The Global Imperative for a Sustainable Healthy Planet

The United Nations Sustainable Development Goals (SDGs) establish targets for achieving inclusive economic growth, social development and natural resource conservation and biodiversity by 2030.

Sustainable agriculture practices and technologies contribute to many of the 17 SDGs by helping to end hunger and malnutrition, reducing post-harvest loss and food waste, mitigating climate change, providing clean energy, preserving biodiversity and promoting good health and gender equality.

What is Sustainable Agriculture?

Sustainable agriculture must satisfy human needs; enhance environmental quality and the natural resource base; sustain the economic vitality of food and agriculture systems and improve the quality of life for farmers, ranchers, forest managers, fishers, agricultural workers and society as a whole.[1]

But achieving these interconnected goals is a growing challenge, particularly in the face of a changing climate and pressure from growing global food and agriculture demand.

Agri-food production systems impact the natural resource base and are the source of nearly one quarter of global greenhouse gas (GHG) emissions. The majority of agricultural emissions are from deforestation and land use change (the conversion of forest to croplands or livestock grazing lands), and from methane emitted from livestock, along with poor soil management.

Agriculture is also impacted by climate change. Recent models show that with a 2° Celsius increase in global mean temperature (the temperature ceiling for a climate-safe planet), yields are expected to decrease, on average, 14 percent for maize, 12 percent for wheat, 6.4 percent for rice and 6.2 percent for soybeans.[2]

Climate change also brings rising threats from the growing assault on crops by insect pests. When average global surface temperatures increase by 2 degrees Celsius, models indicate the median increase in yield losses due to pest pressure is 46 percent for wheat, 19 percent for rice and 31 percent for maize.[3] The Inter-Governmental Panel on Climate Change's (IPCC) fifth assessment report confirms this strong linkage between warming and increased threats to agriculture from pests and disease.

Degraded soils, lack of clean water for agriculture and human consumption, failing crops and livestock and rising temperatures lay the groundwork for food crises and economic and political instability. Conflict, migration and drought are tightly interwoven and must be viewed through the lens of sustainability.

Environmental Issues Resonate with Consumers

Concerned and motivated citizens, private-sector businesses, international scientific bodies and policymakers joined in a global consensus to advance The Paris Climate Agreement, a blueprint for climate action. In 2015 the Paris Agreement was adopted by 188 countries representing 98 percent of the global population, covering almost 99 percent of all global GHG emissions. Countries have created commitments for action to achieve national targets for a low-carbon, climate resilient future.

The value that society places on reducing GHG emissions and better stewardship of soil, water and wildlife is leading to consumer demand for climate-friendly production methods and supply chains.

While agricultural production is a source of emissions, **agriculture itself can serve as a force to mitigate greenhouse gases.** Innovations in agricultural science and products and new, climate-smart agricultural practices by farmers, combined with effective public policies that incentivize soil, water and habitat conservation can lay a strong foundation for making the agri-food system more sustainable and responsive to consumer concerns.

AGRICULTURE BECOMES A MITIGATION POWERHOUSE

By adopting mitigation practices and enhancing productivity, the agriculture and forestry industries will be able to reduce net emissions to half of current levels by 2050 while still providing for global food and agriculture needs.*

Cropland technologies and management: Improved crop genetics and conservation practices increase yield and reduce the amount of land required, slowing the conversion of natural habitats to crop production. Biotechnology and genetic modification can improve crops so that they require fewer herbicide and pesticide applications and less energy to fuel the machinery that applies them. Rotating crops with legumes fixes nitrogen to the soil, enables soils to store organic matter and improves soil carbon sequestration. Planting cover crops preserves soil nutrients, improves the soil's water-holding capacity and helps sequester carbon in the soil.

Nutrient management: Nitrogen in fertilizer and manure can be a source of GHG emissions and pollution. When managed properly and used in precision agriculture systems, over-application can be avoided, runoff reduced and emissions minimized.

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, (2014).

Tillage management: Reduced or no-till systems prevent erosion, soil degradation and carbon loss. They also reduce the cost of farming and thereby maximize returns on investment for farmers. Improvements in farm machinery, in combination with high yielding, herbicide-tolerant GM crops, make it easier for farmers to adopt tillage management systems.

