of contract broiler production by state in India, 2004–05

State	Total production (million birds/month)	Production under contract (million birds/month)	% production under contract
Tamil Nadu	18.5	16.5	90
Karnataka	7.4	6.5	87
Andhra Pradesh	16.0	9.5	60
Maharashtra	11.0	8.5	73
Subtotal	52.9	41.0	78
Gujarat	2.6	0.9	35
West Bengal	14.7	3.0	20
Northern states	30.0	2.0	7
Other states	30.0	1.0	3
Total	**130.2**	**47.9**	**37**

Source: Fairoze et al. 2006.

Table A.10.4: Share of livestock sector in ground-level disbursement of agricultural credit, 2000–01 to 2009–10, at 2004–05 prices

Year	Total agric credit (Rs billions)	Livestock credit (Rs billions)	% share of livestock
2000–01	635	26	4.1
2001–02	719	25	3.5
2002–03	781	30	3.8
2003–04	926	31	3.4
2004–05	1,253	31	3.4
2005–06	1,728	70	4.1
2006–07	2,060	72	3.5
2007–08	2,183	77	3.5
2008–09	2,396	83	3.4
2009–10	2,939	78	2.7

Source: Birthal and Negi 2012.

ANNEXES

ANNEX 11: PUBLIC EXPENDITURE PATTERNS AND IMPACT

Table A.11.1: Analysis of NFSM expenditures for 2013–14 (Rs)

Expenditure category	Gujarat	Bihar	Andhra Pradesh
Input distribution (seeds, micronutrients, other inputs)	2,275	3,895	8,500
Subsidy for agricultural equipment	580	1,750	1,120
Subsidy toward irrigation equipment	320	1,085	1,625
Training and capacity building	60	0	100
Other local initiatives	320	0	0
Project management	110	390	160
Total	3,665	7,120	11,505
Proportion of subsidies in the overall budget	87%	95%	98%

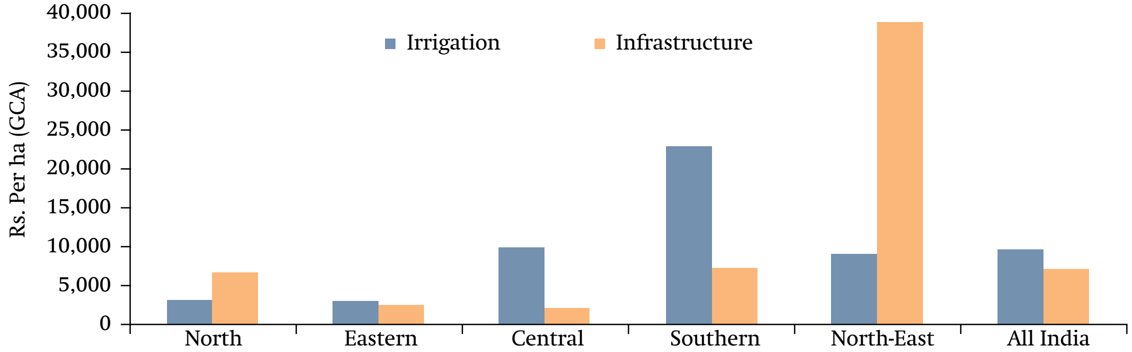
Source: Authors, using information from http://www.nfsm.gov.in

Table A.11.2: Analysis of RKVY expenditure by approved projects for 2012–13 (Rs)

Expenditure category	Gujarat	Bihar	Andhra Pradesh
Input distribution (seeds, micronutrients, other inputs)	350	570	285
Subsidy for agricultural equipment	100	160	320
Subsidy toward irrigation equipment	120	0	0
Training and capacity building	10	5	80
Institutional strengthening (including support for building public assets)	480	100	190
Total	1,060	835	875
Proportion of subsidies in the overall budget	42%	87%	69%

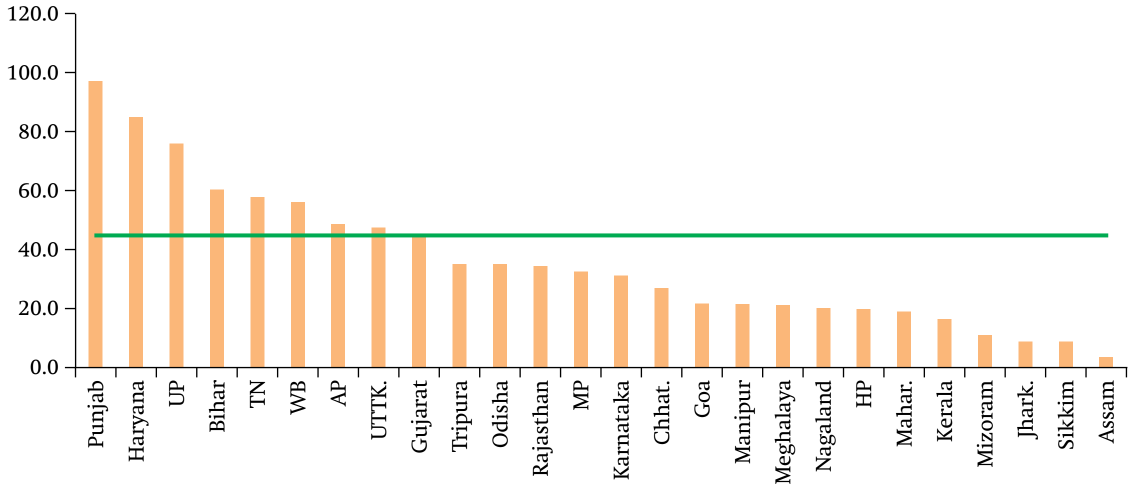
Source: Authors, using information from http://rkvy.nic.in

Figure A.11.1: Regional trends in capital expenditure, cumulative 2000–09 (2004/05 prices)



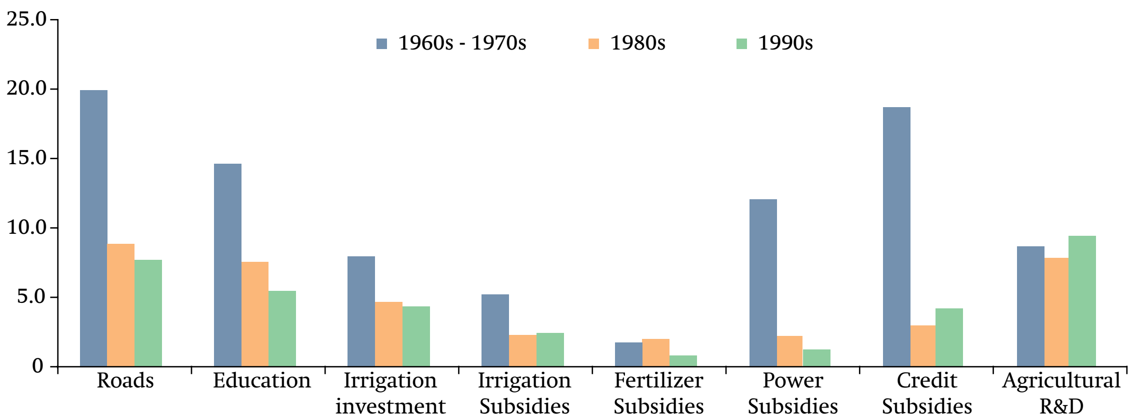
Source: Singh 2011.

Figure A.11.2: Percent area irrigated under major crops by state, 2008–09



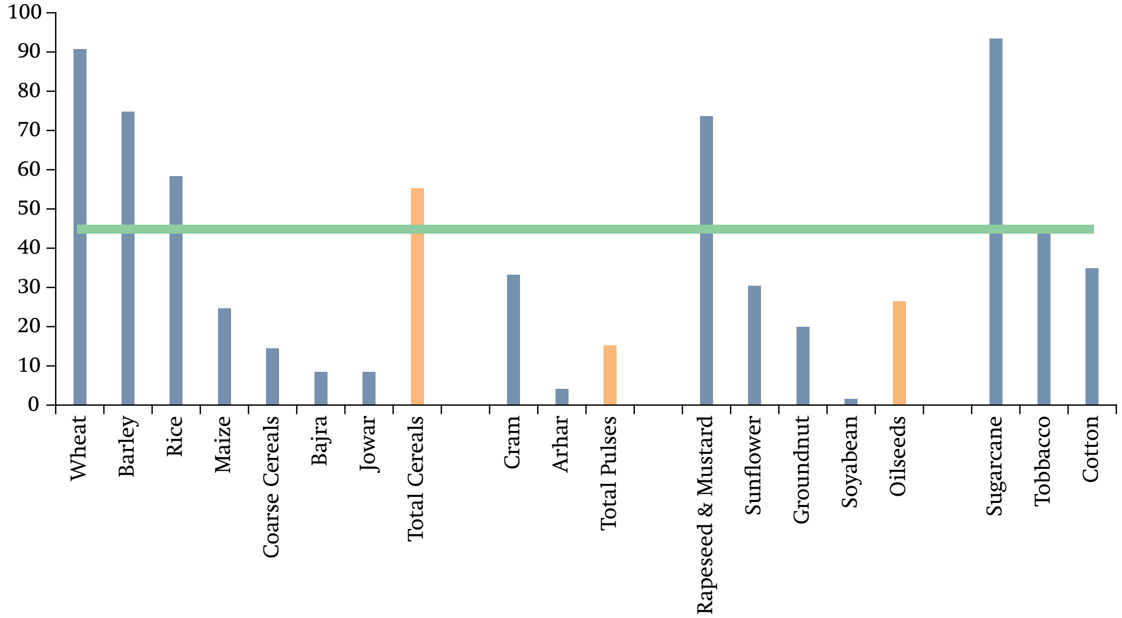
Source: Authors, using DES, MOA data.

