Executive Summary



Agriculture for a Healthy Sustainable World



GLOBAL HARVEST INITIATIVE



2018 Global Agricultural Productivity Report® (GAP Report®)

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Global Harvest Initiative (GHI) was formed in 2009 as a private-sector policy voice to increase the productivity and sustainability of agricultural value chains for food, feed, fiber and biofuel. We believe the right policies, practices and technologies improve global food security and nutrition, accelerate productivity, reduce waste and loss, conserve natural resources and mitigate climate change.

GHI advocates a comprehensive approach that emphasizes increased productivity, access to nutritious food, improving livelihoods for producers and strengthening the resilience of food and agriculture systems.

GHI's member companies are Corteva Agriscience[™], the Agriculture Division of DowDuPont, John Deere, Monsanto Company (acquired by Bayer AG), The Mosaic Company and Smithfield Foods.

Our work is enhanced by contributions from consultative partners who share their knowledge and experience in agriculture, conservation, nutrition and the needs of small-scale farmers: 9b Group, ACDI/VOCA, Congressional Hunger Center, Conservation International, Farm Foundation, Global Alliance for Improved Nutrition, Inter-American Development Bank, Inter-American Institute for Cooperation in Agriculture, The Nature Conservancy, New Markets Lab, Purdue University School of Agriculture, Robert B. Daugherty Water for Food Global Institute at the University of Nebraska, and the Supporters of Agricultural Research (SoAR) Foundation.

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LETTER FROM THE EXECUTIVE DIRECTOR

Agriculture for a Healthy Sustainable World

Food and agriculture production systems provide people with nutrition and products they need to achieve a healthy, comfortable life. Food, clothing, shelter, fuel and consumer goods used every day are the result of complex agricultural production and supply systems.

Yet, today's consumers expect much more from their agriculture and food systems than in previous generations. Through their purchases they express their preferences and values and help shape the decisions producers and retailers make.

Their influence is growing as they consider what they buy, why they buy it and how and where they purchase food and agriculture products.

These consumer trends are global, but the nature and extent of their influence is shaped by geography, cultural norms, government policy and socio-economic status.

The 2018 Global Agricultural Productivity Report[®] **(GAP Report**[®]**)** explores the consumer trends that are transforming the food system and lays out a vision for a world where people thrive and the planet's resources are protected for generations to come. Innovation, investment, partnerships and smart policies will be essential to achieve this vision of a hunger-free, healthy and sustainable world.

The report also highlights challenges that must be surmounted. For the fifth straight year, GHI's **Global Agricultural Productivity (GAP) Index™** reveals that global agricultural productivity growth is not accelerating quickly enough to sustainably meet the demands of our growing world. Coupled with the rise in the number of hungry people, these troubling trends require urgent action now.

Together we must commit to improving and transforming our food and agriculture systems to achieve a well-fed healthy population and a healthy planet.

We hope this report serves as a call to action.

Margart M. Feider

Dr. Margaret M. Zeigler Executive Director Global Harvest Initiative



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THE GLOBAL AGRICULTURAL IMPERATIVE FOR A HEALTHY SUSTAINABLE WORLD

The global population is evolving in ways that are driving changes and creating new challenges for the world's agriculture and food systems. Changes in population growth, age, health and incomes drive global food demand. Yet, the evolution in what consumers buy, why they buy it and where, is transforming the food and agriculture system in unexpected ways. These trends have profound consequences for the short and longer-term future of food and agricultural production, consumption and sustainability.

CONSUMERS

Global Population is Becoming Younger and Older

Even though the rate of global population growth has slowed, by 2050 there will be nearly 10 billion people needing nutritious, safe affordable food.¹ Life expectancies are rising and birthrates are declining; by 2050, the number of people over age 60 will equal the number of people 15 and under.

Cost of Malnutrition Rises

In 2017, prolonged drought and armed conflict drove up the number of hungry people to 821 million; 124 million need immediate food assistance to prevent acute malnutrition and starvation.²



1 in 3 PEOPLE IN THE WORLD DO NOT GET ENOUGH FOOD OR KEY NUTRIENTS, OR THEY ARE OVERWEIGHT OR OBESE.³

Diet-related disease is responsible for 4 million deaths and \$2 trillion in economic losses per year.⁴

PRICE, NUTRITION AND CONVENIENCE DRIVE FOOD CHOICES

WOMEN are the primary producers, purchasers and preparers of food and have substantial influence over the food system. Price, nutrition and convenience drive their food choices.⁵

Consumers are shopping for food in new ways, including online purchases of prepared and readyto-cook meals.⁶

They have access to a wider variety of foods thanks to trade.⁷

Natural Resource Base Imperative

To meet the growing needs of 10 billion people in 2050, we must protect our natural resources, grow more food using less land, water, energy and labor, and waste less of what we grow.



1/3 OF THE EARTH'S SURFACE IS USED FOR AGRICULTURE

Agriculture is the world's single largest use of land, covering 1/3 of the planet's surface; there is limited additional land for sustainable food production.