Water management: Precision irrigation systems ensure efficient use of minimal amounts of water. By applying water exactly when and where it is most needed at variable rates, farmers reduce water use while increasing yields.

Rice management: The high methane emission rates of cultivated wetland rice soils during the growing season can be reduced by coordinating the timing of fertilizer application with dry instead of wet seasons, draining wet fields during the wet season and improving the genetic quality of the rice cultivars.

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

Grazing land management and livestock management: Both over-grazed and under-grazed pastures store less carbon than optimally grazed lands. To reduce methane emissions from cattle and sheep, ranchers can improve feeds and forages, use dietary additives to maximize feed protein uptake and reduce the amount of feed required, and use methane inhibitors that can reduce methane emissions by up to 30 percent. Improved genetics and health care practices can also help reduce these emissions while enabling farmers and ranchers to produce more milk and meat per animal.

Manure management: Animal manure produces nitrous oxide and methane, but emissions of these gases can be reduced by storing it in covered tanks and using methane digesters. Methane can also be captured and used as an energy source.

Processing and transportation: Half of agricultural emissions come in the post-production stages, including processing and transportation. GHGs can be reduced by substituting alternative fuels such as biofuels, using fuel efficient vehicles, reducing food waste along the value chain and using better packaging materials.

Focusing on improving agricultural productivity is a vital first step in reducing agriculture's overall environmental and GHG impacts.

The Baby Boomer and Generation X age groups sparked the first environmental movements in modern agri-food systems, yet it is the Millennial consumer who is scaling up these issues into the marketplace.[4] When it comes to purchasing decisions, 62 percent of U.S. Millennials indicated they would pay more for food derived from environmentally responsible practices, compared to 47 percent of Gen X and 30 percent of Boomers.[5]

By voting with their shopping carts, these young consumers send a message to food retailers, and others in the agri-food system, starting a cascade of market signals that reach to the producer.

The Business Case for Climate and Sustainability Leadership

In addition to reading the market signals favoring climate-friendly products, producers are increasingly aware that climate change is a leading risk factor to the environmental and economic viability of their operations. As climate changes alter production practices, current business models may become irrelevant, creating uncertainty for an industry that thrives on stability and long-term planning.

Yet, the need to address and mitigate climate change also provides new business opportunities for producers, retailers, investors and entrepreneurs in the agri-food value chain.

A growing number of farmers will need crops that have greater heat, drought and pest tolerance; livestock farmers will need genetically improved breeds; farmers will need innovative agricultural mechanization and precision systems to apply crop nutrients and crop protection more efficiently; and all participants in the agri-food system will need better information and decision-support to best grow, store, process, transport and deliver products to consumers in a low-carbon way.

The following stories from Latin America, the United States and Africa demonstrate how agri-food systems are transforming to meet the global sustainability imperative for a healthier planet.

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

Because of its enormous potential to increase agricultural production while satisfying rising demand for food and keeping pantries stocked the world over, Latin America is critical for global food security over the next few decades. Already an agricultural powerhouse, the continent provides 60 percent of the world's imported soybeans, 44 percent of imported beef and a third of the corn that countries buy from abroad. And experts say the region is fully capable of doubling its farm output by 2030.

But these advancements have come at a price, mainly in the destruction of forests and the depletion of land and fresh water resources, which are already having a devastating impact on the health of our planet.

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. Moreover, the resulting biodiversity loss and soil degradation have had a severe impact on the very assets upon which agricultural productivity depends.

Healthy Agricultural Systems in Colombia optimize natural ecosystems to restore vitality to landscapes, making farming both profitable and sustainable and slowing deforestation. Photo credit: Ganaderia Colombiana Sostenible

Increasingly, critical agricultural assets are being recognized as not just "land and water," but rather healthy, regenerating farmland, whose productive capacity is supported by surrounding natural habitats and watersheds. The vitality of these assets is paramount when it comes to the profitability and success of farming and other agricultural businesses in the decades to come. For example, the carbon that is removed from the atmosphere and captured in soils and plant biomass is the same carbon that is key to making agricultural soils more fertile and productive.

