



# 2014 GAP Report<sup>®</sup>

GLOBAL AGRICULTURAL PRODUCTIVITY REPORT<sup>®</sup>



**GLOBAL REVOLUTIONS IN AGRICULTURE:  
THE CHALLENGE AND PROMISE OF 2050**





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The Global Harvest Initiative (GHI) was formed in 2009 by companies that advocate collaborative solutions to meet the rising demand for food and agricultural products through sustainable practices as world population climbs to 9.6 billion by 2050. We serve as a private-sector policy voice for productivity growth throughout the agricultural value chain, advancing technologies and approaches that conserve natural resources, adapt to climate change and improve people's livelihoods, nutrition and living conditions. Our current members are Accenture, DuPont, Elanco, John Deere and Monsanto.

We are joined by consultative partners who share their knowledge and experience in agriculture, conservation, nutrition and the needs of small-scale farmers. Our consultative partners include ACDI/VOCA, Congressional Hunger Center (CHC), Conservation International, Global Alliance for Improved Nutrition (GAIN), Inter-American Development Bank (IDB), Inter-American Institute for Cooperation in Agriculture (IICA), Purdue University School of Agriculture, The Nature Conservancy, New Markets Lab/TransFarm Africa, Robert S. Daugherty Water for Food Institute and World Wildlife Fund.

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# GLOBAL REVOLUTIONS IN AGRICULTURE: THE CHALLENGE AND PROMISE OF 2050



**When the Global Harvest Initiative (GHI)** was founded in 2009, the world confronted a food price crisis that left nearly one billion people hungry and malnourished. The crisis energized collaborative action among governments, farmers and small-scale producers, non-governmental organizations, multilateral institutions and the private sector to jumpstart a comprehensive response. The result has been the emergence of more innovative public-private partnerships, rising levels of investment in agriculture and rural

development, and a focus on more inclusive agricultural supply chains that deliver value to farmers and consumers alike.

The food price crisis has given way to an even more daunting task: sustainably producing sufficient, nutritious and affordable food, along with the required feed, fiber and fuel for an estimated global population of 9.6 billion people by 2050. Since 2009, GHI has provided an in-depth look at progress toward meeting this goal through our Global Agricultural Productivity Report® (GAP Report®).

The 2014 GAP Report® uncovers both challenging and promising trends. Our findings indicate that **productivity in agriculture is not accelerating fast enough** to meet the expected agricultural demand by 2050 through sustainable practices. This serves as a call to action to invest in proven strategies that boost productivity and conserve the natural resource base.

The report also highlights the rise of **promising new global revolutions in agriculture** and provides a spotlight on the special case of **India**. Some 50 years after the Green Revolution began, India has made tremendous progress, becoming self-sufficient in food grains and initiating the “White Revolution” in dairy production. New revolutions in horticulture, aquaculture, poultry and dairy production, data and innovation, extension, and especially in gender and women’s rights, are beginning to bear fruit. The 2014 GAP Report® traces the

path of India’s agricultural successes, highlights new agricultural challenges the nation faces and discusses the policies and investments needed to continue and expand the story of success.

These revolutions are not unique to India — they hold promise for the entire world and will help farmers and producers to **conserve** the environment and natural resource base, **adapt** to climate change, price fluctuations and changing consumer preferences, and **improve** people’s lives and livelihoods. Together, we must continue to enhance the productivity of food and agriculture systems through the right policies and investments to sustainably meet the 2050 challenge.

A handwritten signature in black ink that reads "Margaret M. Zeigler". The script is cursive and fluid.

Margaret M. Zeigler  
*Executive Director*  
Global Harvest Initiative



Photo courtesy of Agribusiness Systems International (ASI), an affiliate of ACDI/VOCA





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# THE GLOBAL AGRICULTURAL IMPERATIVE

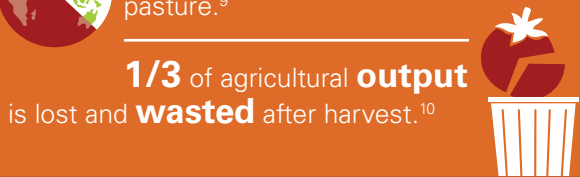
Global agricultural output will have to double in order to meet the expected demand for food, feed, fiber and fuel of 2050.<sup>1</sup>



**Doubling agricultural output to meet growing demand and alleviate hunger will increase pressure on already-stressed resources, requiring greater efficiency in agriculture and food systems.**

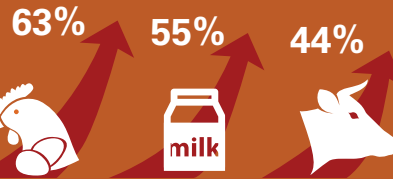
**70%** of extracted **water** worldwide is used for agriculture, and the amount will increase to an estimated **89%** by **2050** — the amount will be even greater in the absence of any technological progress or policy interventions to stem the flow.<sup>8</sup>

**37%** of **land** is used for crops and pasture.<sup>9</sup>  
**1/3** of agricultural **output** is lost and **wasted** after harvest.<sup>10</sup>



## Economic growth is fueling a *Protein Revolution* in global agriculture.

Increased **demand** for livestock, poultry and fish is the largest driver in the world food economy and is expected to **double** by **2050**, with 70% of the increase coming from developing countries.<sup>5</sup> Grains and oilseeds are a major part of animal diets and, accordingly, demand for them will also grow substantially.



From **2013** to **2030** — poultry and egg **demand** will **increase** by **63%**, milk by **55%**, and ruminant meat by **44%**, all of them outpacing population growth.<sup>6</sup>

**9%** From 2013 to 2023, world per capita fish consumption will **increase** by **9%** (1.7 kilograms per person) reaching **20.9 kg** per person in 2023.<sup>7</sup>



**7.18 billion**

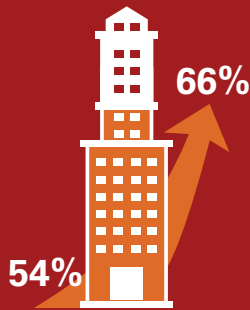
**9.6 billion**

**2014**

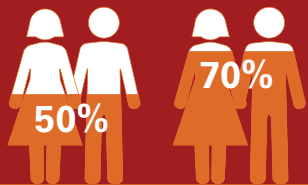
**2050**

By **2050**, the world's **population** will **increase** by one-third (33.7%) — from **7.18 billion** to **9.6 billion** people.<sup>2</sup>

**Urbanization** is accelerating. The share of the world's people living in urban areas will **increase** from **54%** to **66%** by **2050**.<sup>3</sup> More people — living in cities, making more money and shopping in supermarkets — will be able to afford increasingly diverse diets and will demand more expensive foods.



Economies are growing and incomes are increasing. By mid-century the world's **middle class** will **grow** from **50%** to **70%** of the population, with most change taking place in developing countries.<sup>4</sup>





## THE NUTRITION IMPERATIVE

An estimated 165 million children have stunted growth due to poor nutrition, which creates lifelong impediments to physical and cognitive development. Hunger reduces a nation's economic advancement because of productivity losses, poorer cognitive skills and lower school attendance and completion.<sup>11</sup>

Excessive weight is also a global health challenge, contributing to diabetes, heart disease and other non-communicable diseases. The proportion of overweight people in high-income countries is more than double that in low and middle-income countries, but 76 percent of overweight children live in low- and middle-income countries.<sup>12</sup>

Targeted nutrition interventions for women in their reproductive years and for children up to two years of age, improvements in water quality and sanitation, and addressing micronutrient deficiencies and imbalanced diets in the general population are pathways to healthful, productive lives. Micronutrient biofortification of staple crops and enrichment of processed food products are technologies that can improve the amount of vitamins and minerals in the diet. Smooth functioning food value chains allow a variety of nutritious food choices to reach markets and the people who need them. Harmonizing local, regional and international trade is therefore an important part of a food security and nutrition strategy.

**Agriculture will need to adapt to climate change and manage the risk it brings to farming.**<sup>13</sup>



Climate scientists expect that changing rainfall patterns will

make **some areas drier and other areas wetter**, as well as generate more frequent natural disasters.<sup>14</sup>

If current agricultural practices do not become **more efficient and responsive**, food production growth could **slow by 2 percent each decade** for the rest of the century.<sup>15</sup>



**Agricultural innovations, sustainable technologies and improved management practices reduce global greenhouse gases and conserve resources, while increasing output to meet growing needs.**

Delivering **more agricultural product per unit of land** and employing more efficient irrigation will meet growing demand while **reducing the environmental footprint**. Plants



sequester carbon and in agriculture, the most cost-effective mitigation options are cropland management, grazing land management and restoration of soils.<sup>16</sup>

Productive **livestock systems with efficient feed-to-use ratios** will meet increased demand while reducing greenhouse gas emissions.<sup>17</sup>

**Through the use of science-based and information technologies, improved practices and forward-looking policies, we can meet the growing demand for food, feed, fiber and fuel while —**



### **CONSERVING**

land, water, energy and other limited resources,



### **ADAPTING**

to changing dietary patterns and climatic conditions, and



### **IMPROVING**

the livelihoods and living conditions of urban and rural communities and smallholder farmers.



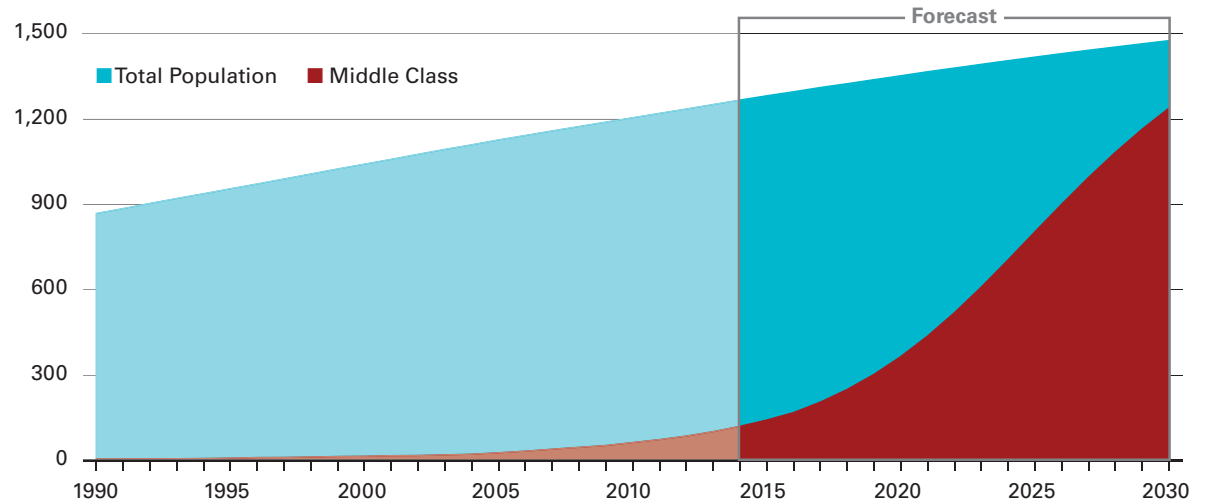


# INDIA AT A CROSSROADS

India, the world's largest democracy and second most populous nation, has long recognized the imperative of increasing agricultural productivity. In the two decades following independence in 1947, India struggled with multiple crop failures and famine. Ambitious government initiatives — such as the **Green Revolution** in wheat and rice (1960s and 1970s) and the **White Revolution** in dairy (1970s) — transferred new technologies and practices to millions of farmers and successfully increased agricultural yields and protected crops against pests and diseases. By 1980, the country was self-sufficient in food grains and now it is a net agricultural exporter with \$41 billion in worldwide sales in market year 2012–2013.<sup>18</sup>

Today, India faces new agricultural challenges: a rising middle class demands a more diverse diet, malnutrition continues to plague millions, staple grain productivity has stagnated and water resources are diminishing. As one of the world's largest emerging economies with an enormous pool of agricultural specialists and entrepreneurs and a stellar research and university system, India is well positioned to turn these challenges into opportunities for agriculture-driven economic growth.

**Figure 1: Total Population and Middle Class\* Growth, India, 1990–2030 (in Millions)**



\*Middle class is defined as those households with daily expenditures between \$10 and \$100 per person in purchasing power parity terms.  
Source: Homi Kharas, Brookings Institution, 2014

## GREATER PROSPERITY FOR MANY, BUT FOOD SECURITY REMAINS A CHALLENGE

**Thanks largely to macro-economic reforms and liberalization in the industrial sector, India has transitioned from a low-income country to the world's third largest economy in terms of purchasing power parity.** Between 2005 and 2012, 137 million people were lifted out of poverty.<sup>19</sup> Over the past 16 years, India's middle class increased from just one million to 108 million people. In the next 16 years, incomes are expected to grow at an astonishing pace, bringing one billion more people into the middle class — increasing from 8 percent to 84 percent of the population (Figure 1).<sup>20</sup>

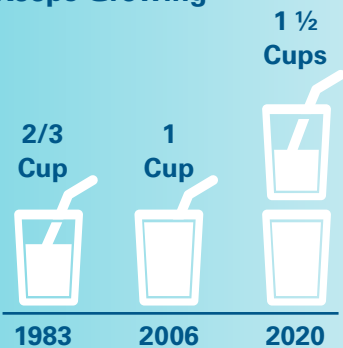
Responding to the evolving food needs and preferences of its expanding middle class, while assuring food security for all its citizens, will be key to sustaining India's economic expansion. It will require policies that incentivize private sector investment and growth, and unleash innovation in agricultural productivity and marketing, water and land conservation, and adaptation to climate change. Behind the challenges, opportunity is waiting.



## A GROWING MIDDLE CLASS CREATES NEW AGRICULTURAL MARKET OPPORTUNITIES

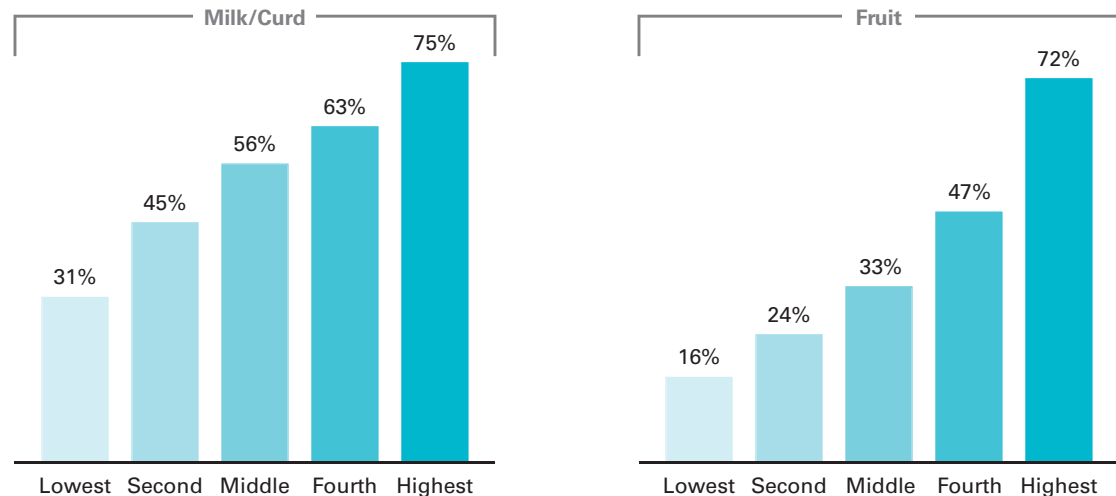
The growing purchasing power of the middle class is reflected in increased demand for meat (mainly poultry), dairy, eggs, fish, fruits and vegetables. Grocery stores, fast-food eateries and convenience foods are also becoming more popular with increasing demand for processed, packaged and prepared food items. The increasing demand for milk, as shown below, illustrates the tremendous growth potential of high-value foods.

### Per Capita Daily Consumption of Milk Keeps Growing



With 1.267 billion people drinking, on average, a little more than one cup a day, India is now the largest producer of milk in the world. Nearly every drop is consumed within the country. There is great opportunity to increase supplies, thereby spur economic growth for 70 million dairy producers, 80 percent of whom own only 1–3 cows, and improving diets throughout the country.<sup>21</sup>

**Figure 2: Weekly Consumption of Milk/Curd and Fruit for Women 15–49 Years by Household Income Quintile**



Source: National Family Health Survey-3, Government of India, August 2009

Dietary surveys conducted by the Government of India show that women's consumption of milk and fruit increases steadily with the level of household wealth (Figure 2).<sup>22</sup> Making milk, fruits and vegetables available to more people at affordable prices requires increased production as well as supply chains that can maintain freshness and quality.

To meet these new demands, farmers must have access to the resources and training that will enable them to produce commodities that meet market specifications. They must also be linked into organized retail systems, which aggregate, process and deliver high-quality food products to consumers. Getting more fruits and vegetables

into cold chain supply systems is particularly important for reducing post-harvest losses, delivering nutrient-rich foods to Indian consumers and expanding export markets.

**Consumer demand for a greater variety of high-quality foods creates new business opportunities for Indian farmers, processors, and retailers, as well as the many industries that provide inputs and services to the agricultural value chain. Increasing the amount of food available through more marketing channels would generate new jobs and economic growth.**

# INDIA'S AGRICULTURE SECTOR: PRODUCTIVITY CHALLENGES



At **169.6 million hectares**, India's cultivated land mass is the largest in the world.<sup>23</sup>



The Government of India's top research institute reports that nearly **60% of agricultural land is at risk** because of fertilizer misuse, poor cropping practices and soil nutrient deficiencies.<sup>24</sup>



India uses **13% of the world's extracted water**, and **87% is used for irrigation**.

Expanding irrigation has been a key strategy for increasing productivity; the proportion of arable land under irrigation increased from 20% to 35% from 1981 to 2013.<sup>25</sup>



The country is faced with the prospect of **declining rainfall during the monsoon**, India's prime growing season for rainfed agriculture.



**Irrigation water use efficiency is very low** 35–40% efficiency in surface irrigation such as flooding or canals, and 65–75% efficiency when pumping groundwater. These **unsustainable practices** are depleting the country's aquifers.<sup>27</sup>



**55% of the population** is engaged in agricultural production. As farms are divided among family members, average **farm size today** (1.16 hectares / 2.87 acres) **is half what it was 40 years ago**.<sup>26</sup>



**Unemployment** among agricultural workers **rose from 9.5% in 1993–1994 to 15.3% in 2004–2005**.<sup>28</sup>



Government **subsidies to farmers** for fertilizer, electricity and irrigation **increased more than eightfold** between 1990–1991 and 2006–2007. Areas receiving the highest subsidies regularly underperform those with lower subsidies.<sup>29</sup>



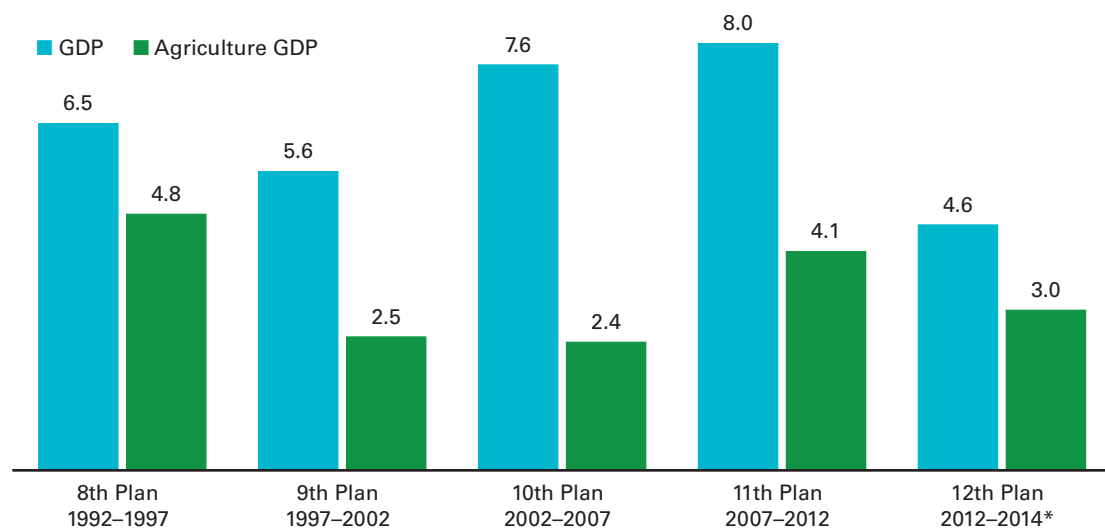
Government **subsidies for** buying and distributing **food grains** to low-income and disadvantaged households **grew from 2.2% of agricultural GDP during the 1990s to 5% in the 2000s**<sup>30</sup>, crowding out investments in agricultural education, research, technology and extension.