Figure A.11.3: Impact of different public expenditures



Source: Fan, Gulati, and Thorat 2008.

Figure A.11.4: Percent area irrigated by crop, all India 2008–09



Source: Authors, using DES, MOA data.

ANNEX 12: STATUS OF AGRICULTURAL MARKET REFORMS

Regulatory impediments to marketing: ECA Act and APMC Act

The two most pervasive regulations affecting the functioning of markets and trade are the Essential Commodities Act (ECA, restricting movement and storage of agricultural products) and the Agricultural Produce Marketing Committees Act (APMC Act, under which agricultural marketing is restricted through regulated markets with licensed traders). There are also a number of other regulations, including the Small Scale Industry Reservation (under which most food processing was reserved for small firms until 1997), and more general policies that also affect other sectors, such as tax policy, border and commercial policies, food laws, and labor policies. Many of the regulations have been relaxed over time, allowing for a potentially more important role and better investment opportunities for the private sector. Implementation of the reforms has been either slow or uneven, however, with reversals on several occasions.

The ECA and the APMC Act affect market development, efficiency, and costs in a number of ways. The zoning and storage restrictions under the ECA and the requirements that all produce be sold at a limited number of licensed and regulated markets have created significant disincentives for private investment in storage, handling, and marketing infrastructure, as well as promoted fragmentation of markets (through movement restrictions and cess/tax implications). Direct marketing arrangements (such as CF or direct purchases by food processers from farmers) are constrained by these regulations, preventing improvements in value chain efficiencies. Thus the full potential for food processing remains untapped, and the industry remains dominated by low-level processing in informal enterprises (Bhavani, Gulati, and Roy 2006, Morisset and Kumar 2008). Farmers as well as consumers bear the brunt of these regulations, which have fostered uncompetitive market structures at the *mandi* (wholesale) level, depressed farmer prices, and raised final prices to consumers. The specifics of the two regulations are discussed in more detail below.

The Essential Commodities Act

The ECA provides for the regulation and control of production, distribution, and pricing of commodities which are classified as "essential" (for maintaining or increasing supplies or for assuring equitable distribution and availability at fair prices). Under the Act, various ministries/ departments of central government, and under the delegated powers, the state governments/ union territory administrations issue orders for regulating production, distribution, pricing,

Box A.12.1: LIST OF COMMODITIES DECLARED ESSENTIAL UNDER THE ESSENTIAL COMMODITIES (AMENDMENT) ACT, 2006
No. 54 of 2006 (24th December 2006)

(1) Drugs:

Explanation: For the purposes of this Schedule, "drugs" has the meaning assigned to in the clause (b) of section 3 of the Drugs and Cosmetics Act, 1940 (23 of 1940)

(2) Fertilizer, whether inorganic, organic or mixed;

(3) Foodstuffs, including edible oilseeds and oils;

(4) Hank yarn made wholly from cotton;

(5) Petroleum and Petroleum Products;

(6) Raw jute and jute textiles;

(7) (i) Seeds of food-crops and seeds of fruits and vegetables;

(ii) Seeds of cattle fodder; and

(iii) Jute seeds;

(iv) Cotton seed*.

* Added vide Notification No.S.O.3267 (E) dated 22nd December, 2009.

and other aspects of trading with respect to the commodities declared as essential. The enforcement/implementation of the provisions of the ECA lies with the state governments and union territory administrations.

The ECA gives the government wide-ranging powers to control the production, storage, transportation, and pricing of essential commodities. Although these controls (for instance, limits on the stocks that can be held by private players or restrictions on the movement of commodities) are imposed sporadically and usually in inflationary situations, they can change suddenly in a short period.

The list of scheduled commodities under the Act changes from time to time. In recent years the list has been pruned significantly and presently includes the seven broad categories of commodities (compared to 70 commodities in 1989), including foodstuffs, seeds, and fertilizers (Box A.12.1).192 There are penalties for noncompliance. During 2006–08, state and union territory governments prosecuted 14,541 persons under provisions of the ECA and secured conviction in 2,310 cases.

The inherent uncertainty in the manner in which the regulations and restrictions on the production, pricing, movement, and storage of commodities are applied creates a strong disincentive for significant private investment in marketing the scheduled commodities. A major casualty is investment in grain storage and handling infrastructure, as well as innovations in marketing, resulting in inefficiency, high costs for consumers, and low prices for producers, outcomes that are contrary to the Act's original intent.

192 The current list includes drugs; fertilizer (inorganic, organic, or mixed); foodstuffs (including edible oilseeds and oils); hank yarn made only from cotton; petroleum and petroleum products; raw jute and jute textiles, and seeds of food-crops, fruits and vegetables, cattle fodder, jute, and cotton (cotton seed was introduced in December 2010).

The Agricultural Produce Market (Development and Regulation) Act

The Agricultural Produce Market (Development and Regulation) Act—APM(D&R)—regulates and governs the buying and selling of agricultural produce through the Agriculture Produce Marketing Committee (APMC) established by each state. The Act empowers states to establish wholesale markets for agricultural produce (known as *mandi* or "APMC" markets). It confers wide powers to the APMCs to construct and manage agricultural markets and regulate all aspects of marketing, including the levy of a user fee for transactions taking place both on and off the wholesale market yards.

The Act extends to whole of the state and makes these markets mandatory conduit for the trading of agricultural produce. The limited number of licenses issued by the APMCs to traders and commission agents in the established markets restricts the choices of sellers and buyers, who are not allowed to conduct transactions directly and outside the *mandi* system.

The management of the APMCs has changed significantly from what was envisaged when the regulation was put in place. Bureaucrats have assumed greater importance in the management of the APMCs, replacing the farmer representatives who were originally intended to predominate. The APMCs have created barriers to entry for newcomers, resulting in limited numbers of traders and a large command area for each market. Market fees have become a source of income for the government instead of being reinvested in market infrastructure (Acharya 2004). Despite large revenues from market fees, the infrastructure in most markets is deficient, as revenues are used for other purposes (Umali-Deininger and Sur 2007; Fafchamps, Vargas-Hill, and Minten 2008).

By restricting the establishment of additional markets and limiting the number of commission agents that can operate within the *mandi*, the net effect has been to stifle competition, generate economic rents for a small number of market operators, promote inefficiency in marketing, lead to under-investment in physical infrastructure by the committee, and generally create strong disincentives for private investment in agricultural marketing and processing (including investment in more efficient markets and supply chains). Ultimately these oligopolistic marketing arrangements reduce the prices received by farmers and raise the prices paid by consumers. Over time, strong vested interests have developed in maintaining status quo (commission agents, "weigh men," unions, and others) and resisting or derailing reforms.

Recognizing the "malfunctioning of regulated markets" and the "need for more transparency and accountability in the functioning of these markets,"[193] the government initiated reforms to facilitate the development agricultural markets and to facilitate greater participation of private sector through legislation, developing the Model State Agricultural Produce Marketing (Development and Regulation) Act, 2003 for guidance and adoption by state governments.

The Model Act provides for the establishment of markets by other agencies (including the private sector), direct marketing and purchase centers, CF, electronic trading, and promotion of public-private partnerships for managing and developing agricultural markets in the country.

193 GOI (2007).

Table A.12.1: Average size of holding of contract growers (acres) by crop and agency

Study and year	Contracting agency and place	Crop	Avg. size of contract grower	Avg. size of holding in state	% area under CF crop
Singh (2002)	Frito Lay (Pepsi), Punjab	Potato	53	9.5	8
-do-	Nijjer Agro, Punjab	Tomato	22	9.5	23
-do-	HLL, Punjab	Tomato	78	9.5	33
-do-	Frito Lay (Pepsi), Punjab	Chilly	90	9.5	4.5
Dev and Rao (2005)	AP Govt. and various processors	Oil palm	10	3	40
-do-	BHC Agro India, AP	Gherkins	7	3	15
Asokan and Singh (2006)	A M Todd, Punjab	Mint	57	9.5	
Kumar (2006)	Many multinationals and local firms in Punjab	Many crops together	37	9.5	12
Singh (2008)	McCain Foods, Gujarat	Potato	19	6.45	21
-do-	Frito Lay (Pepsi) Punjab	Potato	63	9.5	53
-do-	A M Todd, Punjab	Mint	40	9.5	27
R Singh (2008)	Frito Lay, (Pepsi) Punjab	Potato	75	9.5	-
Pritchard & Connell, 2011	Karnataka and AP (AVT McCormick)	Chilly	22.5-42		25-70

Source: Singh 2012.