BY 2050 THE NUMBER OF

PEOPLE > 60 YRS WILL BE EQUAL TO THE NUMBER OF PEOPLE < 15 YRS



AGRICULTURE IS THE LARGEST USER OF WATER GLOBALLY

Agriculture is the largest user of water globally; more than 1/2 of withdrawals from rivers, lakes and aquifers will be used for agriculture by 2050.⁸ Protecting water quality will become more critical.

CLIMATE CHANGE could push more than 100 million additional people into poverty by 2030.⁹

SOILS ARE THE FOUNDATION OF AGRICULTURE

Nearly 80% of the average calorie intake per person comes from crops grown directly in the soil.¹⁰

20% to 30% of the food supply in developed countries is **WASTED** at the retail and consumer level; up to 50% of fruit and vegetable production is **LOST** before leaving the farm.¹¹



4 BILLION PEOPLE WILL LIVE IN INCREASINGLY HOT CLIMATES IN 2030¹³

Agricultural workers will account for 66% of hours lost due to heat stress in 2030.¹⁴

Labor for agriculture is diminishing as young people seek higher wages and off-farm jobs.

44% OF AGRICULTURE WORKERS ARE < 14 YRS & 66% LIVE IN EXTREME POVERTY¹⁵

Producers Face Economic and Resource Challenges

Demand for agricultural products is evolving. Continued uncertainty about **TRADE AND MARKETS** makes it difficult for farmers to plan and invest.

STAGNATING INVESTMENTS in

global public agriculture research and extension systems reduces farmer access to innovation and technology.¹⁶

There is a \$15 TRILLION INFRASTRUCTURE

INVESTMENT GAP. Investments are needed to connect farmers to information and markets and supply food and agriculture products to the world. ¹⁷



URBAN POPULATION WILL DOUBLE TO 5 BILLION IN 2030

Between 2000 and 2030, the global urban population will double from 2.6 billion to 5 billion. With urban area expansion, farmers will compete to grow food on lands with optimum soil.¹²

> A VISION FOR PRODUCTIVE SUSTAINABLE FOOD & AGRICULTURE SYSTEMS



A NEW VISION FOR AGRICULTURE

Meeting the rising demand for nutritious, affordable food as well as materials for fuel, clothing, housing and consumer products requires innovative, productive and sustainable food and agriculture systems.

Food and agriculture production systems provide people with nutrition and products they need to achieve a healthy, comfortable life. Food, clothing, shelter, fuel and consumer goods used every day are the result of complex agricultural production and supply systems.

Together we must commit to improving and transforming these food and agriculture systems to achieve a healthy population and a healthy planet. Improving agricultural sustainability requires multi-faceted, collaborative solutions involving consumers, producers, agribusinesses, transporters, processors, retailers and policymakers.

The 2018 GAP Report[®] describes a vision for a sustainable, healthy world where people thrive and the planet's resources are protected for generations to come. PEOPLE will be able to easily access a variety of nutritious safe foods, including fruits, vegetables, protein and cereals. Their health improves through eating diverse diets along with fortified and biofortified foods and they have a greater understanding of how to achieve a healthy lifestyle. The products they purchase in stores or online will allow them to access science-based information on nutritional content as well as diverse production methods. Consumers will be able to trace products to learn more about the origin of key contents, ensure food safety and drive greater sustainable resource use.

RETAILERS of different

types and scales offer consumers a variety of nutritious, safe affordable food. Technologies for traceability and supply management will reduce food waste and foodborne illness. Retailers will ensure unused foods are either used for feeding people or for clean energy or other productive use. Retailers and restaurants will provide customers with science-based information about nutrition and food content, n contributing to healthy diets.

FOOD PROCESSORS AND PACKAGERS will incorporate

MAN

nutritional concerns into the foods they produce by fortifying foods with essential micronutrients such as vitamin A, zinc and iron. They will use innovative packaging, including bioplastics and recycled content to reduce food loss while cutting the carbon-footprint and environmental impact of materials used. Processors and packagers will incorporate traceability technology for their products and enforce fair labor standards for their workers and those in their supply chains.

AGGREGATORS AND TRADERS purchase

agricultural products from farmers, ranchers, foresters and fishers and use efficient and renewable energy sources for cold chain transport. They store the raw products in energy-efficient warehouses before sending these products to processors. They enforce food safety standards and help move products from rural production zones closer to processing areas near urban markets and ensure food products are

not spoiled or wasted during storage and transport. Farmer cooperatives serve as aggregators and help smaller-scale farmers get a fair price for their crops and livestock as well as increase the quality of products. Cooperatives also help their farmer members access services such as training, improved seeds and fertilizers and lower prices for other inputs and machinery.

AGRICULTURAL SERVICE

PROVIDERS are key components of a sustainable agri-food system. Government extension agents and private agricultural retail service providers share the latest advice and innovation technologies such as precision agriculture systems that boost productivity of crops, livestock, forests and fisheries and help reduce costs for growers while reducing the environmental impact of production. Veterinarians ensure animal well-being and health. Programs that certify professional qualifications are expanded to more agricultural retailers and are tailored for developing country markets. Advisory services ensure best practices on farms for stewardship of natural resources, sustainability and productivity. Service providers create software and data applications tailored for their farmer clients that help them grow more, use inputs precisely, waste less, and boost productivity while cutting costs.

