A CALL TO ACTION



21st Century Agriculture Renaissance:

Solutions from the Land

2021

SOLUTIONS FROM THE LAND

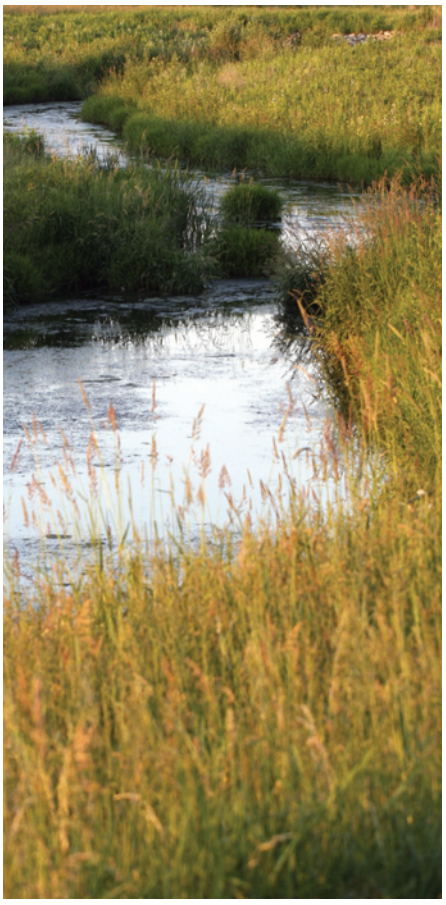














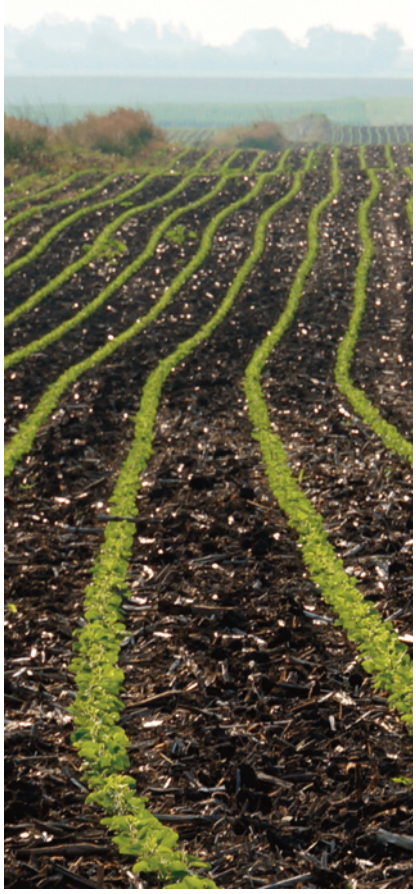
SfL VISION STATEMENT

Our vision is an Agricultural Renaissance led by innovative and entrepreneurial farmers, ranchers, and foresters constructing sustainable, profitable, and resilient systems that lay the foundation for a world of abundance on many scales; capable of producing nutritious food, feed, fiber, clean energy, healthy ecosystems, quality livelihoods and strong rural economies.

The phrase, "farmers, ranchers and foresters" encompasses farmers, ranchers, foresters, orchardists, graziers, aquaculturalists, and all those who are stewards of working landscapes. Working landscapes are agricultural croplands, grasslands, orchards and forests, vineyards, fisheries, and other lands and waters that are managed for livelihoods and the production of food, fiber, energy, and ecosystem services. The transformations that a farmer-led Renaissance brings require broad collaboration with industries, academia, civil society, and policymakers to bring the best science and engineering innovations to system-level solutions.

CITATION

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SOLUTIONS FROM THE LAND

PREAMBLE

There has never been a greater need for an Agricultural Renaissance. The many voices of farmers, echoing across centuries of scarcity and abundance, challenge us to find new ways forward, paths that produce abundance for expanding populations while rejecting wasteful destruction of resources. We must seek these new ways to collaborate and innovate together. For if we can create an unprecedented pathway of collaboration as many peoples who inhabit this small planet, we may be able to tell the remarkable story of our species as it re-learns to thrive sustainably.

As our human population approaches 8 billion, we have altered the landscapes on every continent to feed, clothe, establish and protect ourselves in a multitude of cultures, languages, technical waves and governing structures. We depend on the resources of those landscapes for our survival, but we are rapidly depleting these soils, seas, rivers and forests. Any prolonged collapse of global food systems would create a world of scarcity and struggle wherein nations fight for resources and face the greater threat of battling the inescapable forces of nature that we have tried to control.

Those of us who manage living systems and natural resources to produce food and fiber must understand and acknowledge the past in order to embrace the present and prepare for a challenging, less-predictable future. The United Nation's Sustainable Development Goals (SDGs) for 2030 conjure a bold vision for humanity that is possible but has yet to exist. They lay out an ambitious framework for how humankind might come together in collaboration to build a better world, with systematic international cooperation and strategic design to bring our human systems into alignment and harmony with natural systems. **This vision requires participation and leadership from farmers, ranchers, foresters, and all their partners in agriculture to establish the social and environmental foundation for the successful achievement of the SDGs. For without successful agriculture humankind cannot thrive.**

In this paper the farm and forestry leaders of Solutions from the Land (SfL) set out a vision and pathways for defining agriculture through the lens of a broader reality of living as opposed to simply surviving… and for the resilience needed to maintain abundance in the years to come. Our SfL goal is to speak with farmers, ranchers and foresters, as well as those who recognize the complexity of agricultural systems and the multiple ways they service and inspire civilization. This work is intended for those who appreciate the scope of food systems on our planet. It seeks to stimulate empathy and action towards the many roles that farmers must take on for them to be successful and for all on this planet to live and grow.

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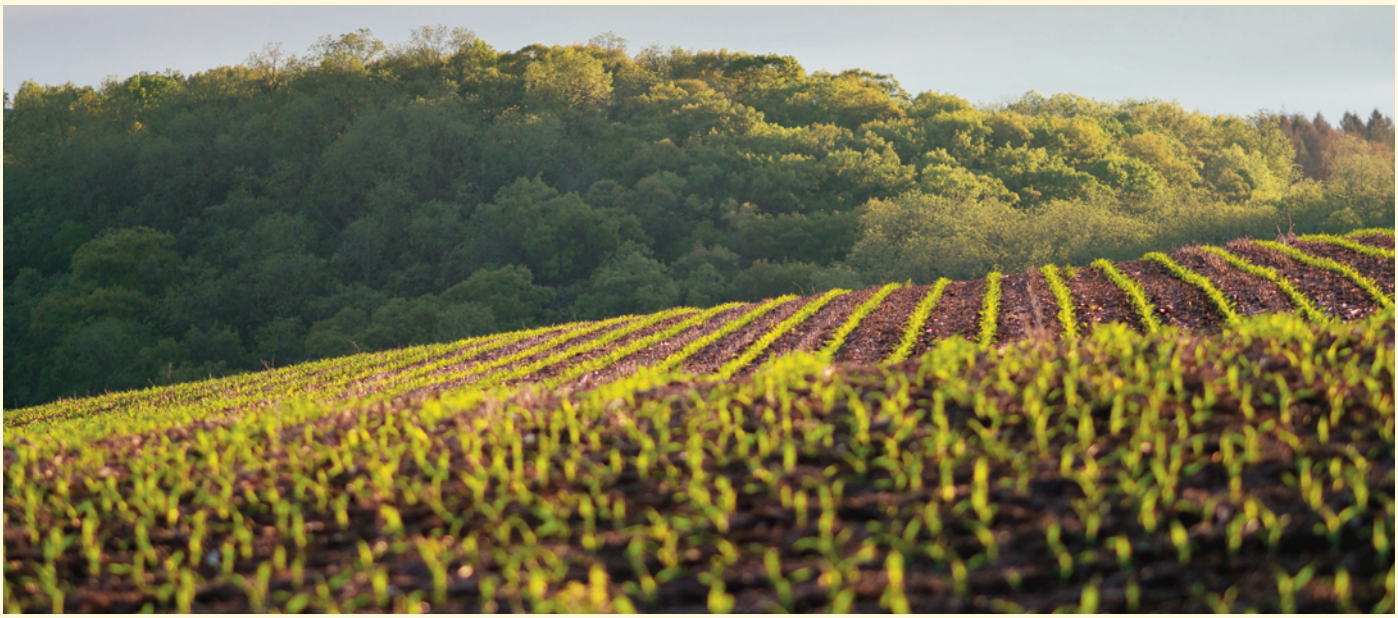












CHAPTER ONE: THE CHALLENGES ARE INCREASING

Today's agriculture must address hunger, livelihoods, water scarcity, clean water, healthy soil, ecosystem resilience, climate change, greenhouse gases and a whole range of local and global realities.