This is the premise behind The Nature Conservancy (TNC)'s work in Latin America. **Using a Healthy Agricultural Systems (HAS) approach** that focuses on increasing productivity while preserving the assets –the water, soil and rich biodiversity that make productivity possible—TNC 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 Nature Conservancy has established several projects that are encouraging this transformation. **In Colombia**, TNC and partners have supported 2,600 ranchers in their transition to healthy agricultural systems over the past seven years. Results have been impressive. Milk and meat production increased by 20 percent. Bird species numbers increased from 140 to 193 and the number of terrestrial mollusks, ants, butterflies, and other wildlife increased. Monitoring studies have confirmed reduced pollution of water sources.

The climate impact of the healthy agricultural systems approach is equally impressive. To date, farmers have contributed to capture 1.5 million tons of CO_2 equivalent by converting degraded pastures into silvopastoral systems (grazing systems incorporating special fodder, grasses and trees with rotational plots for livestock). They have avoided additional emissions by planting secondary forests and by preserving the natural forests within the project areas. Both contributions are highly significant for Colombia, as the country's climate change commitment for the cattle ranching sector is to mitigate 10.3 million tons of CO_2 equivalent by 2030.

Chiapas, Mexico is a region where tremendous biological wealth contrasts with alarming levels of poverty and deforestation. Dairy farmers in Chiapas who incorporated HAS practices–such as silvopastoral systems and rotational grazing practices—saw their milk production increase between 25 and 45 percent over a three-year period while methane emissions decreased by nearly one third. These practices have not only raised yields and profits but have also helped conserve critical natural habitats in Mexico's second most biodiverse state.

(Healthy Agricultural System practices for dairy production yield more milk per hectare, raise farmer profit and conserve critical natural habitat in Chiapas, Mexico. Photo Credit: ©Legado Verde)

Solutions such as these must be adopted and scaled globally to transform agriculture from a source of greenhouse gas emissions to a key solution to climate change.

Research conducted by scientists from **Ohio State University** and universities in Brazil[6] found that low-carbon agricultural systems, such as the those mentioned above, along with no-till cropping and restoring degraded pastureland, have the potential to offset 80 percent of global emissions caused by land use and land use change by 2050.

With a Healthy Agricultural Systems approach, farming becomes more productive and profitable and able to meet the increasing global demand for food. Land is restored and becomes healthier, more fertile and more valuable. Natural areas and biodiversity are preserved and enhanced, while agriculture over time ceases to contribute to climate change—even serving as a carbon sink—and therefore helps alleviate an existential threat to farming itself.

Land Sparing, or Land Sharing?

Growing evidence points to how productivity helps conserve more fragile soils, lessens pressure to convert forests for agriculture production and reduces greenhouse gas emissions while providing more food.[7] When combined with policies and practices that limit agricultural expansion, high-yield intensive farming appears to be more environmentally friendly than strategies that require more land.[8]

Such systems include improved crop genetics, no-till or minimum-till practices that prevent soil erosion and use of machinery equipped with precision-systems to efficiently apply crop nutrients, crop protection and water for irrigation. Climate-smart, sustainable intensification strategies can help spare land conversion and reduce greenhouse gas emissions.

Crop Innovation Supports Climate-Smart Agriculture in Latin America

Case Study: Monsanto Company (Bayer AG)

Latin America is home to nearly one-third of the world's arable land and fresh water, making it a vital global agricultural breadbasket in the coming decades.[9] 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.[10]

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

(Felipe Schwening uses climate-smart agriculture practices to grow soybeans in Brazil. Credit: Cristiano Borges)

CSA practices enable farmers to grow more crops per units of land and other inputs, such as fertilizer or herbicide, thereby reducing the environmental impact of crop production.

Across the region, 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 an integral part of the climate-smart agriculture systems that drive productivity in the region.

The Argentine Association of No-Till Farmers (AAPRESID) organizes regional workshops and field events in which more farmers can adopt climate-smart conservation agriculture systems for the crops they grow. Photo credit: AAPRESID

One of the most widely adopted seed technologies in the region is the Intacta soybean (INTACTA RR2 PRO™), a product of **The 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: Iowa State University, Department of Entomology)

Intacta soybeans have been available since 2013 and rapid commercial planting on nearly 24 million hectares across the APBU region has contributed to a significant reduction in insecticide and machinery fuel use, while improving soil quality and generating higher farm income.[11]

Use of these improved soybeans and other genetically-modified crops enable 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 America:[12]

- 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.