FARMERS, RANCHERS, FORESTERS AND FISHERS become

successful agricultural producers, with stable incomes enabling them to create value for their families and communities. They are recognized as stewards of their soil, water and forest resources and provide nutritious and safe food for a growing and more discerning global population. They seize opportunities to enhance their knowledge and business skills with education and support from government and the agri-food industry. They use modern technologies and science-based practices for crop and livestock production, aquaculture and forestry. They use new forms of media and technology to explain their business models to consumers and engage in conversation with their communities about the challenges and satisfying successes of producing safe, nutritious and affordable food.

GOVERNMENTS and citizens establish agricultural policies and regulations to ensure human health and safety, protect the environment and animal welfare, and foster economic growth for consumer needs. Public policies and research, along with science-based regulatory systems advance innovations and shape the food and agriculture system, contributing to human health and the health of the planet.

SUSTAINABLE AGRICULTURE & FOOD SYSTEMS ARE BUILT ON PRODUCTIVIT

FINANCIAL SERVICES AND RISK MANAGEMENT

PRODUCTS help farmers and the agrifood system withstand external shocks such as weather and market challenges. New credit arrangements help all scales of growers and cooperatives obtain the finance needed to become successful entrepreneurs. Insurance products and commodity exchanges make agri-food industries less risky and are widely available for a broad range of crops and agricultural products.

Sustainable Food and Agriculture Systems Are Built on Productivity

There are multiple strategies for meeting the world's demand for affordable, safe and nutritious food and agriculture products.

- » Land Expansion Expand the amount of land that is being cultivated to generate more output.
- » Irrigation Extension Producers deploy or extend irrigation systems to protect land against drought and improve its productive capacity, which may permit multiple cropping seasons.
- » Input Intensification Producers increase applications of fertilizer, machinery, labor, seeds, herbicides or other inputs on cultivated land to grow more crops or raise more livestock.

These approaches need to be selected and managed with care to protect the resilience and sustainability of the land, water, human and capital resources that are the foundation of food and agriculture systems.

Meeting demand in a way that reflects the needs of producers and consumers today, while safeguarding our future agricultural capacity is best achieved through agricultural productivity.



WHAT IS AGRICULTURAL PRODUCTIVITY?

Agricultural productivity rises when producers use technologies and production practices that result in more output from existing resources. This is measured by **Total Factor Productivity (TFP)** (Figure 1).

To understand what TFP *is*, it is helpful to understand what it *is not*.

TFP is different than output, which measures the gross amount of crops or livestock produced, **and yield**, a measure of the amount of output per unit of production, usually land.

TFP is a ratio that measures changes in how efficiently

agricultural inputs (land, labor, fertilizer, feed, machinery and livestock) are transformed into outputs (crop and livestock).

TFP increases when there is widespread adoption of innovations and practices that enable producers to increase crop and livestock output with the same amount (or less) inputs.

Measuring TFP, in addition to yields or output, gives us insight into how efficiently and sustainably we are using our land, water, human and capital resources.

HOW DOES PRODUCTIVITY GROW?

The substantial increase in U.S. pork productivity demonstrates how TFP works and the economic and environmental benefits of productivity growth.

Widespread adoption of innovative technologies and practices has increased pork output using the same amount (or less) land, labor, fertilizer, feed, machinery and livestock. Efficient use of these inputs has generated cost savings for producers and consumers and improvements in the environmental sustainability of the pork and animal feed value chains.

Pork Productivity Is in the Genes

Genetic researchers and veterinarians analyze hundreds of animal traits to select and pair pigs to breed descendants that are healthier, use less feed and produce more meat. Heritage breeds are cross-bred to create the best meat flavor and quality for consumers.

Productivity From Seed to Feed

Productivity-enhancing crop technologies and practices reduce the amount of land, labor, machinery hours, fuel and fertilizer used to produce hog feed.

Alfalfa, corn and soybean seeds improved through biotechnology and conventional breeding become healthy crops that are pest-resistant and herbicide-tolerant. Best-practices for fertilizer management ensure that the right amount of the appropriate fertilizer is used at the right time and in the right place. Machinery equipped with precision systems, such as GPS, cover every inch of the field with precisely planted seeds and treat each plant with the nutrients and crop protection products needed. Precision systems also allow less productive land to be identified and set aside for conservation use, such as pollinator or wildlife habitat.

Healthy Pigs Are Productive Pigs

These crops are blended with nutrients to make hog feed that is healthier and easier to digest, resulting in fewer methane emissions during the digestive process. "Smart barns" provide consistent temperature, comfortable housing and readily available feed and water. With detailed data on the health and development of the herd, farmers can reduce energy use, save labor and protect pigs from disease.

Growing Sustainable Pork

Extensive use of technological advances and improved practices in the feed and pork value chains means that today it only takes five breeding hogs to produce the same amount of pork that eight hogs produced in 1959, a decrease of 38 percent.¹⁸

In just 25 years, the U.S. has gone from being a net importer to a net exporter of pork, shipping 26 percent of domestic pork production to more than 100 countries each year.¹⁹

At the same time, the carbon footprint of U.S. pork production is just one-third of one percent of total U.S. greenhouse gas (GHG) emissions.²⁰

Producers benefit from the cost savings generated by the efficient use of land, labor, fertilizer, feed, machinery and livestock in the pork and feed value chains. Consumers around the world enjoy high-quality, safe and affordable U.S. pork products.