How do we feed 10 billion people by 2050? The World Bank says we will need 56% more food (Nieuwkoop 2020). How do we produce more food while protecting ecosystems, reducing biodiversity losses and lowering emissions? … while adapting and improving climate resilience …while reducing stress on water and soil resources? …while providing quality livelihoods for those who work in agriculture and the food system? …and, without using more land? Recent research has estimated that food systems contribute 21-37% of global greenhouse gas emissions (Rosenzweig et al., 2020). These are the complex questions farmers, ranchers, foresters, and agriculture's partners are asking; and for which they have already begun to search and find solutions. The answers to these questions require new ways of thinking; uncommon collaborations; innovation and new technologies; and most of all, a new systems approach to how agriculture provides multiple benefits to society while managing Earth's working landscapes. Understanding the past adaptability and resilience of agriculture offers guidance and confidence that we can meet future challenges—the known, the unexpected, and the uncertain.

The transition from subsistence farming—from crops raised for food, clothing, and fuel for one's own family to a commercial enterprise that provides a profitable livelihood—is the history of agriculture, population growth and urbanization, markets, and changing land use (Morton 2020). The U.S. Land Grant University (LGU) system was enacted by the Morrill Act (1862; 1890, 1994) during the Lincoln administration to develop agricultural sciences and technologies and extend new knowledge and practices to

PHOTO CREDIT: DAVE-HOEFLER-ENVK7KTMWTQ-UNSPLASH

farmers, helping them generate surplus products for off-farm sales. Early agricultural farm management curricula were designed to move farmers from subsistence to profitable occupations using scientific, organizational, and management techniques (Warren 1913). The successful farmer was described as a naturalist who—by observation of plants, animals and the land—acquires experiential knowledge and combines it with scientific investigation and business skills. L.H. Bailey, editor of the Rural Text-Book series (1921), explicitly listed the requirements for a good farmer as "the ability to make a full and comfortable living from the land; to rear a family carefully and well; to be of good service to the community; [and] to leave the farm more productive than it was when he took it."

Solutions from the Land farmer leaders embody an additional goal: To "improve the ecology of the landscape." This ideal of experiential observation, proactive concern for the natural environment, and scientific investigation characterizes many modern farmers today. Fourth-generation Ohio farmer Fred Yoder, who has worked the land for over 40 years, reminds us that the business of farming remains vulnerable to economic hardship. In July 2020, he commented that "twenty years ago I was very frustrated, thinking there just wasn't any profit in farming. Productivity was not a problem, but I didn't have enough money left to live on afterwards." When Fred's dilemma led him to research different farming methods to save money, he made the decision to fully commit to no-till farming.

No-till is a growing strategy that minimizes soil turnover and erosion, eliminating labor and fuel costs by reducing the number of trips over each field. Over time, as Fred transitioned his whole farm to no-till, he began to notice that his soil structure improved, the soil retained nutrients better, and his productivity increased (O'Shaughnessy 2020). Throughout the history of agriculture, each generation of farmers has, like Fred, faced personal challenges to their farm operations; has made hard decisions and learned to adapt to better manage their land and conserve their soil and water resources; and, at the end of the day, has had to make a living.

U.S. farmers, ranchers and foresters in the last century experienced tremendous challenges. The dust storms of the drought-stricken Great Plains in the 1930s blew soil

Farming with Allies: Diversified and Climate Smart Crops Give Farmers in a Kenyan Co-Op A New Lease on the Land



Maize is a staple crop in Kenya. Even when it does not make economical or agricultural sense, it is still grown for food. Changes in weather often make it impossible to leave the fields with tangible yields, and when the rains are so limited, the farmer has neither food for the family nor surplus to sell.

Hellen Akinyi Onyango, Kenyan crop aggregator and farmer, says, "Four years ago, a group of smallholder farmers changed to growing white sorghum, a more drought tolerant food crop with better market prices. When we moved to white sorghum we began a new crop rotation, sorghum during the long rains and legumes like beans, green gram and soybean during the short rains. Now we have over 1500 farmers working together to collect and transport the grain at harvest time. The decision to change to sorghum farming has made our lives better and opened our minds to new ideas like trying new seeds and varieties that are resilient to climate change and high yielding."*

> Read Hellen Onyango's story from the land
> Learn more about the Farm to Market Alliance

SfL Pathways: *diversification, soil health, water management, collaboration, adaptation*

Addressing SDGs: *no poverty, zero hunger, decent work and economic growth, climate action, life on land*

*Learn more at solutionsfromtheland.org/stories

PHOTO CREDIT: FARM TO MARKET ALLIANCE

all the way to Washington, D.C., halted agricultural production, bankrupted farmers, accelerated soil erosion rates, and degraded water resources. Farmers, conservationists, scientists, policymakers, and private industry worked together—drawing on historic information, knowledge of the present, and simulations of the future—to find solutions, practices, technologies, and policies to build a new agriculture that fully incorporated conservation of soil, water, grass, and forest resources (Delgado et al. 2020). Soil surveys provided the technology needed to enable farmers and foresters to account for the topography and spatial variability of soil types, engineering grass waterways, terraces, contour farming and diversions to better manage water runoff and soil erosion and replant forest lands.

Unprecedented global population growth post-WWII created a new challenge: For farmers to increase agricultural productivity enough to prevent mass starvation and reduce worldwide food insecurity. New science, policies, and technologies were embraced by farmers around the world as the Green Revolution brought with it improved crop varieties, hybrid seeds, synthetic fertilizers, more intensive cultivation strategies, increased productivity and expanding global markets. However, increased productivity—accompanied by increased use of fertilizers, pesticides, and other agro-chemicals—came with unintended consequences. Nutrients and pesticides leached off-field and off-farm into neighboring water bodies, degrading wetlands, streams, lakes, and rivers while leading to hypoxic dead zones world-wide.

The 21st century is now fully under way, amid weather-related crop failures; locust plagues; wildfires

Partnerships That Help Growers Serve Their Land, Their Communities, and Each Other

Adrienne Mollor's grandparents made their start in agriculture raising 10,000+ chickens, various livestock and annual crops in Southeastern Massachusetts, U.S. They made a good living until 1950s technology changes in poultry markets left livestock-cropping systems increasingly economically unviable. And many of their farming neighbors went out of business as land prices rose and suburban development increased.