Table A.12.2: Average size of holding of retail chain contact/contract vegetable growers by crop and agency

Fruit and vegetable chain	Location	Crop	Avg size of CF holding	Avg size of holding in state	Avg % area under vegetables
ITC's Choupal Fresh	Chandigarh region (Punjab/ Haryana)	Cauliflower, bottlegourd	9.91	9.36 (PB) and 5.26 (HR)	37
Reliance Fresh (RF)	Ahmedabad region	Cauliflower, cabbage	15.9	6.45	47
ABRL's More	Ahmedabad region	Cauliflower, tomato	15.43	6.45	71
ABRL's More	Bangalore region	Cauliflower, tomato	7.52	4(2.9)*	65
RF/ABRL's More (thru supplier)	Belgaum region	Cauliflower, tomato	16.97	4(5)*	33
Namdhari –Fresh	Bangalore region	Okra, baby corn	4.56	4(2.9)*	64

Source: Adapted from Singh 2012.

Note: * figures in brackets are average land holding size in the study district/region.

Table A.12.3: Status of APM (D&R) amendment and reforms

Sl. No.	State	Direct marketing	Contract farming	Private markets	Single license	Single-point levy
1	Andhra Pradesh	✓	✓	✓		✓
2	Assam	✓	✓	✓	✓	
3	Chhattisgarh	✓	✓		✓	✓
4	Gujarat	✓	✓	✓	✓	✓
5	Goa	✓	✓	✓	✓	✓
6	Himachal Pradesh	✓	✓	✓	✓	✓
7	Jharkhand	✓	✓	✓	✓	✓
8	Karnataka	✓	✓	✓	✓	✓
9	Nagaland	✓	✓	✓	✓	✓
10	Madhya Pradesh	✓	✓	★	✓	✓
11	Maharashtra	✓	✓	✓	✓	
12	Mizoram	✓	✓	✓	✓	✓
13	Odisha	✓	✓	✓		
14	Rajasthan	✓	✓	✓	✓	✓
15	Sikkim	✓	✓	✓	✓	✓
16	Tripura	✓	✓	✓		
17	Haryana		✓			
18	Tamil Nadu	Act Not Amended but APM (D&R) Act provides for setting up private markets and direct marketing under section 8 - (1)–C.				
19	Uttar Pradesh	Act not amended, provides for bulk purchases and single license through executive order.				
20	Bihar	APMC Act is repealed w.e.f. 1.9.2006.				
21	Punjab, Meghalaya, Uttarakhand, West Bengal, Puducherry, Chandigarh, NCT of Delhi	Act not amended				
22	Kerala, Manipur, Andaman and Nicobar Islands, Dadra and Nagar Haveli, Daman and Diu, and Lakshadweep.	States/union territories where there is no APMC Act and hence no reforms				

Source: Patnaik and Sharma 2013.

Table A.12.4: Status of rules notification for APM(D&R) Act amendments

Sl.No	State	APM (D&R) Act amended	Amended rules notified
1	Andhra Pradesh	✓	✓
2	Assam	✓	-
3	Chhattisgarh	✓	✓
4	Gujarat	✓	-
5	Goa	✓	✓
6	Himachal Pradesh	✓	✓
7	Jharkhand	✓	-
8	Karnataka	✓	✓
9	Nagaland	✓	*Partially notified
10	Madhya Pradesh	✓	✓
11	Maharashtra	✓	✓
12	Mizoram	✓	*Partially notified
13	Odisha	✓	✓
14	Rajasthan	✓	✓
15	Sikkim	✓	-
16	Tripura	✓	-
17	Haryana	Partially for contract farming	✓

Source: Patnaik and Sharma 2013.

Table A.12.5: Some private sector initiatives

Name of state/ union territory	Initiatives taken	Outcome
Andhra Pradesh	• Act amended on 26-10-2005 • Permission to NDDB for private market	• Contract farming and direct purchase • Heritage (F&V), Reliance (F&V), More (F&V), Metro (F&V), Saguna Poultry Farms (Poultry), Sri Satyanarayana Cold Storage, Sri Bhuvaneshwara Multiplex Pvt. • Srini Mega Food Park given special status for the purpose of sourcing raw material
Assam	• Act amended on 19-01-2007 • North East Mega Food Park given special status for the purpose of sourcing raw material	
Bihar	• Act repealed w.e.f. 01-09-2006 • Private market near Patna has been advertised and awarded (Temptation Foods) • The erstwhile markets are being operated by association of traders under supervision of Officer on special duty (mostly SDM) without regulation of trading practices which is creating various issues and problems	• No progress on establishment of private market reported • Retail network established by M/S Sambodhi in Patna City • A few food-processing units have been established • Kaventer Food Park has been sanctioned by MoFPI

Name of state/ union territory	Initiatives taken	Outcome
Chandigarh	• Partially amended • Private market was proposed but government has not been able to attract any private sector player	• No progress on establishment of private market reported
Chhattisgarh	• Act amended on 10-02-2006 & 2011	• Private market by wholesalers has been established at Raipur • Direct sale to traders at farm-gate by vegetable growers • Purchase of cereals by traders from farm-gate • Contract farming of safflower by Marico (Saffola), of medicinal plants by CG Herbals
Goa	• Act amended on 06-08-2007	
Gujarat	• Act amended on 01-05-2007 • Proposal to set up market in public-private partnership (PPP) mode in Ahmadabad, plus four terminal markets in PPP mode proposed along Delhi–Mumbai freight corridor • Single license • Anil Mega Food Park given special status for the purpose of sourcing raw material	• Contract farming by processors and exporters: McCain (potatoes), Desai Exports (bananas), Bodal Agro (F&V, pomegranates), Ambika Food Produce (F&V), Gujarat Coop. Cotton Federation (cotton), Jayant Agro Organics, Janani Industries • Farm-gate purchase by exporters
Haryana	• Partially amended • Terminal Market project in PPP mode at Gannaur is in the pipeline • E licensing has been introduced	• Contract farming in basmati rice
Himachal Pradesh	• Act amended on 26-05-2005	• Direct purchase against single license under Direct Marketing License provisions by corporate players like Adani Agri Fresh, Dev Bhumi, Reliance Fresh, Fresh & Healthy, Mother Dairy • Contract farming by processors (Himalaya International)
Jharkhand	• Act amended on 16-07-2007 • Jharkhand Mega Food Park given special status for the purpose of sourcing raw material	
Karnataka	• Act amended on 16-08-2007 • Permission for private markets granted at 3 locations • Special status to the market set up by NDDB	• Contract farming by Global Green (gherkins), Marico (Saffola), Ugar Sugar works (barley), Unicorn (gherkins), Katra Phyto Chem (marigold)

Name of state/ union territory	Initiatives taken	Outcome
	• Single license • Integrated Mega Food Park given special status for the purpose of sourcing raw material	• Direct purchase under Direct Marketing provisions by Metro Cash & Carry (F&V), ITC, Wilchy Agro Products
Madhya Pradesh	• Act amended on 15-06-2003 • Chhindwada Mega Food Park given special status for the purpose of sourcing raw material	• Contract farming done by Cargill India, Hindustan Uni Lever, ITC, Sanjivini Orchards (pomegranates), LT Overseas (basmati rice) • Direct purchase by cold store units, processors
Maharashtra	• Act amended on 11-07-2006 • MSAMB is actively setting up markets in PPP mode • Market infrastructure in PPP mode • F&V trade deregulated and exempted from market fee • Paithan Mega Food Park given special status for the purpose of sourcing raw material • Direct Marketing licenses have been issued to more than 80 companies/traders	• Private markets established • Contract Farming by Marico (Saffola), ITC & Pepsico (potatoes), More, Reilance, Big Bazaar (F&V), KB Export (vegetables for export)
Odisha	• Act amended on, 17-05-06 • Market proposed to be developed in PPP mode • MITS Mega Food Park given special status for the purpose of sourcing raw material	• Contract farming by CG Herbals (medicinal plants)
Punjab	• Act amended by Ordinance (lapsed after six months) • International Fresh Farm Products Mega Food Park given special status for the purpose of sourcing raw material	• Contract farming by Pepsico (potatoes), Field Fresh (baby corn), basmati exporters, Nijjar Foods (tomato), Markfed (spinach and mustard leaves)
Rajasthan	• Act amended on 18-11-2005	• Contract farming and operations/ procurement under Direct Marketing licenses by; ITC, Pepsico, Reliance Fresh
Tamil Nadu	• No amendment required, as previous Act has most provisions of the Model Act	• A private modern fruit and vegetable market—APPTA Market (Agricultural Products Producers and Traders Association Market)—constructed at Nagercoil near Kanyakumari in Tamil Nadu
Uttar Pradesh	• Act not amended, but provision made vide administrative order for bulk purchase	• Haldiram, ITC, and Pepsico are major private players in direct marketing from farmers; Big Bazaar and Spencer's (retail outlets) procure from registered vendors.

Source: Patnaik and Sharma 2013.

ANNEXES

ANNEX 13: FOOD PROCESSING: STRUCTURE AND PERFORMANCE

The organized manufacturing sector in India comprises factories registered under sections 2m(i), 2m(ii), and section 85 of the Factories Act of 1948. Under section 2m, factory means any premises including the precincts thereof: 2m (i) wherein ten or more workers are working or were working on any day of preceding twelve months and in any part of which a manufacturing process is being carried on with the aid of power or is ordinarily so carried on. 2m(ii) where in twenty or more workers are working or were working on any day of proceeding twelve months and in any part of which a manufacturing process is being carried on without the aid of power or is ordinarily so carried on and does not include a Mine subject to the operations of the Indian Mines Act, 1923, or a railways running school. Under section 85 of the Factories Act 1948, the state government is empowered to notify any factory not covered under the above two sections.

