COLLEGE OF
AGRICULTURE AND
LIFE SCIENCES
VIRGINIA TECH™

2019
GAP
REPORT®

GLOBAL AGRICULTURAL
PRODUCTIVITY REPORT®

PRODUCTIVITY GROWTH FOR SUSTAINABLE DIETS, AND MORE

Executive Summary

GAP REPORT EXPANDS VIRGINIA TECH'S GLOBAL REACH

Established by the Global Harvest Initiative in 2010, the Global Agricultural Productivity Report® (GAP Report®) is being produced beginning in 2019 by Virginia Tech, a leading U.S. land-grant university in Blacksburg, Virginia.

The GAP Report will create an even larger knowledge platform for the Virginia Tech College of Agriculture and Life Sciences (CALS), which has long been a leader in empowering people around the world to sustainably produce agricultural and food products. The report is part of CALS Global, a unit within the college that builds partnerships, creates opportunities, and empowers success while serving globally.

The GAP Report brings together expertise from the private sector, NGOs, conservation and nutrition organizations, Virginia Tech and other universities, and global research institutions.

Direction and input for the GAP Report and related activities are provided by the **Virginia Tech Internal Advisory Group** and the **GAP Initiative Leadership Council**. Members are listed on the back cover of the executive summary.

SUPPORTING PARTNERS

Supporting Partners provide financial support for the GAP Report and related activities. They offer an important perspective on critical issues facing agricultural systems in the US and around the world.

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Consultative Partners contribute their knowledge of productive, sustainable food and agricultural systems, including the role of agricultural R&D and extension, natural resource conservation, human nutrition, international development, gender equity, and the needs of small-scale farmers.

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Photo credit: Virginia Tech

PRODUCTIVITY GROWTH FOR SUSTAINABLE DIETS, AND MORE

The world must sustainably produce food, feed, fiber, and bioenergy for nearly 10 billion people in 2050. Thanks to growing consumer interest in food production and campaigns by the EAT Foundation and others, radical transformations to the world's food and agricultural systems are being debated in public and policy forums.

Using publicly-available data and peer-reviewed analysis, **the 2019 Global Agricultural Productivity Report® (GAP Report®) puts agricultural productivity growth at the heart of a global strategy for achieving sustainable diets, and more.**

Stories from the private sector, universities, conservation and nutrition organizations, NGOs, development agencies, and international agricultural research institutions demonstrate how agricultural producers, operating at all scales, use strategic combinations of technology, best practices, and attention to ecosystem services to nurture productivity growth, sustainability, and resilience.

READ THE REPORT ONLINE!

GlobalAgriculturalProductivity.org

CONTENTS

Steensland, A., (2019) *2019 Global Agricultural Productivity Report: Productivity Growth for Sustainable Diets, and More* (Thompson, T., Ed.), Virginia Tech College of Agriculture and Life Sciences.

Cover photo credit: ILRI/Apollo Habtamu

www.globalagriculturalproductivity.org

KEY MESSAGES

1 By accelerating productivity growth, particularly in small-and medium-scale livestock production, we can achieve global nutrition and environmental goals, while still providing consumers with the animal-source foods they need and want.

2 Environmental sustainability initiatives should prioritize regions experiencing rapid population growth, low rates of agricultural productivity, and significant shifts in consumption patterns – the primary drivers of unsustainable agricultural practices, such as converting forests to crop and rangeland.

3 Global agricultural productivity, measured as Total Factor Productivity, is growing at an average annual rate of 1.63 percent, less than the 1.73 percent required to sustainably produce sufficient nutritious food and agricultural products for 10 billion people in 2050.

4 Total Factor Productivity in low-income countries is alarmingly low, growing at 1.00 percent annually, far below the UN SDG target of doubling the productivity of the lowest-income farmers.

5 Innovative agricultural technologies and best farm management practices, combined with attention to ecosystem services, drive productivity growth and can be tailored for all scales of agricultural production.

STRATEGIES FOR SUSTAINABLE DIETS, AND MORE

Invest in public agricultural R&D, extension services, and consumer education

Public sector agricultural R&D, extension services, and consumer education programs generate innovation and information that facilitate environmentally sustainable agricultural output growth, improve human health, and support a vibrant agricultural economy.

Embrace science- and information-based technologies and practices

Science- and information-based technologies and practices enable producers of all scales to manage environmental and economic risks, by improving their sustainability, resilience, and competitiveness.

Improve infrastructure and market access for agricultural inputs and outputs

Efficient transportation, communications, and financial infrastructures, as well as affordable and equitable access to markets for agricultural inputs, services, and outputs, support sustainable economic growth, diminish waste and loss, and reduce costs for producers and consumers.

Cultivate partnerships for sustainable agriculture, gender equity, and improved nutrition

Public-private-producer partnerships supporting agricultural development, gender equity, and nutritious food systems leverage public and private investments in economic development, natural resource management, and human health.

Expand and improve regional and global trade

Forward-looking trade agreements, including transparent policies and consistently enforced regulations, facilitate the efficient and cost-effective movement of agricultural inputs, services, and products to the people who need them.

Reduce post-harvest loss and food waste

Reducing post-harvest losses and food waste increases the availability and affordability of nutritious food, eases the environmental impact of food and agricultural production, and preserves the value of the land, labor, water, and other inputs used in the production process.

MORE THAN SUSTAINABLE DIETS

The food price crisis of 2007-2008 brought global attention to the complex web of environmental, economic, and human challenges that urgently need to be addressed if we are to sustainably meet the agricultural needs of 10 billion people in 2050.

Agriculture accounts for **24%** of global greenhouse gas emissions and **71%** of fresh water use.[1, 2]

Soil erosion and desertification have cut land productivity in some parts of the world by **50%,** a loss valued at **$400 billion** (USD) annually.[3]

Natural disasters in developing countries caused **$96 billion** (USD) in damaged or lost crop and livestock production (2005-2015).[4]

150.8 million children under 5 are stunted and **38.3 million** are overweight; **38.9%** of adults are overweight or obese.[5]

56 million people live in conflict zones and urgently **need food** and livelihood assistance.[6]

Calls are intensifying for changes in policy, research priorities, production practices, and consumption patterns to create sustainable food and agricultural systems. The EAT-*Lancet* Commission Report (2019)[7] focuses on environmentally sustainable diets and calls for sweeping changes in food consumption patterns to drive drastic reductions in greenhouse gas (GHG) emissions, stunting (low height for age), and obesity.