Sustainable Production Systems for Rice and Pork

Agricultural production in the United States continues to evolve as consumers, investors, farmers and agribusinesses seek lower-carbon operations and better soil and water quality on farms and in watersheds.

By setting goals for reductions in greenhouse gas emissions, water use, soil erosion, land and energy use, and by entering into conservation partnerships, rice and pork farmers are making continuous improvements in stewardship and sustainability.

Stewardship for Sustainable Rice and Wildlife

Case Study: The Mosaic Company

Rice is the world's most widely consumed grain, sustaining nearly half the global population. Nearly half of the rice produced in the United States is exported; with 3.15 million acres under rice production (2016)[13], rice growers are stewards of wetlands used by North America's waterfowl and 32 other at-risk species.

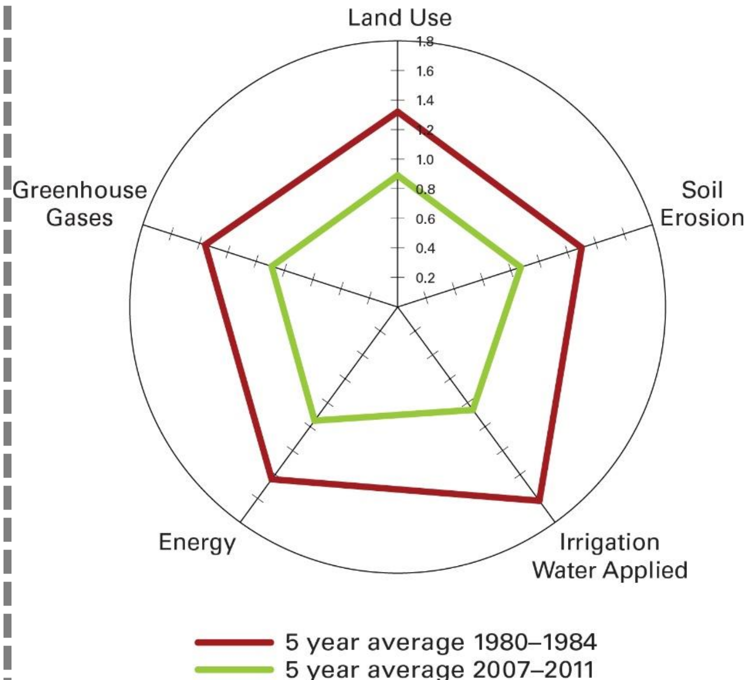
The Rice Stewardship Partnership delivers conservation and greenhouse gas mitigation practices that improve farmer profitability and meet global rice demand. Credit: Mike Checkett

As the world's leader in wetlands conservation, **Ducks Unlimited** counts the rice industry as a key partner in sustaining the future of waterfowl. Together with **USA Rice** and with funding from The Mosaic Company Foundation, the Rice Stewardship Partnership was formed. The partnership works in the Mississippi Alluvial Valley, where most of the U.S. rice crop is grown, and brings on-farm conservation practices that improve water quality, farm profitability and wildlife habitat to more and more acres.

Working with the **U.S. Natural Resources Conservation Service**, the Rice Stewardship Partnership helps farmers meet the increasing global demand for quality rice while improving environmental performance and preserving wetlands. Rice producers receive training, knowledge, tools and new practices that help reduce levels of crop nutrients lost to the Mississippi River. Mosaic's interest in the program stems from a desire to promote the 4R Nutrient Stewardship framework (*Right Nutrient Source, Right Rate, Right Time, Right Place*) at the field level to optimize uptake of nutrients while minimizing environmental impact.

To date, 300,000 acres have been impacted – over 10 percent of U.S. rice acres – making the planet healthier while providing sustainable rice.