In the NSS framework, the unorganized manufacturing sector includes all manufacturing enterprises except: (i) those registered under section 2 m- (i) and 2 m (ii) of the Factories Act, 1948 and Bidi and Cigar Workers (Conditions of Employment) Act, 1966, and (ii) those run by government/public sector enterprises. The term "unorganized manufacture" basically refers to all enterprises not covered by the Annual Survey of Industries (ASI). The data for both the rounds covered the National Industrial Classification (NIC) 2-digit codes 15–37 in terms of NIC 2004 codes. In addition, enterprises engaged in cotton ginning, cleaning, and baling (NIC 2004 code 01405) were also covered under the survey. The survey covered the whole of the Indian Union; the entire study would be done at state as well as national level. However, for the state-level analysis, the focus would be only on 19 "major states": Andhra Pradesh (AP), Assam (Ass), Bihar (Bih), Chhattisgarh (Chat), Gujarat (Guj), Haryana (Har), Jharkhand (Jhar), Karnataka (Kar), Kerala (Ker), Maharashtra (Mah), Madhya Pradesh (MP), Odisha (Oris), Punjab (Punj), Rajasthan (Raj), Tamil Nadu (TN), Uttar Pradesh (UP), Uttaranchal (Uttr), and West Bengal (WB). The survey covered the whole of the Indian Union except (i) villages situated beyond 5 kilometers of bus route in the state of Nagaland, (ii) inaccessible villages of Andaman and Nicobar, and (iii) some first-stage units (numbering less than 0.1 percent of the total) where Economic Census 1998 (EC 98) could not be conducted. Thus the corresponding state/union territory-level estimates and the all-India results presented are based on the areas under survey coverage.

As per NSS, an Own Account Manufacturing Enterprise (OAME) runs without any hired worker employed on a fairly regular basis and is engaged in manufacturing and/or repairing activities. An establishment employing less than six workers (household and hired workers taken together) and engaged in manufacturing activities is termed a Non-directory Manufacturing Establishment (NDME). Finally, a Directory Manufacturing Establishment (DME) is one which has employed six or more workers (household and hired workers taken together) and is engaged in manufacturing activities.

Table A.13.1a: Share of food manufacturing in total organized manufacturing (decadal averages; values in 2004–05 prices)

		AP	AS	BH	GJ	HY	HP	KT	KE	MP	MH	OR	PB	RJ	TN	UP	WB
Factories	1980-90	28.46	47.84	11.76	10.03	13.69	9.58	20.56	18.61	22.96	9.5	22.07	16.87	12.5	23.11	26.71	16.27
	1990-99	32.46	48.24	9.68	8.87	16.45	10.34	17.95	17.38	21.21	10.5	22.43	19.41	10.11	19.61	22.59	16.43
	2000-09	39.59	51.98	11.67	9.19	12.19	13.41	18.69	20.28	17.09	11.78	30.19	20.78	9.14	16.98	17.45	19.11
Employment	1980-90	17.49	59.94	8.56	9.65	10.94	3.6	15.84	33.31	9.58	9.99	6.03	17.16	6.46	14.34	28.76	7.42
	1990-99	16.8	58.87	8.33	9.7	13.21	4.93	13.17	39.29	9.98	11.57	9.26	17.77	6.49	12.54	26.53	8.18
	2000-09	18.81	58.42	18.38	8.59	11.33	8.84	14.23	47.1	12.66	14.41	14.49	22.86	7.86	10.74	25.53	11.62
Investment	1980-90	5.78	11.67	1.97	4.64	3.93	1.3	9.38	4.59	1.33	6.17	0.66	8.72	2.56	5.11	12.1	1.99
	1990-99	9.01	51.02	5.38	5.96	5.93	-23.22	5.59	-2.85	-0.64	7.46	6.6	11.59	0.78	10.5	7.37	7.83
	2000-09	14.99	12.03	48.92	2.7	8.05	0.57	6.63	11.16	4.26	10.98	3.06	11.37	6.72	6.02	-77.61	10.67
Capital stock	1980-90	7.07	32.43	1	4.71	3.6	0.84	8.03	3.33	1.42	6.53	1.26	6.37	2.73	5.64	7.28	3.03
	1990-99	6.66	33.48	2.41	3.52	5.38	2.2	8.35	7.13	4.83	6.44	1.69	10.04	3.62	6.44	9.08	3.66
	2000-09	11.23	24.75	6.3	2.94	6.54	4.28	9.65	11.78	7.68	8.38	2.8	15.44	4.71	6.91	16.87	6.44
Gross value added	1980-90	11.34	51.52	2.62	5.47	6.77	1.78	9.65	11.64	3.4	6.16	2.72	15.68	3.33	8.51	16.09	4.68
	1990-99	12.36	44.02	5.67	4.6	8.83	2.47	9.14	16.89	7.92	7.47	3.19	19.84	5.4	8.78	13.84	5.55
	2000-09	13.72	24.24	25.69	3.74	7.5	3.93	10.72	17.61	12.13	7.29	3.29	27.84	7.67	7.75	16.93	5.96

Source: ASI, CSO.

Table A.13.1b: Share of food manufacturing in total unorganized manufacturing (2000–01 and 2005–06; values in 2004–05 prices)

		AP	AS	BH	CH	GJ	HY	HP	JH	KT	KE	MP	MH	OR	PB	RJ	TN	UP	UK	WB
Enterprise	2000-01	16	31	30	15	14	16	30	21	11	12	12	19	21	12	20	9	21	20	20
	2005-06	10	29	27	9	14	15	28	15	12	14	10	16	28	10	18	7	18	21	13
Workers	2000-01	22	32	29	14	9	15	27	20	19	16	16	16	22	12	18	10	20	22	23
	2005-06	22	32	27	8	10	15	24	16	26	19	12	10	28	11	15	10	19	28	16
Investment	2000-01	31	38	44	24	9	20	41	24	18	22	14	26	39	17	21	14	26	32	22
	2005-06	26	33	47	8	9	14	29	25	20	27	12	22	31	15	17	15	25	38	22
Gross value added	2000-01	26	23	25	15	7	15	27	19	20	17	11	19	27	12	15	12	17	23	21
	2005-06	28	30	30	8	10	17	13	16	33	18	9	21	25	15	17	13	21	30	17

Source: NSS.

Note: Investment or capital in unorganized refers to market value of fixed assets (own+hired).

Table A.13.2a: Shares of states in food manufacturing (decadal averages)

		AP	AS	BH	GJ	HY	HP	KT	KE	MP	MH	OR	PB	RJ	TN	UP	WB
Factories	1980-90	24.29	3.55	0.74	5.14	2.15	0.38	5.65	4.31	2.11	8.69	2.15	6.8	2.09	14.43	6.89	4.63
	1990-99	13.11	5.16	0.85	5.28	3.01	0.35	5.98	11.05	2.11	12.88	1.5	6.83	1.59	10.35	11.25	4.42
	2000-09	11.38	2.02	0.75	5.72	3.83	0.81	7.28	2.27	3.92	16.4	1.57	5.33	1.57	7.28	20.38	3.67
Employment	1980-90	10.62	3.27	1.16	6.26	2.97	0.57	8.04	2.27	3.86	18.71	1.15	5.49	1.93	8.63	16.98	3.68
	1990-99	10.35	2.54	0.88	6.01	3.72	0.52	9.03	3.26	4.47	17.05	0.78	9.35	2.77	8.47	11.81	2.62
	2000-09	23.68	3.49	1.33	5.14	2.69	0.2	5.31	3.42	3.9	8.74	1.66	5.81	2.02	16.33	10.61	4.53
Investment	1980-90	12.83	5.79	1.46	6.06	3.13	0.21	5.1	9.69	3.32	12.24	1.22	5.69	1.34	11.12	15.5	4.73
	1990-99	9.27	3.75	1.25	7.3	2.96	0.56	7.89	2.33	4.21	18.41	1.09	6.18	2.43	10.82	15	3.26
	2000-09	9.63	4.61	1.57	7.02	2.56	0.29	6.42	2.17	5.24	18.6	1	6.22	2.22	9.67	16.38	3.41
Capital stock	1980-90	9.2	5.06	1.3	5.78	3.29	0.21	5.83	4.38	4.73	18.88	0.78	7.9	1.99	10.26	14.31	3.24
	1990-99	19.34	4.34	2.57	5.92	2.08	0.11	6.17	3.12	4.3	7.88	1.77	5.21	1.92	15.31	11.77	5.08
	2000-09	11.08	6.09	2.68	5.98	2.16	0.11	5.45	7.47	3.01	11.06	0.77	4.85	1.25	10.8	19.11	5.48
Gross value added	1980-90	7.8	5.07	1.86	7.22	2.02	0.11	6.69	1.33	4.72	20.69	0.45	6.68	1.82	8.08	17.12	3.2
	1990-99	11.58	4.91	1.66	8.2	2.06	0.14	6.43	1.44	2.29	20.48	0.62	5.42	2.05	8.48	15.65	3.6
	2000-09	7.46	8.41	1.98	6.38	2.47	0.14	5.76	3.95	2.3	16.47	0.53	6.3	1.11	10.28	15.33	4.23

Source: ASI, CSO.