The 2019 GAP Report advocates for a more holistic vision for agriculture that encompasses all agricultural products and purposes and a multi-dimensional approach to sustainability that reflects the UN Sustainable Development Goals (SDGs).

Sustainable agriculture must satisfy human needs; enhance environmental quality and the natural resource base, sustain the economic vitality of global and local food and agricultural systems, and improve the quality of life for society as a whole.[8]

Agriculture's primary purpose is food production, but it also part of a larger bio-economy. Agricultural products are used to create fuels, fibers, building materials, animal feed, pet food, starches, oils, solvents, dyes, resins, specialty chemicals, and pharmaceuticals. The residues and byproducts of foodstuffs are used for animal feed, bioenergy, and in industrial applications.

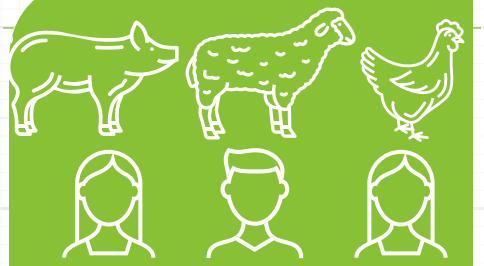
Farmers around the world produce both food and non-food agricultural products. Diversification is an important economic and environmental risk-management strategy. It provides additional sources of income and has agronomic benefits, such as improved soil health.

A broader definition of sustainability accurately reflects the full range of environmental, economic, and human challenges to our agricultural and food systems in the twenty-first century.

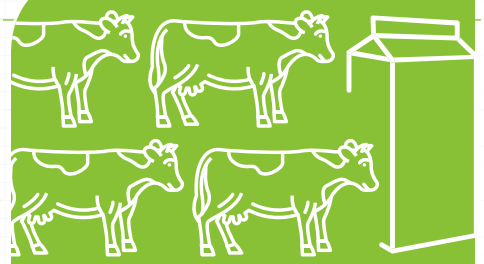
GLOBAL AGRICULTURAL SUSTAINABILITY IMPERATIVE

For our agricultural systems to be sustainable, they must meet the needs of present generations without compromising the ability of future generations to meet their own needs. This is **a systemic challenge**, encompassing environmental, economic, and social dimensions of sustainability. It is also **a global challenge.** The lives and livelihoods of everyone on the planet will be impacted by the choices we make, and we all have a role to play in achieving our sustainability goals. **The Global Agricultural Sustainability Imperative identifies key issues that must be addressed to achieve sustainable production of agricultural products that we *eat*, *use*, and *enjoy*.**

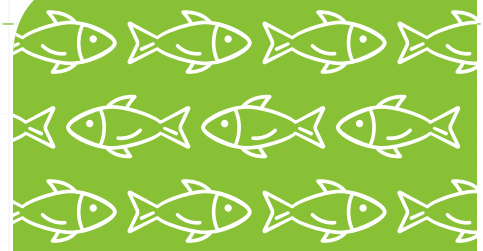
EAT



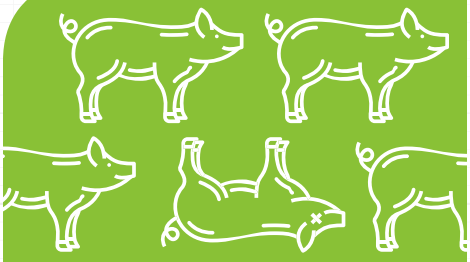
500+ million people depend on livestock for their livelihoods and 2/3 of livestock producers are women.[9]



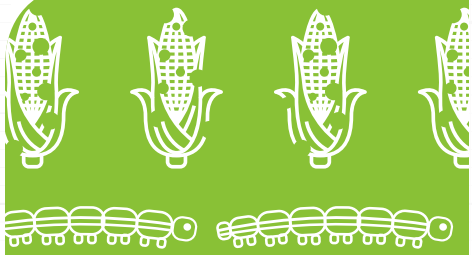
At current milk yields, India would need to add **20 million** dairy cattle and buffalo over the next 10 years to meet rapidly rising domestic demand. [10]



Fish are a primary source of protein for more than 3 billion people and demand is rising.[11]

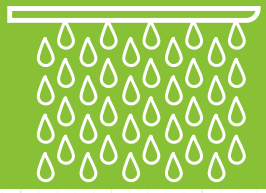


China has already lost **350 million pigs** to African Swine Fever, nearly one-quarter of the global swine population.[12]



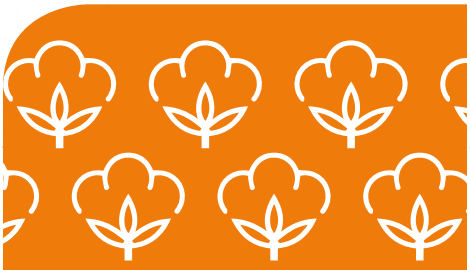
Fall armyworm has caused **$3 billion (USD) in crop damage** in Africa and is rapidly spreading in Asia.[13]

1/3 of food produced for human consumption – 1.3 billion tons – is lost or wasted annually.[14]



4.2 trillion gallons of irrigation water would be needed to produce the fruits and vegetables that Americans throw away every year.[15]

USE



Cotton production will increase by 16% during 2019-2028. Most of this increase will be generated by opening new land for production due to stagnant yields in high-producing countries.[16]

1/3 of the global population depends on forest products and services for income, employment, food, fuel, or medicine; 80% of annual forest loss is to make room for crop and grazing lands.[17]

Only **40%-60%** of the increased oilseed production (soy, rapeseed, sunflower, and groundnut) during the next 10 years will come from yield increases, as farmers put uncultivated land into production to meet demand.[18]