Prioritizing Productivity Growth

Total Factor Productivity (TFP) is the primary contributor to global agricultural output today (Figure 2, green bar). However, the most recent ten-year period of available data (2006-2015) reveals that TFP's contribution to output has declined and more output has been generated by putting additional land into production. (Compare the two columns on the right in Figure 2.)

The downward trend in productivity growth can also be seen in high-income countries (Figure 3). Lowincome countries (Figure 4) show a slight improvement in TFP growth and a reduction in land use in the last 10 years, while input use has intensified.

Productivity growth needs to be prioritized to sustainably meet the demand for food, feed, fiber and biofuel. Yet productivity alone is insufficient to ensure the sustainability of food and agriculture systems. Reducing postharvest loss, food waste and economic and climate risks to the value chain need attention and investment. For the following figures, sources of agricultural output growth are:

- **TFP** Gross amount of crop and livestock outputs per inputs of labor, capital and materials
- **Inputs/Land** Gross amount of fertilizer, machinery, feed and labor per hectare of agricultural land
- **Irrigation** Extension of irrigation to agricultural land
- Land Expansion Extending agriculture to previously forested areas or grasslands

Agricultural Output Growth Rate

Figure 2: Sources of Growth in Global Agricultural Output, 1961–2015



Agricultural productivity supports the needs of producers, consumers and the environment. Productive use of inputs and capital helps farmers control costs during volatile business cycles. Consumers benefit from lower food prices. Natural resources, particularly land and water, are conserved.





In high-income countries, improvements in productivity expand output while reducing inputs used in agriculture. Innovations that are raising productivity include advanced crop and livestock breeding, improved animal care, precision agriculture and better nutrient management.



Figure 4: Sources of Growth in Agricultural Output: Low-Income Countries, 1961–2015

In low-income countries, TFP's contribution to agricultural output has grown during the most recent 10 year period. But, land expansion is still the largest contributor to output growth. Increasing productivity on currently cultivated land needs to be prioritized.

*Depicts data for the most recent ten-year period. Source: USDA Economic Research Service (2018).

Tracking Productivity: The GAP Index[™]

The 2018 Global Agricultural Productivity Index[™] (GAP Index[™]) reveals that for the fifth straight year, global agricultural productivity growth is not accelerating fast enough to sustainably meet the food, feed, fiber and biofuel needs of nearly 10 billion people in 2050.

In 2010, GHI calculated that global agricultural productivity (as measured by TFP) must grow by an average rate of 1.75 percent annually to double agricultural output through productivity growth by 2050.

The U.S. Department of Agriculture's Economic Research Service (USDA ERS) estimates that since 2010, **TFP growth globally has been rising by an average annual rate of only 1.51 percent.**

The average annual TFP growth rate in low-income countries is particularly troubling. **Sustainable Development Goal 2 (SDG2)** calls for doubling productivity for small-scale farmers in the lowest income countries. **The current annual rate of TFP growth in** **low-income countries is only 0.96 percent,** down from 1.5 percent three years ago.

If this downward trend continues, farmers in low-income, food-deficit countries (where population growth is rapidly rising) will use more land and water to increase their output, straining a natural resource base already threatened by extreme weather and climate change.

Low-income countries will need to import food but lack sufficient income to purchase enough to meet the needs of their citizens. Poor urban households will bear the brunt of higher food prices in these countries, but they will also impact low-income rural populations since they are net food buyers.

THE GLOBAL AGRICULTURAL PRODUCTIVITY (GAP) INDEX™





Policy Goals for a Productive, Sustainable Healthy World

The Global Harvest Initiative and its partners have identified **five strategic policy goals** that foster productive sustainable agriculture and food systems.

These policies bring benefits to consumers, the environment and to producers.

They stimulate productivity growth and resiliency in the agricultural value chain while helping producers manage risks during challenging agricultural business cycles.

They increase access to safe, affordable food and provide science-based information, so consumers can make healthy choices.

These policy goals also help reduce waste and loss in the agricultural value chain and mitigate climate change while creating opportunities for economic growth and innovation.

R&D AND EXTENSION

Invest in Public Agricultural Research, Development and Extension

Agricultural R&D and extension programs are essential public goods and the principal drivers of Total Factor Productivity (TFP) growth.

Public sector R&D and extension programs deliver innovation and information to agricultural producers. They provide access to proven techniques such as conservation agriculture and animal care practices to improve sustainability and resilience.

Public R&D provides foundational results that the private sector can further develop to improve specific crops, livestock, machinery or food manufacturing industries. R&D and extension services help producers control costs, reduce loss and waste and become resilient to climate change while conserving natural resources.

Public-private research partnerships improve the nutritional quality of food through crop biofortification. Farmers receive technology and training to cultivate and store their crop and livestock products in a way that preserves their freshness and prevents contamination.

Research partnerships leverage funds to tackle environmental and economic challenges faced by producers and consumers.