Table A.13.2b: Shares of states in food manufacturing (2000–01 and 2005–06)

		AP	AS	BH	CH	GJ	HY	HP	JH	KT	KE	MP	MH	OR	PB	RJ	TN	UP	UK	WB
Enterprise	2000-01	8.8	2.8	8.0	1.3	2.5	1.0	1.0	3.2	3.9	2.1	3.0	7.7	6.9	1.3	4.0	4.5	15.7	0.8	18.7
	2005-06	6.1	4.2	7.9	0.7	3.6	1.3	1.2	3.4	4.6	3.7	3.4	7.0	10.2	1.2	4.5	4.2	16.6	0.6	13.6
Workers	2000-01	10.4	2.3	6.4	1.0	2.0	0.9	0.6	2.6	5.6	2.6	6.9	3.3	7.1	1.3	3.0	5.2	15.5	0.7	19.8
	2005-06	10.1	3.2	6.1	0.6	2.9	1.3	0.6	2.4	8.2	4.2	5.6	2.9	9.0	1.0	3.0	5.3	15.9	0.7	14.1
Investment	2000-01	8.9	1.1	4.4	0.8	3.4	3.4	1.6	1.4	4.6	4.1	11.6	3.7	2.5	5.0	4.6	8.6	14.9	1.0	7.9
	2005-06	8.5	1.4	4.2	0.6	3.6	4.7	1.1	1.1	6.3	7.3	11.1	3.2	1.9	3.5	4.1	9.1	14.9	1.6	7.7
Gross value added	2000-01	10.4	2.0	5.4	0.7	3.1	1.8	0.9	1.9	5.9	3.6	8.8	3.2	3.4	2.8	3.6	7.7	12.6	0.8	16.1
	2005-06	9.1	2.9	4.4	0.4	4.1	3.2	0.5	1.8	11.4	4.2	8.1	3.6	3.3	2.4	4.3	7.6	14.6	0.7	10.4

Source: NSS.
Note: Investment or capital in unorganized refers to market value of fixed assets (own+hired).

Table A.13.3a: Location Quotient and concentration/diversification of investment in the organized food industry (decadal averages)

State	Location Quotient			Relative Diversity Index		
	1980-89	1990-99	2000-09	1980-89	1990-99	2000-09
Andhra Pradesh	1.13	1.20	1.63	1.36	0.63	0.20
Assam	5.19	5.56	1.85	0.04	0.03	0.15
Bihar	0.37	1.50	2.15	0.28	0.26	0.11
Gujarat	0.73	0.44	0.33	0.65	0.23	0.19
Haryana	0.70	0.93	0.98	0.57	1.73	5.90
Himachal Pradesh	0.12	0.83	0.39	0.20	0.77	0.21
Karnataka	1.64	1.24	0.90	0.27	0.53	1.26
Kerala	0.64	1.56	2.04	0.48	0.23	0.12
Madhya Pradesh	0.57	0.96	1.81	0.40	2.96	0.16
Maharashtra	1.14	1.03	0.96	1.27	4.77	3.46
Odisha	0.10	0.48	0.31	0.19	0.25	0.19
Punjab	1.53	2.31	2.12	0.33	0.10	0.11
Rajasthan	0.47	0.55	0.64	0.33	0.28	0.35
Tamil Nadu	0.85	1.14	0.73	1.14	0.95	0.48
Uttar Pradesh	1.62	1.52	4.13	0.28	0.25	0.04
West Bengal	0.49	0.79	0.95	0.34	0.61	2.30
Average	**–**	**–**	**–**	**0.51**	**0.86**	**0.95**

Source: Bathla and Gautam 2013.

Table A.13.3b: Location Quotient and concentration/diversification of investment in the unorganized food industry

State	Location Quotient						Relative Diversity Index					
	2000-01			2005-06			2000-01			2005-06		
	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total
Andhra Pradesh	1.34	1.55	1.64	1.12	1.57	1.4	0.09	0.14	0.08	0.27	0.14	0.14
Assam	1.62	1.38	2.06	1.46	1.16	1.81	0.05	0.21	0.05	0.07	0.52	0.07
Bihar	1.72	1.94	2.34	1.73	2.45	2.55	0.04	0.08	0.04	0.04	0.06	0.04
Chhattisgarh	1.05	1.35	1.28	0.4	0.42	0.44	0.68	0.23	0.19	0.05	0.14	0.1
Gujarat	0.83	0.49	0.5	0.73	0.59	0.51	0.19	0.16	0.11	0.12	0.2	0.11
Haryana	1.21	1.12	1.07	0.68	0.99	0.76	0.15	0.65	0.82	0.1	11.31	0.23
Himachal Pradesh	1.51	1.7	2.2	1.09	1.6	1.59	0.07	0.13	0.05	0.35	0.14	0.09
Jharkhand	0.74	2.23	1.28	0.93	1.61	1.38	0.12	0.06	0.19	0.47	0.13	0.14
Karnataka	0.94	1	0.97	0.87	1.36	1.1	0.53	18.25	1.91	0.24	0.23	0.55
Kerala	0.72	1.58	1.16	1.07	1.18	1.45	0.11	0.13	0.33	0.5	0.46	0.12
Maharashtra	0.94	0.86	0.77	1.04	0.72	0.67	0.55	0.55	0.23	0.77	0.29	0.17
Madhya Pradesh	1.07	1.7	1.38	0.83	1.68	1.22	0.47	0.11	0.14	0.19	0.12	0.24
Odisha	1.45	1.87	2.1	1.15	1.89	1.68	0.07	0.09	0.05	0.22	0.09	0.08
Punjab	0.67	1.22	0.9	0.95	0.93	0.84	0.1	0.36	0.54	0.69	1.15	0.33
Rajasthan	0.91	1.24	1.11	0.9	1	0.95	0.37	0.33	0.49	0.31	16.94	1
Tamil Nadu	0.51	1.02	0.74	0.57	1.1	0.81	0.07	3.2	0.21	0.07	0.85	0.29
Uttar Pradesh	1.13	1.31	1.37	1.43	1.11	1.36	0.25	0.25	0.14	0.07	0.74	0.15
Uttaranchal	1.33	1.53	1.7	1.14	3.34	2.08	0.1	0.15	0.08	0.23	0.03	0.05
West Bengal	0.97	1.21	1.19	1.04	1.01	1.18	0.97	0.37	0.28	0.88	10.47	0.3
Average							0.28	1.28	0.3	0.29	2.21	0.22

Source: Bathla and Gautam 2013.

Table A.13.4: Descriptive statistics on private investment in organized food manufacturing (average 1985–2009; values in 2004–05 price)

State	Investment/ Capital	Investment/ Value Added	Rate of Return: Profit/ Capital	Output/ Capital	Change in Output/ Capital	Capacity Utilization: Capital/VA	Cashflow/ Capital	Outstanding Loan/Capital
Andhra Pradesh	0.12	0.32	0.09	3.51	0.22	2.73	0.29	0.55
Assam	0.11	0.25	0.27	2.22	0.01	2.76	0.29	0.36
Bihar	0.10	0.32	0.07	2.45	0.05	3.19	0.24	0.69
Gujarat	0.12	0.34	0.05	4.36	0.39	2.91	0.39	0.64
Haryana	0.15	0.30	0.17	4.36	0.29	2.05	0.55	0.53
Himachal Pradesh	0.17	0.62	0.06	3.55	0.13	3.29	0.23	0.45
Karnataka	0.14	0.36	0.10	2.49	0.18	2.59	0.27	0.62
Kerala	0.14	0.19	0.33	5.62	0.32	1.44	0.44	0.58
Madhya Pradesh	0.12	0.22	0.14	4.68	0.48	2.83	0.42	0.73
Maharashtra	0.12	0.33	0.06	2.79	0.16	2.74	0.26	0.64
Odisha	0.15	0.54	0.03	3.39	0.25	3.66	0.27	0.67
Punjab	0.13	0.25	0.26	3.76	0.20	1.87	0.30	0.45
Rajasthan	0.12	0.33	0.14	4.36	0.31	2.78	0.33	0.59
Tamil Nadu	0.13	0.30	0.15	2.93	0.18	2.45	0.28	0.45
Uttar Pradesh	0.14	0.42	0.05	2.43	0.17	3.20	0.18	0.55
West Bengal	0.13	0.40	0.06	3.63	0.09	3.13	0.31	0.47

Source: Bathla and Gautam 2013.

Table A.13.5: Determinants of Investment in Food Processing

	Gross Fixed Investment/Capital Stock (-1)	
Lagged Dependent Variable	-0.289	-0.262
((Gross fixed investment/capital stock (-1)(-1))	(5.96)***	(5.45)***
Changes in Demand & Adjustment of Capital	0.015	0.017
(Change in output/capital stock (-1))	(4.56)***	(4.98)***
Accelerator or Expected Profit	0.026	0.043
(Output (-1)/capital stock)	(2.88)***	(4.14)***
Availability of Credit	-0.100	-0.019
(Loan outstanding/capital stock) (-1)	(1.75)*	(0.37)
Infrastructure	0.534	0.172
(Capital expend. on roads & bridges per capita, lagged)	(2.57)**	(0.89)
Agriculture Linkage	0.005	
(Agriculture SDP/SDP) (-1)	(2.85)***	–
Land Productivity		0.266
(Agriculture SDP/NSA)	–	(2.17)**
Localization Index	0.044	0.026
(Location quotient of factories)	(0.78)	(0.46)
Investor Friendliness	-0.101	-0.011
(No. strikes or lockouts per factory)	(0.40)	(0.04)
Constant	-0.066	-0.054
	(0.48)	(0.39)
State effects	Yes	Yes
R^2	0.23	0.22
N	374	374

Source: Bathla and Gautam 2013.