ENJOY

1.3 million hectares of land are used to produce cut flowers, ornamental plants, and bulbs. The global market for flowers and ornamental plants is projected to reach $96 billion (USD) by 2021.[19]

In the U.S., dogs and cats consume as much dietary energy as 62 million Americans.[20] **Global demand for pet food is rising** as the population of domestic cats and dogs grows by 22% and 18% respectively (2018-2024).[21]

Recreational waterways can be contaminated by agricultural nutrient runoff. Nearly **800 coastal ecosystems** around the world are struggling with algae blooms, lack of oxygen, and other problems due to excess nutrients. [22]

PRODUCTIVITY FOR SUSTAINABLE GROWTH

The Global Agricultural Sustainability Imperative does not lend itself to one-size-fits-all solutions, but there are proven strategies for meeting global demand in a sustainable way. The 2019 GAP Report demonstrates how agricultural producers, operating at all scales, use strategic combinations of technology, best practices and attention to ecosystem services to increase productivity and nurture sustainable growth.

SUSTAINABLE AGRICULTURE IS BUILT ON PRODUCTIVITY GROWTH

While global population and incomes are growing more slowly that they did at the turn of the century, 30 years from now, the world's farmers, ranchers, fishers, and foresters will need to sustainably produce food and agricultural products for nearly 10 billion people.

Agricultural producers have a variety of strategies and production practices to choose from, but many threaten the sustainability of our agricultural systems.

Land Expansion: Expand the amount of land used to produce crops and livestock by converting forests and grasslands to agricultural production.

Irrigation Extension: Deploy or extend irrigation systems to protect land against drought, improve its productive capacity, and permit multiple cropping seasons.

Input Intensification: Increase applications of fertilizer, machinery, labor, seeds, herbicides, animals, and other inputs to increase crop or livestock output on currently cultivated crop and rangeland.

These strategies are needed in some circumstances, but if not used appropriately they can lead to negative outcomes: loss of biodiversity, soil degradation and erosion, higher GHG emissions, declining yields over time, reduced water quantity and quality, and vulnerability to environmental shocks and climate change.

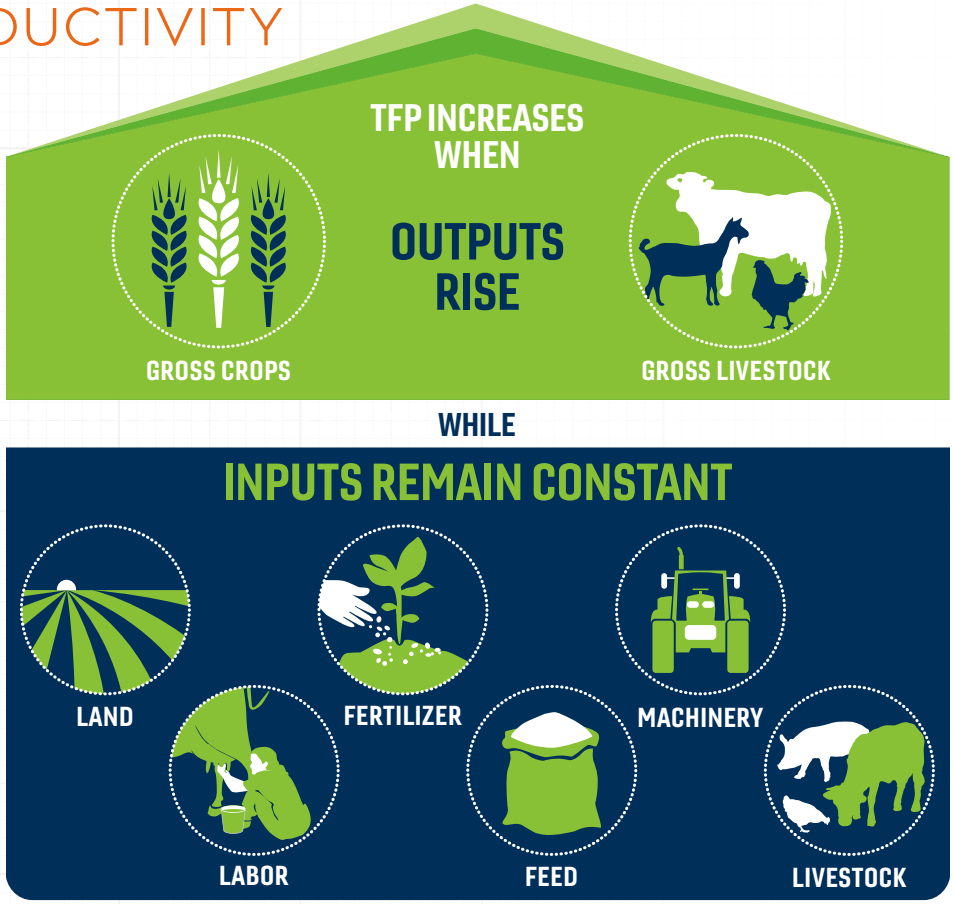


Figure 1: Total Factor Productivity

TOTAL FACTOR PRODUCTIVITY FOR SUSTAINABLE GROWTH

A strategy that emphasizes **sustainable productivity growth** will help meet the needs of producers and consumers today, while safeguarding the environmental, economic, and social sustainability of agriculture for future generations.

Agricultural productivity rises when producers use technologies and production practices that produce more crops and livestock from existing or fewer resources. This increase in efficiency is measured as **Total Factor Productivity, or TFP.**

TFP is not a measure of *output*, the total quantity of crops or livestock produced, nor is it a measure of *yield*, the amount of output per unit of production, usually land.

TFP is a ratio that measure changes in how efficiently agricultural inputs (land, labor, fertilizer, feed, machinery, and livestock) are transformed into outputs (crops and livestock.)