Productive, Sustainable Rice: Index of Per Pound Production Resource Impacts, U.S., 1980–2011



Since the 1980s, farmers have produced more rice using less water, energy and land acreage, along with a reduction in soil erosion and greenhouse gas. Rice growers in the U.S. now use proven irrigation and production practices, saving water and generating carbon emission credits as part of California's carbon cap-and-trade market.

***Field to Market*®** *is a diverse alliance working across the agricultural supply chain for continuous improvements in productivity, environmental quality and human well-being, and provides collaborative leadership that engages in industry-wide dialogue, grounded in science and open to the full range of technology choices.*

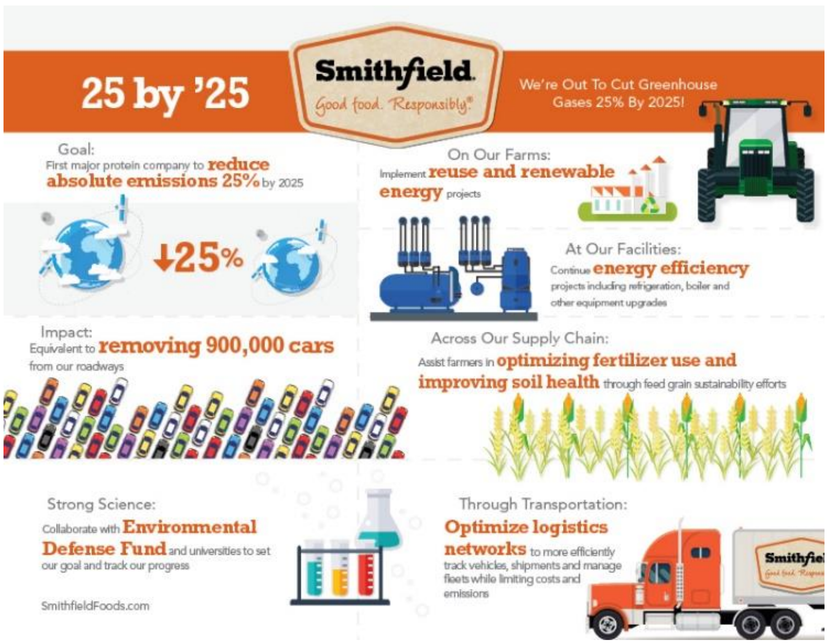
Source: Field to Market, 2012 Environmental and Socioeconomic Indicators Report, Rice.

Additional benefits from the partnership include recommendations for water use efficiency, alternative irrigation strategies, and practices that minimize energy use, reduce diesel fuel, and improve rice crop residue management—all of which translate to reduced GHG emissions and improved air and water quality.

Can Pork Be Produced Sustainably? Yes!

Case Study: Smithfield Foods

Private-sector investment, innovation and scale is helping more farmers and ranchers shift to lower-carbon production systems. **Smithfield Foods**, the world's largest hog producer and pork processor, led the protein industry as the first to announce an ambitious greenhouse gas (GHG) emission reduction goal throughout its entire supply chain. By 2025, Smithfield will reduce its absolute GHG emissions from its 2010 baseline by 25 percent, or four million metric tons, equivalent to removing 900,000 cars from the road.



The 25 by '25 initiative began with the creation of a robust model to estimate the GHG footprint of Smithfield's entire supply chain – a collaboration with the **University of Minnesota's NorthStar Institute for Sustainable Enterprise**, and in partnership with the **Environmental Defense Fund (EDF)**.

To ensure Smithfield reaches this goal, the company launched Smithfield Renewables, a platform within the organization that will unify, lead, and accelerate its carbon reduction and renewable energy efforts. Smithfield made commitments to improve the carbon footprint of the feed crops for their pork production, optimize fertilizer use and improve soil health, install efficient manure management technologies and more efficiently track and manage logistics of transportation fleets to cuts costs and emissions.

In 2017, Smithfield fed its hogs more than 7.4 million pounds of grain. The GHG analysis of the Smithfield supply chain noted that animal feed accounts for 15 to 20 percent of their entire production carbon emissions. By helping farmers in their feed supply chain shift to efficient fertilizer and soil health practices (such as using cover crops, nitrogen sensors and other conservation practices) and by promoting sustainable grains such as sorghum (a resilient crop that costs less to grow, offers good nutrition for pigs and serves as part of a crop-diversification strategy) the program provides a triple win: more profit for farmers, improved soil and water health with less greenhouse gas emissions for the planet, and nutritious sources of feed for healthy pigs.

