Republic of India

Accelerating Agricultural Productivity Growth

OVERVIEW

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Agriculture

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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.

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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

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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

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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,

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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.

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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

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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.

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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.

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The World Bank
1818 H Street, N.W.
Washington, DC 20433 USA