TFP growth indicates that producers are adopting improved technologies and practices. **Tracking TFP gives us insight into how efficiently and sustainably we are using our land, water, human, and capital resources.**

THE GAP INDEX™: GLOBAL TFP GROWTH STAGNANT; LOW-INCOME COUNTRY TFP ALARMINGLY LOW

Data from the USDA Economic Research Service indicate that TFP is not growing fast enough to sustainably meet the demand for food, feed, fiber, and bioenergy needed in 2050.

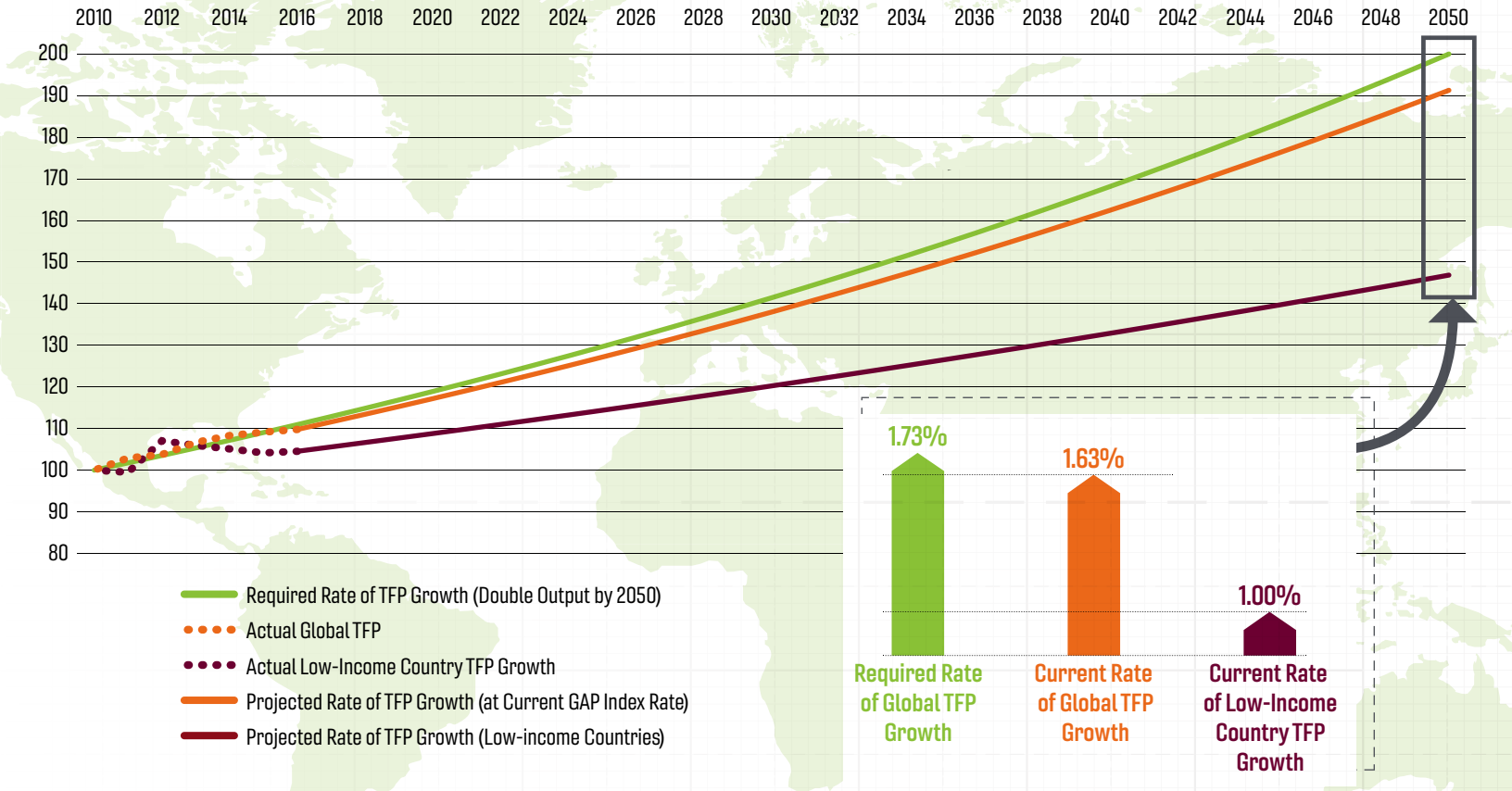
Globally, TFP is rising by an average annual rate of 1.63 percent, less than the estimated 1.73 percent needed to sustainably double agricultural output (2010-2050) through productivity growth. TFP growth is strongest in China and South Asia, but it is slowing in the agricultural powerhouses of North America, Europe, and Latin America.

TFP growth in low-income countries is alarmingly low, just 1.00 percent.

Urgent attention is needed to reverse this trend and achieve Sustainable Development Goal 2 (SDG2), which calls for doubling the productivity for small-scale farmers in the lowest-income counties.

Without timely interventions, productivity trends will produce significant negative consequences for environmental sustainability, economic development, and human nutrition. Farmers will use more land and water to increase output, straining a natural resource base already threatened by climate change. Unable to afford higher-priced nutrient-dense foods, such as animal proteins and fruits and vegetables, consumers will rely on foods made from cheaper cereal grains for most of their calories, exacerbating skyrocketing obesity rates in adults and children.

Policymakers, producers, and consumers can help reverse these trends by investing in agricultural R&D and extension services, adopting science-based technologies and better farm management practices, paying greater attention to ecosystem services, improving transportation infrastructures, reducing food loss and waste, making regional and global trade efficient and cost-effective, and supporting programs for agricultural development, gender equity, and nutrition.



Source: Current and projected TFP growth provided by USDA Economic Research Service (2019).

UNEVEN PRODUCTIVITY GROWTH THREATENS SUSTAINABLE LAND USE

During the past 40 years, TFP growth has been the primary driver of global agricultural output growth, with significant benefits for environmental sustainability, economic growth, and food security. (Figure 2, green bar.) **During that time, agricultural output has increased by 60 percent, while global cropland has increased by just five percent.**[23]

Productive use of inputs and capital helps farmers control costs, protect natural resources, and manage risk during volatile business cycles. Many consumers enjoy access to a variety of nutritious foods that are affordable and safe.