Today, as a woman entrepreneur, Adrienne has overcome these hurdles and transitioned the family's first five acres of cranberry bog into a profitable business, part of over 14,000 acres planted with cranberries and an additional 40,000 acres of support land and wetlands in the area. Adrienne's cranberry marshes preserve open land and biodiversity; recharge the aquifer; provide flood control and stormwater drainage; protect and preserve habitats for plants, fish, and animals; filter the groundwater; store carbon; and are part of a $1.4 billion state industry providing economic growth and local employment. The distinctive cranberry cropping system is working to meet a number of climate change challenges, such as the reduction in winter chill hours as average monthly winter temperatures rise, increased perennial weed pressure, and acidic soil conditions exacerbated by more frequent flooding.*

> Watch a video on Adrienne's work

> Read Adrienne Mollor's story from the land

*Learn more at solutionsfromtheland.org/stories

SfL Pathways: *ecosystem service markets, water management*

Addressing SDGs: *good health and well-being, clean water and sanitation, life below water, life on land, climate action*

PHOTO CREDIT: ALAMY.COM

and deforestation; regional conflicts; loss of biodiversity; erosion of ecosystem health and functionality; a changing climate; and the spillover of 2020's global pandemic into 2021. Each of these accompanies consequent threats to local and world food security, health and well-being, and livelihoods (GFFA 2021). **Our 20th century agricultural production and conservation systems are increasingly under stress and are proving to be inadequate to manage the risks and uncertainties of 21st century production and provide the multiple and varied production-related services needed by society, such as food security, energy, healthy ecosystems, and livelihoods.**

Examples of innovation and technology accomplishments:

- CRISPR (gene editing)
- Biological inputs (to replace / supplement chemical inputs)
- Biodegradable sensors (to monitor water and soil nutrients)

Technologies and innovations to address these challenges are proliferating. Smartphones, computing technologies, geographic information systems (GIS), global positioning systems (GPS), remote sensing, models, robotics, drones, and on-demand local climate projections are being applied to support precision agriculture, agricultural ecosystem and biodiversity management, and easier, more effective ways for farmers and others in farming landscapes to communicate and collaborate (Delgado et al. 2020). Advanced science is uncovering processes in microbiology, plant biology, agroecology and landscape ecology—at field, farm and landscape scales—that can be harnessed to develop nature-positive production systems. Inventions such as robotics,

Diversification: A Potential Key to Successful Sustainable Intensification

The Red River Delta in northern Vietnam is a dense network of rivers, canals, dikes, sluice gates and compartmentalized fields that provide livelihoods to workers, families, and smallholder farmers, and food for over 17 million people who live in the Delta. To stay consistently profitable in this risky landscape, many small-scale farmers integrate aquaculture with other crops to create diversified variations of a system called VAC: garden (Vuon) vegetable and orchard crops, fishpond (Ao), and livestock pen (Chuong) in addition to rice production.

This risk management strategy not only protects their income and livelihoods, but also ensures access to food and nutrition, as well as reduces the harm of rice-only cropping and aqua-monocultures: intensified production systems that frequently are unsustainable over time as disease resistance increases, soil fertility is depleted, and wide market swings in these commodities can leave farmers vulnerable to high



input costs and negative incomes. Diversification within intensified production systems that integrate a variety of high value crops with rice or aquaculture entails a redesign of farm cropping systems and land uses. Vegetable production systems with crop sequences of 8 to 17 crops over a two-year period enable farmers to diversify crops and provide high quality, nutritious foods. Crop rotations can reduce disease pressure and pesticide use, recycle nitrogen (N) and other nutrients, and allow farmers to select high value crops for particular traits related to growing conditions and market demand.*

> Read the published journal article

*Learn more at solutionsfromtheland.org/stories

SfL Pathways: *sustainable intensification, water management, soil health, diverse systems*

Addressing SDGs: *no poverty, zero hunger, decent work and economic growth, climate action, life below water, life on land*



Figure 1. United Nations 17 Sustainable Development Goals (UN SDGs) for 2030 (2015)

machine learning, artificial intelligence, CRISPR, nanotechnologies, genetic and biological engineering, sound wave pulverization and data-rich modeling are rapidly moving beyond conceptualization to experimental trials and mainstream uses.

Yet despite these advances, without the full engagement of farmers, foresters and their partners, our capacity to transform the systems of agriculture for the future will be compromised. The development of a more dynamic and robust toolbox is essential, but will be insufficient without the voice, experience, and understanding that the stewards of the land provide as they move beyond timely projections to address changes and threats in real time. Those on the front line must have support and resources to strike new ground in managing their lands and shaping their working landscapes.

Today's agriculture must address hunger, livelihoods, water scarcity, clean water, healthy soil, ecosystem resilience, climate change, greenhouse gases and a whole range of local and global realities. These are not new concerns, but the urgency to address them has increased. The creation of the United Nations (UN) was an effort to articulate and act on the international issues of education, economics, culture and human well-being which nations and regions were struggling to manage. The 2030 Agenda for Sustainable Development, approved by the UN General Assembly in 2015, is the most recent iteration of these global priorities. The Sustainable Development agenda put forth 17 Sustainable Development Goals (SDGs) that target specific outcomes (Figure 1). While agriculture factors into nearly all of the 17 goals, several are more directly associated with agricultural production, food systems, and agricultural livelihoods: Goal 1, No poverty (profitable livelihoods); Goal 2, Zero hunger (food production); 3, Good health and well-being (nutrition); 6, Clean water and sanitation (efficient management of water); 7, Affordable clean energy; 8, Decent work and economic growth (promoting sustained, inclusive sustainable economic growth and full and productive employment); 12, Responsible consumption and production (managing waste); 13, Climate action (adapting to and mitigating climate change); 14, Life below water; and 15, Life on land (biodiversity dependent on sustainably managing farms and landscapes) (UN SDGs 2015; Lal 2020).

The systems relationships between agricultural production, rural livelihoods and economic well-being, healthy ecosystems, and food security and nutrition are complex

and not always apparent. These relationships extend far beyond agricultural and forestry landowners to the food system workers in our fields, fisheries, food processing facilities, distribution and food delivery infrastructure. All of these sectors are increasingly interdependent and affected by diverse and changing human values and behaviors as well as established, unstable external forces (e.g., population growth, depleted natural resources, fragmented public policies, and changing climate). The difficulty of achieving multiple SDGs at the expense of other SDGs is acknowledged by the Organisation for Economic Cooperation and Development (OECD) in its 2021 "Making Better Policies for Food Systems" report. Figure 2 demonstrates the triple challenge of providing food security and nutrition for a growing population, providing livelihoods for hundreds of millions of people involved in farming and along the food chain, and ensuring environmental sustainability (OECD 2021).

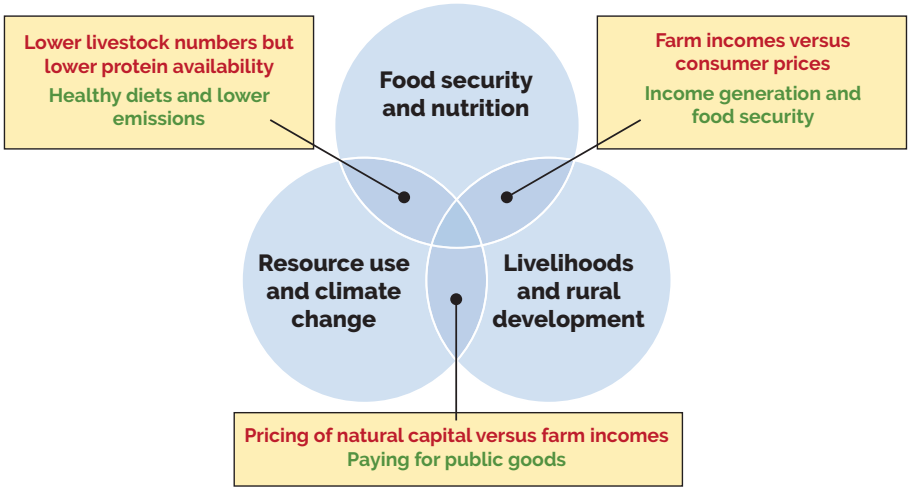


Figure 2. Examples of synergies and trade-offs in food systems. Examples of synergies are noted in green, examples of trade-offs in red (adapted from OECD 2021 p. 13 figure 1.1.)

The Global Forum for Food and Agriculture 2021 Communique on "How to feed the world in times of pandemics and climate change?" affirms that the agriculture ministers of 76 nations worldwide remain committed to the SDGs. They

Coexisting Systems: Cows, Calves and Timber Working Together



Florida's Usher Land and Timber—a family-owned silvopasture operation— grows six tons per acre of timber annually on 6800 acres, alongside cattle, and sorghum and hay for feed, on the remaining acreage. This unique, high-intensity ranch also provides forage services to other cattle farmers such as nontraditional forages, grazing cattle under pine trees for shelter and forage during winter that helps raise cattle weight before sale. They also work with other forest owners who need experienced, environmentally conscious logging crews to manage their woodlands.