TECHNOLOGY

Embrace, Customize and Disseminate Science-Based and Information Technologies

Productive sustainable food and agriculture systems depend on public policies that support the development, customization and dissemination of science-based and information technologies.

Information technologies such as apps and social media help consumers learn more about the food they eat and agriculture products they use.

Technologies help producers manage the ever-present risks in agriculture while improving sustainability and competitiveness.

Advanced plant breeding through biotechnology and gene-editing enhances drought tolerance and yields, while disease management practices keep livestock healthy and productive. Efficient irrigation and cultivation technologies improve water productivity and reduce labor burdens. Storage and cold chain innovations ensure that more agricultural products reach markets rather than landfills.

Producers use technology to access vital information on market prices, weather, pests and soil health. Precision agriculture and data management tools reduce costs and conserve scarce water and soil resources.



INVOLVEMENT

Enhance Private-Sector Involvement in Agriculture and Infrastructure Development

Policies that incentivize privatesector investment in physical and human infrastructures are crucial to increasing the productivity and sustainability of agriculture. An efficient infrastructure system brings safe, nutritious affordable food to more people.

Public-private partnerships to develop road, water, rail and port infrastructures open new markets and reduce transaction costs for producers, retailers and consumers.

Reliable and affordable electricity and cold chain systems as well as access to high-quality, high-speed fixed broadband and mobile cellular coverage make farmers more efficient and competitive, while reducing loss and waste in the value chain.

For small-scale and emerging producers, infrastructure investments reduce costs and connect them with education, innovation and wider market opportunities.

Collaborative efforts between government, industry and communities to develop an educated and entrepreneuriallyminded workforce stimulate off-farm employment and reduce rural poverty.



CULTIVATE PARTNERSHIPS

Cultivate Partnerships for Sustainable Agriculture and Improved Nutrition

To develop their agricultural economies and reduce malnutrition, governments leverage their resources through partnerships with local and international private businesses, non-governmental organizations, foundations, multilateral institutions and development agencies.

Partners agree to share the risk, responsibilities and benefits of their joint investments to increase agricultural productivity and sustainability, improving the lives of small-scale producers and rural communities.

Including producer groups in the design, management, monitoring and evaluation of the partnerships provides local knowledge, increases community buy-in, builds leadership and encourages the inclusion of underserved groups, such as women and youth.

Multi-stakeholder partnerships that share knowledge, innovations and resources are essential to achieving the Sustainable Development Goals (SGDs).

TRADE

Foster Capacity for Regional and Global Agricultural Trade

Forward-looking trade agreements efficiently move products to markets that need them, benefitting consumers and producers.

An enabling policy environment for regional and global trade includes transparent policies and consistently enforced laws and regulations, as well as coherent trade rules across countries.

Since many countries do not have the human or financial capacity to effectively manage complex regional and global trade opportunities, policies can start by building country capacity to facilitate agricultural trade, with an eye toward helping small and medium-scale farmers access larger markets, increase their incomes and expand their businesses.

Improvements in trade policies and infrastructure will enable consumers around the world to access a wider variety of foods, as well as staple foods at competitive prices.

In agriculture, trade in services improves and modernizes production and brings innovation to agri-food systems. Developing countries can unlock the potential of their manufacturing and agricultural sectors by opening to trade in services that boost the sustainability and quality of agricultural production and lowers costs for consumers and businesses.

How Can Partnerships, Innovations and Investments Build Better Food Systems?

Public policies and investments that support agricultural innovation and extension, and public goods such as education, roads and access to markets are the foundation of a sustainable nutritious food system.

Partnerships between civil society, the private-sector and local and national governments leverage these policies and investments for the benefit of producers of all scales and consumers at all income levels.

The 2018 GAP Report[®] highlights how the private sector is bringing agricultural innovation and knowledge to benefit people, the planet and agricultural producers. **Corteva Agriscience™, the Agriculture Division of DowDuPont,** and **The Mosaic Company** are supporting the biofortification of staple crops to reduce micronutrient deficiency in Africa and India. Technology developed by **Monsanto Company** (acquired by **Bayer AG**) is supporting climatesmart agriculture and farmer income in Latin America. Improved animal care practices by **Smithfield** pork farmers improve animal welfare and health. **John Deere** is partnering with Nigerian agribusinesses to support thousands of emerging farmers as they access mechanization.

Multilateral institutions such as the Inter-American Institute for Cooperation on Agriculture, conservation organizations like The Nature Conservancy, and NGOs including the Global Alliance for Improved Nutrition (GAIN) and ACDI/VOCA work with producers and community members to achieve the Sustainable Development Goals, and end poverty and hunger while protecting natural resources.

DISCOVER MORE ONLINE!

At **www.globalagriculturalproductivity.org** you will find more analysis of agricultural productivity and additional case studies that reveal how consumers and producers are contributing to a more a sustainable, healthy world.

Learn about the consumer trends that are transforming food systems and how producers in the U.S., China and sub-Saharan Africa are improving sustainability while tackling climate change.

Download infographics, charts and social media cards for sharing. Watch the GAP Report[®] launch event online. Follow us on social media **@Ag_Productivity, @Harvest2050** and **#GAPReport** to see new stories and analysis throughout the year.