Much of this global improvement can be attributed to a variety of high-income countries where nearly all agricultural output growth is generated by productivity gains. (Figure 3, green bar.)

In the U.S., agricultural output has increased by 36 percent since 1982.[24] At the same time, the total amount of annual soil erosion has decreased by 44 percent, due to wide-spread adoption of advanced seed technologies, precision agriculture, and water management practices. As a result, the **amount of soil erosion per unit of agricultural output has decreased by 60 percent.**

Improvements in animal breeding, feed efficiency, manure management, and animal care make it possible for U.S. livestock producers to provide the world with nutritious meat, milk, and eggs with significantly fewer GHG emissions per unit of output. In Latin America, India, and China, GHG emissions per unit of livestock production are two to 10 times higher than in the U.S.[25]

If animal agriculture was eliminated in the U.S., as some are advocating, it would reduce U.S. GHG emissions by only 2.9 percent, while depriving consumers around the world of the nutrient-dense foods they need and want. [26]

Despite the sustainability progress made in the U.S. and higher-income countries, producers have recently put more land into production and intensified input use as they struggle to adapt to the booms-and-busts of the agricultural markets. Soil health, water quantity and quality, increasingly severe weather events, a warming climate, uncertainty in agricultural markets, and an aging agricultural workforce all pose significant threats to future productivity gains.

- **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 Agricultural Output: **Global**, 1961–2016

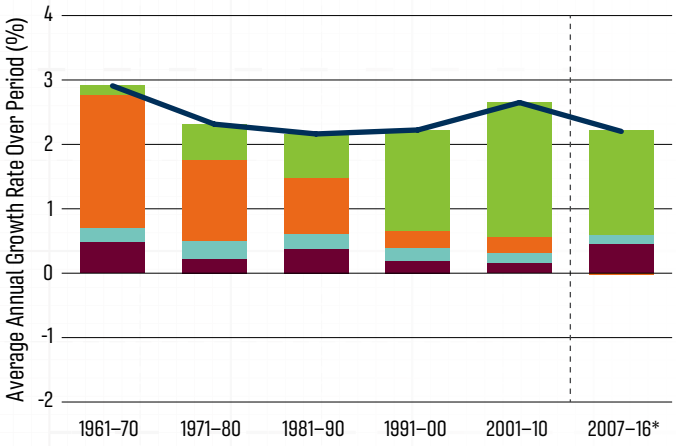
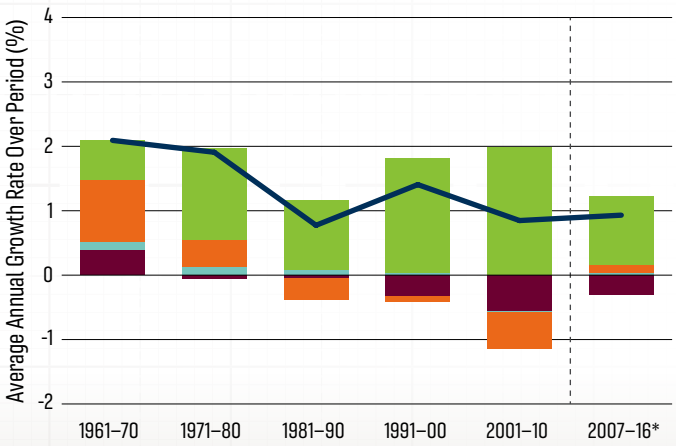


Figure 3: Sources of Growth in Agricultural Output: **High-Income** Countries, 1961–2016



*Depicts data for the most recent ten-year period.
Source: USDA Economic Research Service (2019).

The total amount of land used for agricultural production in the next 10 years is predicted to be flat, as a decrease in pasture is balanced by an increase in cropping area.[27] However, land-use trends and sustainability practices vary greatly by country and region. New research by the **Agricultural Model Intercomparison Improvement Project (AgMIP)**[28], identifies the top three predictors of land use change: **population growth, levels of agricultural productivity, and changes in consumption patterns.**[29]

Figure 4: Sources of Growth in Agricultural Output: **Sub-Saharan Africa**, 1961–2016

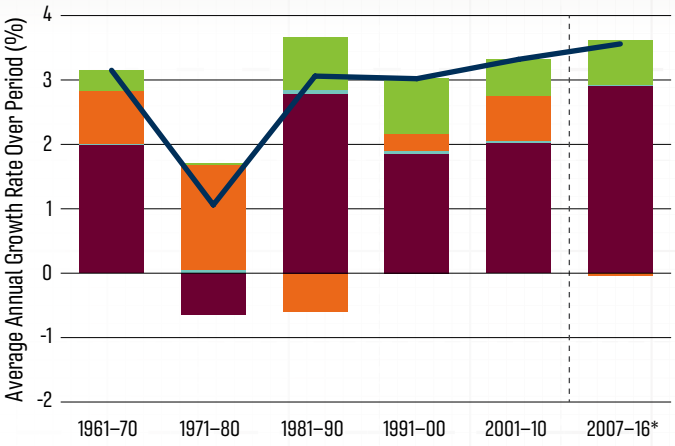
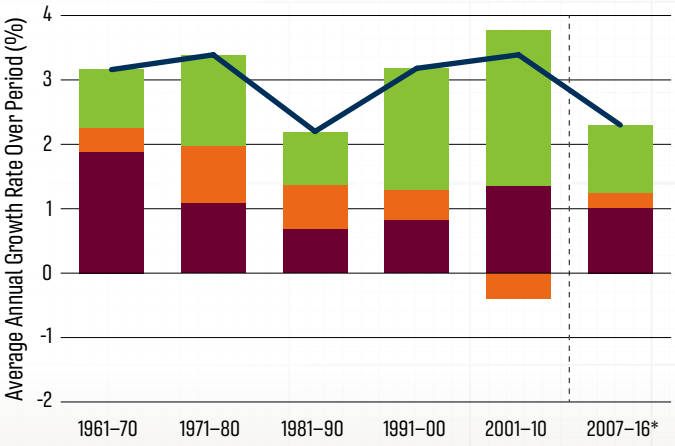


Figure 5: Sources of Growth in Agricultural Output: **Latin America**, 1961–2016



*Depicts data for the most recent ten-year period.
Source: USDA Economic Research Service (2019).