These foresters and ranchers view themselves as primary producers of not wood or beef, but "food, oxygen, and water" — the three necessities of life. With a holistic, diverse operation that integrates the multiple services landscapes can provide, the Usher-Griners seek to use best practices to filter air and water while sequestering carbon dioxide and providing wildlife habitat.*

> Watch a video of Usher Land and Timber at work

> Visit the website

> Read the Usher-Griner family's story from the land

SfL Pathways: *GHG reduction, carbon sequestration, integrated and diverse crop-livestock system, adaptation and resiliency, soil health, water management, recycle animal wastes, livelihoods*

Addressing SDGs: *decent work and economic growth, climate action, life on land*

*Learn more at solutionsfromtheland.org/stories

Waste and Loss in the Value Chain

Transitioning from Linear Food and Agricultural Systems to Circular Economy Systems

Linear economy food and agricultural production systems have losses and wastes along the full value chain (Figure 1)

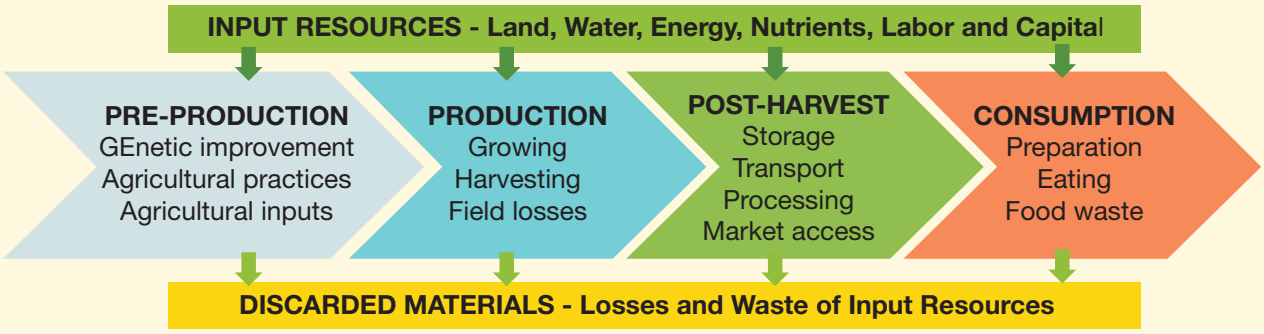


Figure 1. Existing linear food and agricultural systems economies

Linear economy systems can be transitioned into circular economy systems by 1) recovering and recycling discarded wastes for productive use, 2) keep products and material in use, 3) regenerate and redesign natural systems, and 4) provide economic benefits and incentives (Figure 2)

OPTIMIZE (2020-2025)	REPLACE/REDUCE (2025-2035)	REDESIGN (2035-2050)
Digital Agriculture Spatial variable rate application for fertilizer, seed, agrochemicals **Precision Conservation** Idle unproductive/unprofitable land from production for enhanced biodiversity, carbon credits, and nutrient reduction **Regenerative Agriculture and Soil Health Practices** Crop rotation, cover crops, no-till	**New Traits/Genetics** Root system to optimize water and nitrate use efficiencies Traits resistant to diseases **Renewable Energy** On farm energy generation for field operations and drying **Recycle** Collect drainage water for fertigation	**New Processes** Electrification of the Haber-Bosch Process **New Sources** Biological nitrogen synthesis **Smart Systems** Autonomous electrical robots for agronomic practices

Figure 2. Examples of solutions for transforming current farming systems into a more circular system

The American Society of Agricultural and Biological Engineers (ASABE) is engaged with multiple disciplines and public-private sectors to develop pathways for transitioning to circular systems by 2050. Figures prepared by Brahm Verma, verma@uga.edu and Jim Jones jimj@ufl.edu (Basso 2021; Jones 2020; Verma 2021).

articulate an urgent call to action: 1) aim at zero hunger; 2) keep markets open and functioning; and 3) invest in rural areas and rural infrastructure (GFFA 2021). They acknowledge the essential roles farmers play in local and global food systems. Further, they emphasize the critical need to improve the access of small and midsize landholders and family farmers to markets, education, technology, technical support, and resources; as well as the importance of sustaining their activities and livelihoods, respecting and protecting their rights, and helping enhance their resilience (GFFA 2021).

We can no longer afford to think of agriculture and our food system as a linear journey through pre-production, production, post-harvest, and consumption that adds land, water, energy, nutrients, labor, and capital as inputs, and abandons waste lost from the process as discards (ASABE 2021). Rather, agriculture, forests and wetlands, the earth's resources and atmosphere, and humans with their multiple cultures and values are complex, interwoven and multi-dimensional systems simultaneously layered onto each other, interacting spatially and continuously "looping" forward, back, and sideways.

Circular economy systems models offer alternative transitional paths within food and agriculture value chains to 1) design out waste and pollution (recover discarded wastes for productive uses); 2) continually reuse products and materials; 3) protect and renew natural systems; and 4) provide for economic benefits (ASABE 2021). Minimizing input resources, transforming subsystem processes, leveraging interconnections among associated subsystems, capturing resources for reuse or other system inputs from recovered discarded materials, and harnessing breakthrough advances in biology and digital technologies can increase the circularity of existing systems. Our best hope for finding solutions and managing the changes we are encountering now and in the future is to better understand how complex systems work on many levels (Meadows 2008) and develop innovative collaboration strategies that reinforce structures and behaviors that enable us to achieve shared goals like the SDGs.

Examples of innovations we need:

- Growth of more nutritionally dense food
- Nitrogen-fixing plants
- Water and nutrient use efficiency



- Technologies for growing plants in salt water or impaired soil
- Practices and systems to combat invasive species



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CHAPTER TWO: A VISION FOR WORKING LANDSCAPES OF THE FUTURE

SfL Vision Statement:

An Agricultural Renaissance, led by innovative and entrepreneurial farmers, ranchers and foresters constructing sustainable, profitable and resilient systems that lay the foundation for a world of abundance on many scales capable of producing nutritious food, feed, fiber, clean energy, healthy ecosystems, quality livelihoods, and strong rural economies.

A 21st century agriculture and forestry system produces far more than food, energy and fiber. It also filters and stores water; captures carbon; enhances wildlife and biodiversity; generates local wealth; and more broadly, improves quality of life. **What is the vision** of farmers, ranchers and foresters for system changes and landscape-level approaches, which will frame the aspirations and actions needed to address challenges to our working landscapes now and into the future? Where are the most critical knowledge, information, and practice gaps that science and/or policy need to address? **What are the change processes** that will generate simultaneous co-benefits across multiple goals, raise catalytic funding to leverage public financing, de-risk private financing for investments in working landscapes and our food systems, and re-orient the societal consumption preferences necessary to realize the vision? (Nieuwkoop 2020)

Solutions from the Land (SFL) farmers, ranchers and forestry leaders and their partners have set forth a vision for an Agricultural Renaissance and developed a model for constructing sustainable and resilient systems across working landscapes. Implementation of the vision is characterized by broad initiatives that set aside the siloed management approaches of the past and foster multi-stakeholder collaborations that utilize integrated approaches to agriculture, forestry, and food system challenges.

This model (see Figure 3, page 15) brings production, environmental, food, and nutrition policies into harmony and streamlines regulations that are too often overlapping and contradictory. It is a model that engages with farmers to sharpen a shared focus on outcomes, not prescriptive mandates that tell farmers how to farm.

To build upon these themes, the graphic below (Figure 4) presents a visual depiction of specific tactics and solutions pathways that can enable and scale these agricultural and forestry contributions to SDG attainment.

These strategies are anchored by the three overlapping climate smart agriculture (CSA) pillars: productivity, adaptation and resiliency, and greenhouse gas reduction. It is important to note that a CSA model does not prioritize any one of the pillars and represents the simultaneous co-benefits that accrue from their pursuit. The foundation of this strategy is built upon an all-encompassing need to adopt a "many pathways" and "all tools in the toolbox" approach to managing working lands, that a) recognizes the tremendous diversity of agricultural landscapes and ecosystems; and b) enables producers to utilize the systems and practices that best support their own unique situations and circumstances. It also requires a recalibration of what and how we expect the land to produce.

