Sustainable Agriculture Is Built on Productivity

The United Nations defines sustainable growth as, "meeting the needs of the present without compromising the ability of future generations to meet their own needs." No one understands this delicate balancing act better than farmers, ranchers, forest managers and fishers.

Do I plant to the edge of my property to earn more during this season of low crop prices? Or do I place more erodible land in conservation, preserving the health of my soil for the future?

Do I adopt unfamiliar cultivation practices that will help me adapt to climate change even though it will require additional labor for a few years?

Do I buy more livestock to increase my output? Or do I invest in better feed and veterinary services to improve the productivity and health of my current herd?

Do I invest in capital improvements like a tractor or more land that I can pass on to the next generation? Or do I rent them and keep my farm competitive today?

As they balance the demands of the present with the needs of the future, producers decide how much risk they are willing to take. They must consider the risk-management options available to them, as well as factors they cannot control like weather, market prices and economic or political uncertainty.

While trade-offs are inevitable, **policies and investments that support agricultural productivity and expand risk management capacity give producers the best chance to meet current and future needs,** while increasing their adaptability and resilience.

STRATEGIES FOR MEETING AGRICULTURAL DEMAND

There are multiple approaches to meeting the current and future demand for agricultural products.

» **Land Expansion** — Producers use more land to produce more, and in some cases, convert forest to cropland or rangeland.

» **Irrigation** — Producers deploy or extend irrigation systems to protect land against drought and improve its productive capacity, which may permit multiple cropping seasons. If not carefully managed, groundwater may be depleted.

» **Intensification** — Producers increase applications of fertilizer, machinery, labor, seeds, herbicides or other inputs on existing land to grow more crops or raise more livestock.

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

» **Productivity** — Adopting technologies and production practices that result in more output from all existing resources, as measured by **Total Factor Productivity (TFP).**

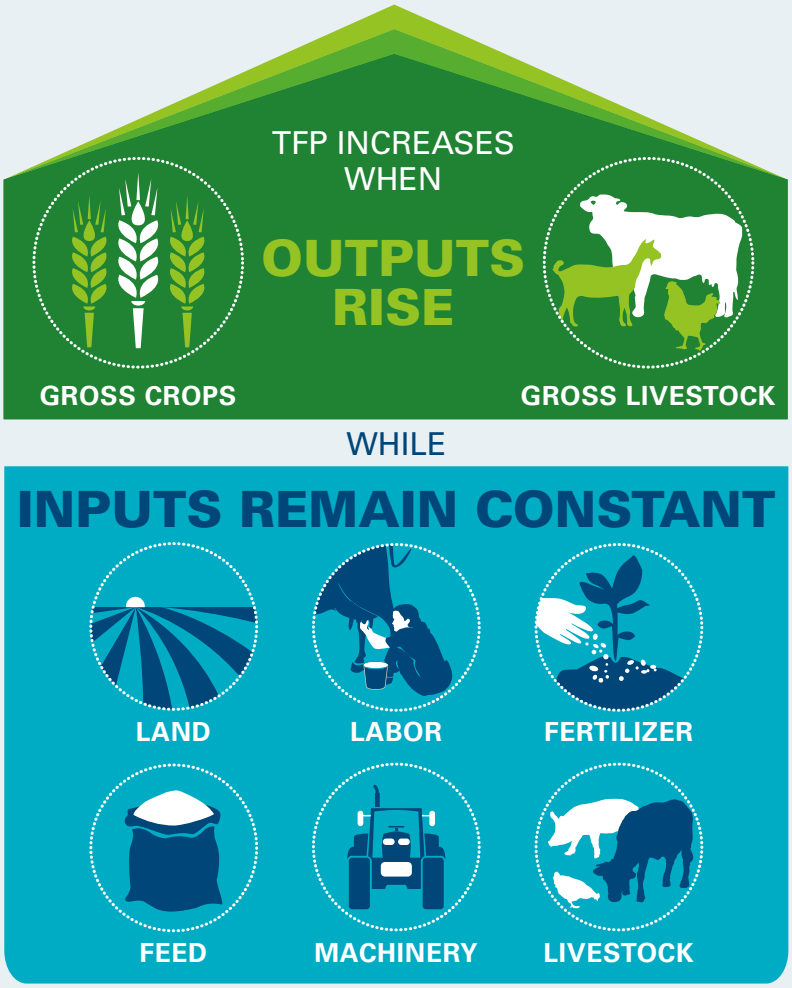
WHAT IS PRODUCTIVITY IN AGRICULTURE?

Agricultural productivity is distinct from output, which refers to the gross amount produced, or yield, which measures the amount of output per unit of production, usually land.

TFP (Figure 1) is the ratio of agricultural outputs (gross crop and livestock output) to inputs (land, labor, fertilizer, feed, machinery and livestock). **TFP measures changes in the efficiency with which these inputs are transformed into outputs.**

By measuring TFP, as opposed to yields or output, we understand the extent to which increased output is due to better use of these critical resources. **Policymakers, development agencies, researchers and producers use TFP to identify where improvements are needed** in agricultural production systems and to determine which investments and policies increase productivity and enhance sustainability.