Note: Estimated coefficients are elasticities. t-statistics in parentheses. Level of significance: ***: 1%; **: 5%; *: 10%.

Table A.13.6: Annual rate of growth in partial productivity in organized and unorganized manufacturing (2004–05 prices)

State	Organized Sector									Unorganized Sector		
	Labor Productivity			Capital Intensity			Capital Productivity			Labor Prod.	Capital Int.	Capital Prod.
	1980-89	1990-99	2000-08	1980-89	1990-99	2000-08	1980-89	1990-99	2000-08	2000-05	2000-05	2000-05
AP	11.41	4.54	4.39	9.01	10.04	4.71	2.21	-4.99	-0.30	3.64	3.56	0.08
Assam	11.57	-0.57	4.09	16.54	6.36	2.39	-4.27	-6.51	1.66	6.92	2.60	4.21
Bihar	18.65	12.03	1.37	32.09	14.19	2.78	-10.18	-1.89	-1.37	2.40	3.55	-1.11
Gujarat	9.14	3.45	3.62	12.90	8.57	1.95	-3.34	-4.72	1.64	3.80	-2.56	6.52
Haryana	11.04	7.63	9.06	10.28	13.06	10.33	0.68	-4.80	-1.15	11.65	3.60	7.77
HP	5.37	9.11	-1.00	5.37	12.23	0.33	-0.003	-2.78	-1.33	-6.86	-3.19	-3.79
Karnataka	14.24	6.84	8.58	17.91	9.67	4.69	-3.11	-2.58	3.71	11.47	2.52	8.73
Kerala	13.97	4.52	-0.77	17.85	11.31	2.85	-3.29	-6.09	-3.52	-1.02	5.45	-6.14
MP	17.38	5.54	9.93	28.60	16.75	1.41	-8.73	-9.61	8.40	11.60	3.43	7.90
Maharashtra	14.80	6.74	3.25	16.69	6.64	4.55	-1.61	0.09	-1.24	8.29	7.18	1.03
Odisha	3.46	2.77	8.29	12.70	12.48	8.03	-8.20	-8.63	0.24	0.47	-5.90	6.77
Punjab	4.43	3.95	9.93	11.46	6.37	5.71	-6.31	-2.27	3.99	7.51	1.30	6.13
Rajasthan	8.37	7.18	9.41	9.91	9.82	0.12	-1.40	-2.40	9.28	9.59	1.68	7.79
Tamil Nadu	11.62	2.28	5.28	14.84	7.45	3.42	-2.81	-4.82	1.80	4.98	4.52	0.45
UP	12.72	8.35	4.63	18.81	12.19	9.15	-5.13	-3.42	-4.14	8.33	3.32	4.85
WB	10.27	1.20	9.44	13.15	9.56	3.46	-2.54	-7.63	5.77	3.59	10.69	-6.42
India	12.15	5.19	5.87	16.76	8.71	4.87	-3.95	-3.23	0.96	5.75	3.87	1.81

Source: Bathla and Gautam 2013.

Note: Capital for unorganized sector refers to fair market value of fixed assest (own+hired).

Table A.13.7: Total factor productivity growth in food manufacturing (2004–05 prices)

State	Organized sector						Unorganized Sector		
	TFP Index (Decadal Average)			TFP Growth (Percent Per Year)			Annual Growth (2000-01 – 2005-06)		
	1980-89	1990-99	2000-09	1980-89	1990-99	2000-09	Rural	Urban	Total
AP	88	96	94	2.6	-0.7	0.4	0.8	-6.7	-1.8
Assam	-138	-4.44	94	–	–	-8.8	1.0	3.5	1.4
Bihar	114	118	115	4.0	1.9	-0.2	-1.7	0.3	-1.3
Gujarat	97	94	99	1.1	-1.1	1.6	4.4	2.1	2.8
Haryana	125	115	109	3.3	-1.3	1.4	4.9	1.4	2.4
HP	101	87	128	–	6.3	-2.8	-0.8	-3.7	-1.1
Karnataka	102	98	103	1.7	0.3	2.7	6.2	-3.8	2.4
Kerala	328	239	132	2.0	-2.2	-3.7	-4.7	2.7	-2.9
MP	135	121	131	-0.2	-4.8	4.6	5.4	-0.6	2.8
Maharashtra	116	122	110	3.4	1.3	0.1	-0.1	1.4	0.6
Odisha	250	211	159	-3.0	-7.0	2.8	5.2	2.0	4.1
Punjab	167	142	143	-2.8	-1.1	4.2	-0.4	3.7	2.5
Rajasthan	66	92	105	2.4	-0.1	5.5	4.1	1.5	3.1
Tamil Nadu	154	128	109	0.8	-2.2	2.3	-2.4	0.5	-0.5
UP	104	100	89	2.0	0.4	-1.5	2.8	-1.1	1.5
WB	128	119	91	3.2	-2.7	6.4	-6.3	-0.9	-4.5
India	126	116	106	1.3	-0.5	1.8	0.3	-0.5	0.1

Source: Bathla and Gautam 2013.

Table A.13.8: Decadal averages of technical efficiency using time varying decay inefficiency model

Period	AP	Assam	Bihar	Gujarat	Haryana	HP
1985-86 to 1989-90	0.77	0.79	0.87	0.85	0.97	0.96
1990-91 to 1999-00	0.70	0.72	0.82	0.80	0.96	0.95
2000-01 to 2008-09	0.59	0.62	0.75	0.72	0.94	0.93
1985-86 to 2008-09	0.67	0.70	0.80	0.78	0.96	0.94
	Karnataka	**Kerala**	**MP**	**Maharashtra**	**Odisha**	**PB**
1985-86 to 1989-90	0.93	0.81	0.97	0.90	0.72	0.98
1990-91 to 1999-00	0.90	0.75	0.96	0.87	0.64	0.98
2000-01 to 2008-09	0.86	0.66	0.94	0.81	0.51	0.96
1985-86 to 2008-09	0.89	0.73	0.95	0.85	0.61	0.97
	Rajasthan	**TN**	**UP**	**WB**		
1985-86 to 1989-90	0.98	0.84	0.78	0.75		
1990-91 to 1999-00	0.97	0.78	0.71	0.67		
2000-01 to 2008-09	0.95	0.69	0.60	0.55		
1985-86 to 2008-09	0.96	0.76	0.68	0.64		

Source: Bathla and Gautam 2013.

Table A.13.9: Determinants of TFP in organized food-processing

	TFP Index	
Road density	0.030	0.155
(Km/'000 km^2)	(0.87)	(1.68)*
Agriculture electricity consumption	-0.168	0.033
(% of consumption in total consumption)	(5.49)***	(0.62)
Total electricity consumption	-0.025	-0.008
(Million kilowatts per capita)	(0.64)	(0.10)
Agricultural linkage	0.335	0.290
(Agricultural SDP/total SDP)	(3.05)***	(2.07)**
Urbanization	0.582	0.022
(% urban population)	(5.50)***	(0.07)
Localization index	-0.060	0.132
(Location Quotient based on factories)	(1.08)	(1.05)
Investor friendliness	-0.047	-0.017
(No. of strikes/lockouts per factory)	(6.31)***	(2.54)**
Trend	-0.018	-0.001
	(2.21)**	(0.12)
Year effects	Yes	Yes
State effects	No	Yes
Constant	37.56	4.24
	(2.27)**	(0.23)
Adj. R^2	0.188	0.525
N	381	381

Source: Batha and Gautam 2013.