The first pillar of our 21st century CSA model is **sustainable intensification of production**. When we talk about production, the focus of our vision is not just on the commodities we produce, but more importantly the outcomes we can achieve with sustainable agricultural and forestry systems—an end to hunger, good health and well-being, clean water and sanitation, healthy watersheds, affordable clean energy, decent work and economic growth, strong communities, sustained biodiversity, and adaptation to and mitigation of climate change. The good news is that we can achieve all of these

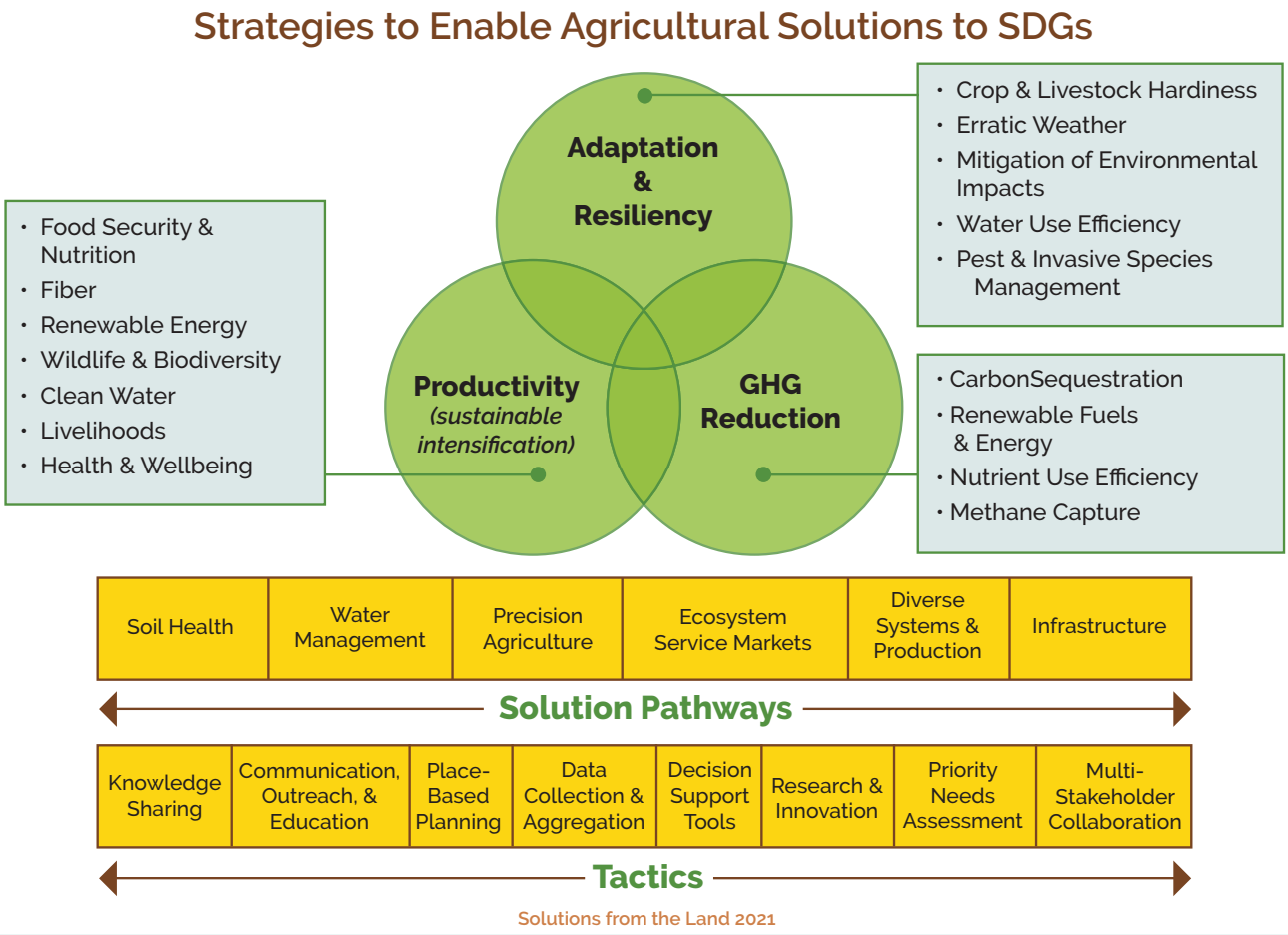


Figure 4. Climate Smart Agriculture Strategies to Enable Agricultural Solutions to Sustainable Development Goals (SDGs) (Solutions from the Land 2021)

Novel Research Project Unites Corn, Soy and Livestock Producers



In collaboration with the Iowa Smart Agriculture (IASA) initiative, supported by Solutions from the Land and Iowa State University (ISU), researchers and farmer leaders are exploring the feasibility of using cover crops, which help retain carbon in the soil, as a feedstock for anaerobic digestion, which produces renewable natural gas that can be used to fire generators and produce electrical power. This novel project connects two subsectors of agriculture; corn and soy producers who are seeking solutions to erosion, nutrient leaching and soil health challenges, with livestock producers looking for value added ways to manage manure; in a quest for win-win-win outcomes that benefits producers and the planet. IASA is participating with ISU providing farmer input into the research and spearheading farmer-to-farmer knowledge sharing.

IASA is partnering with the Consortium for Cultivating Human And Naturally reGenerative Enterprises, or C-CHANGE, to catalyze new science and engineering breakthroughs to deliver abundant, affordable and safe food to 10 billion people without compromising the Earth's supportive capacity in the long term.*

> Watch the video
> Read more in *Successful Farming*
> Learn more about C-CHANGE
> Read about the grant enabling this initiative
> Learn more about Iowa Smart Agriculture

SfL Pathways: *integrated solutions to SDGs, multi-stakeholder collaboration, landscape scale, market-based mechanisms that can boost ecosystem services, soil health, infrastructure*

Addressing SDGs: *affordable and clean energy, decent work and economic growth, sustainable cities and communities, climate action, life on land*

*Learn more at solutionsfromtheland.org/stories

outcomes when agriculture is successful.

The second CSA pillar is **adaptive management**. By its nature, agriculture has always been adapting. But climate change, growing populations, continued malnutrition, and degradation of soil, water, and biodiversity—coupled with COVID-based evidence that agricultural supply chains are easily disrupted—require that we prioritize adaptive management and work to improve the resilience of agricultural production systems. This needs to happen in many ways, including through diversified production to improve access to nutritious foods, change in how we manage water, land, vegetation and nutrients, and investment in research and measures to improve resilience and prevent or mitigate disasters.

The third pillar of our 21st century CSA vison is a commitment to **greenhouse gas reduction** that embraces the myriad ways in which **agricultural landscapes can be managed to deliver high-value, near-term carbon mitigation and sequestration services**. At a time when an all-hands-on deck approach to addressing the climate crisis is required, these landscapes can be managed to improve nutrient use efficiency, reduce emissions, retain and sequester carbon in soils and vegetation, capture methane, and produce clean energy in the form of electricity and renewable natural gas.

As shown in a recent study by researchers at Environmental Health & Engineering Inc., ethanol, biodiesel and other homegrown renewables—such as corn-based

PHOTO CREDIT: VIDEO STILL FROM ROESLEIN ALTERNATIVE ENERGY OVERVIEW

4R Solution Project: Nutrient Stewardship in Ghana and Ethiopia Increases Agricultural Productivity and Improves Livelihoods







Many of the soils farmed by smallholder men and women in Ghana and Ethiopia are eroded and nutrient-deficient. A major barrier to smallholders successful co-producing food, energy, healthy ecosystems, and profitable livelihoods under increasing temperature extremes and drought is their limited access to scientifically determined, pragmatic agronomic practices, suited to crops grown in plot-specific soils, their specific micro-climates, and within available water resources.