Figure 1: Total Factor Productivity



PRODUCTIVITY PROMOTES COMPETITIVENESS AND CONSERVATION

TFP looks beyond how much we are producing. It reveals how efficiently we are producing it and indicates how well we are conserving available resources to meet our future needs.

Productivity growth in agriculture lowers the cost per unit of output, helping producers succeed in today's competitive business cycle, and enables agri-food systems to provide lower prices for consumers. Farmers use productive technologies and practices such as improved seeds and farm equipment, genetically improved livestock and good animal husbandry to increase output while conserving land and water and protecting soils for future generations.

In addition to promoting competitiveness and conservation, **productive technologies and good practices also support the SDG goals** to end hunger and malnutrition, protect the safety of the water supply and reduce greenhouse gas emissions.

Case studies throughout the 2017 GAP Report® demonstrate how farmers of all scales, producing a variety of products in different geographies, are conserving and protecting their soil and water resources while reducing their climate impact.

Some of the innovations highlighted in the 2017 GAP Report® include drought-tolerant seeds that enable poor farmers in dryland areas to grow in stressful conditions; precision agriculture technologies that enrich soil in the field and keep nutrients out of streams; and animal care innovations and practices that improve the health and productivity of each animal while reducing emissions from livestock production.

Productivity on the Rise, With Room to Grow

TFP accounts for the largest share of growth in global agricultural output today (Figure 2). In the 1960s, the Green Revolution introduced high-yielding seeds to millions of farmers, along with access to fertilizers, irrigation and machinery. As farmers began to use those inputs more efficiently, the contribution of inputs per land area to agriculture output declined (orange bar) and TFP's contribution increased (green bar).

Low-income countries have mirrored the global trend in TFP growth and enjoyed a substantial increase in agricultural output (Figure 3). However, since the 1980s, opening new land for agricultural production (red bar) remains the primary driver of agricultural output. Economic and political forces have driven land expansion in low-income countries: transitions to market-based economies, the introduction of input subsidies and prices supports, growing populations needing more land to cultivate and the extension of irrigation. While some land is suitable for agricultural expansion, **greater productivity on existing cultivated land needs to be prioritized to minimize agriculture's impact on soil, water, forests and wildlife.**

Low labor productivity on small-scale farms, predominantly found in low-income country agricultural systems, largely accounts for the higher inputs per hectare of agricultural land results (Figure 3, orange bar). Small-scale farms are labor-intensive due to insufficient off-farm or urban employment opportunities that could absorb the excess labor in rural areas. Small-scale farmers also struggle to purchase or rent machinery at competitive prices relative to their labor cost. This contributes to high rates of rural poverty and food insecurity.

In **high-income countries,** all growth in agricultural output is now generated by TFP, while the amount of inputs per hectare of land has declined and **land and labor have been taken out of agricultural production** and put into conservation or to other productive uses (Figure 4). Technologies such as pest-resistant high-yielding seeds, precision agriculture machinery systems and improved animal care and production practices enable farmers to increase their output while controlling costs, conserving land and water resources and reducing the environmental footprint of agriculture.

Nevertheless, **TFP growth has slowed** in high income countries (Figure 4, green bar). Future TFP growth will be driven by innovations such as advanced crop and livestock breeding and data systems that monitor plant growth and animal health. However, public-sector investments in the research and development (R&D) that drive agricultural innovation has slowed in many high-income countries.

Public R&D provides discoveries that are the foundation for further private-sector innovation; lower public investments constrict the innovation pipeline. Private-sector research investments, while significant, cannot make up the public R&D funding gap. **Increased public-sector R&D investments are needed to reinvigorate productivity growth.**

Additionally, as urbanization increases, so does **competition for land and water resources.** Continued farm consolidation will create some additional efficiencies, but land and water-use policies must balance the resource needs of agricultural producers with those of their urban customers.

REDUCING RISK AND WASTE

Productivity alone is insufficient to achieve economically, environmentally and socially sustainable food and agriculture systems. **Food and agriculture systems are vulnerable to a variety of risks,** including extreme weather events and climate change, market volatility and political instability. During times of crisis, agricultural producers seek to minimize their losses without putting their future productivity at risk. Good innovations and an enabling policy environment can ensure they stay productive during seasons of risk. This also helps stabilize the supply and price of food and agriculture products.

Public and private insurance programs, such as crop insurance or weather index insurance, help preserve producer incomes and enable them to keep their most productive assets. Some producers participate in conservation programs that reward them for protecting their soil and water resources.