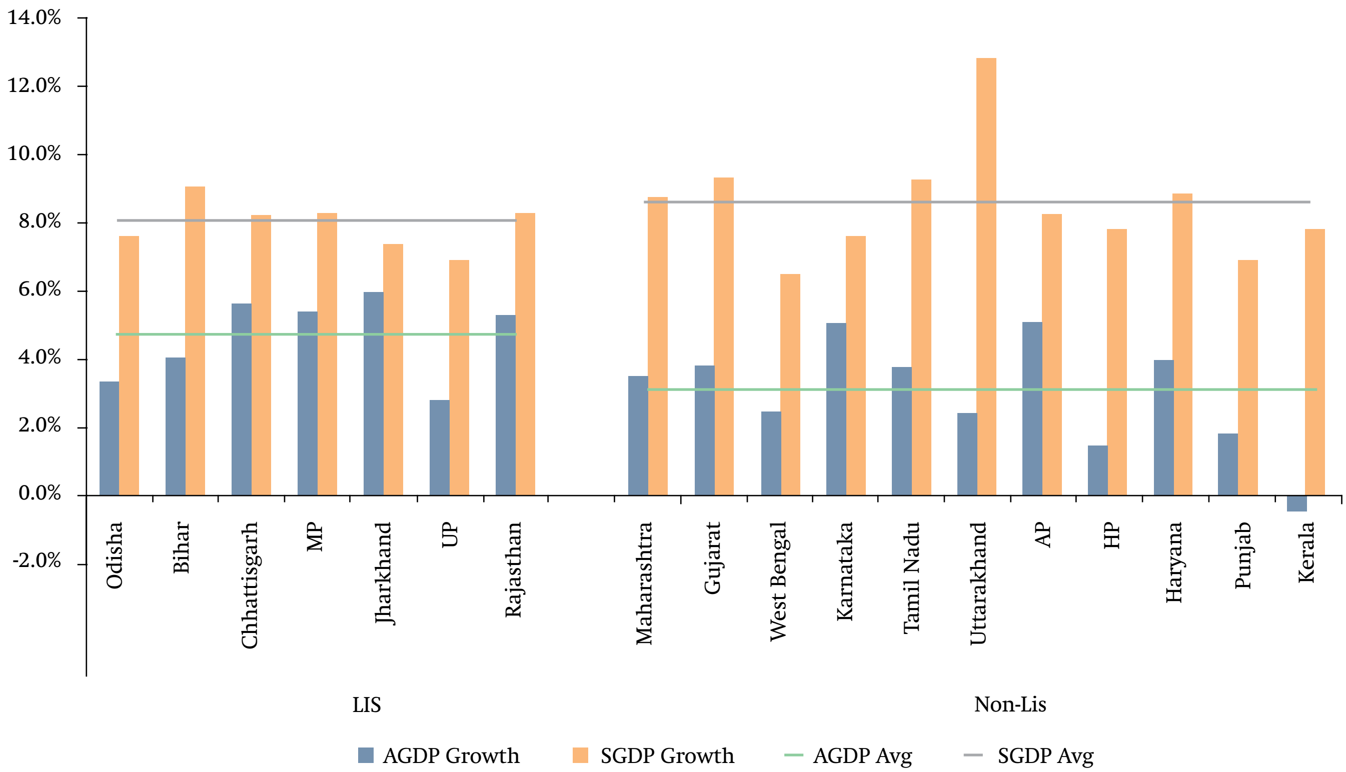
Note: Estimated coefficients are elasticities. t-statistics in parentheses.

Level of significance: ***: 1% ; **: 5%; *: 10%.

ANNEXES

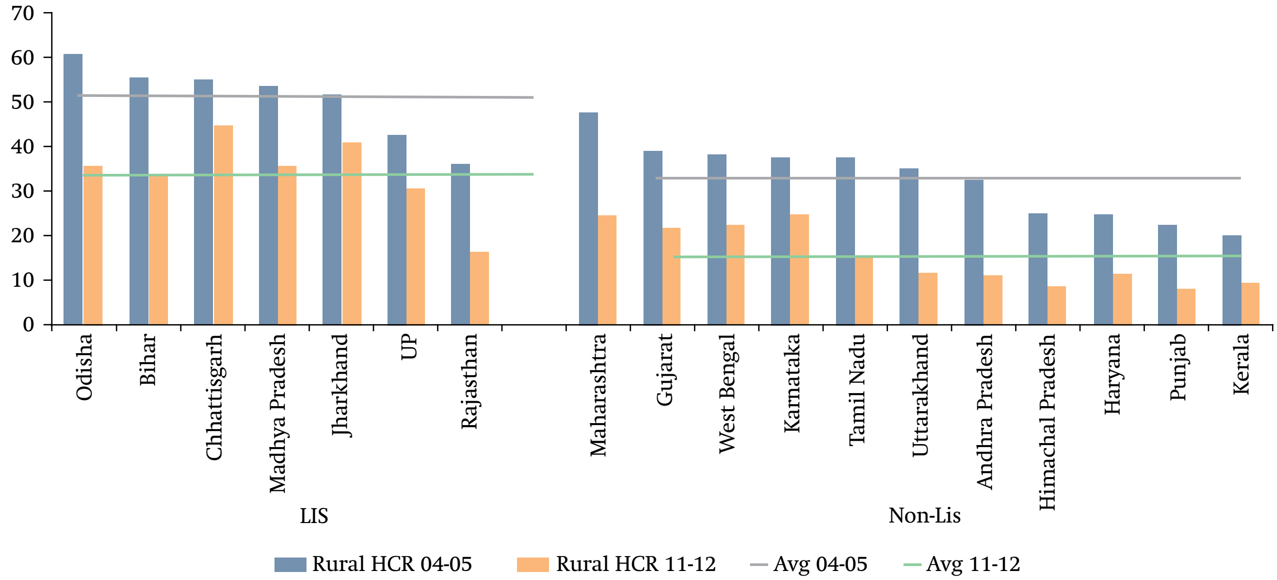
ANNEX 14: BIHAR AND ODISHA: AGRICULTURE PERFORMANCE AND CONSTRAINTS

Figure A.14.1: Average annual growth rates in AGDP and SGDP for selected states (2004–12)



Source: Authors, using CSO data.

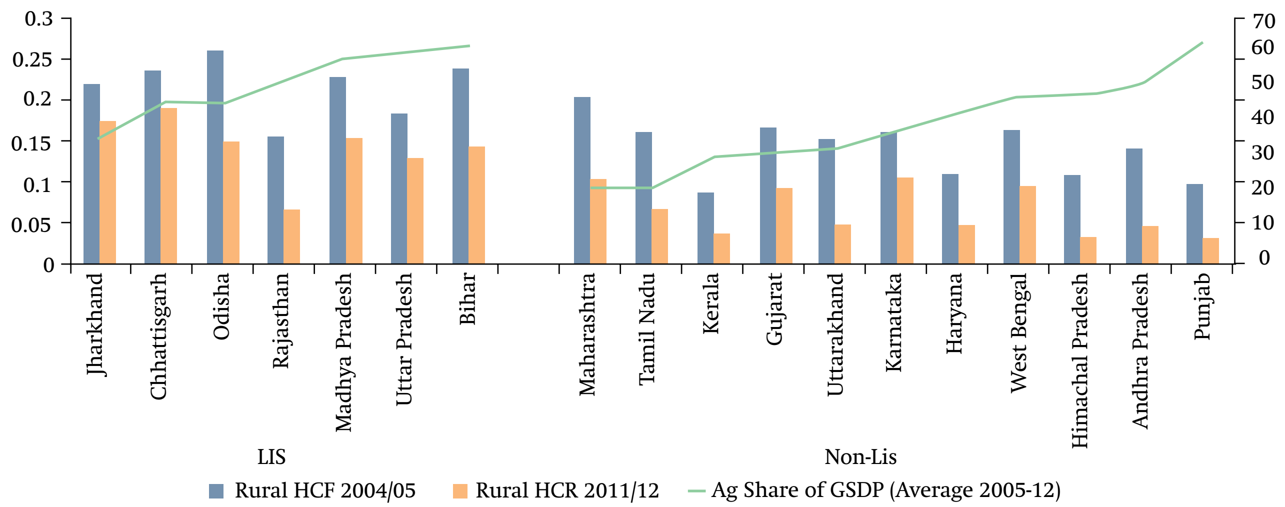
Figure A.14.2: Poverty rates in LIS compared to selected non-LIS (2004–05, 2011–12)



Source: Calculated using estimates from Planning Commission as follows: 1993–94 and 2004–05 Estimates: Press Note on Poverty Estimates, Planning Commission, Govt. of India, Jan 2011; 2009–10 Estimates: Press Note on Poverty Estimates, 2009-10, Planning Commission, Govt. of India March 2012; 2011–12 Estimates: Press Note on Poverty Estimates, 2011–12, Planning Commission, GOI, July 2013.

Note: The estimates for Chhattisgarh, Madhya Pradesh, Bihar, Jharkhand, Uttar Pradesh, and Uttaranchal are for states as they exist after bifurcation in 2001. The estimates for 1993–94 have been calculated from the unit data using district and state boundaries of the divided states in 1993–94. Poverty estimates are based on the new official poverty line, using the Tendulkar methodology. Population as on 1st March 2010 has been used for estimating number of persons below poverty line (interpolated between 2001 and 2011 population census).

Figure A.14.3: Rural poverty rates and share of agriculture in state GDP (2004–05, 2011–12)



Source: Authors, using data from Planning Commission website and CSO.

Table A.14.1: Sector shares in Bihar, Odisha, and India overall between 2004 and 2012 (%)

	2004–05	2005–06	2006–07	2007–08	2008–09	2009–10	2010–11	2011–12
Bihar								
Agric.	32	30	31	28	27	24	23	22
Industry	14	15	15	17	18	19	19	20
Services	55	55	53	55	55	58	58	58
Odisha								
Agric.	23	23	21	20	19	19	18	16
Industry	34	33	36	38	37	35	35	36
Services	42	44	44	43	45	46	47	48
India								
Agric.	19	18	17	17	16	15	14	14
Industry	18	18	19	19	18	18	18	18
Services	63	64	64	65	66	67	67	68

Source: Estimates from MOSPI 2013.

Note: Agriculture and allied sector includes agriculture, forestry, and fishing.

Table A.14.2: Distribution of land holdings in Bihar (2005–06) and Odisha (2006–07)

Holding size (ha)	Number of holdings (million)	Share of total holdings (%)
Bihar		
<0.5	10.6	72.3
0.5–1.0	2.5	17.3
1.0–2.0	1	6.7
2.0–5.0	0.5	3.4
> 5.0	0.04	0.3
Odisha		
<1.0	2.6	59.6
1.0–2.0	1.16	26.5
2.0–4.0	0.47	10.8
4.0–10.0	0.12	2.7
> 10.0	0.01	0.3

Source: MOA 2005.