Access to this knowledge and technology, as well as the capacity to experiment with and use these proven practices, requires farmers to integrate agronomy research and indigenous knowledge through personal on-farm experimentation, technical support, and extension and outreach training. Fertilizer Canada and partners are teaching farmers to apply the 4Rs: the Right source at the Right rate, the Right time, and Right place. This translates into using the types of nutrients that the soil lacks and that their crop needs to grow well; applying the correct amount (at a rate not too much or too little) of those nutrients; doing so at the best time for the nutrient to be well used by the crop; and placing the needed nutrient in where roots and leaves will make best use of it. The 4Rs help farmers make better decisions for nutrient use in their cropping systems in ways that improve plant growth and yields, enrich the soil, prevent off-field and off-farm nutrient losses, and the avoid excess cost of using more fertilizer than the plants need.*

> Read more about the 4R Solution
> Read the 4R story from the land

*Learn more at solutionsfromtheland.org/stories

SfL Pathways: *precision agriculture, research and innovation, knowledge sharing, communication outreach, education*

Addressing SDGs: *no poverty, zero hunger, good health and well-being, gender equality, climate action, life on land*

Back to the Future: Restoring Productivity to Degraded Cropland and Pastures Can Help Preserve Forests



The Cerrado, Brazil's vast, diverse, tropical savanna, has in recent decades been degraded by intensive agriculture, overgrazing, and deforestation. As these challenges are exacerbated by a changing climate, almost 18 million hectares of soil lie barren or have become low-productive pastureland.

Reverte is an ambitious collaborative effort led by Syngenta and The Nature Conservancy (TNC) to provide tools and technical support that enable local farmers to restore the degraded lands of the Cerrado ecoregion and make a living. The project aims to 1) reduce the rate of deforestation and land use change to agriculture, 2) demonstrate the technological viability and economic potential of land regeneration, and 3) enable farmers and landowners to improve productivity of degraded soils. Reverte applies systems approaches that integrate a variety of technologies and production practices, financing, seed varieties adapted to local conditions and soils, agronomic practices that improve soil health, and precision agriculture and other digital tools, giving growers the capacity to control and monitor improvements in their soil conditions.*

> Learn more about the Reverte project

> Read Syngenta's public policy positions on important issues facing agriculture

SfL Pathways: *carbon sequestration, soil health, water management, sustainable intensification, precision agriculture*

Addressing SDGs: *zero hunger, decent work and economic growth, responsible consumption and production, climate action, life on land*

*Learn more at solutionsfromtheland.org/stories

PHOTO CREDIT: © EDWARD PARKER / WWF

ethanol, which represents a 46 percent greenhouse gas emissions reduction compared to gasoline—offer low-cost, dependable fuel alternatives that help enhance energy security, reduce carbon emissions, and improve public health (Scully 2021). These pathways can reinforce and amplify place-based management of soil, vegetation, and animal systems that could, applied worldwide, achieve by 2100 a drawdown of 157 parts per million in atmospheric CO_2: more than the total increase from pre-industrial levels to date (Lal 2020). Enabling policies and programs that address climate change can give each land manager a menu of options to both best serve their individual needs, and work cooperatively with others in their landscapes to unlock the enormous potential of farms, ranches, and forests to lead the world in both economic and environmental sustainability.

The overarching objective of this vision for 21st century agricultural and forestry production systems is the attainment of the Sustainable Development Goals (SDGs), by which all countries and all peoples will benefit from the multiple outcomes that agriculture and forestry can bring. By letting farmers and foresters lead and focusing on the economic viability of managing working landscapes, policymakers can encourage win-win scenarios in which agriculture presents solutions for global challenges while improving environmental resilience, building strong rural communities, engaging consumers, and enhancing public health through access to nutritious food.

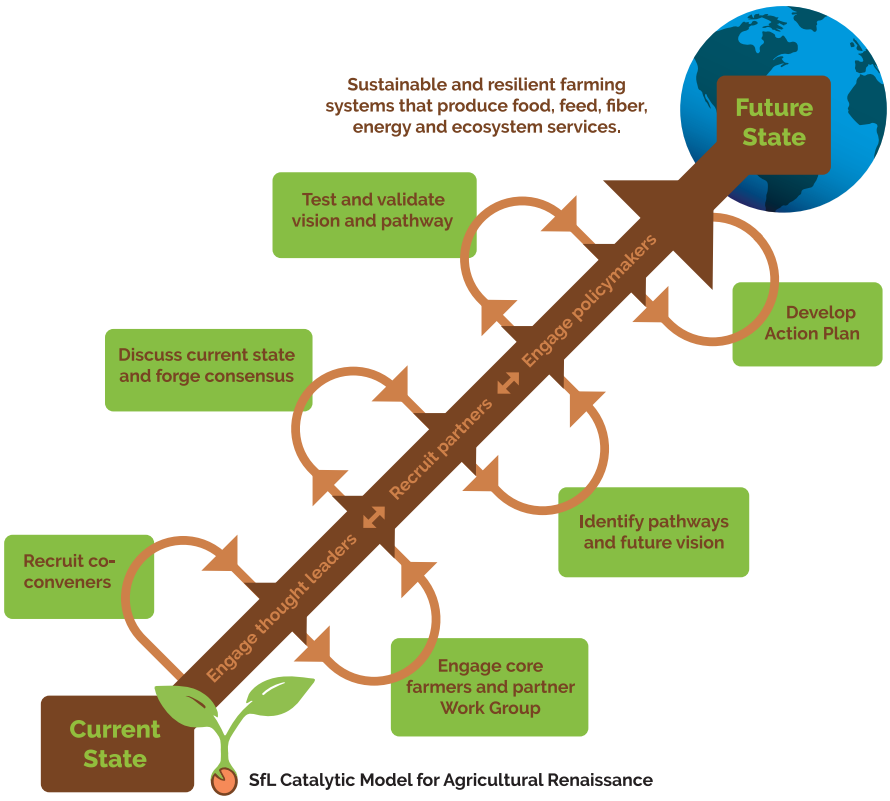


Figure 3. SfL Catalytic Model for Agricultural Renaissance (Solutions from the Land 2021)

"There is a need to adopt a 'many pathways' and 'all tools in the toolbox' approach."





CHAPTER THREE: FARMERS IMPLEMENTING A SYSTEMS APPROACH

If farmers, ranchers and foresters cannot make a living, they will not be able to deliver the outcomes that society hopes or expects .

Resilience arises from a rich structure of many feedback loops that work in different ways to divert and redirect major catastrophes and restore systems, even after a large perturbation (Meadows 2008). Meta-resilience occurs when a set of feedback loops in one system can restore or rebuild integrity in another; mega-resilience comes from the kind of adaptive management that fosters learning, creating, design and the capacity to evolve. The core principles and high-level action items below are guided by both systems thinking and resilience goals that promote redundancy, and extensive feedback shifts that encourage learning and innovation. They recognize that policies and actions must meet high standards of clarity, transparency, and flexibility to enable farmers, ranchers and foresters to be resilient and adapt as situations become fluid and uncertain and conditions change.

Core Principles

- **Context-specific priorities and solutions must be aligned with national policies and priorities,** based on the social, economic, and environmental conditions determined at site (including the diversity in type and scale of agricultural and forestry activities), and subject to evaluation of potential synergies, tradeoffs and net benefits (NACSAA 2015).
- **Farmer, rancher, and forester profitability is a central component** of any plan to transform agricultural and forestry systems to meet climate and other sustainable development goals, regardless of farm size. If farmers, ranchers and foresters cannot make a living, they will not be

able to deliver the outcomes that society hopes or expects (GFFA 2021).

- **Uncommon collaborations are needed.** Multi-stakeholder collaborative models— inclusive of government, the private sector, academia, agriculture, food systems, forestry and aquaculture sectors, and civil society at appropriate landscape levels (watershed, country, region, etc.)—should be used to develop, implement, and monitor land and water uses and management policies that enable priority economic, social, and environmental outcomes (GFFA 2021).
- **Both improved production efficiency per unit of land and water and ecosystem/habitat-enhancing production and management practices** are necessary if agricultural and forestry systems are to meet the food, nutrition and fiber needs of the future; greatly enhance ecosystem health by regenerating soils, watersheds, and habitat for biodiversity at scale; and serve as a critical sink for greenhouse gases (Campbell et al. 2014; GFFA 2021).
- **Farmers, ranchers and foresters—as targets of national and global policies and regulations—have systematic opportunities** both within and outside of typical policymaking structures **to provide significant input** to problem identification and solution design in advance of policy and regulatory mandates, through discussions and development of recommendations with decision makers (NACSAA 2020; Nieuwkoop 2020).