Technology and Data Help the Planet: The Era of Precision Conservation

Precision agriculture is the use of data and technology to increase the productivity and profitability of agricultural operations, including crops, livestock, aquaculture, dairy forests and orchards. Precision agriculture is also a powerful tool that helps producers shift to precision conservation and reduce greenhouse gas emissions.

Farmers use tractors, combines and sprayers with **global positioning system (GPS) devices** and **precision guidance satellite receivers** that enable them to navigate for sub-inch accuracy in the field. Using equipment such as **in-field monitors and sensors**, farmers and farm service providers can record data on temperature, rainfall, soil conditions and plant growth, capturing information for analysis and to generate models that help them make good decisions about operations and investments.

Integrated software that contains data about their operations helps farmers precisely apply crop nutrients, control weeds and pests and add water only where it is needed for maximum yield and at lowest cost.

Remote sensing is widely used along with **satellite imagery** to collect data; **unmanned aerial vehicles** (drones) also collect data and are used to generate maps and assess crop health.

Precision systems enable each farmer to manage and track, year after year, progress towards maximizing the productivity of each field, while placing less productive areas into conservation or creating refuges for pollinators and wildlife.

(*Prairie grass and pollinator and woodland habitat are established on less productive farmland. Credit: Tim McCabe, USDA NRCS)*

For livestock operations, **sensors** on the animals can alert ranchers to the presence of a disease before it spreads throughout an entire herd. **Livestock monitors** check animals for breeding cycles and disease and track the amount of food and water consumed. Using their own data, precision systems help farmers raise healthier animals and manage grazing lands for sustainability goals. Farmers also invest in automated and computer-controlled barns that provide consistent temperatures and readily available feed and water.

In forest operations, **remote sensing images** can measure tree height and canopy information, as well as tree diameter and biomass as part of a carbon sequestration strategy. Estimating timber volume allows forest managers to make better decisions about where and when to harvest trees.

As a whole, precision systems can monitor, manage and optimize irrigation, farm vehicles, livestock, greenhouses and stables, aquaculture, forests and storage of crop and livestock products; such integrated systems can reduce energy, labor, and make the best use of scarce natural resources.

Artificial Intelligence: A More Precise Green Revolution

Case Study: John Deere

The next revolution in precision agriculture has arrived. New technology is customizing the already efficient gains in modern agriculture to move to **individual plant and animal precision management**. In crop production, this exciting development is being made possible by applying the advanced technology of artificial intelligence to farming equipment by industry leaders such as **John Deere**.

John Deere Labs opened its office in San Francisco in the spring of 2017 to focus on high technology ventures and product development. Shortly thereafter it acquired Blue River Technology, a startup with computer vision and machine learning technology that can identify weeds, making it possible to spray herbicides only where needed.

See and Spray technology, developed by John Deere and Blue River Technology, uses machine learning to identify weeds and spray chemicals only where needed.

By using computer vision and machine learning technologies, machinery can be "trained" to recognize harmful weeds that require a precise dose of herbicide, while allowing other crops around the weed to avoid spraying. This "see and spray" technology has the potential to reduce herbicide applications by up to 95 percent, avoiding the need to spray an entire field and reducing costs and environmental impact.

Similar machine learning can be programmed for targeted applications of fertilizers and irrigation and to detect disease, yield, and quality of crops and soils. The technology will be especially helpful to inform irrigation decisions and water management in water-scarce regions. New applications are also being test to assist with customized livestock management, improving animal health and well-being. A comprehensive review of machine learning and artificial intelligence in agriculture outlines the benefits this emerging technology brings to farmers, the environment and the agri-food system.

Can AgTech Go Global?

The need for agri-food systems technology (AgTech from farm to fork) is greater than ever, and growing investments are beginning to make an impact by picking up the pace of innovation and disrupting the business-as-usual approach. AgTech startups are changing the face of agriculture by rapidly developing new products and services that respond to the consumer demand for novel foods, delivered quickly and rapidly as well as meeting consumer interest for sustainable production.