Table A.14.3: Value of output of major commodities in total value of output of agriculture, Bihar and Odisha (%)

	Bihar			Odisha		
	1990–91	2001–02	2008–09	1990–91	2001–02	2008–09
Rice	20	13	11	29.7	29.3	24.5
Wheat	14	11	8			
Maize	3	3	2	0.7	0.1	0.3
Pulses	7	3	2	11.9	2.4	2.9
Fruits and Vegetables	14	28	23	22.1	31.2	29.4
Livestock	30	25	40	9.2	11.8	18.2
Fisheries		3	4		5.8	6.6

Source: MOSPI 2013.

TableA.14.4: Biotic problems by physiographic zone in Odisha

Crops	Zone I (Central table land)		Zone II (Eastern ghat)		Zone III (Coastal plains)		Zone IV (Northern plateau)		Extent of damage caused (per cent)
	Diseases	Pest	Diseases	Pest	Diseases	Pest	Diseases	Pest	
Paddy	Blast	Stem-borer, swarming caterpillar	Blast, (fungal diseases) (once in a season)	BPH, Stem-borer (once in a season)	Blast (every year, *rampant during September & October*), bacterial blight	Sucking pests; green leafhopper (every year, *rampant during September & October)*	Blast	Stem-borer	**Zone I:** Blast (20%), stem borer (20%), swarming caterpillar (25%); **Zone II:** Blast (25%), BPH (25%), Stem-borer (25%); **(Zone III:** Sucking pests (50%), green leafhopper (50%), Blast (50%);
Maize	Turcicum leaf blight	Stem-borer, swarming caterpillar	Turcicum leaf blight	Stem-borer, aphid, defoliating caterpillars, termite	Turcicum leaf blight	Stem-borer, aphid, defoliating caterpillars, termite,	Turcicum leaf blight	Stem-borer, aphid, defoliating caterpillars, termite,	Turcicum leaf blight (up to 70%)
Wheat	Loose smut, leaf blight, alternaria leaf blight, wilt	Termite, pink borer, aphid	Loose smut, leaf blight, alternaria leaf blight, wilt	Termite, pink borer, aphid	Loose smut, leaf blight, alternaria leaf blight, wilt	Termite, pink borer, aphid	Loose smut, leaf blight, alternaria leaf blight, wilt	Termite, pink borer, aphid	
Pulses	Powdery mildew, seed rot & seedling damage, wilt, collar rot, yellow mosaic virus, leaf spot	Leaf eating caterpillars and pod borers, aphids, white fly	mildew, seed rot & seedling damage, wilt, collar rot, yellow mosaic virus, leaf spot	Leaf eating caterpillars and pod borers, aphids, white fly	mildew, seed rot & seedling damage, wilt, collar rot, yellow mosaic virus, leaf spot	Leaf eating caterpillars and pod borers, aphids, white fly	mildew, seed rot & seedling damage, wilt, collar rot, yellow mosaic virus, leaf spot	Leaf eating caterpillars and pod borers, aphids, white fly	
Vegetables	Blight; damping-off of seedlings in brinjal, tomato and chilli; leaf spot, bacterial and fungal wilt; mildew	Stem-borer, aphids and jassids	Blight; damping-off of seedlings in brinjal, tomato and chilli; leaf spot, bacterial and fungal wilt; mildew	Stem-borer, aphids and jassids	Blight; damping-off of seedlings in brinjal, tomato and chilli; leaf spot, bacterial and fungal wilt; mildew	Stem-borer, aphids and jassids	Blight; damping-off of seedlings in brinjal, tomato and chilli; leaf spot, bacterial and fungal wilt; mildew	Stem-borer, aphids and jassids	

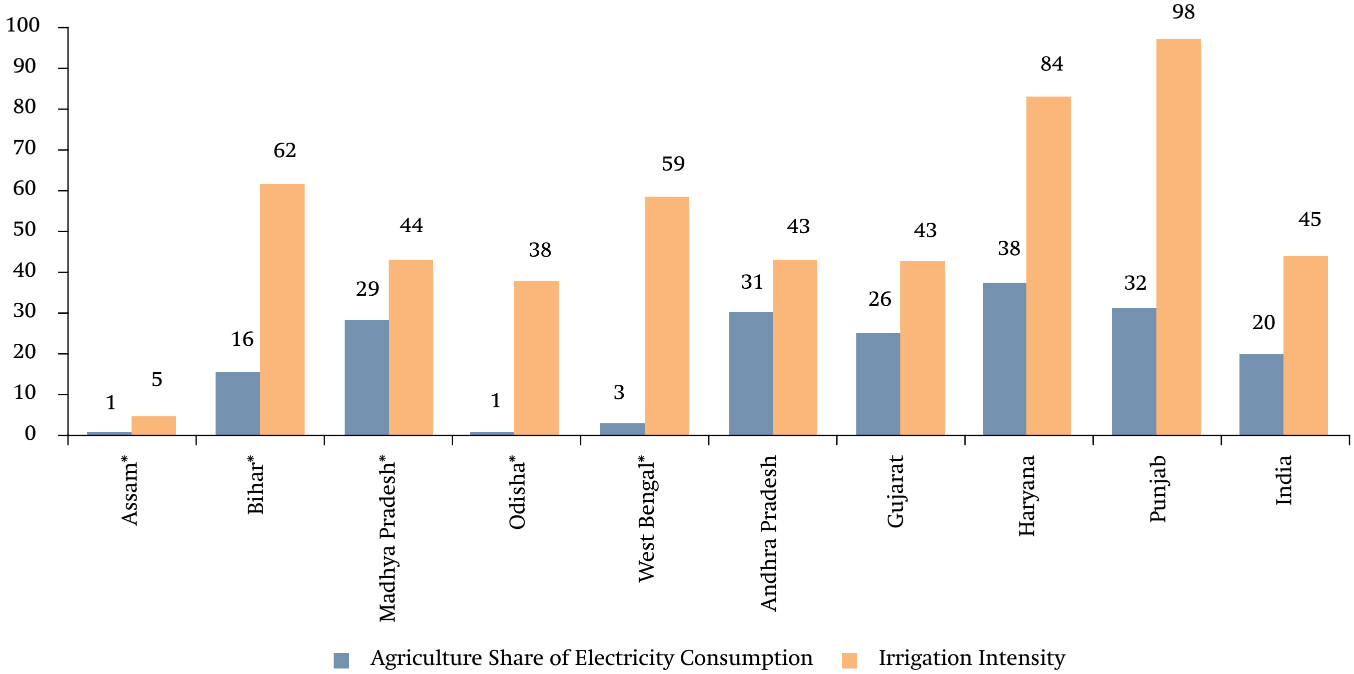
Source: IFPRI 2012b.

Table A.14.5: Abiotic and institutional problems by physiographic zone in Odisha

Sl. No.	Type of problem	Zone I (Central table land)	Zone II (Eastern ghat)	Zone III (Coastal plains)	Zone IV) (Northern plateau)
1.	Flood	Every year	No	Every year (also cyclone-prone and hail-prone)	No
2.	Drought	Slightly drought prone	Once in 2 to 3 years	No	Drought prone (low rainfall)
3.	Salinity/alkalinity	Slight alkalinity in some parts	No	Yes	Salinity and alkalinity
4.	Acidity	Exists in some parts	Exists in some parts	Moderately acidic	Highly acidic
5	Water-logging	Every year	Every year	8 to 10 days in 5 to 6 years	No
6.	Credit	Poor access to institutional loan	Poor access to institutional loan	Short-term loan (for 6 months) is available through primary cooperative society (interest rate 9% p.a.), but it is grossly insufficient for farmers who take *easily-accessible* loan from local money-lender (interest rate 36% p.a.)	Poor access to institutional loan
7.	Marketing	Farmers sell the produce to traders due to lack of effective procurement by government agency.	Farmers sell the produce to traders due to lack of effective procurement by government agency; farmers bear the transport-charges and receive a price of Rs 1,000 per quintal against MSP of Rs 1,080 per quintal	Farmers sell the produce to local traders due to lack of effective procurement by government agency; farmers bear the transport-charges and receive a price of Rs 750 to 850 per quintal against MSP of Rs 1080 per quintal	Farmers sell the produce to traders due to lack of effective procurement by government agency.

Source: IFPRI (2012b).

Figure A.14.4: Agriculture share of electricity consumption and irrigation intensity in selected states (%)



Source: Planning Commission website.

Note: * indicates status as lagging state; irrigation intensity is irrigated area as share of net sown area in 2007.

Table A.14.6: Spending and growth in spending on agricultural research and extension

	Spending (Rs millions)	Average annual growth in spending (%)			
	2007	1971–1980	1981–1990	1991–2000	2001-08
Agricultural research					
Bihar	289.76	27	9	0	11
Odisha	169.11	16	7	–1	15
India	6,244.22	9	8	7	2
Agricultural extension					
Bihar	97.27	–7	8	–6	0
Odisha	11.34	–3	18	7	2
India	1,654.81	–3	11	3	7

Source: IFPRI 2012a and 2012b.

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