India's Ministry of Agriculture reports that from 2005 to 2007, **30% of harvest and post-harvest economic losses came from the fruit and vegetable sectors**, although that sector comprised only 13.6% of total production.<sup>31</sup>



**Figure 3: Percent GDP Growth and Agriculture GDP Growth Compared for India's Five-Year Plans since 1992**



\*Results during first two years of the plan are shown  
Source: Gulati A (2014)

## OPPORTUNITY IN INNOVATION AND AGRICULTURAL VALUE CHAINS

Despite impressive economic growth overall, agriculture's share of GDP has been rapidly declining, dropping from 30 percent in 2000 to 14 percent in 2012.<sup>32</sup> From 2002 to 2012, during India's 10th and 11th Five-Year Plans, GDP growth was robust, averaging 7.8 percent, but agricultural GDP growth was half that level, averaging 3.25 percent (Figure 3).<sup>33</sup>

India's agriculture sector is at a crossroads: **application of agricultural innovations and integration of value chains** must accelerate to use inputs more efficiently, conserve natural

resources and increase food choices and availability throughout the country.

**Innovations to boost productivity and conserve resources:** In India's Twelfth Five-Year Plan (2012–2017), agricultural priorities include better weather forecasting, water management and agricultural technologies that can help farmers increase yields without depleting natural resources. Steady investments in research and the development of modern technologies; expansion of financial services and cooperatives to increase farmers' business opportunities and access to farming inputs and equipment; and extension services to disseminate best practices are crucial for reaching these goals. Fortification of staple foods — by

breeding crops to have essential nutrients or through micronutrient fortification of staple food products — can help improve nutrition.

If current levels of agricultural subsidies and supports continue, the agricultural budget will need to expand considerably to meet these goals. [See *Minimum Support Price and Public Distribution System* box on page 10.] For example, India has excellent agricultural research institutes and universities, but, currently, only 0.40 percent of agricultural GDP is spent on public agricultural research.<sup>34</sup> The commonly accepted target for public spending on agricultural research and development for developing countries is one percent of agricultural GDP.<sup>35</sup>

**Investments to build out value chains:** Economic drivers are shifting away from large government schemes to consumer-led, demand-driven growth. Substantial government intervention in agricultural production and marketing systems, limitations on land ownership and transfer, and differing regulations and policies from state-to-state make it difficult for Indian entrepreneurs and agribusinesses to establish efficient and integrated value chains. As a result, private sector investment in agriculture is low, about 17 percent of the total investment in the sector.<sup>36</sup> For example, in most states farmers are required to sell through government-regulated markets, which limit a farmer's marketing options, can result in high transaction fees and low prices, and inhibit the development of organized food retailing systems for fruits, vegetables and groceries.



**States have authority to adjust agricultural policies and several have found innovative ways to reduce regulatory complexity and encourage investment in agricultural production and marketing systems.** Successful models include public-private partnerships that increase productivity and incomes of smallholder farmers, improve transportation and storage networks, and expand food manufacturing and marketing. Allowing farmers to sell directly to buyers rather than going through the government-mandated marketing system has helped increase supplies of fruit and vegetable products, creating more jobs and economic growth. Building on those models and facilitating continued expansion in the “sunrise sectors” of horticulture, meat, dairy, poultry and eggs are pathways for accelerating agricultural growth.

The section on Cultivating Prosperity through Stronger Agricultural Value Chains (page 32) highlights some of the innovative and successful developments in Indian value chains, sustainable technologies and improving the quality of food products.

## MINIMUM SUPPORT PRICE AND THE PUBLIC DISTRIBUTION SYSTEM

For nearly three decades following independence, India was plagued with famines and widespread malnutrition. In the 1960s, minimum price supports for farmers and subsidized foods for low-income consumers were introduced to address those problems. Today, the Indian government is still heavily vested in food safety net programs, which now provide supplemental food to an estimated 800 million people.<sup>37</sup>

This is achieved primarily through the **Public Distribution System (PDS)**. Rice and wheat, and sometimes other products, are bought by the **Food Corporation of India (FCI)** from farmers at a government-fixed minimum support price. To a certain degree, minimum support prices have played a risk protection role for farmers and spurred expansion of rice and wheat cultivation, particularly in states where the FCI has extensive operations for buying, transporting and storing grain. Some of the grains are stored by the FCI as buffer stocks and distributed for school meal and early-childhood development programs, but most are distributed through the PDS to **Fair Price Shops**, where they are sold at subsidized prices to eligible beneficiaries, and targeted nutrition programs for women, children and infants.

The **National Food Security Act of 2013** changed the eligibility requirements for India’s supplemental nutrition programs. Because malnutrition affects more people than just the poor, the government expanded the number of people who are eligible for subsidized foods. Before, the PDS covered households that fell below the poverty line. Now, it extends to people above the poverty line, too, doubling in size to reach 67 percent of the population. To provide the minimum required ration for each household, the government must buy 55 million metric tons of cereal a year — about 38 percent of national consumption — which the Government of India estimates will cost \$19 billion in 2014.<sup>38</sup>

The **Commission for Agricultural Costs and Prices** found that in 2009–2010, 40 percent of PDS grains did not reach intended low-income and disadvantaged beneficiaries due to insufficient storage facilities and faulty management.<sup>39</sup> In July 2014, India’s Finance Minister told the Parliament that “restructuring the FCI, reducing transportation and distribution losses and improving the efficacy of the PDS” are all government priorities.<sup>40</sup>





## PRODUCING MORE WITH LESS

**Enhancing and accelerating agricultural productivity** is a central component of a comprehensive strategy to sustainably meet the coming global agricultural demands we face in 2050. As population and incomes have grown, agricultural output has gradually kept pace with the demand. But we face a critical challenge for the future: can we continue the pace of production of food, feed, fiber and fuel needed by 2050 while reducing the environmental impact on the natural resource base? Farmers and producers in every region of the world — from the small-scale farmer in Sub-Saharan Africa to large-scale commercial exporters in developed countries — can and must be part of the solution.

Accelerating agricultural productivity is a necessary, but not sufficient, component of food and nutrition security. Other key components of a comprehensive strategy include reducing agricultural loss and food waste along the entire agricultural value chain and ensuring access to sufficient, nutritious food for the most vulnerable populations — rural smallholder farmers, landless laborers, urban poor, women and children. Governments must prioritize and strengthen programs that effectively improve the incomes, diets, sanitation and hygiene of vulnerable populations.

## MEASURING PRODUCTIVITY

Understanding and assessing the potential for greater productivity is a critical first step on the pathway to produce more with less. Agricultural productivity is typically measured in terms of yield: how many bushels per acre, kilograms per hectare, pounds of meat per animal or liters of milk per cow.

To increase crop and livestock yields, producers may use a range of strategies:

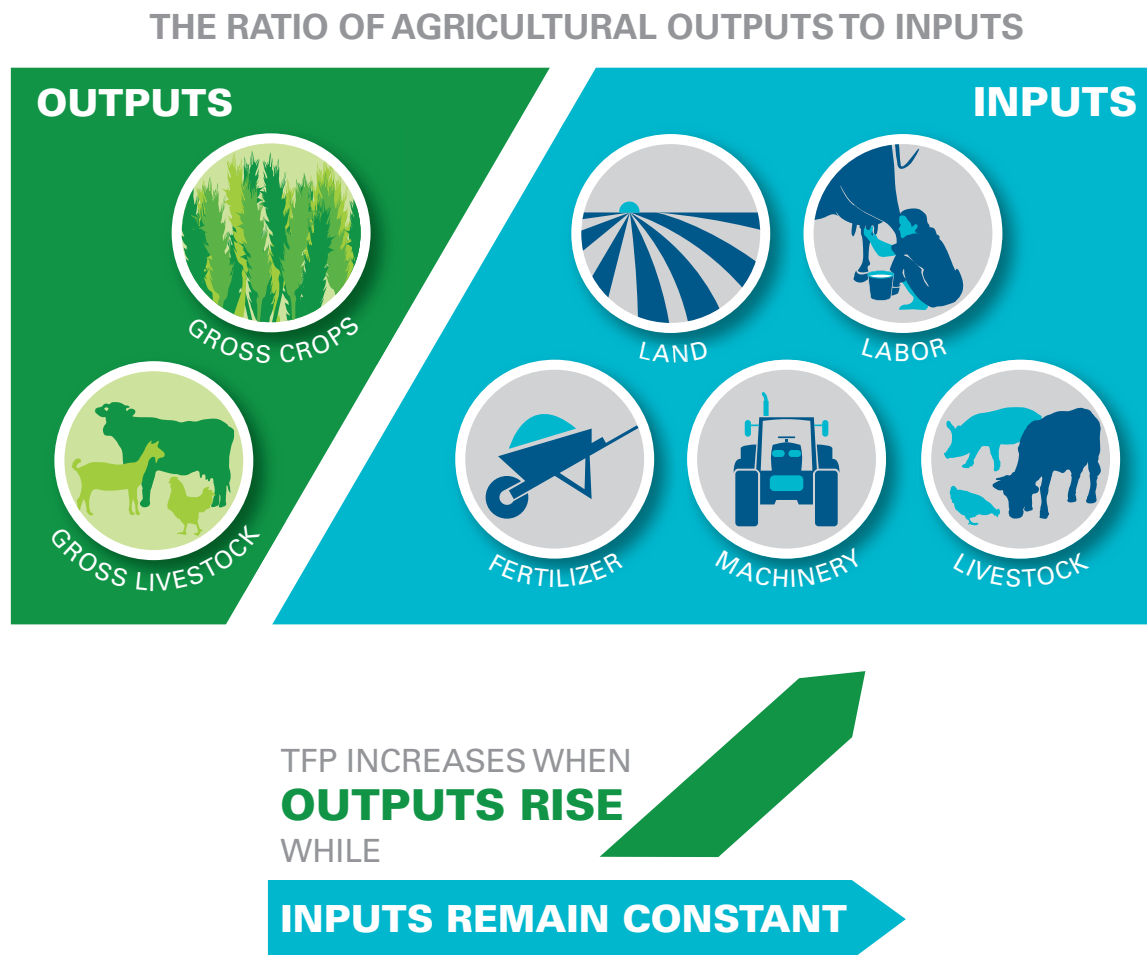
**Expansion** — extending irrigation to cropland so that it can be harvested more frequently and protected against drought;

**Intensification** — increasing application of fertilizer, machinery, labor or other inputs on land used to grow crops or raise livestock; or,

**Efficiency** — adopting technologies and farming practices that result in more output from existing resources, measured by **total factor productivity (TFP)**.

TFP is the ratio of agricultural outputs (gross crop and livestock output) to inputs (land, labor, fertilizer, machinery and livestock). As producers use inputs more effectively and precisely, or adopt improved cultivation and livestock raising practices, their TFP grows while using a fixed or even reduced amount of inputs (Figure 4). For crops, TFP results from higher yielding, disease resistant and drought or flood tolerant crop varieties, more efficient and timely cultivation and harvesting practices, or using technologies that indicate precisely when and how much water and fertilizer to apply. For raising livestock, breeding animals for favorable genetic qualities and behavior, using better animal care and disease management practices, and adoption of high quality feeds contribute to greater productivity.

Figure 4: Total Factor Productivity



### Trends in Global TFP

The deployment in the 1960s of breakthrough crop technologies — the Green Revolution — marked the start of an agricultural growth spurt. Since then, thanks to continued research at

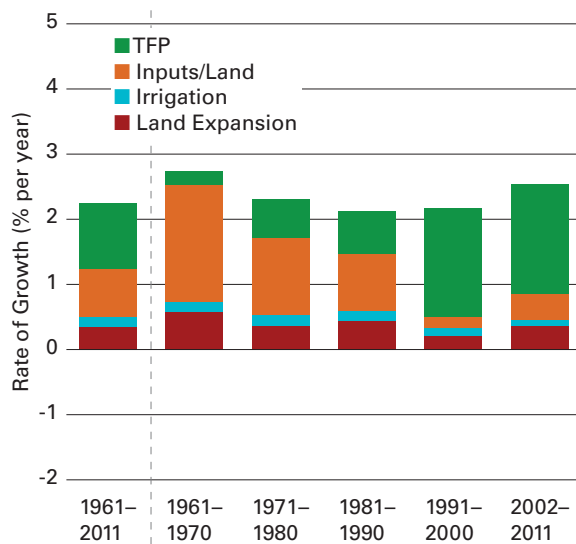
agricultural universities, specialized institutes and private companies and the spread of more efficient cultivation and water use strategies and technologies to farmers, TFP has become the largest contributor to global agricultural output growth (see Figure 5).



**For the following figures, sources of agricultural output growth are:**

- **TFP** — gross amount of crop and livestock outputs per inputs (labor, capital and materials)
- **Inputs/Land** — gross amount of fertilizer, machinery, labor and other inputs per hectares of agricultural land
- **Irrigation** — extension of irrigation to agricultural land
- **Land Expansion**

**Figure 5: Sources of Growth in Global Agricultural Output, 1961–2011**



Source: Economic Research Service (2014)

**Global TFP: Variation by Income**

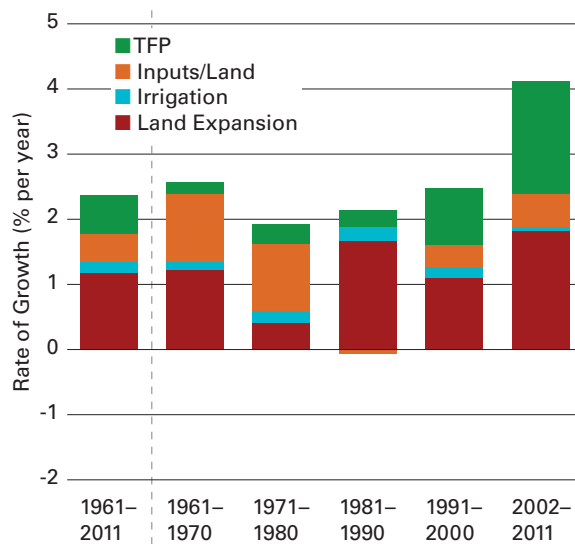
While Figure 5 indicates a promising global trend in producing more output with fewer resources, Figures 6 and 7 show there is considerable variation across countries, particularly when considering per capita income and development level.<sup>41</sup>

**Low-income countries** have boosted their agricultural output dramatically since the mid-1980s, and a growing share of their agricultural output is now attributable to TFP or efficiency of production (Figure 6). Raising productivity in low-income countries will require massive investments

in agricultural research and development, extension services, rural infrastructure and value chains and the creation of new public-private partnerships to support the special needs of smallholder farmers, women producers and cooperative producer associations. Keeping agriculture at the center of the policy agenda must be paramount in low-income countries to attract the needed investments and innovations for sustainable productivity.

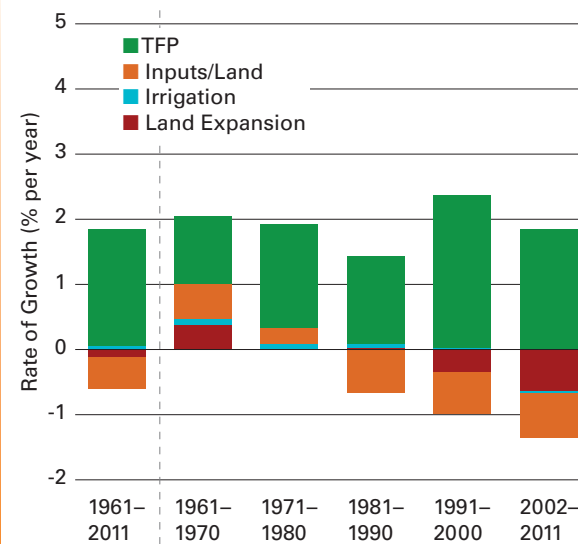
In **high-income countries**, decades of public and private investments have had a powerful impact on agricultural research and development,

**Figure 6: Sources of Growth in Agricultural Output: Low-Income Countries, 1961–2011**



Source: Economic Research Service (2014)

**Figure 7: Sources of Growth in Agricultural Output: High-Income Countries, 1961–2011**



Source: Economic Research Service (2014)



rural infrastructure and extension of productive technologies and innovations to the farm level. Because of these investments and an enabling policy environment, countries such as the United States, Canada, Australia and the European Union nations have already achieved significant gains in TFP growth (Figure 7). To ensure that productivity does not stagnate or falter, high-income countries must continue to make critical investments in the key drivers of innovation and technology — agricultural research and development and extension services.

TFP growth in these countries has been consistently higher than output growth for the last several decades, enabling resources to be withdrawn from agriculture for other productive uses. A troublesome trend is the declining rate of TFP growth in the most recent decade, which may lead to slower output growth. In the coming years, new innovations in precision agriculture, disease management and more adaptive crops may help improve the efficiency of production, particularly in the face of climate change.



Photo courtesy of John Deere

## PRECISION AGRICULTURE — THE DATA REVOLUTION

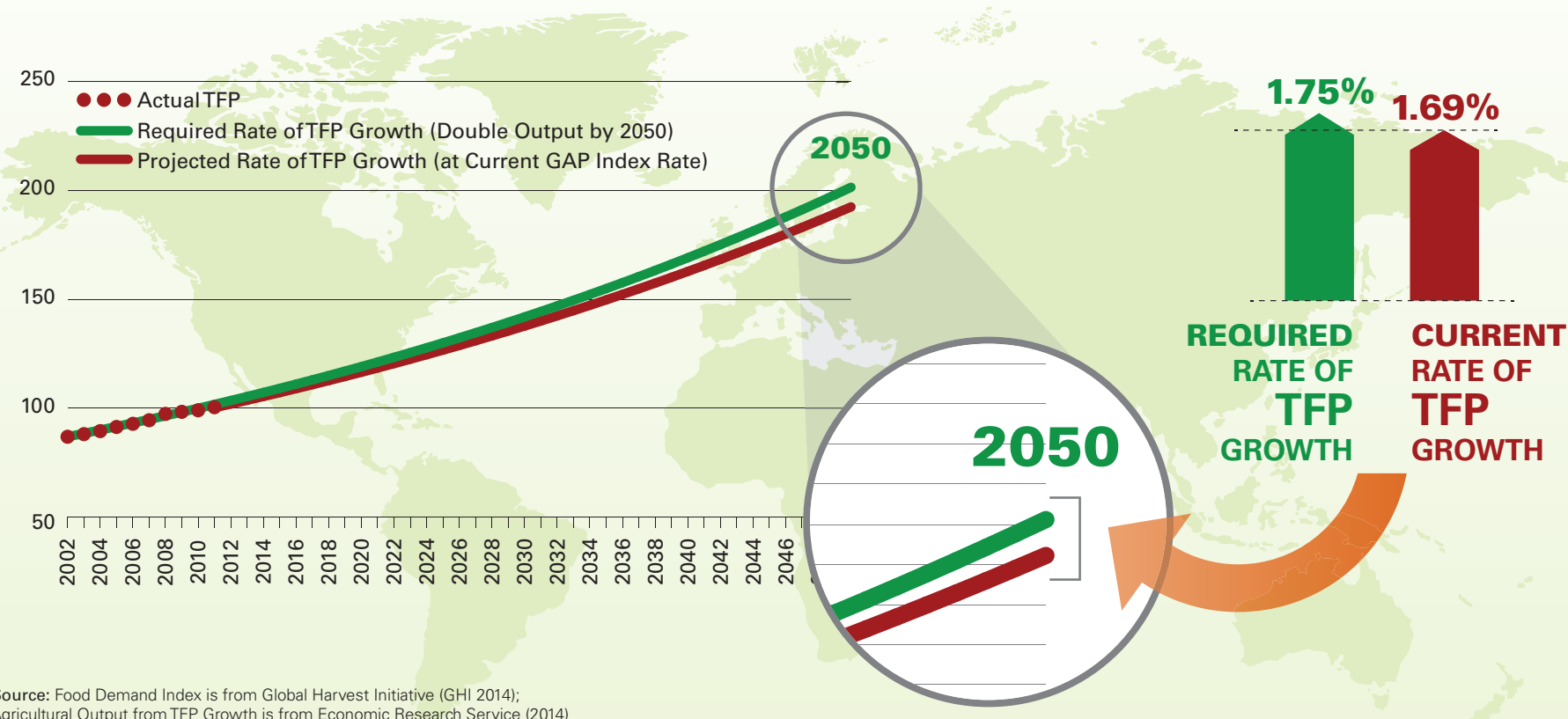
Farmers are now able to use ever-increasing amounts of data from their fields through “precision agriculture” technology to boost yields, lower costs and reduce risk — increasing the amount of revenue and product they squeeze out of every acre while precisely applying fertilizer, water and other resources. Smartphones, iPads, apps and faster wireless networks

are catalysts for information gathering. Technology has evolved to make just-in-time information available to farmers to help guide production and harvesting decisions.

Many agribusiness companies provide customized, analytical services to their customers. They take samples from a farmer’s field and analyze them to determine the topography, nutrient content and other characteristics of the soil. Additional information, such as weather patterns or yield trends from previous growing seasons, is incorporated into the analysis to help a farmer select the most appropriate seed and application for a particular plot in a field, and establish how much fertilizer and chemicals are needed and when to apply them. Sensors in farm equipment test soil conditions and apply fertilizer, water and pesticides at variable rates for extremely precise applications. Similar data measurements can be utilized to improve grazing and feeding systems for livestock, to conserve fragile soils and to track and improve animal health.