Across Africa and India, 90 million very poor people depend on various types of millet for daily food and income. Photo credit: ICRISAT

MAKING THE CROPS THAT FEED MILLIONS MORE NUTRITIOUS AND PRODUCTIVE

Across the drylands of India and Africa, farmers and consumers grow and eat sorghum and millets, annual grasses that produce small seeded grains. These cereals are exceptionally resilient in dry conditions, require short growing seasons (three to four months from planting to harvest), are suited to lowinput smallholder farming systems and are culturally accepted staple foods for about one billion people.²¹

While sorghum and millets have great potential to transform the health, nutrition and livelihoods of farmers and consumers, barriers exist to their greater use as highvalue food products in the food system. Millets, and especially sorghum, can have

levels of an anti-nutrient called phytate that inhibits the uptake of iron and zinc. Low levels of pro-vitamin A also can be problematic.

With additional partnerships and investments, sorghum and millets can be enhanced to bring even greater benefits to consumers, farmers and to the planet.

In April of 2018, a multi-year partnership was established between the **International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)** and **Corteva Agriscience™, the Agriculture Division of DowDuPont.** The partnership will strengthen food security by boosting the productivity of sorghum and millet varieties through sharing modern breeding technologies.

Corteva Agriscience[™] will provide access to advanced plant breeding tools like CRISPR-Cas²² and guiding principles for gene-editing, as well as its intellectual property, technology capabilities, infrastructure and scientific

expertise. ICRISAT has research capabilities and relationships with national agricultural research

institutions across Africa and India, where sorghum and millet germplasms can be customized into seed varieties for local smallholder farmers.

A Need for Seed — And Seed Systems

Developing improved affordable seeds and getting them into the hands of smallholder farmers in a timely way is a complex and challenging process. Continued investment and capacity building of seed systems in countries across sub-Saharan Africa and South Asia will be critical in the delivery of improved sorghum and millets to farmers.²³

To enable widespread adoption of these new varieties, farmer organizations and cooperatives can help their members purchase improved seeds and gain growing skills. Cooperatives can also develop seed production ventures. Agricultural retailers can provide certified seeds, fertilizers and crop protection products and agronomic advice to accompany improved seed. Small-size seed packets enable farmers to experiment with new varieties at a lower price with less risk.

Government regulatory agencies can streamline and harmonize national and regional seed standards so that farmers can gain access to quality, improved seeds and increase the nutritional quality of these staple crops.



Ms.Velma Okaron, Research Assistant, Biotechnology Lab ICRISAT Kenya, conducts research on sorghum, millet and groundnuts for nutrition and income security. Photo credit: ©ICRISAT/Njeri N. Maina



The ICRISAT and Corteva Agriscience[™] partnership brings together expertise in state-of-the-art transformational breeding techniques and plant biochemical pathways with a global network of research institutions.

HARVESTING ZINC FOR HEALTHY SOILS, CROPS AND PEOPLE

Micronutrient deficiency, a lack of vitamins and minerals in the diet, is a devastating form of malnutrition — or hidden hunger — afflicting 2 billion people, including half of the world's children under the age of five.24

Zinc deficiency is a particularly debilitating condition that causes premature birth, cognitive and physical underdevelopment and immune system suppression. Seventeen percent of the global population does not get enough zinc in their diets and nearly half-a-million people die from zinc deficiency every year.²⁵

Zinc deficiency rates are highest in the rural areas of developing countries where millions of small-scale farmers grow and consume cereal grains (maize, wheat or rice) that have inherently very low levels of zinc.²⁶ Improving the zinc concentrations in these crops can dramatically reduce zinc deficiencies for this vulnerable population.

The Mosaic Company is one of the private-sector, foundation and university supporters of the HarvestZinc project which has identified methods for biofortifying cereal crops with zinc through fertilization. The project was led by HarvestPlus, a CGIAR institution that develops biofortified food crop technologies to improve nutrition and agricultural productivity.

Biofortification is typically done with a breeding technique that produces plants with a higher micronutrient content. Millions of small-scale farmers use biofortified seeds and benefit from the higher nutrient levels.



Photo Credit: Dr. Ismail Cakmak

an agronomic biofortification strategy where biofortification of the crop happens within the plant during the growth and development process.

Field trials over nine years in 12 countries demonstrated that spraying a fertilizer



containing zinc on plants toward the end of the growing process doubles the zinc concentration in the harvested grain.²⁷ This technique is called **foliar fertilization**.

Depending on the soil's zinc status, application of zinccontaining fertilizers to the soil may also contribute to improved grain zinc levels.

Field trials revealed that fertilizing the soils with a combination of zinc and nitrogen, in addition to foliar fertilization, further enhanced the zinc levels in the plants and the grain. These results indicate that soil fertilization strengthens the root growth and root uptake system which improves the plant's ability to retain zinc and supports increases in yields.

Of the crops tested, wheat and rice had the strongest improvements in zinc concentration following zinc fertilization.