Sub-Saharan Africa and Latin America show how these dynamics can lead to unsustainable land use.

SUB-SAHARAN AFRICA

In the 1980s and 1990s, agricultural productivity grew as African governments reformed or removed state controls over the cost and quantity of agricultural inputs and outputs available in the market.[30]

As the impact of those reforms has dissipated, **strong population growth and persistent low agricultural productivity** are driving farmers to open new lands for pasture and crop cultivation.

The size and buying-power of Africa's middle class will grow more slowly during the next decade, suppressing per capita consumption of agricultural products. Total demand will continue to increase, however, due to rapid population growth. The UN predicts that **18 African countries will double, or even triple, their current populations by 2050.**[31]

Without better access to advanced agricultural inputs and mechanization, extension services, financing, and land tenure, Africa's farmers will continue to convert forests and grasslands to agricultural production, while further depleting the soils and pastures already in use.

LATIN AMERICA

Since 1990, Latin America has become a global breadbasket. **In response to increased domestic and global demand for food and feed crops, fruits and vegetables, and livestock products,** producers invested in precision machinery, adopted advanced seed technologies, and improved their livestock management systems.[32]

To maximize their investments and control costs, farmers specialized in fewer crops or livestock products. This contributed to remarkable TFP growth, but **it has also taken a toll on the region's biodiversity as farmers take advantage of their increased efficiency and convert more forests and fragile lands to agricultural production.**

Smart land-use policy and increased investment in public agricultural R&D and extension can reduce land expansion and help producers improve the health and productivity of current crop and grazing lands.

TECHNOLOGY, BEST PRACTICES, AND ATTENTION TO ECOSYSTEM SERVICES DRIVE PRODUCTIVITY GROWTH

Agricultural technologies that enable producers to increase their output using the same amount, or less, land, labor, capital, and other inputs, are the primary drivers of productivity growth. Yet, technology alone is insufficient to achieve long-term TFP gains.

A farm management system that utilizes the appropriate agricultural technologies and practices, complemented by the attention to ecosystem services, can realize short-term productivity gains and increase them over time, while strengthening their resilience to weather and economic shocks.[33]

Agricultural ecosystems are defined by the plants, water, soil, air, microbes, and animals in and around areas where agricultural activity takes place. The interaction between these elements create benefits, or *ecosystem services*, that make agriculture more productive, sustainable, and resilient.

Ecosystem services include pollination, erosion prevention, carbon sequestration, nutrient cycling, soil fertility, air and water quality control, and pest and disease management. The economic value of ecosystem services is not captured in TFP, yet they **are the "natural capital" of the agricultural system.**

The **CGIAR Research Program on Water, Land and Ecosystems** estimates that the value of pollination services provided by wild bees, insects, and birds exceeds $150 million annually.[34]

Consumer demand plays an important role in determining how and what food and agricultural goods are produced.

However, a strategy that relies primarily on consumer behavior to drive systemic change neglects what research has shown: **wide-spread and lasting changes in agriculture are driven by policies, investments, and partnerships that facilitate the adoption of agricultural technologies, best practices, and attention to ecosystem services,** such as:

- **Providing training and financial support to producers to identify and enhance ecosystem services.**
- **Developing tailored interventions to reduce GHG emissions from small-scale livestock production**.
- **Scaling-up R&D investments to make staple and non-staple food crops more productive, climate resilient, and nutritious.**
- **Using smart land-use policies to ensure that productivity growth does not stimulate land expansion.**
- **Strengthening rural economies by investing in infrastructure, sanitation, healthcare, and education.**

Waste not, conserve more

Sustainable agriculture systems cannot be achieved without drastic reductions in food loss and waste (FLW). SDG2 calls for a 50 percent reduction in global FLW by 2030. Reducing FLW keeps critical nutrients in the food system and preserves the investment of natural and capital resources used to produce them.[35]

By combining agricultural technologies with best practices and attention to ecosystem services, agricultural producers can reduce net GHG emissions to half of current levels by 2050, while still providing for global food and agriculture needs.*

CROP GENETICS: Improved crop genetics increase yield, preventing the conversion of biodiverse habitats to crop production. Locally cultivated crop varieties contain genetic material that improves the productivity and climate resilience of hybrid and biotech seeds.

SOIL HEALTH: Rotating crops with legumes and planting cover crops can preserve soil nutrients, increase the soil's water-holding capacity, and improve soil carbon sequestration.

TILLAGE MANAGEMENT: Reduced or no-till systems prevent erosion, soil degradation, and carbon loss. Improvements in precision agriculture and data analytics, in combination with high yielding, herbicide-tolerant crops, make it easier for farmers to adopt tillage management systems.

WATER AND NUTRIENT MANAGEMENT: When nutrients are properly managed, particularly through precision systems, over-application can be avoided, runoff reduced, and emissions minimized. Precision and drip irrigation, ensure efficient use of minimal amounts of water to increase yields.

DIVERSIFICATION: Combining livestock production and food crops on land where timber and trees are grown conserves carbon and nutrients in the soil, improves the profitability of tree production, prevents erosion, and provides shade for animals.

PEST CONTROL AND POLLINATION: Flowering strips, hedgerows, and small forest patches near cropped areas create habitats for insects and animals that provide pollination and pest control.

INTEGRATED AQUACULTURE: Integrating animals, feed crops, and aquaculture production increases productivity and reduces producer costs by recycling nutrients through a closed system.

RUMINANT RECYCLERS: Cows, goats, and sheep eat agricultural by-products that are not consumable by humans and recycle them into nutritious animal proteins and fertilizer. Improved feed and forages, advanced animal genetics, and better animal care practices reduce methane emissions created in the digestive process, while increasing milk, egg, and meat output per animal.