Farmers must be assured that the data generated about their operations are secure. The development of secure data standards and systems is therefore a priority for both agribusiness and farmers. Exciting new applications of crop and animal diagnostics are being developed for farmers in developing countries, using mobile technology. As precision agriculture is tested and deployed, it will bring a range of productivity benefits to farmers of all scales in coming decades.

# THE GLOBAL AGRICULTURAL PRODUCTIVITY (GAP) INDEX™



Source: Food Demand Index is from Global Harvest Initiative (GHI 2014); Agricultural Output from TFP Growth is from Economic Research Service (2014)

## THE GAP INDEX™

In 2010, GHI calculated that global agricultural TFP must grow by an average rate of at least 1.75 percent annually in order to double agricultural output through productivity gains by 2050. While output of food, fiber, feed and fuel will most likely accelerate in coming decades to keep up with growing demand, the central concern remains — will this output be from more efficient uses of all factors of production, with less impact on soil and water? Or will producers open up fragile lands, use more water and other inputs,

and fail to take advantage of proven strategies to produce more with less?

**TFP growth is not accelerating fast enough to meet the expected agricultural output needs of 2050.** The U.S. Department of Agriculture’s Economic Research Service (USDA ERS), using FAO and other data sources, estimates that since 2002, TFP has been rising by an average annual rate of only 1.69 percent. While this growth rate does not seem much lower than the required 1.75 percent needed to meet future demand, when compounded over 40 years, output would grow by 94 percent, falling six percent short of the target.

**The impact of this productivity gap will fall hardest on low-income, food-deficit countries.**

Such countries lack the income to produce and import sufficient food to meet nutritional needs and, consequently, stagnant or declining productivity will raise prices and the proportion of income required to buy food. Poor urban households bear the brunt of higher prices in those countries, and rural populations suffer, too, since they are typically net food buyers. The lack of productivity growth leads to farmland expansion, endangering fragile tropical forest zones, and places greater stress on existing water resources.

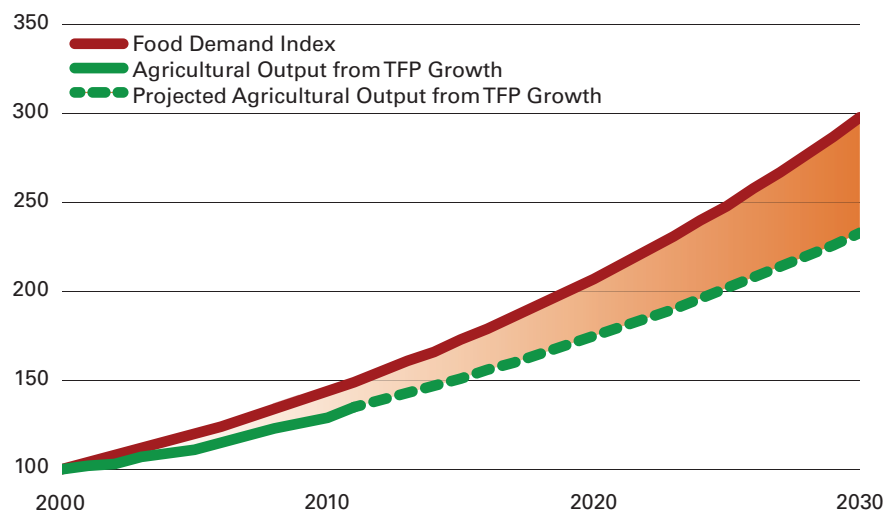


## SPOTLIGHT ON REGIONAL PRODUCTIVITY GAPS

Regional differences in productivity gaps are dramatic and demonstrate why even a small falloff in the global rate of growth requires immediate attention. In the 2012 GAP Report®, GHI established a series of regional estimations comparing food demand indexes against projected agriculture output from TFP growth from 2000 to 2030. Figures 8 through 11 update these estimates for East Asia, South and Southeast Asia, Sub-Saharan Africa and the Latin America/Caribbean regions.

**Each region, with the exception of Latin America/Caribbean, shows insufficient growth in TFP to meet future estimated food and agriculture demand. If current trends continue to 2030, the gap in East Asia will be 33 percent; in South and Southeast Asia, 13 percent; and in Sub-Saharan Africa, 82 percent. These regions will need to significantly expand the resources they use in agricultural production and rely increasingly on imports to meet their growing food demands.**

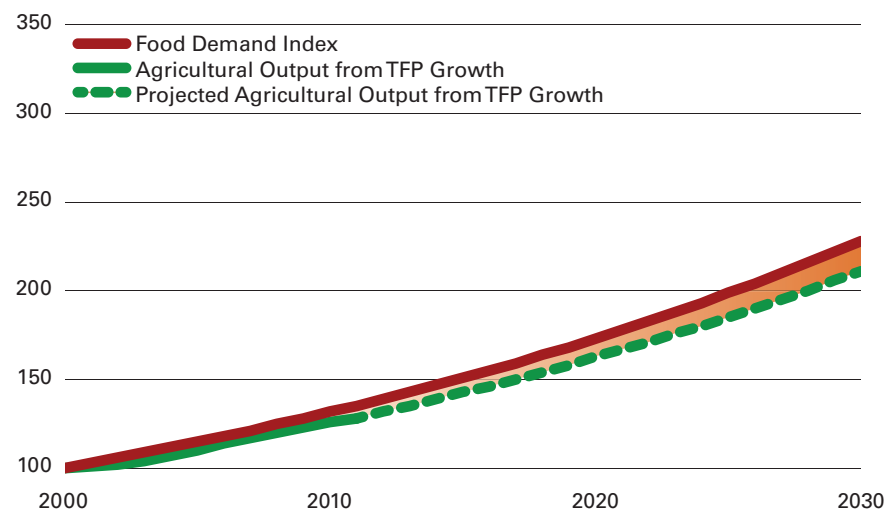
**Figure 8: Food Demand Compared to Agricultural Output from TFP Growth in East Asia, 2000–2030**



Source: Food Demand Index is from Global Harvest Initiative (GHI 2014); Agricultural Output from TFP Growth is from Economic Research Service (2014)

**67%** of total East Asia demand can be met by maintaining the current TFP growth rate.

**Figure 9: Food Demand Compared to Agricultural Output from TFP Growth in South and Southeast Asia, 2000–2030**



Source: Food Demand Index is from Global Harvest Initiative (GHI 2014); Agricultural Output from TFP Growth is from Economic Research Service (2014)

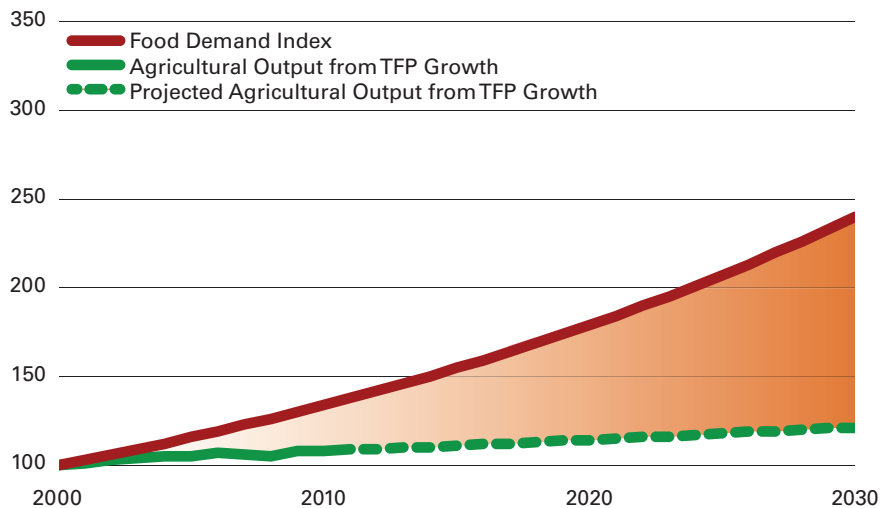
**87%** of total South and Southeast Asia demand can be met by maintaining the current TFP growth rate.

*Note on methodology: The projection of agricultural output from TFP growth uses Economic Research Service (2014) estimate of average TFP growth during 2002–2011 and assumes this is maintained through 2030. The projected growth in food demand uses UN estimates of population, PricewaterhouseCoopers LLP (PwC) estimates of GDP growth, and estimates of the income elasticity of food demand from Tweeten and Thompson (2008). The income elasticity of food demand indicates the share of the growth in per capita income that will be spent on food. Multiplying the income elasticity with the growth rate in per capita income gives the growth in per capita food consumption holding food prices fixed. Adding this to the population growth gives the total growth in food demand for a given price level.*

The role of trade will be critical in closing the gap between areas of high food and agriculture demand and those areas able to supply more food, feed, fiber and fuel. Continual improvement in global and regional supply chains and greater harmonization of trade rules across nations will assure that all countries have access to the agricultural goods they need and can help reduce price volatility. The Latin American region, and particularly the southern cone nations of Argentina, Brazil, Paraguay and Uruguay (ABPU), comprise the largest

net exporting zone for agriculture on the planet.<sup>42</sup> Latin America is rapidly becoming the next global breadbasket,<sup>43</sup> and the potential is immense for Sub-Saharan Africa to also dramatically increase food and agriculture production in future decades through sustainable practices. **Investments to improve TFP will help low-income countries achieve food security and take advantage of global agricultural markets.**

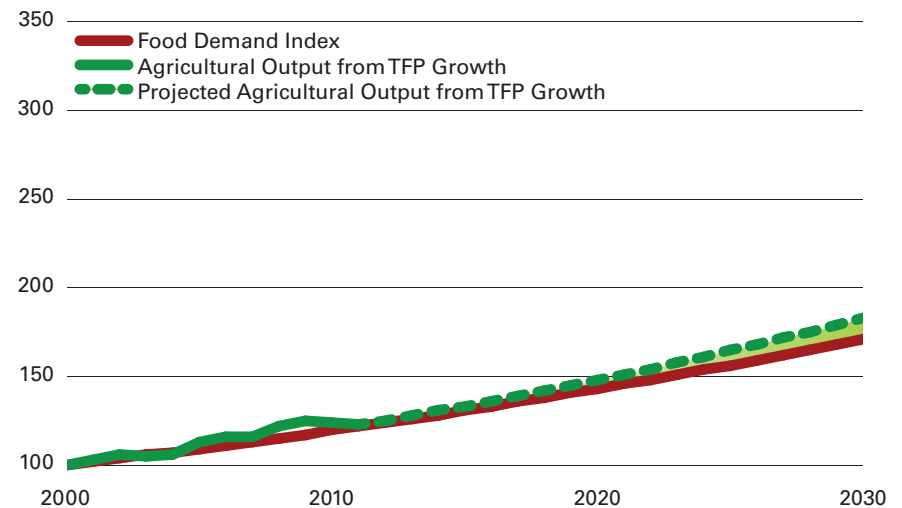
**Figure 10: Food Demand Compared to Agricultural Output from TFP Growth in Sub-Saharan Africa, 2000–2030**



Source: Food Demand Index is from Global Harvest Initiative (GHI 2014); Agricultural Output from TFP Growth is from Economic Research Service (2014)

**15%** of total Sub-Saharan Africa demand can be met by maintaining the current TFP growth rate.

**Figure 11: Food Demand Compared to Agricultural Output from TFP Growth in Latin America/Caribbean, 2000–2030**



Source: Food Demand Index is from Global Harvest Initiative (GHI 2014); Agricultural Output from TFP Growth is from Economic Research Service (2014)

**116%** of total Latin America/Caribbean demand can be met by maintaining the current TFP growth rate.





## MEASURING AGRICULTURAL PRODUCTIVITY GROWTH IN INDIA

**India's agricultural sector is rich and diverse.** It is the world's second largest rice and wheat producing country and the largest exporter of rice. It is also the largest producer, consumer and importer of pulses such as pigeon peas, chick peas, mung beans and lentils. One-fifth of beef traded worldwide is from India — an industry that grew nearly fivefold between 2008 and 2013.<sup>44</sup> India also accounts for one-tenth of the world's fish and seafood trade.<sup>45</sup> A wide variety of spices and fruit juices are sourced from India and the country is the world's top producer of milk.<sup>46</sup> ►►

To achieve these results, India's agricultural sector has been transformed over the past six decades. Following years of food shortages, early advancements in crop production relied heavily on expanding cropland, irrigation and fertilizer use, as well as the introduction of improved seeds for food grains. In the past three decades, research and technology-led growth helped reduce the cost of cereal production by 1 to 2.3 percent per year and today there is new growth in vegetable, fruit, feed grain and livestock production.<sup>47</sup>

As pressure on water and land resources intensifies due to population growth, urbanization, and industrialization, India's agriculture sector will need to continue to close yield gaps and reduce production costs through Total Factor Productivity (TFP) growth. As TFP increases, the cost of production decreases, and prices fall and stabilize.<sup>48</sup>

## AGRICULTURAL PRODUCTIVITY GROWTH 1947–1980

From independence in 1947 until 1956, little progress was made in agricultural development as the new government's attention focused on Partition and rehabilitation. This changed dramatically from 1957 to 1968, when the expansion of the country's research capacity and initiation of price support programs for farmers set the stage for the Green Revolution.<sup>49</sup>

### Building Institutional Capacity

In 1957, the Rockefeller Foundation initiated a program with the Government of India to develop national research programs to improve cereal crops, working with the **Indian Council on Agricultural Research (ICAR)** and the **Indian Agricultural Research Institute (IARI)**.<sup>50</sup> To

increase research, education and extension capacity across the country, India established a system of agricultural universities based on the U.S. land-grant model. The first nine universities were completed by 1968, the start of the Green Revolution. India's **National Academy of Agricultural Sciences** concluded that the Green Revolution, "with its impressive social and economic impact, would have not been possible without the significant contributions made by the agricultural universities, both in the form of trained scientific manpower and the generation of new technologies."<sup>51</sup>

### Farmer Incentives

Severe droughts and famine in the 1960s convinced the Government of India to prioritize self-sufficiency in rice and wheat — the staple foods of the country — in national policies. However, this would require farmers to adopt new technologies that the vast majority could not afford. Food grain procurement and public distribution programs were established and managed by a newly-formed **Food Corporation of India**. The Indian government set incentive prices for food grains, assuring farmers that their crop would be procured at the full cost recovery price, plus some profit.

### The Green Revolution and Dissemination of New Technologies

Early in the Green Revolution (1969–75), high-yielding, semi-dwarf varieties of wheat and rice were introduced to farmers, along with increased use of fertilizers, agricultural chemicals, machinery and irrigation. Subsidies were provided for seed, water and fertilizers. There were tremendous productivity gains and, by 1980, the country produced enough rice and wheat to meet basic

needs. The economic benefits to farmers, however, were strongly skewed toward a few northern states where the Green Revolution was started.<sup>52</sup>

To create greater equity in access to resources, from 1975 through the 1980s, the Indian government disseminated crop production inputs and technologies to farmers in more states. An unintended consequence was less discriminating use of inputs, including water, pesticides and fertilizers, leading to land degradation and reduced groundwater in some areas of the country.

These experiences drove home the message that simply increasing inputs or expanding irrigation and cropland is not the answer to food security concerns; rather, farmers need to increase productivity without degrading the resource base. This requires choosing the right seeds and the right types and amounts of inputs for local conditions, and applying them in the right way, to assure that productivity growth is truly sustainable. Measuring TFP is one of the ways the Government of India determines whether productivity changes are due to application of improved technologies rather than just increased use of water and other inputs, which helps guide policy decisions.

In addition to technology-driven efficiencies, TFP growth can be driven by shifting to crops with a higher economic benefit. Both of these factors have played a role in India's agricultural productivity growth.<sup>53</sup>



## POST-GREEN REVOLUTION AGRICULTURAL PRODUCTIVITY GROWTH IN INDIA

Using Indian government data, Dr. Nicholas Rada's new study<sup>54</sup> (2013) examines farm productivity growth for 59 crops and 4 livestock products between 1980 and 2008 in 16 states, 6 regions and on the national level. TFP was measured for these crops and regions (Figures 12 and 13).

**Figure 12: Six Regions and 16 States Examined by the Rada Study (2013)**

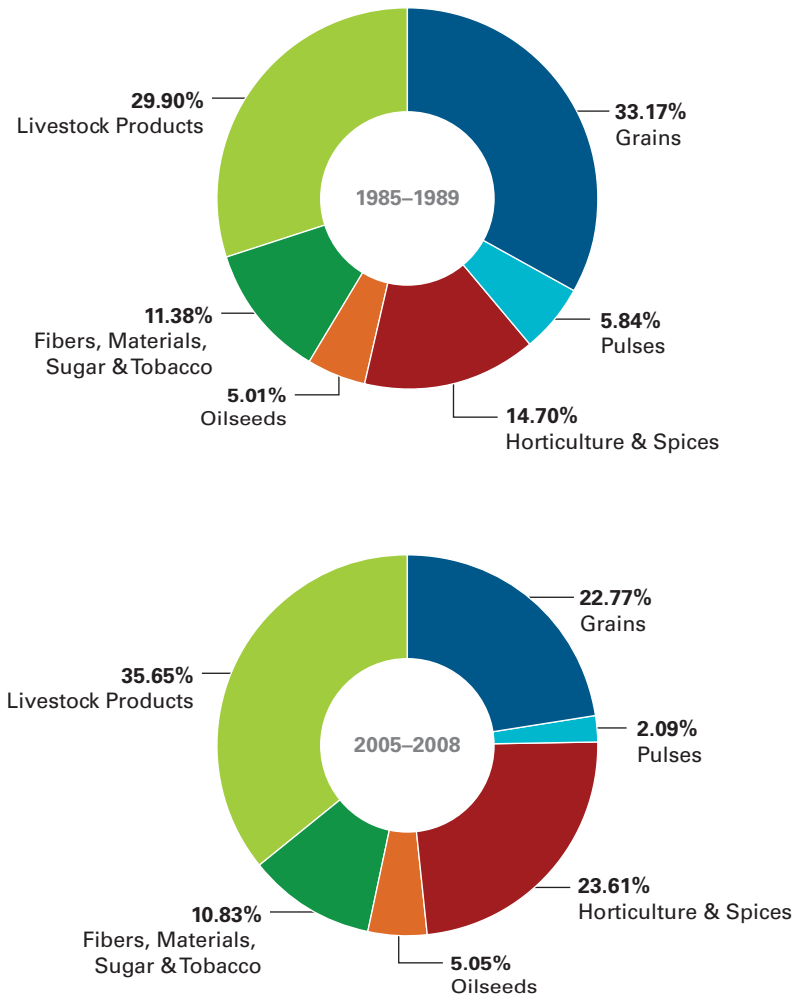


**Figure 13: Agricultural Crops and Livestock Products Examined by Rada (2013)**

<b>Grains</b>	Rice, Maize, Wheat, Sorghum (Jowar), Pearl Millet (Bajra), Finger Millet (Ragi) and Barley
<b>Pulses</b>	Pigeon Pea (Arhar), Chick Pea (Gram), Urad (Black Gram), Moong (Green Gram), Kultha (Horse Gram) and Lentils (Masoor)
<b>Horticulture &amp; Spices</b>	Dry Peas, Potatoes, Tomatoes, Onions, Cabbages, Cauliflower, Green Peas, Sweet Potatoes, Tapioca, Cashew nuts, Bananas, Pineapples, Mangoes & Guavas, Oranges (2 types), Lemons, Grapes, Melons, Papayas, Apples, Pears & Quince, Coffee, Tea, Cardamom, Coriander, Ginger, Turmeric, Chillies, Garlic and Arecanuts
<b>Oilseeds</b>	Soybeans, Groundnuts, Linseed, Sunflower seed, Castor, Nigerseed, Safflower and Sesamum
<b>Specialty Crops</b>	Natural Rubber, Coconuts, Cotton, Jute, Mesta, Sannhemp, Sugarcane, Tobacco and Guarseed
<b>Livestock Products</b>	Wool, Eggs, Milk and Meat

The Rada study shows several prominent trends in productivity growth of different crops, as well as shifting agricultural production patterns in different regions of the country.

**Figure 14: Composition of India's Production Growth by Commodity Group (1985–1989 and 2005–2008)**



As shown in Figure 14, the share of area planted with primary food grains, such as rice and wheat, has declined since the 1980s and there has been a slowdown in cereal grain productivity. Over the past 30 years, the national trend has been toward higher valued crops — grains, pulses, oilseeds and specialty crops have given way to vegetables, fruits and livestock products such as eggs, milk, poultry and meat. The reallocation of land to higher valued crops is driven by increased yield potential and growing demand for those products. Livestock product growth was greater than aggregate crop production in all regions studied except for two states, Assam and West Bengal.