Agronomic biofortification is a promising and costeffective strategy for combating malnutrition in the era of climate change. Increased atmospheric CO₂ may cause a decline in the nutrient concentration of crops, including zinc.²⁸

Properly applied zinc fertilizer is a rapid, effective solution to reducing zinc deficiency, especially for small-scale farmers who grow most of their food. Combining plant breeding technologies with agronomic biofortification techniques would amplify the benefits of both approaches and holds significant promise for reducing zinc deficiency in human nutrition while improving crop yield and resilience.



Felipe Schwening uses climate-smart agriculture practices to grow soybeans in Brazil.

Photo Credit: Cristiano Borges

CROP INNOVATIONS PROTECT THE PLANET AND REWARD LATIN AMERICAN FARMERS

Latin America is home to nearly one-third of the world's arable land and fresh water, making it a critical global agricultural breadbasket in the coming decades.²⁹ The region is already a leading contributor to the global food system; Argentina, Brazil, Paraguay and Uruguay (ABPU) together are the largest net exporters of food and agriculture products in the world.³⁰

The success in ABPU is, in part, a result of innovative crop genetics combined with environmentally-friendly climate-smart agriculture practices that are used by farmers across the region.

These practices enable farmers to grow more crops per unit of land and other inputs, such as fertilizer or herbicide, thereby reducing the environmental impact of crop production. Networks of farmers learn from one another how to use precision agriculture technology, biotechnology and no-till agriculture practices to grow more, use and waste less and

improve the natural resource base.

Modern seed technologies for corn, cotton and soybeans that produce higher yields and resist pests are critical to the climatesmart agriculture systems that drive productivity in the region.

One of the most widely adopted seed technologies is the Intacta soybean (INTACTA RR2 PRO[™]), a product of **Monsanto Company** (acquired by **Bayer AG**) in June 2018. This genetically-modified seed technology is tolerant to the herbicide glyphosate and resistant to insects that feed upon soybeans (velvet-bean caterpillar, soybean looper, bean shoot borer, corn stalk borer and stem borer).



Soybean looper larva. Photo credit: lowa State University, Department of Entomology

Intacta soybeans have been available since 2013 and rapid commercial planting on nearly 24 million hectares across APBU region has contributed to a significant reduction in insecticide and machinery fuel use, while improving soil quality and generating higher farm income.³¹

Use of these improved soybeans and other genetically-modified crops enables farmers to adopt no-till productions systems, as tillage is no longer required to control weeds and prepare seed-beds. No-till systems reduce tractor fuel use and keep more carbon in the soil, resulting in lower greenhouse gas emissions.

BETWEEN 2013–2018, USE OF INTACTA SOYBEANS IN SOUTH AMERICA³²



Increased total farmer income by \$7.64 billion, or a gain of \$3.88 for every \$1 invested;



Saved 774 million liters of fuel, or 2.1 billion kilograms of carbon dioxide not released into the atmosphere—equivalent to removing 1.28 million cars off the road for one year, from less frequent herbicide and insecticide applications;



Enhanced soil health through no-till systems, sequestering more carbon in the soil; this avoided 4.759 million kilograms of carbon dioxide released into the atmosphere, equivalent to removing 2.94 million cars off the road for one year; and,



Reduced pressure to bring additional land into production as farmers grew additional soybeans equivalent to an area of 2.2 million hectares from existing land.

EMBRACING ANIMAL WELFARE STRENGTHENS PRODUCTIVE SUSTAINABLE FOOD SYSTEMS

Consumers are increasingly interested and concerned about the welfare and well-being of livestock and animals in the food and agriculture system. The animal agriculture community, made up of farmers and ranchers, veterinarians, nutritionists, meat processing companies and retailers, recognizes these concerns and is creating a more innovative and transparent food system. Enacting good animal welfare systems is a "triple win" and is good for livestock, producers and consumers.



A Leader in Animal Care

Healthy animals raised with good animal welfare practices result in safe, wholesome, high quality meat, dairy and poultry products. A commitment to transparency and access to information about production practices can help bridge the "trust gap" between farmers, processors and consumers today.

For many years, the standard practice of pork producers has been to keep sows (female breeding pigs) in individual pens for much of their adult life to efficiently feed and care for the animals, protect piglets after birth and during nursing and ensure the safety of farm workers.

Group Housing System for Pregnant Sows



Smithfield Foods, a global food company that is also the world's largest hog producer and pork processor, was the first in its industry to develop and implement a comprehensive, systematic animal welfare management system.

Further underscoring their commitment to animal care, Smithfield was the first large-scale producer in the industry to convert to group housing. All pregnant sows on company-owned farms, including joint ventures in Mexico, are now in group housing systems. Smithfield leads the pork industry with improved animal welfare practices, while continuing to balance the need for safety of animals and workers.

Smithfield announced this commitment in 2007, investing more than \$360 million to complete the transition over 10 years. Sows are now housed in groups during pregnancy and are moved into individual stalls when they give birth and until the piglets are weaned.

Smithfield also released a 360-degree video so consumers can "visit" a company-owned sow farm operation and learn more about these and many other innovative pork production practices. A similar video of a wean-to-finish farm is also available.

Smithfield recommends that all contract sow growers in the United States complete a transition to group housing by the end of 2022 and provides guidance and expertise when requested to help growers make the conversion.

Embracing and implementing high standards of animal welfare is an integral part of a responsible, sustainable food system, bringing benefits to farmers and their livestock, the environment and to consumers.