*Climate Change 2014: Mitigation of Climate Change, Contribution of Working Group 3 of the Fifth Assessment Report of the Inter-Governmental Panel on Climate Change.

PARTNERSHIPS FOR PRODUCTIVE, SUSTAINABLE GROWTH

Partnerships between the public sector, private enterprise, and communities play a critical role in sustainably increasing productivity and improving the lives of producers and consumers. The following stories from Virginia Tech and the GAP Report Supporting and Consultative Partners demonstrate how companies, governments, organizations, and individuals are working together to ensure we have sustainable diets, and more, for generations to come. Additional stories can be found on the GAP Report website, **GlobalAgriculturalProductivity.org**

Photo credit: Bayer Crop Science

A Tailored Approach to Sustainable Farming

There is no one-size-fits-all solution when it comes to sustainable farming. Recognizing this, **Bayer Crop Science** teamed up with independent farmers to create **Bayer ForwardFarming**, a knowledge platform that demonstrates sustainable agriculture in practice.

The platform focuses on demonstrating the importance of seeds and traits, crop protection, digital tools, and related services, with the **end goal of sustainably increasing yield by making the best use of all resources, while preserving the environment.**

ForwardFarms are independently owned farms that proactively seek improvements in sustainable agriculture practices, and in return their farms serve as hubs for exchange of ideas and insights that can be implemented locally and globally.

At the **Nossa Senhora Aparecide Farm** in Brazil, soil health is the top priority for the Fiorese family. The Fioreses work with Bayer advisors and soil consultants to implement no-till, a technique that helps to reduce and eliminate soil preparation tasks and has given the family more flexibility and efficiency in farm management. They have also employed a multi-cropping approach for their soy, corn, beans, wheat and sorghum, and use cover crops such as oats. These changes have resulted in improved soil structure, increased soil organic matter, and improved water infiltration and water holding capacity.

In Brazil, and around the world, the ForwardFarming initiative is powering a sustainable movement down to the individual farm level – and everyone benefits with higher quality food and a healthier environment.

HarvestPlus and GAIN Accelerate Access to Biofortified Staple Crops

Two billion people worldwide suffer from micronutrient deficiency because they cannot afford a diverse, nourishing diet. Today, 50 million people have access to biofortified varieties of vitamin A maize, cassava and sweet potato; iron-rich beans and pearl millet; high-zinc maize, rice and wheat, and other food crops. **HarvestPlus** and the **Global Alliance for Improved Nutrition (GAIN)** are working together to commercialize and expand the reach and availability of biofortified crops, bringing the benefits of biofortification to millions more.

Photo credit: Smithfield Foods

Sustainable Grains for Sustainable Pork

Smithfield Foods doesn't own the farms that produce their animal feed, but they found that approximately 15 to 20 percent of their carbon footprint originated from purchased feed.

They partnered with the **Environmental Defense Fund (EDF)** to assist farmers with sustainable grain farming solutions.

Starting in 2013, they aimed to purchase 75 percent of grain from roughly 450,000 acres engaging in efficient fertilizer and soil health practices.

Smithfield teamed up with EDF to help farmers find ways to optimize fertilizer use and improve soil health through their Smithfield Agronomics program, known as **SmithfieldGro**.

Smithfield hired agronomists who work directly with and provide custom insight to farmers in nutrient management, cover crops, reduced-cost seed, and precision agriculture. They help grain farmers to implement cover crops, nitrogen sensors, and other conservation practices throughout the Southeast and, more recently, the Midwest.

By choosing the right crops, practicing more efficient fertilizer application, and adopting best practices – such as cover crops – farmers can boost soil health, improve water quality, and reduce GHG emissions – all while controlling costs.

By the end of 2018, **80 percent of grain purchased by Smithfield came from approximately 560,000 acres** where sustainable practices were implemented, marking a 76 percent growth in just four years. This was a monumental step toward the company's goal to reduce their greenhouse gas (GHG) emissions by 25 percent by 2025 – the first protein company to make such a commitment.

Communities in Senegal Embrace Mung Bean

Mung bean is a nutrient-dense grain legume rich in protein and micronutrients, such as iron and folate, that are critical for human health. Mung bean also has agronomic benefits that support sustainability and resilience. It has a short growing season, fixes nitrogen to the soil, and grows in drought-prone climates.

Virginia Tech's College of Agriculture and Life Sciences (VT CALS) and **Counterpart International** are working with communities in the St. Louis region of Senegal to increase the production and consumption of mung bean in homes and schools. The project is collaborating with the **Institut Sénégalais de Recherches Agricole** to identify open pollinated mung bean varieties that are well-adapted to the local soils and climate.

Farmers participating in the program benefit by improving the health and resilience of their soils, reducing micronutrient deficiency, and shortening the hunger season, the period between harvests when families have little or no food to eat.

Mung beans are not typically part of the local food system, which is dominated by rice and vegetables.

VT CALS School of Plant and Environmental Sciences and **Virginia Cooperative Extension** helped develop a community-based learning model that taps into existing social structures, such as farm groups and schools, to train children and adults, in basic agronomy, soil sustainability, and the cultivation, processing, and cooking of mung bean.

Photo credit: John Deere

Changing Perceptions of Agriculture at the World's Largest Consumer Electronics Expo

Agribusiness is looking for new venues to engage consumers in conversations about the critical importance of agricultural technology for the sustainability, availability, and affordability of the food and agricultural products they enjoy.

Precision systems enable farmers to manage and track, year after year, progress toward maximizing the productivity of each field. Less productive areas can be put into conservation, preserving the biodiversity that supports ecosystem services, such as pollination and water filtration.

Yet most consumers are surprised to learn how much advanced technology, including artificial intelligence, computer vision, machine learning, and robotics, is already being used in agriculture.

Visitors to the 2019 Consumer Electronics Show (CES) found themselves staring up at a 20-ton **John Deere** combine for a closer look at the technology-packed machine on display at John Deere's booth. It was **the first time a combine ever appeared at the world-renowned technology trade show.**

For many visitors and representatives of the tech media, John Deere's appearance at the world's-biggest technology show was initially a mystery. At first many didn't understand what they were seeing when they came upon the massive green and yellow machines and displays.