Before 1980, the northern part of India led in agricultural productivity since it was the center of irrigation expansion and Green Revolution technology-led growth. In the 1990s, spending on irrigation, water management and scientific research was cut and extension services declined. There were limited advances in traditional food crops and agricultural productivity growth stalled.<sup>55</sup>

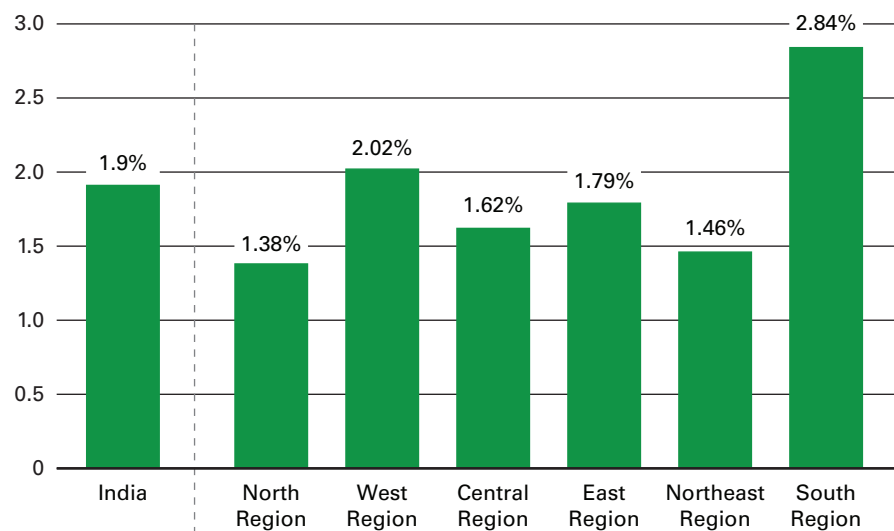
The North still has the highest mean revenue share, but production growth has now shifted from the North to rainfed areas in the South and West. As shown in Figure 15, from 1980 to 2008, agricultural output growth in the South and West was driven by diversification from grains and pulses to high-value crops, particularly vegetables, spices and livestock, resulting in the highest TFP gains (Figure 16).

**Figure 15: Average Annual Changes in Commodities' Share of Output Growth, 1980–2008**

	Grains	Pulses	Horticulture & Spices	Oilseeds	Specialty Crops	Livestock Products
<b>India</b>	<b>-1.83%</b>	<b>-4.03%</b>	<b>2.45%</b>	<b>-0.12%</b>	<b>-0.41%</b>	<b>1.18%</b>
North	0.32%	-8.50%	-1.06%	-5.18%	-2.11%	1.38%
West	-4.66%	-3.90%	6.18%	-1.02%	-2.56%	0.46%
Central	-4.05%	-3.12%	1.51%	8.20%	-5.18%	-1.41%
East	-0.57%	-11.57%	2.64%	-8.88%	-3.13%	0.07%
Northeast	-0.91%	-2.43%	1.59%	4.50%	-2.70%	-1.74%
South	-4.78%	-1.18%	2.77%	-4.04%	-0.76%	1.81%



**Figure 16: Comparative 1980–2008 TFP Growth Rates for India and the Six Regions\***



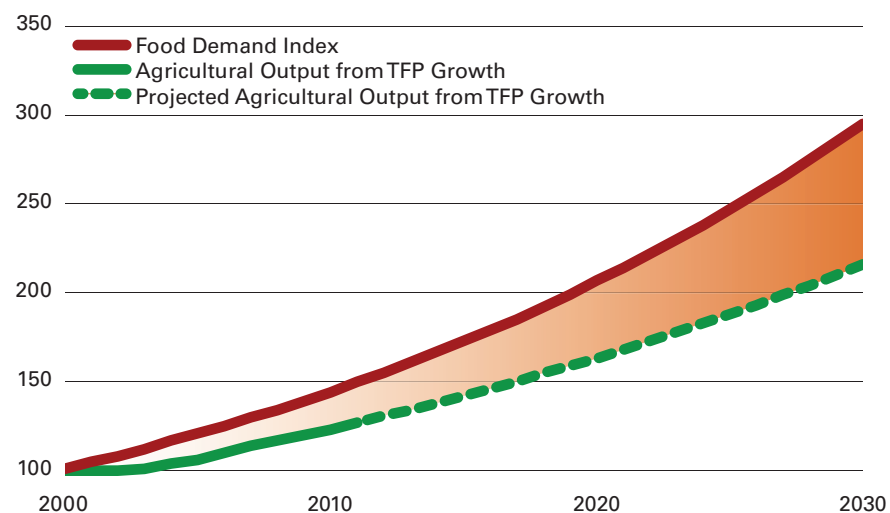
\*TFP Growth Rates for this chart were updated by N. Rada in August, 2014 by personal communication.

For the North, the TFP growth rate from 1980 to 2008 was the lowest of all the regions, 1.38 percent, while the South was the highest at 2.84 percent, and the West was second highest, 2.02 percent (Figure 16). A 2014 World Bank and FAO study found that nearly half of the differences in TFP growth rates across the country can be attributed to state-specific policies, institutions and public investments. In addition, the study suggests that intensive input use negatively affects TFP in highly-subsidized grains, compromising future productivity growth.<sup>56</sup>

At the current rate of TFP growth, domestic production by 2030 will meet only 59 percent of India’s food demand (Figure 17).<sup>57</sup> This indicates that greater attention is needed to increasing productivity through technologies and practices that do not stress the resource base and, if the current trend continues, imports will become more important for meeting growing demand.

In 2011, Chand *et al.* assessed the contribution of different productivity-enhancing factors to TFP growth for a variety of Indian crops.<sup>58</sup> They found

**Figure 17: Food Demand Compared to Agricultural Output from TFP Growth in India, 2000–2030.**



Source: Food Demand Index is from Global Harvest Initiative (GHI 2014); Agricultural Output from TFP Growth is from Economic Research Service (2014)

**59%** of total India demand can be met by maintaining the current TFP growth rate.

that public investment in agricultural research constituted a significant source of TFP growth in 11 out of 15 crops. Public investment in extension and technology transfer contributed positively toward TFP enhancement in only two crops, which likely reflects suboptimal investment. The authors suggest that improvements in both the investment levels and quality of extension services are needed. In addition, to achieve the 4 percent growth per annum in agricultural GDP — the Government of India’s Planning Commission target — greater emphasis should be placed on the development of livestock, horticulture and fisheries.

**When Indian Finance Minister Arun Jaitley presented the government’s 2014–15 budget in July 2014 he said, “the government is committed to sustaining 4 percent growth in agricultural GDP and for this we will bring a technology driven second green revolution with focus on higher productivity,” including a “Protein Revolution” and expanded “Blue Revolution” of inland fisheries.**<sup>59</sup>



**Figure 18: Yields and Profits from Hybrid Rice and Seed**

Yield Advantage of Hybrid vs. Inbred Rice	1.0-1.5 tons/hectare
Additional Net Profit from Cultivation of Hybrids vs. Inbred Rice	Rupees 2,781 to 6,291/hectare US\$45.15 to 102.13/hectare
Net Profit from Hybrid Seed Production at 1 ton/hectare and Farmgate seed price of Rupees 50	Rupees 21,000 US\$340.91

Source: Directorate of Rice Research, Hyderabad, India

## INCREASING RICE PRODUCTIVITY IN EASTERN INDIA

The results of some of new and promising initiatives to increase productivity are not reflected in the Rada study, such as **Bringing the Green Revolution to Eastern India (BGREI)**, which began in 2011 with a focus on increasing rice and wheat production through improved varieties, cultivation practices and water use efficiency. The seven eastern states account for 56 percent of India's cropland that is used for rice production, but they produce only 48 percent of the nation's crop.<sup>60</sup> In contrast, the Punjab accounts for 6 percent of land under rice cultivation and it produces 11 percent of the nation's rice crop.<sup>61</sup> Improved rice productivity would have a significant impact on household food security and income generation and on the region's economic growth.

In the eastern region, developing and using the best seeds for different types of soil and climatic conditions is a priority for increasing productivity. **India's Directorate of Rice Research** coordinates multi-site evaluations of promising experimental hybrids from both public and private researchers at 25 to 30 locations representing different agro-climatic zones of the country. For example, water conditions vary throughout the country and hybrid seeds have been identified that are

best used in either water submergence, flood, drought or salinity prone areas. In Eastern India, hybrid seeds developed through this process have achieved, on average, 30 percent higher yields in farmers' fields than existing inbred rice varieties.<sup>62</sup>

Pusa RH-10, a hybrid basmati rice developed by the **Indian Agricultural Research Institute (IARI)**, shows even higher increases under rainfed upland conditions and the aromatic flavor and texture is very popular. Since the private sector has been more effective than government in hybrid rice seed production, a public-private partnership between IARI and the non-profit **Indian Foundation Seed and Services Association** was formed, which resulted in the faster spread of the Pusa RH-10 hybrid. Evaluations indicate that seed production was highly lucrative for farmers. A particular benefit was the generation of additional employment of 65 person days/hectare and most of the producers are women. BGREI, and similar science-based initiatives and public-private partnerships, create numerous benefits and have a positive, cascading impact on the economy.<sup>63</sup>



# POLICIES THAT PROMOTE SUSTAINABLE FOOD & AGRICULTURAL SYSTEMS

**Global population growth** and an expanding middle class are increasing demand for food, fuel, feed and fiber. Agricultural output can increase to meet this growing demand, but nations must work together to identify pathways for closing the productivity gap in a sustainable manner that **conserves** natural resources, **adapts** to climate change and **improves** people's lives.

GHI and its partners have identified **five strategic policy goals** that create the enabling environment for improving agricultural productivity, increasing the availability of food to more people at affordable prices, conserving natural resources and reducing waste and loss.

## FIVE STRATEGIC POLICY GOALS



### Invest in agricultural research and development (R&D)

These investments support the discovery of materials, methodologies and information that more effectively and efficiently boost agricultural productivity. The private sector is a growing source of R&D funding, but greater public-sector investment is critical for innovation, basic research and making research findings and technologies widely available.

### INDIA'S POLICIES

Research investments in India create high returns in terms of output growth and more efficient use of resources, and they help meet the government's food security goals. The **Indian Council for Agricultural Research (ICAR)** is a semi-autonomous institute that coordinates research and education conducted by 99 specialized institutes and 53 agricultural universities across the country.

One of the greatest successes has been in cotton. In the past decade, the Government of India's spending on agricultural research has stagnated at 0.4 percent of agricultural GDP.<sup>64</sup> Meanwhile, farm-level input subsidies for nitrogen and phosphorous fertilizer (to farmers), urea (through manufacturers),

and power (borne by utilities) are increasing — from 2008 to 2012, they grew by 8.2 percent.<sup>65</sup> Notably, cotton had the greatest productivity growth during that period, which was not attributed to subsidies, but rather to research, development and government approval of 90 cotton Bt hybrids, which are high-yielding varieties that have built-in protection against bollworm and other pests and significantly reduce the use of pesticides.<sup>66</sup> Due to synthetic pesticide resistance, farmers had previously been losing much of their cotton to tobacco budworms, cotton bollworms and pink bollworms.

Science-based and consistently applied regulations and approval procedures at the national and state levels would encourage additional research and private sector investments in the production sector. **The 1988 Policy on Seed Development** allowed import of germplasm for research and lowered import duties for seed and seed-processing equipment, which resulted in the registration of more than 400 seed companies.<sup>67</sup> **The National Biodiversity Act**, on the other hand, limits germplasm movement out of the country to protect domestic stocks and thereby has inadvertently restricted scientists from taking germplasm to research sites outside of the country to create improved hybrids.

In July 2014, the new government, headed by Prime Minister Narendra Modi, expressed strong support for improving agricultural research and development and announced plans to establish two new research centers and four new agricultural universities, but the government has not yet indicated how it will approach genetic engineering trials.<sup>68</sup>



## Embrace and apply science-based and information technologies

Technological innovations are the backbone of productive and resilient farms, fisheries and livestock operations and a safe, wholesome food supply. They contribute to improvements in the quality of seeds, animal stock and inputs, labor-saving devices, effective production and conservation practices, reduction of post-harvest losses, efficient price discovery mechanisms and control of pests, diseases and contamination. Access to these innovations will be essential if farmers and producers along the value chain are to meet the rising global demand for agriculture in the face of climate change.

### INDIA'S POLICIES

Numerous technologies and approaches for improving Total Factor Productivity (TFP) have been developed by Indian companies and institutes, from water and fertilizer efficiency and matching seed technology with local soil and climatic conditions to diversification and multi-cropping. Technology-led output growth helped decrease the cost of production in India by 1 to 2.3 percent a year from 1985 to 2005, which helped contain consumer prices.<sup>69</sup>

## BETTER ACCESS TO CREDIT

Government-funded short-term loans for seasonal production and harvest expenditures are made available to farmers through commercial banks, cooperative banks and regional rural banks. For the 2013–2014 season, the interest rate for loans up to 300,000 Rupees (\$4,900) is 7 percent, and is reduced to 4 percent if paid promptly.<sup>73</sup> Although agricultural credit increased nearly tenfold between 2000–01 and 2010–11, loans are rarely available to farmers in the bottom 40 percent income bracket.<sup>74</sup> Without access to formal credit, they are forced to seek high-interest loans from informal sources that can lead to spiraling debt that put their future livelihoods at risk.<sup>75</sup>

Since 2005, however, public spending on extension services averaged 0.14 percent of agricultural GDP, which is insufficient for transferring technologies to producers.<sup>70</sup> Consequently, the crop sector is now experiencing diminished returns to input use.

**India's Planning Commission** dug deeper to determine what is working and what needs to change. It found that food crop productivity is lagging in the most traditional growing areas that rely heavily on irrigation and receive the highest subsidies, while yields have picked up in rainfed areas due to improved seed, higher seed replacement and better practices. As a result, **India's Twelfth Five-Year Plan for Agriculture (2012–2017)** concludes that investments in conservation, water management, extension and universities are good choices for more efficient use of agro-ecological resources and the agricultural budget.<sup>71</sup>

Farmer demand for mechanization is growing. A variety of manufacturers and dealers sell farm equipment tailored for the Indian environment and some offer customized financing in order to make tractors, implements and harvesters available to more farmers. Efficient micro-irrigation systems are

also being introduced along with seeds, chemicals and fertilizers that more precisely meet needs, but to significantly improve yields, these technologies need to be more widely adopted.

Better technologies and extension services are also needed to increase productivity in the livestock sector. India leads in global livestock production and although health and veterinary services account for the highest share of public expenditure in this sector, productivity per animal is about half the world average.<sup>72</sup>

Animal husbandry and health service companies offering technologies and advice, have expanded operations due to market-driven growth in the livestock, poultry and dairy sectors. Crop service and input dealers use mobile phones and on-site visits to collect soil, water and farming practice information, identify technologies that are most suited to the farm operation, and troubleshoot production problems. Overall, private sector has taken on a more robust role in developing and transferring innovative agricultural technologies in India.





## Enhance private sector involvement in agriculture and rural infrastructure development

GHI estimates an investment gap of \$80 billion annually in developing countries to make the infrastructure upgrades that are needed to meet the agricultural production and food system demands of 2050.<sup>76</sup> Transparency and coordination between the public and private sector, starting at the early stages of development, attracts financing and promotes successful outcomes. The private sector is an increasingly critical source that can effectively close this investment gap and private-public partnerships are one of the ways forward.

### INDIA'S POLICIES

Road density and rail are important determinants of rural sector and agricultural development in India.<sup>77</sup> Progress has been made in road infrastructure: from 1991 to 2011, the highway network doubled from 34,000 km to 71,000 km, and from 2001 to 2011, 400,000 rural roads were built or upgraded to all-weather roads, reaching 85,000 small villages.<sup>78</sup> Under the current **National Highway Development Program**, 40 percent of new roads will be built through public-private partnerships.<sup>79</sup>

## GUJARAT'S POLICIES GROW AGRICULTURAL GDP

The state of Gujarat achieved 10 percent agricultural growth during the past decade through better energy and water management and by approving Bt cotton use. The government of Gujarat also addressed the problem of fragmented markets by adopting a model law that waives **Agricultural Produce Market Committee Act (APMC)** marketing fees and allows private companies to contract directly with farmers for horticultural products. An integrated value chain also facilitated financing for technological improvements, such as micro-irrigation and better post-harvest handling and storage, including cold-chain systems.

In July 2014, India's Finance Minister told Parliament that the Modi government plans to increase agricultural market competition and accelerate development of integrated markets across the country. Thus, the central government will work closely with state governments "to re-orient their APMCs and establish private market yards/private markets."<sup>82</sup>

Freight rail is a more economical way to transport agricultural commodities and products. Because repairs and expansion of freight railways have not kept pace with transportation needs, the amount of freight moved by rail dropped from 89 percent in 1951 to 36 percent in 2008.<sup>80</sup> Barriers to rail freight development include getting land clearances, moving utilities and resettling people.

**The Indian Railway** has found a solution. **Dedicated Freight Corridors (DFC)** for the East and West are under development through a separate corporate entity, which plans to increase carriage capacity on faster trains and thereby lower costs. For the Western DFC, the **Japan International Cooperation Agency (JICA)** provided a loan at below-market rates to finance two-thirds of the construction costs and the **Ministry of Railways** will pay the remainder of the costs. The Eastern DFC will be funded by the **World Bank** and **Asian Development Bank**.

Indicating the importance that Prime Minister Modi's government places on addressing the deficit in infrastructure expenditures, on August 6, 2014, the Cabinet approved Foreign Direct Investment (FDI) for some railways, including public-private partnerships and dedicated freight lines, and 100 percent FDI for some railway segments, such as last mile connectivity to ports and mines.

Some states have taken their own steps to motivate private sector investment in market infrastructure, including financing of port facilities and connector roads. Maritime handling capacity has nearly tripled over the past decade, largely through private investment. The private sector also plays the predominant role in capital formation in agriculture, accounting for nearly 80 percent of investments, compared to about 50 percent in the early 1980s.<sup>81</sup>



## Remove barriers to internal, regional and global agricultural trade

An enabling environment for market development and trade — with transparent and consistently enforced laws, regulations and policies — is central to meeting global food needs, providing greater income opportunity to farmers of all sizes, and building out agricultural value chains. Multi-lateral trade agreements and the **World Trade Organization (WTO)** are critical for advancing international investment and cooperation in agricultural development. Regional and bilateral trade agreements also improve access to food and agriculture products for nations that cannot meet their own demand through local production. GHI advocates trade policy that is forward-looking and innovative so that farmers of all sizes may take advantage of market opportunities.

### INDIA'S POLICIES

India is a net exporter of agricultural products, with a \$22 billion trade surplus in 2013. Rice, cotton and fish are the leading exports, and it is the largest bovine meat exporter in the world.<sup>83</sup> It is the top world importer of edible oils and pulses.<sup>84</sup> Thus, both imports and exports are important to the country's food security.

## NEW FOOD SECURITY LAW INCREASES GOVERNMENT SUBSIDIES

Nutrition policy in India focuses primarily on access to food through three large programs. On-site cooked meals and distributed weaning foods are provided through the **Integrated Child Development Services**, which promotes growth and development of pre-school children in rural, tribal and poor urban neighborhoods. The **MidDay Meals Scheme** serves primary and upper school children throughout the entire country. The **Public Distribution System (PDS)** is the largest program — providing subsidized food grains through **Fair Price Shops**.

In 2013, India enacted a new **National Food Security Act** that in 2014 will nearly double the number of people who are eligible to receive benefits through the PDS. The government will therefore become an even larger buyer of wheat and rice, the mainstays of food security programs. It will require much higher government outlays to buy grains from farmers at guaranteed minimum prices and then sell them at low prices to beneficiaries, which could breach India's WTO obligations to contain domestic agricultural subsidies at 10 percent of agricultural output.<sup>85</sup>

India therefore insists that the WTO give more flexibility for food stockpiling by developing countries for their food security programs and is seeking upward adjustments in base prices used for calculating domestic subsidies. At the WTO Bali Ministerial Conference in December 2013, the members agreed to address stockpiling by 2017, and, until then, to hold harmless developing countries that helped poor farmers by procuring food that would be used for food security needs.<sup>86</sup> India believes it is important to settle these issues now, not in 2017. In July 2014, India held up action on the WTO's trade facilitation agreement, indicating it would continue to do so until its concerns are addressed.<sup>87</sup>

India's trade policy is designed to achieve self-sufficiency in grains, reduce import dependency and promote commercial exports. During the 2000s, the country shifted away from quantitative import restrictions to higher tariffs designed to protect against import surges that could displace local production when world market prices fall. This was accomplished by renegotiating tariff limits under the WTO, setting higher maximum rates for products that the country wants to protect

for domestic production such as corn, rice and dry nonfat milk. India still uses export restrictions when concerned about domestic supplies, but to a lesser degree than in the past. For example, reduced monsoon rains this year caused concerns about onion supplies and the government took steps to discourage hoarding, allowed imports, and set minimum export prices, but it did not ban exports.



## Can New Policies Unleash Growth?

Some of the policies intended to assure self-sufficiency and protect smallholders now pose challenges to expanding agricultural productivity and marketing.