MECHANIZATION IS A PATH TO PRODUCTIVITY IN NIGERIA

Nigeria is rich in agricultural resources. Its land, rainfall and climate make it an African agricultural powerhouse. Total cereal production has steadily increased from 7.8 million tons in 1960 to 25 million tons in 2016.³³ Even with its oil resources, agriculture is the base of the nation's economy and the largest source of employment.³⁴

Yet the agriculture sector has struggled to meet its potential. Agricultural output grew by an average of 1.2 percent per year from 2005 to 2014, not nearly enough to meet domestic demand.³⁵ In 2016, Nigeria imported 4 million tons of rice, despite being the largest rice producer in Africa.³⁶ Substantial growth in agricultural output will be needed if Nigeria is to feed more than 300 million people in 2050.

One of the reasons for the gap between domestic production and consumption of rice and other cereals is that most of Nigeria's farmers are operating at very small scales, with little access to inputs, such as improved seeds, fertilizer and pesticides, or to mechanization. Mechanization use has increased just two percent annually (2005–2014).³⁷

In April 2018, **Alluvial**, a Nigerian company that works with smallholder farmers, and **John Deere** through its distributor **Tata Group**, formed a partnership to lease up to 300 tractors to be used by 100,000 smallholder farmers in the Niger Delta region of Nigeria.

Oil wealth dominates the economy of the Delta region, but most people rely on farming for their food and livelihoods. Rates of food insecurity, malnutrition and poverty in the region are high. Irrigated rice field in Nigeria. Photo credit: World Bank/Arne Hoel

"With the proper inputs and mechanization, farmers could produce more than \$300 million worth of rice per year, at current prices," says Dimieari Von Kemedi, founder of Alluvial.³⁸

To increase the competitiveness of small-scale agriculture in the Niger Delta region, Alluvial groups together farmers operating on contiguous parcels of land. They aggregate the farmers' output to sell on commercial markets and provide inputs, such as seeds and fertilizer, at competitive prices.

Alluvial's farmers will be able to rent a John Deere tractor to plow, harrow and harvest. The cost per acre for one growing season is around \$100. The tractor leasing program will bring mechanization to farmers cultivating 460 square miles of cropland.

The Nigerian government is also investing in mechanization leasing programs. In May 2018, the government announced the purchase of 10,000 John Deere tractors over the next five years. Smallholder farmers will be able to rent the tractors from local service providers for five percent less than the market price for mechanization rental.³⁹

"Nigerian farmers are knowledgeable, motivated and passionate. We believe in the country and are looking forward to partnering with Nigeria," said Mark Von Pentz, President of John Deere Agriculture & Turf Division — Europe, CIS, Asia, Africa and Global Tractor Platform.⁴⁰

For small-scale farmers in Nigeria, mechanization service rentals are a path to better land and labor productivity. Expanding access to these technologies will help lift farmers out of poverty while increasing food availability for Nigeria's rapidly growing population.

Read these stories from GHI's Partner Organizations at www.globalagriculturalproductivity.org

Adapting and Thriving in the Changing **Climate of Northern** Ghana

For farmers in the savannahs of central and northern Ghana. climate change is not a distant, future threat. Higher temperatures, extreme weather, and prolonged droughts exacerbated by climate change are real and present dangers to their crops and livelihoods.

ACDI/VOCA leads the USAID Feed the Future Ghana Agriculture Development and Value Chain Enhancement (ADVANCE II)

program which brings farmers the technological innovations, climate-smart agricultural practices, and strategic partnerships they need to adapt and thrive in their changing environment.

TOBAGO GOAT

SHEEP SOCIETY

Moove Over Cows; Goats Got My Dairy!

The Trinidad and **Tobago Goat and Sheep Society** (TTGSS) has

TRINIDADAN strategically developed a dairy goat product industry. The 150 members of TTGSS include women and youth; more than 90 percent are small to medium in operation size.

Since 2014, International Institute for Cooperation on Agriculture (IICA) has partnered with TTGSS, providing direct technical assistance and helping the producers adopt a value-chain approach, allowing for many complementary interventions to improve productivity and business management.

Photo credits from top to bottom: Laura Bell for ACDI/VOCA; Ganaderia Colombiana Sostenible: IICA: GAIN

Healthy Agricultural Systems: A New Model for Agriculture and the **Environment in Latin America**

Today, Latin American agriculture is responsible for almost a third of global greenhouse gas emissions that come from land use and land conversion. More than half the forest loss in the world is happening in the region, with deforestation three times the global rate.

The Nature

Conservancy and its partners are enabling farmers of all sizes to adopt practices that repair the land and sequester carbon, thereby ensuring more productive and profitable farm operations.

The "Golden Girls" and "Sunny Boys" of Bangladesh Stand Up for Nutrition

Bangladesh is grappling with a staggering adolescent nutrition problem. Of the 30 million adolescents in Bangladesh, 26 percent (7.8 million) are underweight and live in rural areas. The Global

Alliance for Improved Nutrition (GAIN)

is working with a dynamic network of Bangladeshi young women and men known as the Golden Girls and Sunny Boys who advocate with their political leaders for better nutrition.

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