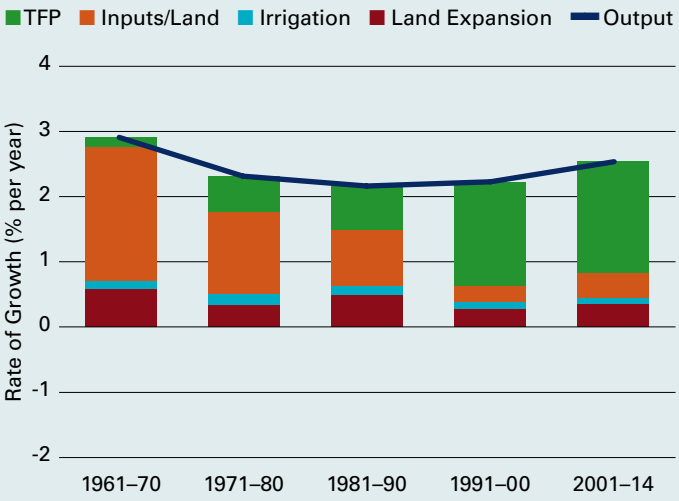
Those without access to insurance and conservation programs face difficult choices. During hard times, small-scale farmers usually raise cash by selling cattle and equipment or by leasing their land; the poorest farmers have little to sell, so they reduce their consumption of food and may resort to pulling children from school and into labor. These coping strategies have generational impacts on the health and economic prospects of the family as well as their farm operations.

Consumers also face risks from economic instability or food price shocks. Governments are establishing social protection programs to stabilize households experiencing food and income insecurity. Some countries rely on national reserves to feed their population and manage food prices. Ensuring that agricultural trade remains open

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

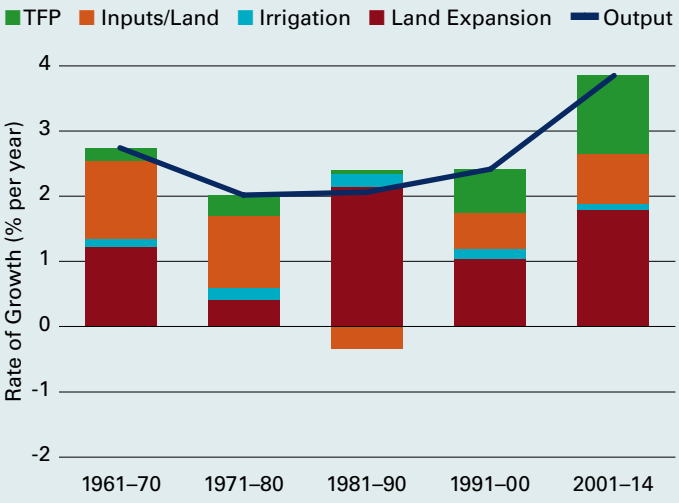
- **TFP** — Gross amount of crop and livestock outputs per inputs (labor, capital and materials)
- **Inputs/Land** — Gross amount of fertilizer, machinery, feed, labor and other inputs per hectare of agricultural land
- **Irrigation** — Extension of irrigation to agricultural land (which raises the number of crop harvests per year as well as yield per harvest)
- **Land Expansion** — Opening up additional land resources to extend production

Figure 2: Sources of Growth in **Global** Agricultural Output, 1961–2014



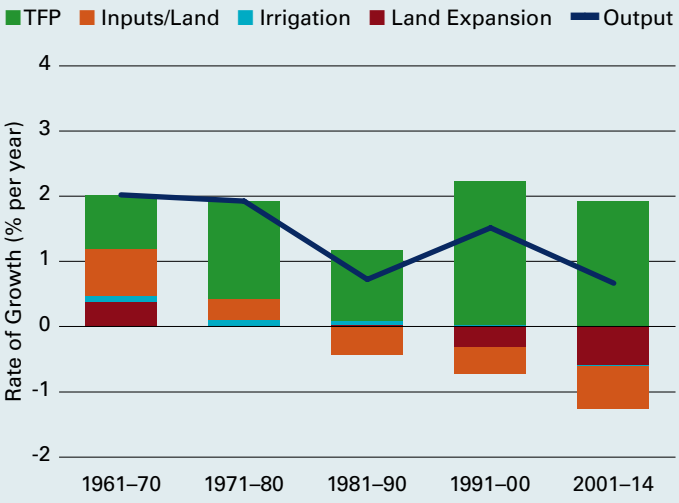
Source: USDA Economic Research Service (2017).

Figure 3: Sources of Growth in Agricultural Output: **Low-Income** Countries, 1961–2014



Source: USDA Economic Research Service (2017).

Figure 4: Sources of Growth in Agricultural Output: **High-Income** Countries, 1961–2014



Source: USDA Economic Research Service (2017).

is essential to keeping food prices stable, especially when commodity stocks are low.

Reducing agricultural losses on the farm and food lost throughout the agricultural value chain avoids wasted resources and unnecessary greenhouse gas emissions. Improvements must be targeted throughout every part of the value chain: better harvesting and storage practices, better livestock care to reduce disease, improvements to the cold chain and the transportation infrastructure it relies on, reductions in waste at the processing and retail levels and changes in consumer behavior. Reducing loss and waste on a wide scale depends on government investments in public goods, such as infrastructure. An enabling policy environment that supports private-sector innovation in harvest and storage technologies and stimulates behavior change by consumers is also vital.

In addition, there are opportunities to increase the productive use of unconsumed food and agricultural byproducts. These are potential sources of bio-energy, animal feed, fertilizer and new products. Reducing loss and waste and creating more opportunities to use waste productively will help meet the growing global demand for agricultural products, generate clean energy, mitigate carbon emission, create new jobs and industries and improve incomes and food security, especially for small-scale producers.