State Initiatives Envision the Future of Agriculture



Ohio Smart Agriculture (OSA) is another example of a state-wide, landscape-scale Work Group, who came together to conclude that changing markets, volatile weather, environmental degradation, and food insecurity presented Ohio agriculture with unprecedented challenges. To face them, a diverse team of farmer leaders – representing all scales and systems of agriculture from large to small – joined with foresters, public health and nutrition experts, agribusiness leaders, academics, environmentalists, and others in an uncommon collaboration. Their mission: to assess the current state of agriculture in Ohio and determine how to move forward.



The OSA Call to Action report resulting from this process lays out a farmer-led vision of Ohio agriculture's transformation towards environmental resilience, achieved in ways that generated economic growth on farms and in farm communities, while reducing hunger and improving nutrition.*

> Read the OSA Call to Action Report
> Watch the video at the OSA website
> Learn more about SfL's network of initiatives
> Learn more about the Delmarva Land and Litter Collaborative

SfL Pathways: *integrated solutions to SDGs, advocacy, regional coalitions, landscape scale, multiple-systems approach*

Addressing SDGs: *no poverty, zero hunger, decent work and economic growth, sustainable cities and communities, climate action, life on land, life below water*

*Learn more at solutionsfromtheland.org/stories

- **Effective adaptation strategies require system approaches that are scale-appropriate** and utilize a combination of improved efficiency, substitution (e.g. new crop varieties and breeds), and redesign/system transformation, to reflexively respond to continuous short- and long-term changes in climate's impacts on cultivated and natural ecosystem conditions (Tittonell 2014; Pretty 2018). Integrated methods in crop modeling (see, e.g., AgMIP; Rosenzweig et al., 2013) for current or future conditions are already being used to investigate possible benefits and trade-offs for consideration of policymakers.
- **Science-based practices and technologies, in conjunction with farmers', ranchers', and foresters' experiential knowledge and indigenous innovation, are the foundation** for the adaptation, adoption and mitigation of climate smart agriculture and the creation of transformational production systems (USDA 2021; SfL 2013).

High Priority System-Level Actions

To effectively move towards agricultural and forestry system resilience and achieve the SDGs, the following priority system-level actions involving policies, markets, research, and knowledge-sharing activities are proposed:

1. **Develop and enable diversified and sustainable agricultural intensification production strategies** appropriate to different geographies; ecosystems and watersheds; cultures; a wide variety of farm types and scales; and possible changes in future conditions. These solutions can produce high quality protein, grains, and fruits and vegetables, and reconnect with production

Hooves on the Ground: A Path to Sustainable Landscape-Scale Water Management





In the arid western United States, the Ladder Ranch makes strategic use of their local water resources to keep their herds healthy and income-producing.

But as the O'Toole family tailors their approach to create productive pastureland, they deliberately pursue the "side effects" of a rich, biodiverse habitat for threatened species; improved soil health; irrigated land to grow crops for income diversification; local trout fisheries; and a beautiful landscape for those who come to their ranch tours to enjoy for even more income diversification. Pat O'Toole believes that an enhanced agroforestry focus that emphasizes the critical relationship between heathy forests and water yield will become a big part of his family's future.*

> Watch a video on Ladder Ranch's work
> Visit the website
> Read the O'Toole family's story from the land

SfL Pathways: *carbon sequestration, soil health, water management*

Addressing SDGs: *zero hunger, decent work and economic growth, responsible consumption and production, climate action, life on land*

*Learn more at solutionsfromtheland.org/stories

processes that reintegrate livestock, orchards and forests, aquaculture, and crop agriculture as systems to better recycle nutrients on existing lands.

2. **Manage the Water Cycle.** Acknowledge and prioritize through funding, infrastructure, and practices the extreme variations in the hydrologic cycle marked by drought; evapotranspiration; increased and more intense precipitation events; erosive runoff; sediment transfers to rivers and oceans; and increasing degradation of soil and water resources. Changes in the water cycle are iteratively driven by changes in weather and climate, land uses and human land, water, and water reuse management. Shifts in the timing, intensity and volume of rain and snowpack in turn influence land surface erosion from flowing water, saturated and ponded soils, water storage capacity and flooding. While pressure is growing to 'solve' current urban and environmental water shortages by simply moving water away from irrigated agriculture, a diversified water management portfolio that provides benefits to multiple use sectors is needed. Continue to emphasize water conservation, water recycling, watershed management, desalination, and water transfers, but concurrently prioritize investments in modernized conveyance, groundwater storage, and surface storage projects.
3. **Integrate climate adaptation and mitigation strategies in climate smart agriculture and food**

Building on Cultural and Nutritional Heritage: African Plant Scientists Breeding African Crops for African Farmers



Assessments of a larger number of individual crops that have cultural, indigenous and regional importance are critical if we are to expand climate adaption options, ensure food security and improve nutrition, create diversified and integrated systems that reflect local conditions and cultures, and increase the stability of agriculture and forestry livelihoods. 101 crops that form the backbone of the pan-African food system have not had the attention of plant breeders' efforts to develop superior nutritional varieties that will end chronic hunger and malnutrition, a cause of stunting.

To address this shortcoming, 115 mid-career plant breeders from 27 African countries have graduated from the African Plant Breeding Academy after being trained by some of the best plant breeders in the world, after learning how to improve these 101 key crops through breeding for improved nutrition, higher yields, water and nutrient use efficiency, pest and disease resistance and climatic resilience. These graduates have launched 37 improved crop varieties, published over 180 peer reviewed scientific papers, and initiated over 200 national breeding programs. The African Orphan Crop Consortium's students become leaders in the field of plant breeding who will pass on their knowledge to the next generation of African plant breeders and develop the future annuals, perennials and trees that will end chronic hunger and malnutrition in Africa. This uncommon collaboration includes The African Union Development Agency-NEPAD, The World Agroforestry Centre, UC Davis, FAO, Mars, Incorporated, World Food Program, and Wageningen University to mention a few of the consortia.*

> Read the African Orphan Crops Consortium 2019 Progress Report

> Read the history of the orphan crop project

SfL Pathways: *research, innovation technologies, uncommon collaborations*

Addressing SDGs: *zero hunger, good health and well-being, climate action, life on land*

*Learn more at solutionsfromtheland.org/stories

Raising Nature on Florida Ranchlands



Former Florida Cattlemen's Association president Jim Strickland at his Blackbeard's Ranch east of Sarasota.

Florida Climate Smart Agriculture Co-Chair Jim Strickland is working to prove that Florida's ranchlands can provide not only meat, but critical habitat protection, water filtration, and even climate services.*

> Read the award-winning article by Virginia Gewin
> Learn more about Florida Climate Smart Agriculture
> Watch conservation efforts at Blackbeard's Ranch

*Learn more at solutionsfromtheland.org/stories

systems assessments, research, and technologies, with special attention to a larger number of individual food crops and other products with regional, cultural, and ecological importance to food security, nutrition, and livelihoods (Porter et al. 2019; Rivera-Ferre 2020).