Investment in AgTech start-ups boomed in 2017, with $10.1 billion in funding. But the clear majority of this funding (45 percent) was targeted to eGrocery (online stores and marketplaces for sale and delivery of processed and un-processed products to the consumer) and restaurant marketplaces (online tech platforms delivering food from a wide range of vendors), that tend to be located in developed country markets.

Precision agriculture and information technology does have the potential to be scale-neutral and can be customized for use in many countries. A core requirement for extending such innovation more widely is to increase the availability and reliability of broadband access for farmers and producers who live in rural areas, enabling them to connect within their operations as well as to global markets in real time.

Bringing More Data and More Sustainability to Smallholder Farmers

In many parts of Africa, Asia and Latin America, smallholder farmers have a particularly hard time accessing information that would help their growing practices and help them supply markets with their goods. Yet, smallholder farmers produce nearly 80 percent of food for their communities and countries and need new technologies to help them learn, grow and market their food, while lowering the impact of production on the natural resource base.

Bringing "Big Data" tools and more precision systems to these farmers requires new paradigms, partnerships and investments. It also requires broadband and wireless access for rural areas so new precision data services can reach farmers.

Solutions for broadband in sub-Saharan Africa are now focusing on using wireless radio links and leveraging so-called TV white spaces spectrum (TVWS, operating on UHF frequencies). In Kenya, the Mawingu Project ("cloud" in Swahili) is now being tested and seeks to connect unserved rural communities with affordable, high-speed solar-powered broadband.

The government of Kenya has authorized **Microsoft East Africa** to use TVWS to deploy affordable high-speed broadband through solar-powered internet hot-spot kiosks in rural communities. Libraries, schools, farms and local government offices in rural areas access the internet; the project is serving as a model for other communications providers in countries such as Tanzania, rural areas of the U.S., and around the world.

(Credit: Microsoft)

Apps for Kenyan Farmers

Kenya's Ministry of Agriculture has recognized the need to get data and advice into the hands of farmers. **The Kenya Agricultural and Livestock Research Organization (KALRO)** has invested in and launched 14 mobile applications in 2018, helping dryland farmers, chicken producers and farmers who grow seeds, as well as farmers producing avocado, banana, cassava, maize, guava, cowpea and potato. The apps are downloadable from **Google Play** on smart phones over internet connections.

These apps help farmers identify and prevent crop pests and disease, and get advice for livestock rearing, weather and climate change, land preparation, timely planting and harvesting, and market prices. Technical experts are now expanding the services by translating the apps into additional local languages.

Improving Livestock Productivity through Big Data

Digital technologies (large sets of data that are often geo-referenced turned into models that help farm decisions) can help smallholder farmers and revolutionize their operations. To demonstrate how big data can transform research and farming, the CGIAR Platform for Big Data in Agriculture was created to convene partners and demonstrate potential through inspiring projects. The six-year (2017-2022) initiative is accelerating and promoting the best use of data for developing country smallholder farmers.

Exciting collaborative projects from the Platform include Livestock Data for Decisions that aims to identify and address the data needs of **Ethiopian dairy sector stakeholders**. The study will inform recommendations on how modelling and data analyses can support livestock sector development and productivity in target low and middle-income countries.

India is the single largest dairy producer in the world, thanks to a **"White Revolution" in dairy farming** that began in the 1960s. Some 75 million dairy farmers on average care for between three and ten cattle. India's dairy value chain is ripe today for improvements in sustainability and productivity that can be brought through digitization. Private-sector and other venture capital investors are seeking to improve India's dairy industry with big data aimed at small dairy producers.

(Credit: Stellapps Technologies)

With investments from the **Bill and Melinda Gates Foundation** and **Omnivore Partners**, among others, Stellapps Technologies is developing digital products, apps and other dairy services for farmers and dairy chain participants in extreme rural areas of India that were previously unreached.

The Stellapps digital dairy platform uses sensors, automation and machine learning to improve milk production, procurement and cold chain logistics for the Indian dairy industry. As the platform improves and more investors join, the goal is to expand globally to help more dairy industries and dairy farmers in the developing world become sustainable and productive businesses.

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