- » While the minimum support price for wheat and rice worked to incentivize production, it is less useful now as the **Food Corporation of India's (FCI)** infrastructure for procurement and storage is focused in just a few states despite shifting demand to other products.
- » The **Essential Commodities Act** limits the amount of warehousing available to the private sector, creating a barrier to developing efficient market systems.
- » Landholding is limited to about 18 acres with restrictions on leasing and average farm size is 1.16 hectares.<sup>88</sup> Such fragmentation makes it difficult to build economies of scale at the farm level and to link into value chains.
- » Fruits and vegetables are reserved for small-scale industry processing, which has impeded industry growth and increased wastage because small processors cannot afford the cold-chain development and handling costs for perishable foods.
- » Organized retail could build out value chains for perishable and processed foods. Officially, up to 51 percent of FDI in multi-brand retail operations is permitted and a few states have implemented that law, but due to some policy uncertainty, many foreign companies are hesitant to invest.

***In cases where reforms have been introduced, many studies show that "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."***<sup>89</sup>



## Strengthen and coordinate international development assistance

The 2009 Group of Eight Summit in L'Aquila, Italy, marked a new beginning for global food security and agriculture policies. Governments rallied around a comprehensive, coordinated approach that leverages public, private and multi-lateral assistance in support of well-designed plans by developing countries to transform their agricultural economies. Change takes time and GHI seeks continued support for the global food security agenda and urges members of the international donor community to meet their promised commitments to global food security and agriculture.

### INDIA'S POLICIES

India plays a dual role in foreign assistance — providing support and technical assistance to less developed countries and receiving multi-lateral financial support for its own investment plans.

India participates in **USAID's Feed the Future (FTF)** programs for sustainable agricultural intensification and climate resilient crop. In 2010, the United States and India entered into a

Triangular Cooperation agreement, a joint effort for transferring agricultural innovations proven in India to Kenya, Malawi and Liberia.

Indian research and academic institutions collaborate with institutes in many other countries on research and through teacher and student exchange programs. One example is a partnership between **St. John's Research Institute** in Bangalore and **Tufts** and **Harvard Universities** in Boston to address the need for trained nutrition scientists in the region.

The **World Bank** has been a major funder to India for years. In fiscal year 2014, it provided \$5.109 billion in loans for 17 new and supplemental programs.<sup>90</sup> Some of these projects are important for agricultural development, including dedicated rail freight corridors, road modernization, watershed management and support for dairy development.

India is a member of the **BRICS** (i.e., Brazil, the Russian Federation, India, China, and South Africa), a group of countries that is growing in economic influence and is creating its own approach to development. On July 15, 2014, they established a "contingent reserve arrangement to forestall short-term balance of payments pressures, provide mutual support and further strengthen financial stability," pledging a total of \$100 billion as the first tranche.<sup>91</sup> Notably, this institution is exempt from the economic adjustments and contingencies that the **International Monetary Fund** requires before lending money to a country.



Photo courtesy of John Coonrod/The Hunger Project

## GENDER REVOLUTION IN INDIA

India's Constitution calls for a strongly decentralized and participatory state and local democracy. The implementation of this federal structure and policy devolution, however, varies across India's 29 states and seven union territories. Local governments are under the authority of state governments and are divided into urban authorities, or municipalities, and rural authorities, or panchayats. Amendments to the Constitution in 1993 require each panchayat and municipality to reserve a minimum of one-third of the seats in its elected government bodies for women. Implementation of this quota has varied among states. More recently, 10 states have now adopted a 50 percent reservation of seats for women. For example, the southern Indian state of Kerala encourages all Gram Sabhas (elected assemblies) to have a majority of women members.<sup>92</sup>

Women are highly motivated to improve the health of their communities and their participation in government can have an enormous impact.

**The Hunger Project**, a global movement committed to ending hunger by organizing leadership, training and education, has helped women become leading decision-makers and change agents in their villages. To give greater voice to women in government bodies, The Hunger Project-India organized 118 **Strengthening Women's Leadership Workshops** across India, and has trained more than 87,000 elected women leaders in effective methods for identifying and advocating for local development priorities. These women have successfully brought potable water, health care services and education to their villages. More than 900 women from the State of Odisha became polling agents and proposers/seconders, who specialize in helping women candidates qualify for and register to participate in local elections.<sup>93</sup>

Since the Constitutional requirement for women's representation applies only to local government, women across the country are now rallying the national parliament to pass the **Women's Reservation Bill**, which would ensure that one-third of the seats in national and state assemblies are also reserved for women. This bill passed the upper house in 2010, but the lower house yet to act. Currently, women only hold 11 percent of seats in both lower and upper houses of the national parliament.<sup>94</sup>

Literacy, education and skills development are also critical to advancing women's role in society. India's free and compulsory primary education as well as the Mid-Day Meals scheme have helped increase literacy rates overall — the proportion of Indian children above the age of seven who are able to read and write increased from 65 to 74 percent between 2001 and 2011. Nonetheless, there is disparity between men and women — the literacy rate for males is 82 percent and for females 65 percent.<sup>95</sup>

Setting a tone of respect for women and emphasizing their importance as equal partners in the development of the country, on August 15, 2014, in his first Independence Day speech as Prime Minister, Narendra Modi said, "Girls also contribute to India's fame and glory. Let's recognize it. Let's take them along, shoulder to shoulder. This way we can get over the evils that have crept in social life."<sup>96</sup> In June, the Modi government announced the launch of a country wide '**Beti Bachao-Beti Padhao**' (save girl child, teach girl child) campaign to protect and educate girls and prevent crimes against women.



# INDIA'S AGRICULTURAL VALUE CHAIN

An agricultural value chain (AVC) is the sequence of steps from production through delivery of a product to the consumer, which includes feedback between the participants in the chain to create efficiencies and to provide more desirable and better quality products. Ideally, AVCs will offer opportunities at each link for increasing productivity, reducing waste and loss, providing economic and social benefits, and protecting the environment and natural resources. To ensure AVCs efficiently provide benefit from producer to the consumer, GHI's five strategic policy goals introduced on page 24 create the enabling environment that will allow India to conserve natural resources, adapt to climate change and consumer preferences, and improve nutrition and livelihoods.

## FIVE STRATEGIC POLICY GOALS



### FARMERS/PRODUCERS

Producers need technology and information to improve quality, increase crop and animal output and reduce post-harvest losses, while conserving resources and minimizing the impact on the environment. In India, collaboration among state and national governments, research institutes, agricultural industries, service providers, agro-businesses and farmers can foster the use of improved seed varieties, conservation farming practices, labor-saving machinery, better animal nutrition and disease management, efficient irrigation systems, and efficient post-harvest systems for the delivery of more diverse and wholesome foods.



### AGRICULTURAL SERVICE PROVIDERS

Specialists in agronomy, plant varieties, pest and disease control, animal nutrition, conservation, post-harvest technologies, business development and financial management are among the service providers that help producers obtain finance, run successful agricultural operations and expand into value-added agricultural businesses. Indian agricultural producers need greater access to expertise and resources from universities, veterinarians, government research institutes, financial firms and agricultural product companies to increase productivity and incomes. One successful approach used by agricultural input and equipment dealers is the deployment of agents to visit farms and provide advice in person and through handheld tablets or phones.



### AGGREGATORS/MIDLEMEN

While some producers have large on-site storage facilities to maintain quality and freshness, most need to store some or all of their produce at specialized warehouses. They can sell their produce directly to the warehouse owner or pay storage fees and sell it over time. Farmer cooperatives effectively aggregate and market agricultural goods on behalf of small-scale producers, and also help farmers access inputs and services at lower prices. In India, with a few exceptions, State Agricultural Produce Marketing Committee (APMC) Acts govern the marketing of agricultural products by farmers. The APMC designates marketing areas within the state and farmers are required to pay a fee and sell their produce in those markets to licensed middlemen, who then sell to processors, wholesalers, retailers and others. The government's Food Corporation of India buys from farmers wheat, rice and sometimes other commodities, which are stored and used for national food security programs. Cooperatives are very strong in some food sectors and, in some states, private firms can contract to buy directly from farmers without paying commission fees.



### FINANCIAL SERVICES

Access to credit on reasonable terms stimulates the expansion of agricultural value chains. India provides seasonal crop loans to producers of all sizes through commercial banks, cooperative banks and Regional Rural Banks, with lower rates available for small and marginal farmers. Warehouse receipts may be used by farmers as collateral against agricultural loans, but it is a nascent industry and mainly available to larger producers and processors. Government supported loans are also available for specific agricultural uses, such as dairy, land acquisition and machinery, and commercial loans are available for a range of agro-business investments.



### RISK MANAGEMENT

Agriculture production and marketing is subject to numerous risks, including price and weather fluctuations. A variety of services, such as insurance and commodity exchanges, are available to make agricultural investments less risky but they are not widely available in India except for a few crops. Exchanges function well when the contracts reflect the typical size, quality and terms of sale for the particular commodity, and the price discovery process is based on market forces and unlikely to be altered by unpredictable government actions or a few large traders.



### AGRO-PROCESSORS

Agro-processors add value to raw agricultural products and provide employment and opportunities for nutrient fortification and expanded markets. They need access to the equipment, infrastructure, services and human resources necessary to support operations and reach retail markets. Investment decisions are also influenced by whether a country's tax, tariff, trade, manufacturing and food safety policies are fair and consistently applied. India has many small- and medium-sized processors, such as village mills, as well as large companies and cooperatives that process and manufacture food.



### RETAILERS

Rising incomes and diversified diets worldwide have led to many different forms of retail, including farmers' markets, specialized food stores and supermarkets. Retail food in India is predominantly comprised of small and family-owned businesses. Multiple taxes and regulations at the national, state and local levels, limitations on foreign direct investment, and the APMC system — which does not allow direct buying of produce from farmers — have created barriers to and increased the costs of aggregation and integration. Nonetheless, with rising incomes, urbanization and diversification of diets, organized food retail has been growing, including supermarkets and chains, and the Indian government is placing greater emphasis on expanding this sector. As part of India's Public Distribution System, Fair Price Shops sell foodstuffs at subsidized prices to eligible beneficiaries.



### CONSUMERS

Meeting consumer expectations and needs are paramount in the AVC. As consumers become more affluent and discerning, they seek more fruits, vegetables, meat, fish, dairy, poultry and processed products, which, in turn, provides opportunities for agricultural producers and processors to grow and capture the value of higher-priced goods. Indian consumer interest in diverse and healthier foods is growing, and the government and industry are exploring ways to meet those demands and to address nutrient deficiencies.

# CULTIVATING PROSPERITY THROUGH STRONGER AGRICULTURAL VALUE CHAINS



**India is on the threshold of a new agricultural revolution.** Livestock, fisheries and high-value crops are needed to feed a growing population and an even faster growing middle class, while grains and legumes continue to be the mainstay of the diet. Doors are opening wider for exports — cotton, spices, processed and fresh produce, buffalo meat, dairy products, seafood and spices. Research institutes and the private sector are developing new technologies and agronomic practices to conserve natural resources and increase yields. Agro-companies and retailers are eagerly looking for opportunities to invest and expand. Urbanization, a large off-farm rural workforce and more women seeking employment creates a pool of labor for expanding the country's food industry. All together, growth in the food and agricultural sector offers India a more prosperous, food secure future.

This section of the GAP Report® presents case studies from India that demonstrate how successful value chains can be both productive and sustainable by conserving natural resources, adapting to climate change and consumer preferences, and improving nutrition and livelihoods. GHI's five strategic policy goals create an enabling environment to encourage investments in transport and infrastructure, research and extension, and innovative financial services that drive inclusive economic growth. Accompanying each case study in this section of the report are icons that symbolize which policy goals contribute to its success.



The **Economist Intelligence Unit's (EIU) Global Food Security Index (GFSI)**, sponsored by **DuPont**, is a powerful data-driven tool to understand the root causes and drivers of food security. A set of tested indicators is used to evaluate the food security performance of the 107 countries where quality data is available, allowing global and regional comparisons. The GFSI is updated regularly, revealing trends that can be used by governments, NGOs and the private sector to monitor progress and guide decisions.

The 2013 GFSI shows that India performs relatively well in assuring food availability and food safety, and in providing food for vulnerable and poor populations.<sup>97</sup> Overall, however, kilocalories, iron and protein available per day per person are in the low range. A key challenge is food affordability, particularly since India is vulnerable to food price shocks and has relatively high import tariffs. Other research indicates that the poorest 30 percent of Indian households spend an estimated 60 percent of their monthly expenditures on food.<sup>98</sup> Notably, the GFSI also ranks India low in public expenditures on agricultural research and development.

According to additional research conducted by the EIU, 85 percent of landholdings in India are less than 2 hectares and smallholders represent 44 percent of land under cultivation.<sup>99</sup> Over 40 percent of smallholders are from Scheduled Castes and Tribes, which are socially disadvantaged groups. Small-scale producers face a variety of disadvantages, including low penetration of institutional credit, higher production costs and limited access to inputs, services and value-added opportunities. Contract, collective and cooperative farming are some of the approaches that have helped improve access to inputs, services and markets for small-scale producers.

To learn more about food security and agriculture in India and 106 other countries, visit the GFSI website at <http://foodsecurityindex.eiu.com/>.



## TAILORING TECHNOLOGIES FOR ALL FARMERS

The average farm size in India is 1.16 hectares. Getting more value out of farmland, conserving water use and improving productivity without expansion to marginal lands is critical for income growth and sustainability of both small and large farm operations, and for preserving India's natural habitat. The country's research institutes and the private sector are developing technologies that, when applied by farmers, can meet the objectives of producing more with less, adapting to climate change and improving food security for all.



### ADAPTING TO CLIMATE CHANGE

Changing climatic conditions and extreme weather events are particularly treacherous for small, resource-poor farmers who do not have fallback savings, alternative income options or insurance. The **Indian Agricultural Research Institute (IARI)** was the lead agency in a World Bank supported **Climate Change Adaption Project** to test technologies and strategies for sustainable livelihood security in rural communities that are vulnerable to climate risks in the Mewat District of Haryana State.<sup>100</sup>

Mewat is a low rainfall, drought-prone area. Analysis of past weather data (1969–2005) showed that the mean minimum temperature increased at the rate of 0.18 degrees Celsius every 10 years during the monsoon (Kharif) season, and by 0.47 Celsius every ten years during the dry (Rabi) season. Between 2020 and 2050, temperature change is expected to accelerate, with minimum temperatures increasing by 1.87 degrees Celsius during the monsoon season and by 2.73 percent during the dry season. Based on these findings, along with an analysis of the bio-physical characteristics of the region and participatory rural appraisals of socio-economic stresses, IARI developed a customized set of interventions to conserve resources, adapt to climate changes and improve livelihoods.

Superior seed varieties were tested and the successful ones are being made available through village seed banks. Heat stress tolerant varieties



*Abundant vegetable yields, such as this eggplant crop, increased incomes in the IARI Climate Change Adaption Project in Haryana State.*

Photo courtesy of IARI

of wheat — which is the major dry season crop — were introduced, increasing yields by 12 to 18 percent. Conservation farming practices were also introduced, as well as integrated pest management and soil nutrient management.<sup>101</sup>

Before the program, farmers had typically pumped groundwater and flooded their fields to irrigate wheat and mustard crops, a process that lacked precision, and much of the water was lost to ▶▶

evaporation. Laser leveling of farm land improved water use efficiency for wheat and mustard crops by about 15 to 20 percent. Underground pipeline was laid in farmers' fields and used for delivering drip irrigation, which resulted in an additional 40 percent savings. Overall irrigated area increased by 45 percent and cut labor hours required for irrigating crops by 28 percent.<sup>102</sup>

Another important strategy to help farmers adapt to climate change and improve nutrition is to plant diversified crops. High yielding varieties of chili, eggplant, tomato and onion, accompanied by improved production technologies (e.g., raised bed planting, starting seedlings in a nursery, and micro and sprinkler irrigation) increased household profits by US\$495 (INR 30,000) per hectare. Households that planted diversified crops had incomes that were 44 to 86 percent higher than households that maintained conventional cropping of just pearl millet, wheat and mustard.

Farmers in Mewat were also given access to an information and communications technology platform, **mKRISHI**, which is operated by **Tata Consulting Services**. Using their mobile phones, farmers and farmers' groups are connected to weather forecasting and agricultural production advisory services.

Thanks to the Climate Change Adaptation Project, communities in Mewat obtained higher yields and incomes; irrigation was expanded and efficiency of water use was improved; and, for long-term sustainability and continued economic growth, village seed and resource centers were developed. ■



## REVIVING INDIA'S RICE BOWL THROUGH DEEP WATER RICE

The east coast region of India is considered the rice bowl of the country, but that role is fading due to low productivity. Construction of roads, embankments and canals on both sides of rivers, siltation in river beds and congested drainage channels have led to rising groundwater tables and waterlogged soils. During the monsoon season, rice is the only crop that farmers in coastal areas can grow, but prolonged waterlogging interferes with plant growth. Heavy rainfall early in the growing season submerges the plants at the seedling stage, and can irreparably damage a crop. Combined with increasing salinization, these challenges threaten the livelihoods of the farmers, who each cultivate, on average, only 0.75 hectares of land.<sup>103</sup>

The **Directorate of Water Management of the Indian Council of Agricultural Research (ICAR)** concluded that strategies are urgently needed to enhance the productivity of the coastal waterlogged ecosystem. Among the eastern states, Odisha is most affected since the Bay of Bengal is the center of low pressure systems that cause heavy rains and cyclones.

Studies were conducted between 2007 and 2010 to test different technologies and production strategies. An integrated, multi-seasonal approach was found most successful for improving incomes and productivity. Establishment of the rice crop before the onset of flooding in the monsoon



*Deep water rice cultivars can thrive in excess water.*

Photo courtesy of IRRI

season and adoption of deep waterlogging tolerant rice varieties give farmers the best chance to increase profits.

Based on the recommendation of ICAR, the Odisha government adopted the deep water rice cultivar "Hangeswari" for large-scale seed production through its state farming system. Partner institutes in Odisha introduced technologies that use excess water to create fish and duck ponds, providing an additional source of income and food. Strategies for the dry season include planting of saline-tolerant vegetables and the construction of tube wells that are deep enough to reach fresh water.

ICAR and its partner institutes organized village level training and awareness sessions to introduce the new technologies and cultivation practices. These efforts continue through agricultural institutions and extension services in the State of Odisha, creating more sustainable livelihoods for the residents of flood-prone, rural coastal areas. ■





## TIMELY ADVICE TO HELP FARMERS AND CROPS

To meet the evolving challenges they face, farmers not only need high quality seeds but good partners as well. Access to information and insights from others can make a huge difference in crop productivity. Farmers require timely and relevant information to make decisions about when to plant and harvest their crops, the most efficient cultivation and irrigation practices to use, and how to manage pests and volatile weather conditions. Many companies have developed services to meet those needs. One example is **Monsanto Farm AgVisory Services (MFAS)**, which provides Indian farmers with customized, timely information available in seven languages (Hindi, Marathi, Gujarati, Telugu, Kannada, Punjabi and Bangla) to help them achieve the best results with each crop. MFAS provides support to Monsanto's farmer customers, free-of-charge, throughout the production cycle for cotton, corn and vegetables (hot pepper, tomato, cabbage and cauliflower).

MFAS has a three-level support system. At the first level, a farmer calls a toll-free number from her/his phone and accesses an advisor at the call center who answers the farmer's questions. If the Advisor is not able to resolve the query, it is escalated to a technical expert who reviews the issue and comments that same day. If the case is not solved by the technical expert, it is escalated to Monsanto's field team members, who personally visit the farmer's field, evaluate the problem and devise a solution. On average, the turnaround time is one to four days.

More than 1.3 million Indian farmers in 18 states are registered to use MFAS. Experts visit farms regularly and gather information about cropping patterns, soil, water and other conditions. Those data can be accessed by an Advisor when a farmer calls with a question or concern. Among other things, MFAS collaborates with farmers to help identify and manage pests, address slow growth and determine which fertilizer blend to use and when to use it. In 2014, the platform expanded SMS (text-based) to provide farmers with agricultural advisory services including real-time information on market prices, weather alerts and other support services. The expansion will reach an additional 1.3 million local farmers in three states.<sup>104</sup>

This year, farmers made 400,000 calls to MFAS and 16 million advisories were sent via SMS to customers. Assuring that farmers get advice and solutions when they need it makes a huge difference in crop performance.<sup>105</sup> ■



*Experts visit a farm family's home to collect information, determine the source of problems and identify solutions to help farmers.*



*MFAS Call Center Advisors respond to farmers' inquiries.*



## PUBLIC-PRIVATE PARTNERSHIPS MAKE FARMING PROFITABLE FOR LOW-INCOME COMMUNITIES

Resource-poor Indian farmers have a particularly hard time accessing information, inputs and equipment that can improve their yields and incomes. India is home to over 700 tribes, comprising 8.6 percent of the population.<sup>106</sup> Their communities have distinct cultural and social norms, are fairly isolated from the general population and are typically located in forests and hilly areas of the country. Scheduled Tribes are considered a disadvantaged class under the Constitution and Indian law and are afforded special consideration for education and economic advancement and protection from social injustice and exploitation. They are mainly agrarian and as a class, the poorest segment of the population.