4. **Produce beyond food security goals to grow nutritious healthy foods;** and energize and accelerate the systems integration of agriculture, food and nutrition policies and research to achieve the SDGs. This will require substantial investment that incentivizes multi-disciplinary, integrative research, encompassing food and nutritional sciences, plant and livestock genetics, agriculture production, forestry, and the social sciences (GFFA 2021).
5. **Create new markets for ecosystem services through economic incentives** for all scales of sustainable production of agricultural and forestry products; nutritious food; effective management of natural resources; conservation of wild plants and animals; and improvement of rural livelihoods. Support the development of quantified ecosystem benefits and voluntary, market-based, government and/or private-sector funding mechanisms and incentives for ecosystem services. Redirect government agricultural production subsidies to payments for ecosystem services.
6. **Use outcome goals and metrics** in policies and programs, enabling the use of multiple strategies and pathways to achieve desired objectives rather than prescribing specific top-down regulatory standards that act (at times inefficiently) on practices. Harmonize conflicting policy frameworks.
7. **Provide financial assistance and incentives** to promote and assist voluntary, locally led, incentive-based landscape-level conservation and ecosystem management efforts—adapted to the context of each district, region, and nation—rather than "one-size-fits-all" policies. Support proven scale-appropriate farm, ranch and forest practices, technologies; and innovations for nutrient, water

and biodiversity stewardship such as 4R nutrient stewardship, no-till, low-till and cover crops, agroecology practices, and on farm technologies and innovations.

8. **Incorporate indigenous and local knowledge with science-based technical knowledge in active and systematic ways** to expand knowledge exchanges and adaptation options that increase biodiversity and ecosystem management on working landscapes.
9. **Involve, educate, encourage and equip farmers, ranchers and foresters to participate** in the development of policy and research agendas in order to expand capacities to deliver multiple co-benefits that improve both food security, nutrition, and rural livelihoods, and the quality of soil, water and ecosystem services.
10. **Transform and modernize technical assistance and information networks** through investments that enhance the research infrastructure of USDA's Agricultural Research Service, Land Grant Universities, 1890 Universities, and similar public sector institutions in other countries, renewing linkage with education, and extension networks that include public-private partnerships. Reduce information asymmetry between consumers and farmers to support and accelerate the exchange of accurate, accessible, and easy-to-understand information exchanges among consumers and farmers.

Nature in the Marketplace: Agroecology Practices and Access to Trade Restore an Ecosystem



Without consistent income, many subsidence-level smallholder farmers have relied on not only harmful cropping practices— but on the destruction of crop-raiding nuisance animals, use of local forests for fuel, and even poaching. Zambia's wildlife population and biodiversity have been badly impacted over time by these practices, and, as shown in a Wildlife Conservation Society population survey from the 1990s, their prevalence was directly linked to incomes that could be up to four times higher for poachers.

To address the poverty at the root of these issues, the Community Markets for Conservation program changed the microeconomic incentives for lower-income farmers. It traded new technologies and seeds directly for traps and snares, then organized producer groups to pursue income-generating activities, providing a local depot to export products to a regional community trading center, which processes, packages, and markets their goods. Members can maintain their standing by adhering to these practices; in exchange they receive their share of the greater profits of the profits. This combination marries market incentives with diversification, combining nature-based conservation practices like no-till and homemade fertilizers.*

> Learn more about Community Markets for Conservation

> Read the Oakland Institute case study report

SfL Pathways: *innovative landscape-scale solutions*

Addressing SDGs: *no poverty, zero hunger, decent work and economic growth, life on land*

*Learn more at solutionsfromtheland.org/stories

PHOTO CREDIT: HTTPS://ITSWILD.ORG/#PRETTYPHOTO

Innovation, Technologies and the Public Domain

New approaches, innovations and technologies are key strategies necessary for the Agricultural Renaissance to renew and transform systems of farming, ranching, forestry, and aquaculture to ensure resilience and sustainability. It is critical that investments be made in public domain science and technologies so as to increase the speed of innovation that otherwise would be restricted by exclusive property rights.

The challenge of controlling pests and diseases in agriculture has long been a critical, time sensitive undertaking of trial and error, failure, and success. It has been over half a century since the term "Integrated Pest Management" or "IPM" was first introduced as a more benign and sustainable way to go about protecting our food supply. Instead of eliminating all bugs, the learning curve that taught us to allow beneficial insects and microbes to help defend our crops continues to yield new insights and tools. Today many producers are utilizing biological predators and other organisms to populate their fields and colonize their root systems or animal guts. New research and technology that allows researchers to identify naturally occurring beneficial nematodes or fungi and place them in suspension or rear them for eggs and spore release are part of the exciting new arsenal of tools in the producer "toolbox."

Underlying these IPM management interventions is the research that discovered the pathways and complex mechanisms by which insects and pathogens weaken plants or enable plant health productivity. Cyst nematodes, a group of pathogens responsible for lost yields in sugar beets, soybeans, and other crops, feed from one location inside the plant root, where each nematode develops a parasitic relationship in the host plant. What had not been known is how this nematode is able to infect root plant cells and orchestrate massive plant gene expression changes. However, recent research led by Iowa State University scientists has revealed an important mechanism by which parasitic cyst nematodes reprogram cells in a host plant to enable their parasitism[1].



Biocontrol screening of bacteria and phage for managing bacterial wilt and CYVD in organic cucurbit production, Dr. Gwyn Beattie Lab. USDA Resilient Systems for Sustainable Management of Cucurbit Crops Project. Award number2019-51300-30248. USDA Organic Agriculture Research & Extension Initiative (OREI). Photos by Benzhong Fu and Jose Gonzalez-Acuna.

Dr. Thomas Baum explains, "The nematode injects a mixture of proteins into plant cells. We discovered that one of these nematode proteins alters the conformation of the host plant's genetic material, redirecting the plant's gene expression machinery to enable parasitism."

"We still have a lot to learn," says lead scientist Dr. Paramasivan Vijayapalani, "Other effector proteins are likely to be involved. Even so, knowing more about how cyst nematodes redirect their hosts' molecular mechanisms to survive is important to be able to devise effective control strategies, such as engineering resistant crops."

This collaborative research was made possible by USDA Hatch Act and State of Iowa funds, USDA NIFA-AFRI (Grant 2015- 67013-23511), the Iowa Soybean Association, the North Central Soybean Research Project, and the French Laboratory of Excellence project TULIP (ANR-10-LABX-41 and ANR-11-IDEX-0002-02).*

> Read the USDA National Institute of Food and Agriculture press release on "Iowa State Scientists Lead Discovery of a Mechanism Cyst Nematodes Use to Reprogram Plant Host Cells"

*Learn more at solutionsfromtheland.org/stories

[1]Heterodera schachtii derepresses host rRNA genes by altering histone acetylation. The Plant Cell, 30, 2795–2812.

EPILOGUE

In this paper, SfL's farmer, rancher and forester leaders advance a new and exciting vision for global agriculture, one that redefines humankind's oldest endeavor. Going forward, we imagine stewards of the land, on whatever continent they reside, being recognized, valued and compensated—not just for the food, feed and fiber they sustainably produce, but for the equally important water they filter and store, biodiversity and wildlife habitat they enhance, carbon they sequester in the soil, clean energy they generate, and perhaps most importantly, for the livelihoods they improve.

As documented in the "stories from the land" included in this report, a renaissance ushering a new era of global agriculture is well under way, poised for further evolution and in some instances, transformational change. How exciting a time it is to be a farmer!

Thanks to hard work, indigenous knowledge, innovation and technology, and uncommon collaboration among those who make their living off the land, agriculture is poised to bloom, grow, and emerge as a primary solution pathway towards the achievement of worldwide sustainable development goals. For our vison to be realized, however, all actors within our food systems need to unite and collaborate in ways we can only yet imagine.

The future of our world is calling. SfL invites partners across the planet to join in this epic quest and movement to position farmers, ranchers and foresters at the forefront of addressing global challenges.

About Solutions from the Land

SOLUTIONS FROM THE LAND

Solutions from the Land (SfL) is a 501c3 nonprofit focused on land-based solutions to global challenges. SfL builds and facilitates state, national, and global initiatives and alliances through which farmers, ranchers, foresters and collaborating partners showcase examples of innovation and proactively advocate for policies, partnerships, investments, and research that will enable agricultural landscapes to deliver near-term, cost-effective, integrated solutions to global mega-challenges: food and energy security; sustainable economic development; and environmental improvement. For more information, see solutionsfromtheland.org.

Acknowledgments

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Throughout much of 2020, a year of unprecedented global crisis, these individuals stepped up and away from their own concerns to examine our food systems and imagine an Agricultural Renaissance that would bring the world to a better place. We offer our thanks and gratitude.

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