Visitors walked away with a better understanding of how technology and farming are intertwined – and why that's good for farmers, consumers, and the planet.

Photo credit: International Potato Center/ S de Haan

Custodians of Potato Productivity and Biodiversity

By Stef de Haan, agri-food systems scientist, International Potato Center

The **International Potato Center (CIP)** is working with custodian farmers to preserve the diversity of potato crops, which offer important income and nutrition opportunities to these small-scale farmers.

Custodian farmers have a special ability and passion for managing agrobiodiversity in the Andes. Of the more than 3,000 unique potato landraces in Peru, each farmer grows up to 400, often inherited from their parents or grandparents. The genetic diversity contained in these crops will be critical to securing potato yields around the world as the climate changes.

In 2014, a group of custodian farmers from 50 Andean communities established the Asociación de Guardianes de Papa Native del Centro de Peru (AGUAPAN) to facilitate the exchange of good practices between custodians and help ensure local farmers benefit from the genetic diversity in their communities.

With technical support from CIP, the local NGO Grupo Yanapai, Peru's Instituto Nacional de Innovación Agraria, and the Sociedad Peruana de Derecho Ambiental, have broadened traditional indicators of yield to include stability (output over time), adaptability (output under stress) and quality (micronutrients per unit of production). Private sector initiatives, such as the one funded by international potato breeding companies, including HZPC and AGRICO, provide financial support to farmers so they can dedicate time to adaptive landrace preservation.

Photo credit: ACDI/VOCA

Enriching the Lives of 400,000 Smallholder Farmers Through Improved Market Systems

Last year, around **820 million people went hungry** around the globe. Africa is the hot spot, with undernourishment reaching nearly 20 percent of the continent's population. To address the challenge of global hunger, **Corteva Agriscience™** is partnering with governments and NGOs to advance technologies and innovations which strengthen smallholder farmer market systems.

These collaborations align with Corteva's purpose statement: **Enrich the lives of those who produce and those who consume to ensure progress for generations to come.**

Corteva collaborates with the **United States Agency for International Development (USAID)** on its global hunger and food security initiative called Feed the Future (FtF). Corteva and USAID are part of a powerful and diverse coalition setting out to end global hunger, poverty, and malnutrition by focusing efforts in select countries.

In Tanzania, for example, Corteva and the international development nonprofit organization **ACDI/VOCA** have come together on the **USAID FtF Tanzania Staples Value Chain (NAFAKA) II: Cereals Market System Development** project to **enrich the lives of 400,000 smallholder farmers over the next three years.** Together, they are strengthening the smallholder farmer market system in rural areas by increasing access to high quality seed and crop protection technologies, improving agricultural practices, and increasing farmers' access to credit.

The result? Higher yields and higher incomes mean the lives of farmers and their communities are enriched through increased food security, improved nutrition, and better access to health and education, ensuring progress for generations to come.

Trade Knowledge Critical in Uncertain Times

Producers of agricultural commodities in developed and developing countries alike have made significant progress over time in improving their productivity, competitiveness and profitability through innovation and farm management practices. However, with these recent trade disruptions, markets have become more volatile and unpredictable, leading to shifts in trade flows that impact productivity and potentially shift production toward the suboptimal use of natural capital, particularly water and land.

Farm Foundation's Food and Agricultural Trade Resource Center was created to provide clear, concise and unbiased trade information that helps to bring clarity to trade discussions and enable productive dialogue on trade policy issues. This goal is in keeping with the mission that has driven Farm Foundation's work for more than eight decades: to cultivate dynamic, non-partisan collaboration to meet society's needs for food, fiber, feed and energy. The Foundation connects leaders in farming, business, academia, organizations, and government through proactive, rigorous debate and objective issues analysis.

Farmers Use the 4Rs to Improve Vegetable Productivity and Protect Water Quality

Southwest Florida farmers rank second in the United States for fresh market vegetable production, just behind California.

Since 2013, **The Mosaic Company** and **The Nature Conservancy** (TNC) have helped farmers in the region improve productivity and profitability while reducing their environmental impact by encouraging the adoption of the **4R Nutrient Stewardship** framework: **utilizing the right nutrient source at the right rate, at the right time, and in the right place.**

These practices keep nutrients in the soils and plants and out of waterways. TNC educates agricultural retailers and growers on fertilizer best management practices to improve yields and reduce nutrient losses.

A vegetable farmer in Manatee County agreed to try the 4R practice of banding fertilizer, applying fertilizer in a band below the soil surface, on part of his fields and was astonished by the results.

The improved nutrient management resulted in **a 13% increase in production.** In addition, the cabbages were higher quality, bigger, more uniform, and more profitable. The cabbages also utilized the banded fertilizer more efficiently, keeping the nutrients in the soils and the plants, and out of the waterways.

Thanks in part to a $3.1 million investment by The Mosaic Company Foundation, more than 4,500 growers and ranchers, operating more than 350,000 acres, are implementing 4R practices.

Photo credit: Tanager

Empowering Women Farmers in India, One Signature at a Time

How well could you farm your land and care for your family if you could not read, write, or even sign your name? This is a challenge for millions of women farmers in India. Since 2014, **Tanager**, an ACDI/VOCA affiliated international NGO, and **Mars Wrigley Confectionery** have partnered on the **Shubh Mint project**, which organizes **Self Help Groups (SHGs)** to empower women farmers in the mint supply chain of Uttar Pradesh, India.

In these groups, women learn about sustainable farming practices as well as skills many people take for granted, like the ability to sign one's own name. This basic skill is an important step to financial literacy and gender equality.

This is not only important for the women, it is also a priority for Mars Wrigley Confectionery. Mint farmers in India produce 70% of the world's supply of mint, an essential ingredient in Mars Wrigley Confectionary's products. The Shubh Mint project is part of the company's commitment to sustainably sourcing mint through improved livelihoods for smallholder producers and responsible water usage.

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