### MODERNIZING AGRICULTURAL PRODUCTION IN GUJARAT

**John Deere India** has a world-class technology center and five manufacturing facilities in India. It is the largest exporter of tractors from India and the company employs 6,000 people. Recognizing that many farmers lack access to financing for equipment, the company also provides financing to buyers and works in partnership with local communities and state governments to help small farmers gain access to modern equipment.<sup>107</sup>

The **Government of Gujarat** and John Deere are working with tribal communities in a public-private partnership that helps farmers upgrade to modern methods of farming, reducing drudgery (monotonous heavy labor) and increasing incomes. The company set up an **Agricultural Implement Resource Center (AIRC)** that is supplying 50 tractors to tribal farmers in five districts through a subsidized loan financed by the Government of Gujarat.

The government pays John Deere a fixed sum for its services and monitors project implementation. After five years, the operations will be transferred to the Tribal Farmer Federations. Until then, the company repairs and maintains the equipment at subsidized rates and trains the operators and mechanics who will continue to work for AIRC after it is transferred to the Federations. Four partner NGOs identify the beneficiaries within the tribal communities, develop the Federations, and provide agricultural extension services.



*Women participate in training as part of the John Deere partnership with the Government of Gujarat.*

In its first three years, May 2011 through April 2014, the program exceeded expectations, assisting an average of 12,714 beneficiaries per year (25 percent above the 9,600 beneficiary target) and covering an average of 11,957 acres per year (20 percent above the 9,600 acre target). The enthusiastic response from the tribal communities and the five years of training and hands-on experience provided for operators and mechanics sets the stage for successful continuation once John Deere management of the project ends in 2016. ■



## ECONOMIC SELF-SUFFICIENCY THROUGH IMPROVED TECHNOLOGY

Public-private partnerships are helping farmers gain access to improved technologies and skills in India. In 2009, **Monsanto India** and the **Government of Rajasthan's Department of Agriculture** joined in a partnership called Project Golden Rays to empower low-income farm families with improved seeds, inputs and skills.

Project Golden Rays dispensed inputs and primary information through 977 distribution centers mapped to the locations of village councils (Gram Panchayats). Monsanto hired 220 Market Development Officers (MDOs), each covering 20–25 villages, to assist farmers with input management, share information about the best agronomic practices and trouble shoot throughout the crop production cycle.

State governments contributed to the project by identifying eligible farm families, providing financial support for seeds and inputs and assessing outcomes. Awareness-raising campaigns by village councils generated strong farmer participation. Within two years of the project's launch, 783,000 farm families saw their maize yields improve by 200 percent and their incomes increased 175 percent.<sup>108</sup>

The success of this project paved the way for another project in **Odisha**, where maize is grown mostly in tribal districts during the monsoon



*Monsanto India collaborated with the Government of Rajasthan in Project Golden Rays, which within two years, increased maize yields by 200 percent and incomes by 175 percent for 783,000 Below-Poverty Level farm families.*



*Local village leaders and buzz campaigns raised awareness of the project and 220 Market Development Officers were hired to assist farmers throughout the crop cycle.*

season in non-irrigated uplands. With increased demand for maize, commodity prices have been rising and farmers prefer maize as one of their key cash crops. Before Project Golden Rays began in 2013, Odisha farmers tried using high-yielding hybrid maize seeds, but poor management practices and cultivation on marginal land resulted in sub-optimal yields.

The **Government of Odisha** partnered with Monsanto India to conduct the project on 8,000 hectares in five tribal districts. High-yielding hybrid maize seeds customized to the local geography and agronomic conditions were chosen. Monsanto

provided advice and assistance to farmers throughout the planting cycle. As a result, maize farmers in Odisha were able to increase yields and improve their quality of life through enhanced incomes.

Golden Rays has demonstrated the importance of collaboration and customized extension services to help farmers and their communities. It has become a model for public-private partnerships that is being adopted by many state governments and private companies. ■



# EXPANDING THE ROLES, OPTIONS AND INCOMES OF WOMEN IN AGRICULTURE

Achieving better access to information, updated technologies, financing and marketing options is a challenge for many small-scale producers. In India, it is particularly challenging for women farmers due to social norms that limit women's mobility, access to skills-training and financing, or control over their incomes and household investment decisions. This section features two programs that have helped women overcome these barriers.



## FARMERS' GROUPS AND EXTENSION SERVICES EMPOWER AND INCREASE INCOMES OF WOMEN FARMERS

**Agribusiness Systems International's (ASI, an affiliate of ACDI/VOCA) Sunhara ("Prosperous") Project in Uttar Pradesh** demonstrated several successful approaches for empowering women farmers. From 2009 to 2013, Sunhara increased economic opportunities for 25,000 smallholder farmers engaged in fruit and vegetable production by introducing improved production and post-harvest technologies and practices and by linking farmers to buyers, local retailers and exporters. ASI conducted the project in partnership with several Indian NGOs and six private sector partners, including **PepsiCo** and **Bharti Walmart**. Participating farmers increased their incomes by 87 percent and established hundreds of groups — 277 of which are women-only — that facilitate



*After harvest, crated cabbages are quickly transported to markets.*

cooperative action, economies of scale and ongoing access to financing, inputs and high-value marketing options.<sup>109</sup>

From the beginning, the project set a goal of ensuring women comprised at least 25 percent of participants. According to a gender-impact assessment of Sunhara conducted in March 2013, women participants had notable increases in mobility, decision-making in the household and control over their incomes.<sup>110</sup>



*The Sunhara Project trained smallholder farmers to produce high-value crops and increased women's income and status.*

Photos courtesy of Agribusiness Systems International (ASI), an affiliate of ACDI/VOCA

Training extension agents in gender awareness and equality was a critical factor in the project's ability to increase the stature, productivity and incomes of women. Agents were innovative and enthusiastic, going beyond the scope of their duties to respond to requests for advice and training from men and women alike.

Women farmers' groups also played a key role in their empowerment. In areas where these groups were established, there was greater management and control by women over production and marketing decisions. ■





## WOMEN OVERCOME BARRIERS TO INTRODUCE IMPROVED AGRICULTURAL PRACTICES

The **UN International Fund for Agricultural Development (IFAD)** is supporting the **Tejaswini Rural Women's Empowerment Program (TRWEP)** to facilitate social and economic empowerment in the six poorest districts in the State of Madhya Pradesh, where there is little resource or technology utilization and limited livelihood options or access to markets and credit. The state government, banks and beneficiaries are co-funding the project and the Department of Women and Children's Development is the implementing agency. Since the Tejaswini Program's start in 2007, more than 12,000 Self-Help Groups (SHG) have been formed, which provide the platform for social/gender equity discussions, savings groups and livelihoods, skills and leadership training.<sup>111</sup>

The program targets 166,000 of the poorest households by supporting 12,442 SHGs. The key achievements as of September 2013 were:

- » 82 percent of the households now have cash income and need not rely solely on bartering, compared to 47 percent with cash income in control villages;
- » 86 percent of participating households have improved food security and reduction in occasional food shortages; and



*In the System for Rice Intensification (SRI), Women farmers spread nutrients in unflooded fields to prepare nursery beds for seeds.*

Photos courtesy of IFAD

- » in participating villages, 1,809 SHG members were elected to Panchayati Raj Institutions (village assemblies that develop economic and social plans) and 62 percent of the members of the assemblies were women, exceeding the 50 percent reserved for women by law.

The Tejaswini Program introduced the **System for Rice Intensification (SRI)**, using high-yielding certified seeds that are first tested for germination and then sown in a nursery with the right amount of water to ensure quality seedlings. Within eight days, the seedlings are transplanted to the fields with uniform spacing. An NGO, **PRADAN**, demonstrated how the system worked and trained 124 village-level agents to provide field training and support to women farmers at each critical stage



*Weeders make it easier for women to tend fields once the rice starts growing.*

— nursery raising, transplantation and weeding. The **Madhya Pradesh Department of Agriculture** provided the certified seeds and inputs — including weeders, sprays, pesticides, manure and rope for lining up the rows.

At first, many women had difficulty convincing their families to allow them to try the new technologies. ►►



As one participant, Mrs. Kulasti, explained, “Neither my husband nor my father-in-law believed that I could learn something that would be useful for the entire family.”<sup>112</sup> Mrs. Kulasti’s family acquiesced to allow her to use half a hectare of their land to demonstrate the technique, but if her production was lower than their side (with the traditional method), then she would have to leave the house or work extra hours as a laborer to earn the deficit.

Mrs. Kulasti produced twice as much rice as her family on the same amount of land using substantially less seed. Her experience was similar to many other women and the high levels of productivity convinced other families to adopt the technology as well.

The success of SRI changed attitudes in the village — people were open to new ideas. Villagers started growing maize as a second crop and are also growing tomatoes, eggplant, coriander, spinach, spices and chilies in their backyards or on upper land. The village started making collective decisions about agricultural production — something they had never been done before.

Now, the Gadhar village has surplus food, extra income and almost no cases of child malnutrition. Men help with farming since they are willing to use the mechanical weeders, while hand weeding was considered women’s work. Women have more confidence and leadership roles, and they do not have to work as laborers in order to earn additional wages. ■



*Women are now producing abundant rice crops.*

Photo courtesy of IFAD



# RESEARCH AND COLLABORATION IMPROVE PRODUCTIVITY AND ECONOMIC GROWTH



## USER-FRIENDLY WEB-BASED TOOLS FOR DROUGHT MITIGATION

When drought strikes, U.S. farmers can rely on an abundance of tools that help mitigate the impact on their crops and livestock and adjust planting and marketing strategies based on local and global conditions. **The U.S. Drought Monitor** is a weekly map of drought conditions broken down by county. The Monitor's web-based tools convey to farmers the extent of drought and water insecurity for agriculture, helping farmers manage risk and become more resilient in hotter, drier climate patterns.

The U.S. Drought Monitor is a joint effort of the **National Oceanic and Atmospheric Administration (NOAA)**, the **U.S. Department of Agriculture (USDA)** and the **National Drought Mitigation Center (NDMC)** of the **University of Nebraska-Lincoln**. The maps are released each Thursday morning at 8:30 a.m. (Eastern), based on data through 7:00 a.m. the preceding Tuesday. The map is based on measurements of climatic, hydrologic and soil conditions as well as reported



impacts and observations from more than 350 contributors around the country.

USDA uses the U.S. Drought Monitor for analyzing losses and allocating drought relief to farmers and ranchers through the Farm Service Agency, Livestock Forage Disaster Program and Livestock

Assistance Grant Program. Thanks to the user-friendly and visually dramatic presentation of data, both policymakers and the media are better able to convey and respond to the drought situations in farm country. During the severe drought of 2012, USDA streamlined the process for disaster declarations, making them nearly automatic for a county shown on the monitor in severe drought for eight consecutive weeks.<sup>113</sup>

Many countries, including India, are seeking to develop similar monitoring capabilities that can be adapted for their national agricultural contexts. Brazil and Morocco along with India are currently in dialogue with the NDMC to establish comprehensive drought monitoring capacity. The NDMC is providing strategic advice to the **Water Technology Centre (WTC)** of the **Indian Agricultural Research Institute (IARI)** and momentum is building for further collaboration. Effective drought monitoring and advisory services tailored for Indian agriculture holds great promise and must be prioritized for investment by the government, foundations, and the private sector to meet the challenge of climate change and drought. ■





## REVOLUTIONIZING COTTON

National average cotton yields in India have steadily increased since the 1970s, but most dramatically with the near doubling of yields from 2002 to 2012.<sup>114</sup> This coincided with the introduction of **Bt cotton**, starting with Gujarat and spreading to a total of nine states. Farmer surveys in leading cotton-producing states have shown that more than 6 million small-scale farmers are seeing positive yield impacts from Bt cotton. Today, Bt technologies are used in 90 percent of India's cotton fields.

Cotton plants with Bt technology have built-in protection against bollworm and other pests. Insecticide spraying for bollworms as a percentage of total insecticide use for cotton decreased from 46 percent in 2001 to 3 percent in 2011.<sup>115</sup> Together, the increased productivity and reduced expenditures on pesticides have benefited farmers.<sup>116</sup> In addition to the economic value, the significant drop in pesticide use has also had positive health benefits for farmers.<sup>117</sup>

India is now the world's second largest producer and exporter of cotton, which creates multiple value streams in the country. The plant's fiber is used domestically and exported for textiles. Cottonseed oil is extracted and refined, which has helped offset the edible oil shortfall in the country, supplying 1.2 million metric tons per year.<sup>118</sup> Cotton stalk biomass has potential to be used as feedstock for biofuel energy. Cottonseed meal, a byproduct that has a high protein content, is used for cattle feed. As with so many agricultural commodities, an innovative technology has unleashed numerous economic, employment and nutritional opportunities for producers, agro-businesses and consumers. The success of the Bt cotton value chain can serve as a model for how to improve other crop and livestock value chains in India. ■



## BORLAUG WHEAT RUST PARTNERSHIP

India is the second largest wheat producer worldwide. Wheat-based food, such as roti and chapatti, are staples of the Indian diet, providing 50 percent of the calories.<sup>119</sup> About 40 to 45 percent of wheat is retained by farmers for household use and as seed for the next season, leaving less than one-quarter of the crop for sale to private millers and traders. While there is a growing domestic market for flour, baked goods and other processed wheat products, the largest market share is wheat berries, which consumers have custom milled into atta, whole wheat flour derived from the entire berry.<sup>120</sup>

The Government of India dominates the wheat market, buying one-third of production over the past five years at a government-set minimum support price (MSP) that has been steadily increasing.<sup>121</sup> As a result, there is little private sector investment in the wheat value chain, and research and development into new varieties and to improve disease resistance is largely conducted by the **Indian Center for Agricultural Research (ICAR)** and **State Agricultural Universities (SAUs)**. ICAR and SAUs develop new varieties with higher yield and quality potential, but uptake by producers is low due to limited distribution and extension services. ►►

One of the major concerns for ICAR is controlling the spread of wheat rust, a disease produced by spores of the *Puccinia graminis* fungus that germinate on wheat plants, rapidly reproduce and feed off the plant, leaving it fruitless and destroying entire crops. Yellow rust, also called stripe rust, occurs in most wheat areas with cool and moist weather conditions during the growing season. It is the most serious constraint to wheat production in India.

Resistant wheat cultivars have been developed by Indian institutions and are available to farmers, but not all farmers recognize or have had access to extension services to learn the preventative benefits and ultimate savings that using the rust resistant seeds would provide. As a result, incidence of yellow rust remains high as farmers continue to use older varieties of wheat not recommended by ICAR.

In 2008, ICAR joined with the **International Center for Agricultural Research in the Dry Areas (ICARDA)**, the **International Maize and Wheat Improvement Center (CIMMYT)**, the **U.N. Food and Agricultural Organization (FAO)** and **Cornell University** to establish the **Borlaug Global Rust Initiative (BGRI)**, which is now a consortium of more than 100 researchers worldwide working to reduce vulnerability to stem, yellow, and leaf rusts. The initiative is named for Norman Borlaug, who won the Nobel Peace Prize in 1970 for his painstaking work to identify a gene that, when transplanted into wheat, enabled it to resist the *P. graminis* fungus.



*Yellow rust is a persistent disease of wheat worldwide, leaving wheat pods empty of seeds and thereby ruining the crop. In India, resistant seed varieties are available, but not all farmers use them, so the disease spreads.*

Photo courtesy of Directorate of Wheat Research, India

The BGRI is closely monitoring, researching and rapidly disseminating information about a new wheat rust pathogen, Ug99, that was discovered in Uganda in 1999. Since then, seven variants have been identified. It has spread to Kenya, Ethiopia, Sudan, Yemen and Iran and strains have also been found in South Africa and Zimbabwe. Because of its destructiveness and the economic and food security importance of its host, scientists are collaborating globally to find solutions before one of these strains enters India or other major wheat producing areas of the world. ■



*The Borlaug Global Rust Initiative is a global partnership to reduce vulnerability to all wheat rusts. It is closely monitoring and working on new technologies to limit the impact of Ug99, a new, highly destructive wheat rust pathogen discovered in Uganda in 1999 that is spreading in Africa and has crossed the Red Sea into Yemen.*

Photos courtesy of The Borlaug Global Rust Institute



# THE POULTRY REVOLUTION PICKS UP PACE



## WHICH CAME FIRST — DEVELOPMENT OF THE CHICKEN AND EGG INDUSTRIES

Domestic consumption drives India's poultry sector growth, with a 10 percent increase in broiler meat and 6 percent increase in egg production from 2002–2012. This has been accompanied by a change in production methods, shifting from native country birds to hybrids that provide increased hatchability, faster growth of chicks and more eggs or meat per bird. Advancements have been made in genetics, veterinary health, poultry feed and processing.<sup>122</sup>

Although the broiler industry is about 75 percent integrated, processing and retailing have not modernized quickly. Customers retain an overwhelming preference for live birds (92 to 93 percent of the market), creating barriers for greater access to safe, high quality poultry products. The high cost of feed ingredients and rumors of bird flu have created challenges for expanding production and maintaining profits. Long-term, the prospects for the industry are good and marketing strategies seek to capitalize on changing preferences towards convenience foods, fast-food restaurants and increased protein consumption.

The largest integrated poultry operation in India is **Suguna Poultry Farm Ltd.**, which had a turnover of \$450 million in 2007–2008 with more than 15,000 contract growers in 11 states.<sup>123</sup> Suguna provides contract growers with quality day-old chicks, feed, medicines and technical support and guidance. The company markets the output, paying producers an agreed price/kilogram based on weight gained, plus incentives for reduced mortality and improved feed conversion.

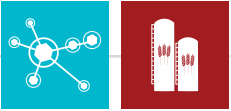
**Venkateshwara Hatcheries** is a contract broiler operation with a similar out-grower model, except contract producers sell the chickens at the fixed **BOMARK (All India Broiler Farmers Marketing Cooperative Ltd.)** price.<sup>124</sup> Growers receive any additional profits accrued if prices increase, and they get an incentive for increasing feed-conversion efficiency. ■

## PRODUCTIVITY FOR POULTRY FEED IN INDIA

Feed conversion ratio (FCR) is a measure of how well poultry convert feed intake (feed usage) into live weight. The best way to improve FCR is to provide poultry with good nutrition, reliable systems of feed procurement and production, good care and husbandry, and disease control to ensure efficient poultry and egg production. Recently, farmers in India of all sizes, have improved FCR using innovative, time-saving pre-mix feeds that combine feed with health and efficiency-enhancing technologies.

**Elanco India**, the Indian subsidiary of a global animal health company, supplies the poultry feed industry with modern, state-of-the-art feed additives and enzymes that improve nutritional content of the feed, thereby improving the productivity of meat and egg production per bird. Elanco also supplies medicines and vaccines that protect poultry from infectious disease. When combined with good care and husbandry, Indian poultry producers can ramp up production to meet the growing consumer demand for safe, nutritious and affordable food.

Elanco India has estimated that a five percent improvement in FCR means a national savings of \$180 million annually in the amount of corn and soymeal that must be produced for feed.<sup>125</sup>



## CORN FEEDS THE POULTRY VALUE CHAIN

Nearly 80 percent of poultry feed in India is comprised of corn.<sup>126</sup> As the poultry industry grows, so does the demand for corn. Maize production expanded from 12.04 million metric tons in 2001 to 14.71 million metric tons in 2006 to 21.73 million metric tons in 2011.<sup>127</sup> Expanding demand has improved prices, enticing more farmers to produce corn, and adoption of hybrid seeds is increasing yields per hectare.

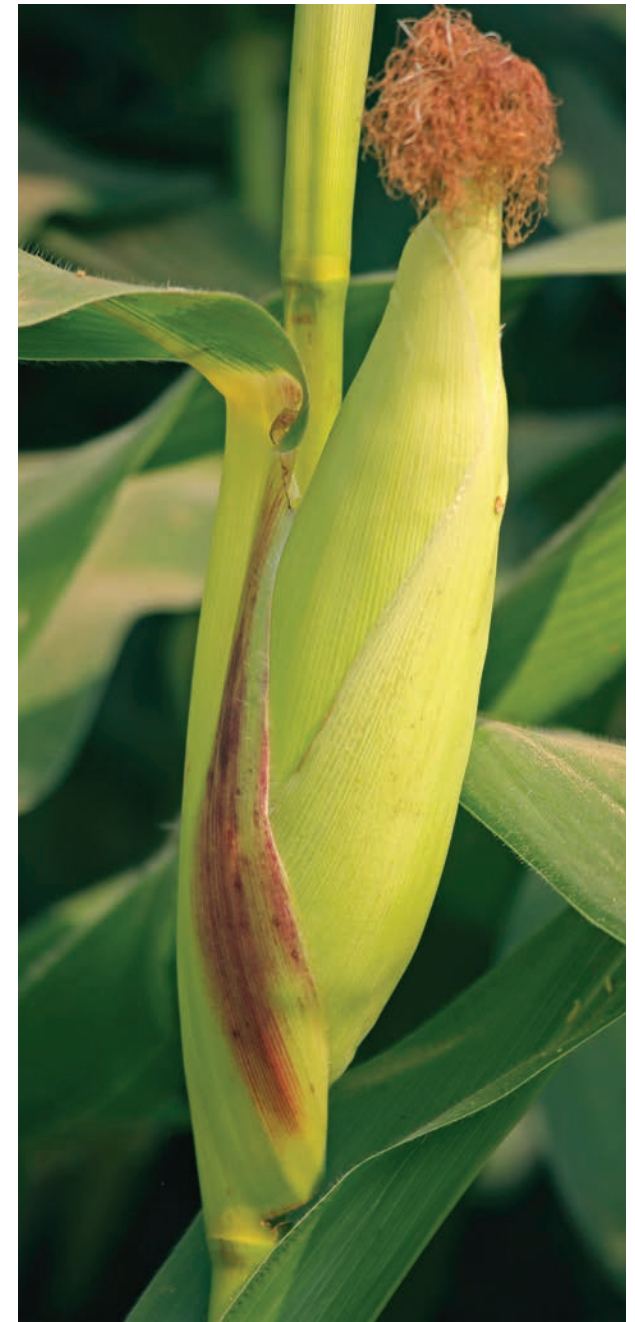
At the same time, the Indo-Gangetic plain aquifer is decreasing by an alarming 33 cm/year and the Indian government is encouraging farmers who grow rice in the three affected states to diversify from rice to corn, which requires one-fifth the amount of water to grow.<sup>128</sup> **DuPont Pioneer** is helping farmers make that transition in partnership with the **Government of Punjab**.<sup>129</sup>

Pioneer agronomists investigate which hybrids are most appropriate for each region, season and intended use and assure timely availability of the seeds. A package of optimum practices is developed — such as soil moisture levels, plant spacing and when, what types and how much herbicide, pesticide and fertilizer to apply. Training in crop management and economics is provided for government and farmer representatives who then provide ongoing extension services for producers.

Farmer meetings, social media campaigns and mass media coverage help raise awareness that technical assistance is available for those who wish to, or already have, diversified to corn production. The Punjab-Pioneer partnership is also facilitating sales to feed mills and the poultry and egg industries. ■



*DuPont Pioneer partners with Punjabi farmers providing extension services to produce hybrid corn to meet increasing feed demand for poultry and egg production.*



Photos courtesy of DuPont Pioneer India



# THE NEW WHITE REVOLUTION



## A FARMER-LED DAIRY VALUE CHAIN

In 1965, the **National Dairy Development Board (NDDB)** was established to transform dairying into an instrument for the development of India's rural sector. Farmer cooperatives sprang up around the country. They collected and processed milk and other dairy products and sold them in villages and cities. This endeavor, financed with World Bank assistance and known as **Operation Flood**, created a "White Revolution" by successfully increasing the incomes of 80 million farmers and expanding people's access to an important source of protein, minerals and vitamins.<sup>130</sup> Today, India is number one in milk production worldwide.

Despite this remarkable achievement, domestic liquid milk demand outpaces production. A growing (and increasingly urban) middle class seeks more diverse, processed dairy products — such as frozen desserts, flavored drinks and yogurts, and cheeses — and food manufacturing industries want to invest in and expand dairy processing. The barriers to meeting demand are low per animal milk productivity and inadequate village-level milk collection facilities with access to organized food manufacturers.

To address these two challenges, the Government of India developed a new **National Dairy Plan (NDP-I)** that, from 2011–2012 through 2016–2017, will provide \$454 million to NDDB to improve animal genetics and nutrition, expand bulk milk collection infrastructure, and create farmer cooperatives and companies in 40,000 villages across 14 states that account for 90 percent of total milk production.<sup>131</sup> A line of credit from the **World Bank Group's International Development Association (IDA)** finances some 80 percent of NDP-I, with the remainder consisting of Indian Government budgetary outlays.<sup>132</sup>

Increasing per animal milk productivity through improved genetics is a key facet of the project. Dissemination of high-quality semen to farmers to increase milk production per cow is critical for the future growth of the Indian dairy sector. Thus, to participate in the project, potential partners and locations at the state level (e.g., **Dairy Unions and Federations**) are vetted to assure they have the geographical and technical capacity to support the raising of bulls with desired traits and to produce, store and deliver disease-free, high quality semen in large quantities to farmers. The participating states must also commit to six regulatory reforms that facilitate artificial insemination services through private technicians and adopt minimum standards and protocols for breeding and to prevent and control infections. To date, the 15 participating states have substantially completed these reforms.



*India's National Dairy Plan is expanding bulk milk collection by farmer cooperatives and introducing improved animal genetics and nutrition to boost productivity and meet growing consumer demand.*

Photo courtesy of The World Bank

Improved animal nutrition is also critical for increasing production per cow. Local Resource Persons are trained to provide advice to farmers about balanced feeding regimens that increase per animal milk productivity, improve conception rates, reduce feeding costs and reduce methane gas emissions per unit of milk produced.

Increasing collection and sales of milk into the organized food industry sector is central to the NDP-I. This is accomplished by: (i) expanding existing **Dairy Cooperative Societies** to cover more villages; (ii) promoting the development of new milk producer companies that can meet the quality standards of dairy product manufacturers; and (iii) extending milk collection infrastructure to improve cold-chain management. ►►



In order to increase productivity more rapidly and fully and improve the economics of the dairy sector, there is also a movement toward modernized dairy farms. Some food processors, such as **Nestlé**, are helping farmers transition to larger farms with more cattle, improved genetics, modern facilities, mechanization and transfer of knowledge and technology for better feed and upkeep of animals.<sup>133</sup>

An organized dairy industry offers benefits to all parties engaged in the value chain, from farmers to consumers.<sup>134</sup> Nearly two-thirds of the money from milk sales is received by farmers, ultra high temperature processing enables longer shelf life and less loss of milk, with greater convenience to buyers, and demand for high-value products creates new opportunities for dairy manufacturers. For example, whey, a by-product in manufacturing dairy products like the fresh cheese called “paneer,” has not yet been fully utilized by the Indian dairy industry. It is highly nutritious and could be used more fully to boost the nutrient value of weaning foods, bakery products and dairy products.

Thus, NDDDB, through the National Dairy Plan, is advancing a new White Revolution by promoting high-quality, cost-effective technologies that help farmers increase milk production and by integrating milk production into the organized food industry sector. ■



*Farmers bring their fresh milk to collection centers, where it is tested for quality and processed for sale.*

Photo courtesy of The World Bank





# AQUACULTURE – THE BLUE REVOLUTION



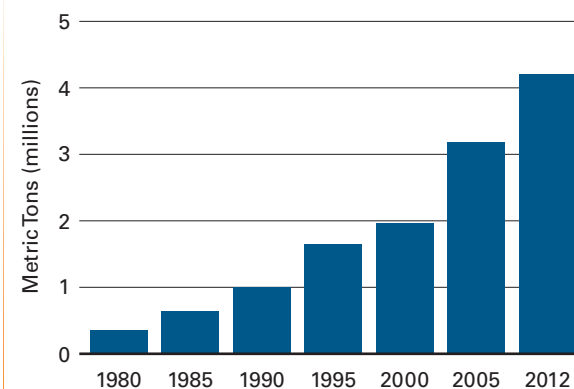
## FISH FOR INDIA'S FUTURE

Aquaculture is the process of breeding, rearing and harvesting plants and animals in water environments. Many types of fish and seafood are raised — or “farmed” — in this manner. Freshwater aquaculture primarily takes place in natural or manmade ponds while marine aquaculture takes place in enclosures in oceans, on the seafloor and sometimes in simulated marine water environments on land.

In India, aquaculture production has increased tenfold since 1980 (Figure 19). It has enabled inland and coastal communities to reap economic potential from previously unused and underutilized land and water resources, creating multiple socioeconomic benefits — elevated employment levels, increased incomes and substantial export and foreign exchange earnings.<sup>135</sup> Freshwater breeds include carp, catia, rohu, magu, freshwater prawn, freshwater pearl culture and ornamental fish. Brackish water is primarily used for shrimp production.<sup>136</sup>

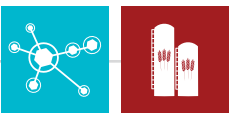
In the 1980s, during the early years of the industry’s development, coastal production dominated. But now inland fisheries dominate, accounting for 85 percent of production. Total

**Figure 19:** Reported Aquaculture Production in India, 1980–2012



Source: FAO: National Aquaculture Sector Overview Fact Sheets, India, 2014.

global market share is now more than 10 percent, which ranks India near the top for national aquaculture production.<sup>137</sup> Since fish and seafood businesses have created multiple positive benefits to the country’s economy and food security, India will strive to increase its position in the market and will continue to be a leading supplier in the years ahead. ■



## TECHNOLOGICAL ADVANCES IMPROVE FISH SUPPLY

India's government has identified catfish farming as a national priority and emphasizes diversification of practices in order to match demand with supply. In particular, new investments are stimulating further increases in development of aquaculture industries and capabilities.

The introduction of insulated fish trucks, for example, enables the transport of iced fish over longer distances, sometimes more than two thousand kilometers.<sup>138</sup> This technology allows for a bigger supply and distribution network in order to meet growing demand, as well as to minimize wasted product. Overall, the push is to develop technology that streamlines the post-harvest processing of aquaculture products. Because aquaculture products are extremely perishable after harvest, technology is desperately needed to keep products safe and fresh until they reach markets.

**Omnivore Partners** is a venture capital fund in India investing in early stage agriculture and food technology companies. The goal is to target investment towards innovations that increase agricultural sustainability, modernize agribusiness supply chains, and promote farm-sourced food products. Omnivore Partners has invested in **Eruvaka Technologies**, a company that has created technology for fish-farming diagnostics. These are floating sensors, mobile connections for automation, and other electronic decision tools that analyze data to help aquaculture producers



*Tilapia farm in Andhra Pradesh, India.*

Photo courtesy of The Rajiv Gandhi Centre for Aquaculture

minimize loss and maximize safety. Farmers purchase these sensors and are connected to their products 24/7 through a smartphone app. The patented 'Floating Sensor Buoy' is placed in a pond and monitors aquatic farm products with automated equipment including aerators and feeders. Farmers are able to measure and manage their ponds more efficiently due to the sensors' constant feedback. ■





Photo courtesy of Elizabeth Whelan/CHC

## BOOSTING MICRONUTRIENT INTAKE

Vitamin and mineral deficiencies are found in all Indian socio-economic groups. While 22 percent of the population lives below the poverty line, 65.3 percent of pre-school age children suffer from one or more symptoms of vitamin A deficiency,<sup>139</sup> and 70 percent of children aged six months to five years are anemic, as are 56 percent of women.<sup>140</sup> Other deficiencies include folate, iodine, B vitamins, vitamin D and zinc. Diets of low-income families are largely cereal based and they have the most pronounced micronutrient deficiencies.

Access to a greater variety of foods, dietary changes and better sanitary and hygiene practices are all necessary for addressing nutrient imbalances and deficiencies. India is moving in that direction and is also taking steps to enhance the nutrient profile of staple foods in order to assure widespread consumption of essential minerals and vitamins.



## STAPLE FOOD FORTIFICATION

**The Global Alliance for Improved Nutrition (GAIN)**, a Swiss foundation granted special international status by the Swiss government, is financially supporting implementation of India's national policy to improve nutrition through cost-effective fortification of staple foods in partnerships with private sector and government agencies. Fortification is a relatively straightforward technology to implement and it has a positive record of improving nutritional status in other countries where micronutrient deficiencies had been a problem.<sup>141</sup>

In Rajasthan, between 2011 and 2013, GAIN partnered with the **Institute of Health Management Research (IHMR)** to improve the nutritional quality of wheat flour, milk and oil — products that are consumed in high quantity by all population groups. Participating food processing industry partners bought the vitamin-mineral premix and were shown the process of fortification. Laboratory workers were trained in quality assurance and quality control protocols to assure the correct amounts of micronutrients were in the final products.

Workshops for print and electronic media helped spread the word about the advantages of consuming fortified foods to reduce micronutrient malnutrition. A social marketing and communications campaign, including displays in stores and information on the food packages,

raised awareness of the value of fortified products to human health and children's development.

Fortified wheat flour, oil and milk are now being made available through open market channels, and flour is also distributed through the **Public Distribution System (PDS)** to reach vulnerable populations. Technical assistance and some financial support are given to central kitchens for fortification of foods for the **Mid-Day Meal program** in public schools and the **Integrated Child Development Services**, which implements health, nutrition and developmental programs among socially disadvantaged groups.

The Rajasthan initiative and a similar one in Madhya Pradesh had a ripple effect. Other state governments also started providing fortified foods through their PDS and other food safety net programs. The success of the social media campaign stimulated private companies to take action on their own. **Britannia**, a well-known food manufacturer with a popular biscuit and other products, has fortified more than 50 percent of its product portfolio. **Cargill India**, a Business Alliance partner of GAIN, voluntarily fortified its entire refined edible oil range with vitamins A, D and E. Other companies have followed suit. **Mother Dairy**, which produces dairy products, fruit juices and edible oils, fortifies 50 percent of its oils and also sells vitamin A-fortified milk. **Bunge India Private Limited** fortifies its Dalda brand vegetable oils. ■



## SCALING UP NUTRIENT ENHANCED CROPS

Biofortification is the breeding of crops to enhance nutrient contents. In developing countries where a few staple foods comprise the bulk of the national diet, biofortification of those foods is an effective mechanism for assuring the consumption of sufficient amounts of micronutrients. It is particularly important for the poor since their diets are the least diversified.<sup>142</sup>

Lentils are important source of protein, vitamins and minerals in South Asian diets. Because they have small-sized seeds with soft seed coats, they cook in less than 30 minutes, which preserves more nutrients than the long cooking periods for pulses with hard seed coats. Research has shown considerable variations in iron and zinc content depending on the seed variety and the location where the plant is grown. The **International Center for Agricultural Research in the Dry Areas (ICARDA)** collaborated with the institutes throughout the region, including the **Indian Agricultural Research Institute**, to determine which varieties can produce high levels of zinc and iron and to use those seeds as parental stock for breeding stable varieties that can produce high yields under local conditions.

New international lentil nurseries were established to allow testing of different micronutrient-rich genotypes to see how they perform in terms



*Working with local institutes and organizations, ICARDA has helped increase production of high-yielding red lentil varieties that are also high in iron and zinc.*

Photo courtesy of ICARDA

of yield and micronutrient content and whether they are stable and can retain their favorable characteristics through multiple generations.

The next step was to work with farmers to show them how using this certified seed will provide a better harvest, earning higher returns, even though the seed may cost more than local varieties. State extension service agents created demonstration plots to show the increased productivity and lower costs of inputs to farmers by using no till methods, improved cultivation techniques to reduce seed loss and reduced application of urea fertilizer. The farmers were pleased with the results and were

willing to buy the certified seeds and adopt the new practices. Farmers' clubs are being used to produce the certified seeds for sale.

As a result of this ICARDA initiative, food and nutritional security has been enhanced in several ways. Indian farmers are cultivating a nutritionally enhanced lentil variety that has high yields and requires less labor and inputs to grow, thereby conserving resources while helping the nation reduce the prevalence of iron and zinc micronutrient deficiencies. ■





## WATER USE EFFICIENCY AND MANAGEMENT

Wasteful irrigation practices and poor water use management are major threats to meeting India's growing agricultural, industrial and household water needs. Total demand for water is expected to grow by 63 percent from 2010 to 2050 (656 km<sup>3</sup> to 1069 km<sup>3</sup>).<sup>143</sup> Irrigation consumes 85 percent of India's water resources.<sup>144</sup>

In the 1960s and 1970s, irrigation and improved technologies were instrumental in India's agricultural productivity growth and achievement of food self-sufficiency. Now, over-extraction of groundwater and inefficient application practices are endangering both agricultural and economic growth. A third of the groundwater aquifers are already approaching or going beyond their sustainable yields, including in the irrigation-dependent northwestern states where cereal production is centered.<sup>145</sup> There is less rain during the monsoon season than there used to be, thereby reducing a primary source of water for the 13 major river basins in India. Poorly planned extraction of water upstream reduces access to water and harms ecosystems downstream.

Multi-institutional coordination and private sector and local participation are essential to reversing this trend. Adopting precision irrigation methodologies, recharging groundwater, recycling wastewater and integrating weather forecasting with hydrology are some the technological approaches that can reduce loss and mitigate the impact of adverse weather conditions.



### NEW DIRECTIONS: SHIFTING TO A WATER MANAGEMENT APPROACH

In December 2013, the central government's **Ministry of Water Resources** issued guidelines for states to submit proposals requesting matching funds under the **Command Area Development and Water Management (CAD&WM) Program**, which provides incentives for better water management rather than building new major and medium irrigation projects. This signals a change in direction from past approaches that had focused on new construction or repair of poorly maintained structures.

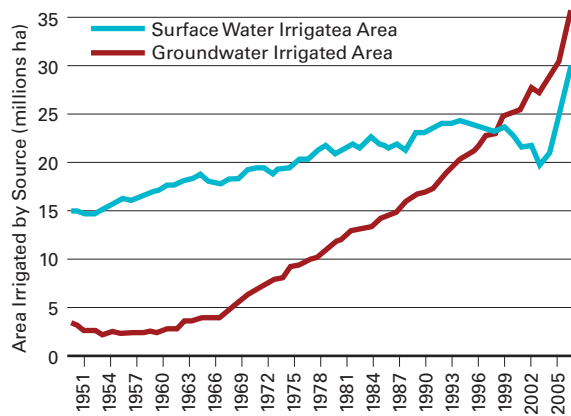
The CAD&WM will support the establishment of policies and infrastructure that extend irrigation to more farmers, improve water use efficiency, increase agricultural productivity and production, and improve management and sustainability through local participatory processes. Preference is given to projects with micro-irrigation, water audit and volumetric water distribution.<sup>146</sup> ■



## CO-MANAGEMENT OF ENERGY AND WATER RESOURCES CONSERVES GROUNDWATER

Large scale irrigation schemes introduced during the Green Revolution to increase productivity and staple food production were concentrated in Punjab, Haryana and Uttar Pradesh. Dams and canals were built to channel water from rivers and catchments to farmers' fields. Many of those systems are now in disrepair or do not reach the small-scale producers that predominate in Indian agriculture, resulting in declining use of surface water irrigation and increased reliance on groundwater extraction (Figure 20).<sup>147</sup>

**Figure 20: Surface Water and Groundwater Irrigation Use Growth, 1951–2007**



Source: Faures and Mukherji (2011)

Tube well technology is easily used by small-scale producers to extract groundwater. A pointed steel tube with perforations near the end is driven into the ground until water is reached and then a suction pump is applied, which is powered by either electrical or diesel energy, and the pumped water is distributed through PVC or rubber tubing. Millions of privately owned wells and tube wells have emerged as mainstays of smallholder agriculture.<sup>148</sup> While this basic technology has revolutionized access to irrigation and improved productivity, particularly in the non-monsoon seasons and in areas with less rain overall, it also has led to uncontrolled water use by farmers.

Water and energy policies vary significantly from state to state, but most do not install meters to measure the electricity used by each farm operation to pump groundwater, so tracking and controlling water use is difficult. Instead, flat tariffs are typically applied so farmers who pump a great deal of water pay the same amount as farmers who pump less.

For example, in Gujarat, a state with many drought-prone areas, farmer-owned wells are used to water 82 percent of irrigated agricultural land. From 1971 to 2001, as rural electrification spread, the **Gujarat Electricity Board (GEB)** applied a flat tariff rate based on the horsepower of groundwater pumps, rather than charging by the amount of electricity (and, indirectly, water) used.<sup>149</sup> During that period, the use of electrical pumps increased by 585 percent.<sup>150</sup> With water available around the clock and no extra charge for pumping more

often, Gujarati farmers extracted more water than they actually needed, which left the GEB nearly bankrupt and in some areas, groundwater fell to unsustainable levels.<sup>151</sup>

Metering the electricity used by tube well pumps might have solved this problem, but it was strongly opposed by farmers. The **International Water Management Institute** suggested a “second best” policy of separating electrical feeders that provided power to tube wells as a way of controlling the amount of energy consumed. In 2003, the Gujarat government adopted this approach.<sup>152</sup>

Called the **Jyotigram (“lighted village”) Scheme**, the GEB supplies power 24 hours a day to rural villages for domestic, school, hospital and other commercial uses. For agricultural uses, power is supplied eight hours a day, according to a pre-announced schedule. This system provides equitable distribution of electricity for household, commercial and agricultural uses.

The Gujarat government reported that gross irrigated area increased by 16.9 percent between 2000 and 2007 (from 3.7 to 4.4 million hectares), which was used mainly to expand wheat, cotton, fruit and vegetable production.<sup>153</sup> The success of the Jyotigram Scheme demonstrates that integrated management of electricity and groundwater for agriculture can curtail inefficient irrigation practices, freeing water to produce more crops or raise livestock and supplying continuous electrical service to rural households and for local commercial activity. ■





## ECO-FRIENDLY TECHNOLOGY RECYCLES WASTEWATER FOR AGRICULTURAL USE

India's urban areas generate 42 billion liters of wastewater a day,<sup>154</sup> but sewage treatment facilities can handle less than one-third of the wastewater and only 55 percent of them are operational.<sup>155</sup> Since freshwater is scarce, farmers in nearby areas use wastewater to water their crops, endangering consumer health. Heavy metal contaminants found in wastewater are now seen in food consumed by the poor.<sup>156</sup>

If urban wastewater could be made safe for agricultural use, it would irrigate 1.5 million hectares or 4 percent of agricultural land.<sup>157</sup> The **Indian Agricultural Research Institute (IARI)** developed an innovative, ecofriendly technology that could do just that: it cleans contaminants and makes wastewater safe for agricultural use.

To demonstrate how it works, IARI constructed a wetland at its Delhi campus, covering 1.42 hectares, which holds and treats sewage from the Krishi Kunj Colony adjoining IARI's campus. Emergent wetland plants (*s.a. Typha latifolia*) and native microorganisms present in the wastewater remove contaminants from 2.2 million liters of sewage water per day, which can irrigate 132 hectares (330 acres) of IARI farmlands.

Testing over the past year and a half shows consistent, exemplary results — a wide range of pollutants are removed or reduced to safe levels,

including nitrates, phosphate, lead, iron, nickel, zinc and sulphate. The quality of the treated water is similar to local groundwater samples, which are safe for agricultural use. Moreover, the system is energy efficient, using one percent of the energy required for traditional wastewater treatment, and it produces no chemicals or sludge.

In addition, a **Cash from Trash** business model is integrated into the system, which is expected to generate nearly \$30,000 in the second year of operation. The plants in each of the three treatment cells are harvested once every two months, yielding 12 tons of dry biomass per year per cell, which can be transformed into particle board or sold to particle board manufacturers.

IARI's eco-friendly wastewater treatment plant has promise for use in other localities, creating another way to save fresh water, reduce energy use and cut costs while increasing agricultural productivity. ■



*At IARI's Delhi campus, a 1.42 hectare wetland was constructed containing *Typha latifolia*, large plants that absorb pollutants, which clean 2.2 million liters of sewage water per day and generate biomass that is harvested and transformed into particle board.*

Photo courtesy of Indian Agricultural Research Institute



## WATERSHED MANAGEMENT IMPROVES AGRICULTURAL PRODUCTIVITY AND INCOMES

Located in the foothills of the Himalayan Range, 92 percent of Uttarakhand is hilly and only nine percent of the land in the valleys and surrounding hills is cropped. Nearly 80 percent of the 8.5 million inhabitants rely on agriculture for sustenance and to make a living, producing 1.2 to 1.4 tons of cereals per hectare, less than half the yields found in the plains. Although annual rainfall is high, more than 90 percent occurs during the July to September monsoon months, resulting in severe soil erosion, sedimentation of tributaries and runoff loss of rainwater. Poor families with small landholdings cannot make a living from the degraded lands.<sup>158</sup>

In response to these challenges, the **Uttarakhand Decentralized Watershed Development Project**, known locally as **Gramya I**, was designed to increase incomes of 255,000 rural residents in 20 watersheds through socially inclusive and institutionally and environmentally sustainable approaches.<sup>159</sup> Implemented from 2004 to 2012, the project was jointly funded by a loan from **The World Bank's (WB) International Development Association (IDA)**, a grant from the **WB Global Environment Facility (GEF)**, a grant from the **State of Uttarakhand** and in-kind contributions from farmers. The project had enormous positive impact, improving local government decision-making and resource management practices, preserving soil and water, and resulting in



*The steep hillsides of Uttarakhand State are prone to floods and soil erosion. Terraced hillsides, water catchments, orchards, and check dams are some of the ways that the Uttarakhand's Decentralized Watershed Management Program has controlled water flow, restored land and increased farmers' incomes.*

enhanced economic opportunities and income growth for farmers.

Academic institutions and specialized government agencies provided training to local officials on the watershed concept, participatory planning and implementation and financial management, and trained community members to serve as accountants, monitors and educators. All 468 local governments (known as Gram Panchayats) in the targeted watersheds prepared Watershed Development Plans, which led to extensive civil works projects incorporating conservation measures such as the construction of retaining walls and check dams to slow the velocity of water runoff, trap sediment and push water underground, as well as village ponds and other measures to recharge springs and harvest rainfall. Terracing hillsides and planting vegetables, orchards and fruit plantations retained water and stopped erosion, while also creating new income-generating businesses for farmers.

With these and other measures, availability of water for domestic use in the region increased by 12 percent and availability of water for agricultural use increased by 16 percent. This, in turn, led to new agricultural value chain opportunities. Nearly 700 Farmer Interest Groups (FIGs) were formed to train farmers in improved technologies for producing high-value crops and off-season vegetables. Their aggregated crops were marketed through 27 registered Farmer Federations. The project also created nineteen processing centers that collected fresh produce from 414 FIGS and produced juices, chutneys, purees, pickles, spices, flours, cereals, and a variety of graded and packaged products. The Farmer Federations sold these crops locally and in urban centers, earning \$9.7 million.

A follow-on project has been developed to expand the participatory watershed management planning and civil works activities, and scale up the agribusiness development work of the Farmer Federations.<sup>160</sup> ■



## FROM FIELD TO FORK: STRENGTHENING VALUE CHAINS TO BOOST PRODUCTIVITY AND REDUCE FOOD LOSS

Across India, farmers, scientists, production managers and policymakers are striving to improve agricultural productivity and reduce spoilage, loss and waste through better technologies, policies and management practices. This section explores some of the ways that the public and private sectors in the country are addressing gaps and making improvements along the value chain.



### THE RISE OF FRUITS AND VEGETABLES: INTEGRATED VALUE CHAINS INCREASE PRODUCTIVITY

Fruits and vegetables comprise the fastest growing agricultural sector in India, and they now exceed the value of cereals produced.<sup>161</sup> Mangos, bananas, potatoes, tomatoes and onions are some of the largest crops. Buying fresh fruits and vegetables from small farms, aggregating the produce and maintaining quality control of perishable foods requires an integrated value chain from producer to customer. To reduce loss and increase shelf-life, most organized fruit and vegetable retail in India consists of processed foods.

At the center of this phenomenon is **Jain Irrigation Systems Limited (JISL)**, an Indian multinational company that manufactures micro-irrigation systems, plastic sheets and pipes and several other products, in addition to providing agricultural inputs and financial services. Through contract farming and technical services for producers, it has developed a large portfolio of processed fruit- and vegetable-based products that are sold internationally and domestically. JISL's commitment to conserving India's natural resources and serving the needs of farmers as well as customers permeates its approach to agricultural development.

JISL is the largest manufacturer of mango pulp, puree and concentrate in India and sells 60 percent of its pulp production to **Coca-Cola** for fruit drinks.



*Ultra High Density Mango Plantations use drip irrigation and have up to 600 fast-growing, shorter trees per acre, compared to the conventional tall trees planted 40 per acre, maximizing water efficiency and producing much higher yields and incomes for farmers.*

Photo courtesy of Jain Irrigation

The company contracts with farmers to procure mangos and, in partnership with Coca-Cola, is introducing **Ultra High Density Plantation (UHDP)** mango planting to its contract farmers, a sustainable method for increasing production. Mango grafts of commercial varieties are planted at very close spacing of (3m x 1m or 3m x 2m) to attain good growth quickly. Orchards start commercial production from the third year onwards, twice as fast as traditional plantings. Up to 600 trees can be planted per acre compared to the conventional 40 trees per acre. JISL is teaching farmers special techniques for pruning trees to ►►

increase the density of branches and shoots and to obtain maximum light interception, which spurs growth. This is combined with drip irrigation, which provides the precise amount of water needed. The UHDP method produces very high yields and significantly higher income for farmers per acre.

JISL also manufactures **dehydrated onions and other vegetables** at a large, state-of-the-art facility in Jalgaon, Maharashtra, close to the fields where most of its vegetables are sourced. The area has rain during the June to September monsoon, then a prolonged dry season with high evaporation levels. Groundwater is typically pumped for flood irrigation of fields, but this has led to overuse and reduction of groundwater. Concerned about the rate of water extraction, JISL advocates drip irrigation to its producers because it is more precise, reduces evaporation loss and will not over-tax groundwater resources. A water footprint assessment conducted by **JISL** and the **World Bank's International Finance Corporation (IFC)**, with support from **The Nature Conservancy** and **Limno Tech**, indicated that micro-irrigation, as well as water harvesting and aquifer recharging projects, would be a good way to prevent overdraft.<sup>162</sup>

In addition, JISL supplies high quality seeds to growers and buys vegetables grown on contract, generating good income for farmers on small parcels of land. Onions are manually harvested at the peak of maturity, flavor and taste and quickly transported to the processing facility, with minimal losses. After milling, the products are packed in bags that are sealed and put in boxes, which are stored at low temperature and low humidity and then supplied to customers throughout the world. Elaborate marking, labeling and recording systems ensure complete traceability. ■



## CONTRACT FARMING: CONNECTING FARMERS AND AGRIBUSINESS TO MARKET FRESH VEGETABLES

An estimated 30 percent of fruits and vegetables grown in India are lost or wasted annually due to gaps in the cold chain — the temperature-controlled supply chain required to maintain freshness and quality of produce.<sup>163</sup> Inefficient methods of picking and packing fruits and vegetables result in more losses.<sup>164</sup> Without on-farm technology and training and links to well-organized value chains, Indian farmers miss opportunities to market their fresh produce and increase their incomes. Agribusiness will not be interested in investing if it cannot secure sufficient, continuous quantities of produce that meet their quality specifications.

With an eye toward implementing contract farming as a solution, the **Convergence of Agricultural Interventions in Maharashtra (CAIM)**, supported by the **International Fund for Agricultural Development (IFAD)** and **Sir Ratan Tata Trust (SRTT)**, facilitated the linkage between a cluster of smallholder farmers living in the Akola District of Maharashtra and **FieldFresh Foods Pvt. Ltd.**, a joint venture between **Bharti Enterprises** and **Del Monte Pacific Limited**.<sup>165</sup> FieldFresh Foods was established in 2004 with the purpose of exporting India's fresh produce to world markets. The Akola District has a good climate and growing conditions for vegetables, but before the project the district



*FieldFresh Foods has 15 percent of the UK market for baby corn and is expanding its production in India in partnership with IFAD and Sir Ratan Tata Trust in projects that increase incomes for smallholder farmers.*

Photo courtesy of IFAD

was not connected to good marketing systems, which meant crops that could not be sold and consumed locally were often lost.

For the 2012 to 2013 season, FieldFresh Foods entered into contracts with 100 Akola district farmers and started providing technical assistance for the production of baby sweet corn on 100 acres of land for export to the United Kingdom. ►►



Freshfield Foods managed the process to assure that farmers' harvests would be aligned with the schedule of deliveries to UK stores and the size and shape of the baby corn would meet the buyers' specifications. The company supplied hybrid seed, advised farmers when they should plant and apply nutrients, and provided access to technical and extension services. Only certain pest prevention products were allowed and residual levels were measured after harvest to make sure they met UK standards.

When a farmer picked the corn, it was put in a bag labeled with her/his name. The cobs were transported six hours that evening to the packhouse, where they were immediately chilled for six hours. Cobs meeting the standards were then shucked and packed, transported by air to Mumbai (3.5 hours) and then to the UK (9 hours). Depending on output, a farmer's income for one crop was \$330 to \$527 per acre with additional revenue from selling the plant stalks for livestock fodder.

FieldFresh has 15 percent of the UK market for baby corn and plans to expand there and in other European markets. It is quadrupling the area under production in Akola District for the 2013 to 2014 season and also plans to work with farmers to plant chilies and asparagus for export. ■



## PREVENTING LOSS IN THE PUBLIC DISTRIBUTION SYSTEM

Nearly one percent of India's GDP was spent on the government's **Public Distribution System (PDS)** in 2012,<sup>166</sup> and researchers estimate that 40 percent of the grains in the system are lost before the food reaches the beneficiaries.<sup>167</sup> In 2001, the **State of Chhattisgarh**, which has relatively higher poverty and food insecurity levels than the rest of India, started implementing a series of reforms to reduce losses and to assure each eligible household receives its full complement of benefits. Surveys indicate that the reforms had an impact and the PDS there is now operating more transparently and efficiently.<sup>168</sup>

The first reforms were centered on the way Chhattisgarh obtained its PDS commodities. Starting in 2002, rather than receiving rice and wheat from the central government to use in the PDS, the state government began buying those commodities from local farmers at the minimum support price and was reimbursed by the central government. Once the state had control over its commodity budget, it was able to buy much more grain than it previously received from the central government.<sup>169</sup>

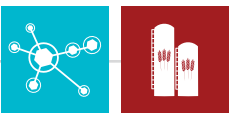
In addition, the state government improved the efficiency and transparency of **Fair Price Shops (FPSs)** where PDS food grains are sold, requiring that FPSs be operated by local village or town governments, cooperative societies, self-help groups or forest protection committees. Records



*Chhattisgarh State's Fair Price Shops provide foods at subsidized prices to eligible low-income beneficiaries and follow strict accountability standards.*

were computerized, electronic weighing machines were introduced to measure rations and lists of ration card holders were publically displayed. All transactions had to be disclosed to local government bodies and the shops were subject to inspections and social audits.

By 2010, nearly 95 percent of beneficiaries surveyed reported receiving their full grain rations and indicated that they were pleased with the new system.<sup>170</sup> In a study of the reforms, the **USDA Economic Research Service** found that from 1999–2000 to 2009–2010, the average number of calories consumed from PDS grains in Chhattisgarh increased significantly.<sup>171</sup> Unfortunately, after the economic shocks of the second half of the decade, these gains began to pale in comparison to the increased need for food assistance, thereby clouding the picture regarding which safety net approaches effectively improve nutrition and food security of the poor. The Chhattisgarh government is now experimenting with selling onions and potatoes at FPSs at wholesale prices, which would be supplied by women's self-help groups, bypassing the market middlemen who collect commission fees.<sup>172</sup> ■



## AIRTIGHT STORAGE PREVENTS POST-HARVEST SPOILAGE

Hermetic storage (HS) technology has emerged as a significant alternative to other methods of storage for crops and a range of agricultural commodity products that protect them from insects and molds. Among the advantages of hermetic storage is the generation of a modified atmosphere within the container eliminating the need for chemical treatments, fumigants, and climate control.

The rapid growth in adoption of HS is due to the increasing demand for safe and sustainable technologies that are simple to use and reasonably priced. Some HS units are characterized by their ease of installation and additional benefits such as protection from pests and rodents, favorable costs, ease of relocation, and very modest requirements for infrastructure.

In India, spices are a rising high value commodity, for both consumption in India as well as regional and global export. HS products developed by **GrainPro Inc.**, are used to help ensure preservation of high quality, high value spices. Hermetic storage preserves and maintains the aroma and flavor of such commodities as coriander, turmeric, red chili pepper, coffee, cocoa and basmati rice. Indian companies like **Jayanti Spices**,



Red chillies are stored in a GrainPro Cocoon™

Photo courtesy of GrainPro, Inc.

**Sresta Natural Bioproducts, Pravin Masalewale, Fern Spices & Pickles, Arvind Ltd, Suminter Organic Foods** and many others have been using **GrainPro Cocoons™** for storing and fumigating their spices organically. Cocoons have not only helped them to control infestation but also have helped them to preserve the aroma and flavor of spices for short and long duration while keeping optimal moisture levels. ■





## AGRICULTURAL FINANCIAL SERVICES

Indian agriculture's excellent growth potential is imperiled by an underdeveloped financial infrastructure. Leading financial firms are working with agricultural businesses to develop a more robust lineup of financing options and risk management instruments for producers, processors and others businesses along the value chain.



### NON-BANKING FINANCING COLLABORATION

While production loans for Indian farmers have picked up in recent years, they still meet only a fraction of the need. Loans for processing equipment and other capital investments continue to be scarce. In response, some input dealers and offtake buyers provide financing to farmers through an entire production cycle, or give inputs and technical assistance in lieu of financing. An emerging solution for stimulating expansion throughout the agricultural value chain is for nonbank entities to attract equity investors and work with farmers and agribusiness in developing special financial packages.

In 2011, India's first nonbank finance company was incorporated in Mumbai. **Sustainable Agro-commercial Finance Ltd. (SAFL)** is supported by **Jain Irrigation Systems Limited (JISL)** and the **International Finance Corporation (IFC)**. It was established to provide a variety of financing options to small farmers and to promote growth throughout the value chain. All of the loans have socio-economic development objectives and some are designed specifically to reduce the environmental footprint of agriculture by advancing sustainable practices.<sup>173</sup>

SAFL provides small business loans to farmers to meet financing needs for up to one year at a time. Farmers can receive loans for micro-irrigation equipment, which are not limited to products manufactured by JISL systems, and the payment



term is up to five years. Third party financing is also available in cases where a farmer has a contract to sell to a processor or trader and the loan can be provided through the buyer rather than directly to the farmer.

For those who have a strong credit history, larger agricultural project loans are offered for a maximum period of five years to finance expansion of operations and income. Examples include small dairy sheds, greenhouses, nurseries, small farm equipment, biogas generators, cattle and fruit orchards. To encourage investment in renewable energy, loans of up to five years are also available for procurement and installation of solar panels for hot water systems, water pumps and lighting.

Expansion of SAFL and the establishment of more agribusiness-financial firm collaborations could fuel a new agricultural revolution for economic growth. ■



## HELPING INDIAN FARMERS MANAGE RISK

Severe threats from drought, insufficient monsoon rain, heavy rains or pests can destroy crops and livestock and ruin a farmer's livelihood. Agricultural risk management plays a crucial role as part of a broad strategy to provide food, preserve jobs and enable farm families to stay involved in agriculture and land management. Failure to manage risk can result in low farm productivity or neglect to develop land that could be useful in agricultural production.

Weather risks pose the most severe shocks to agricultural producers and can result in catastrophic losses for entire regions and communities. More than half of Indians<sup>174</sup> are employed in agriculture, but agricultural insurance penetration (defined as agricultural insurance premiums as a percentage of agricultural value added) is estimated at only 0.19 percent, leaving most farmers exposed to significant risk.<sup>175</sup>

The historical evidence shows that, on a global basis, the most effective agricultural risk management strategies are both market-based and government-supported and include elements of risk prevention, risk-control and financing.<sup>176</sup> Traditional indemnity insurance used in developed country markets to protect agricultural producers in case of weather-related loss is more difficult and costly to administer in developing country contexts where there are many smallholder farmers, little recorded information about a farmers' production

practices and yields, and limited penetration of formal financial services into rural areas.

The Government of India's crop insurance program (**National Agricultural Insurance Scheme, or NAIS**), which was established in the 1970s, strained government budgets and did not settle claims quickly. In 2010, India partnered with private sector insurers and reinsurers to pilot a modified crop insurance program (**MNAIS**), which will generate more benefits to farmers by extending coverage to both sowing/planting risk and post-harvest losses resulting from natural calamities, pests and disease. It also increases the minimum indemnity level from 60 percent to 80 and 90 percent, based on more precise calculations of threshold yield.

Another innovative insurance program is the **Weather Based Crop Insurance Scheme (WBCIS)**. Weather insurance was launched in 2003 as an innovative risk management tool for Indian agriculture. The government provided subsidies to make WBCIS cost effective and gave the market a boost.

**Index-Based Insurance** is an approach tailored for developing country farmers and businesses in the agricultural value chain. In India, government owned insurer **Agriculture Insurance Company of India Limited (AICI)** and about nine other private insurers provide two types of index-based crop insurance products, and are reinsured by international reinsurers like **Swiss Re: area-yield insurance (NAIS and MNAIS)**, which bases a payout on the shortfall between a current yield relative to an average historical yield, and *weather-based insurance (WBCIS)*, which bases a payout on triggers — such as high temperatures, low temperatures or excess, deficit rainfall — that

create catastrophic crop loss. These products rely on geographically-tied data for weather and prices in order to determine accurately the nature of the losses.

The use of financial institutions and banks is also an important part of the insurance system, as insurance companies operate in partnership with banks to collect premiums and to pay out for losses. A major challenge in scaling up these programs lies in the large number of rural farmers across India who do not participate in formal banking systems, estimated at approximately 60 percent of the population.<sup>177</sup> These unbanked farmers are hard to reach with a number of services that can help them improve productivity, access lower-cost loans and participate in risk management programs.

For farmers who participate in index-insurance programs, an approach is being piloted that combines timely risk warning messages and advice via mobile phones in advance of severe weather events. ■



*The weather risk insurance market in India is the world's largest, covering more than nine million farmers. [World Bank, 2012]*

Photo courtesy of Ashok Saravanan, Ayashok Photography



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