



FACING THE CHALLENGE TOGETHER
**SUSTAINABLE
FOOD FOR THE
21ST CENTURY**



A VISION FOR TRANSFORMATION

WWF seeks to transform markets towards greater sustainability through partnerships with leading food and agriculture organizations and companies. By establishing ways to produce commodities at affordable costs with measurably reduced environmental impacts, and by creating significant demand for such products, entire commodity markets can improve their environmental outcomes on a large scale.

Dairy is one such commodity. Since 2009, WWF and the Innovation Center for US Dairy have been working to advance mutual conservation goals through a formal partnership to improve the environmental sustainability of the US dairy industry. To learn more about the partnership, visit worldwildlife.org/industries/dairy.

The Innovation Center for US Dairy is a sponsoring partner of the Sustainable Food for the 21st Century project and this white paper. WWF is solely responsible for the content of this paper. This paper presents the results from interviews with 52 thought leaders in the space of environmentally sustainable food production. The definitions and views regarding sustainable food production as shared by the interviewees include environmental, social and economic dimensions. WWF will use the results from the interviews for discussions with a blue ribbon panel to identify solutions for sustainable food production systems for the 21st century, with a focus on US dairy.



About WWF: The world's leading conservation organization, WWF works in 100 countries and is supported by 1.2 million members in the United States and close to 5 million globally. WWF's unique way of working combines global reach with a foundation in science, involves action at every level from local to global, and ensures the delivery of innovative solutions that meet the needs of both people and nature.



About the Innovation Center for US Dairy: The Innovation Center for US Dairy provides a forum for the dairy industry to work precompetitively to address barriers to and opportunities for innovation and sales growth. The Innovation Center aligns the collective resources of the industry to offer consumers nutritious dairy products and ingredients and promote the health of people, communities, the planet and the industry.





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FOREWORD



On September 30, 2014, WWF launched its biennial *Living Planet Report*. It shows that we are continuing to consume the planet's renewable resources at rates that cannot be replenished. In fact, the report suggests that we are living beyond the carrying capacity, that we are currently living at 1.5 planets and that

our rate of using resources is still increasing. The *Living Planet Report* measures more than 10,000 representative populations of mammals, birds, reptiles, amphibians and fish. The data show that the populations of these species have declined by 52% since 1970. In other words, in just two human generations, the total population of vertebrates on Earth has declined by half.

And the biggest threat to life on Earth for some time has been where and how we produce and consume food. Imagine the challenge, then, to produce enough food for 2 billion more people by 2050, when everyone on the planet has an average income of nearly three times what it is today. The biggest threat to biodiversity and ecosystems services today and going forward is food production. Put another way, the biggest threat to WWF's mission is agricultural sprawl because that is the driver of biodiversity loss. However, if we intensify food production and produce more with less, then we will also have to take great care not to pollute air and water or deplete our soils.

If we want to draw the line in the sand and say “this and no more,” then we need to freeze the footprint of food. And we will have to find ways to produce more with less—more nutrition with less land, water and other inputs. There is no silver bullet to do this; we will need to work at the issue from several sides. We will need to increase productivity and efficiency while at the same time reduce waste (including post-harvest losses) and change consumption patterns. While no single strategy will solve the problem, by combining them we can achieve the results both we and the planet need.

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WWF began to work on these issues several years ago, but most recently we have redoubled our efforts and created a Food Goal in order to address this threat. To advance towards that goal, we have formed a new unit focusing on animal protein—livestock, aquaculture and feed. Our work with the Innovation Center for US Dairy has been pivotal in shaping our thinking about what producer groups are able to do as well as what we can do in partnership with them.

This white paper was conceived as a way to gather insights, test our own assumptions and help define the next steps. This includes creating awareness about the key issues, building consensus about how to address them, and identifying the research and technologies that are needed to meet our goals as well as documenting the innovations that already exist that can be shared more broadly. The paper is meant to prompt action and scalable change on the ground. Sustainability is a journey, but it doesn't have to be one that every entity approaches alone; no single organization can solve all these problems. We are all in this together precompetitively, and we must learn from one another quicker than ever before because the speed of change is faster today than ever.

In closing, I want to express my appreciation for the experts and thought leaders who are on this journey with us who shared their vision and invaluable insights on how we can address these complex challenges.

JASON CLAY
Senior Vice President, Food and Markets | WWF



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The core members of the Sustainable Food for the 21st Century project team are

- **WWF:** Jason Clay, Sandra Vijn and Marlena White
- **Innovation Center for US Dairy:** Erin Fitzgerald, Chad Frahm and Laura Mandell

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- All the individuals who participated in the interviews that led to this white paper (listed below)
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Interviewees

Jon Alby, Ann Bartuska, Sarah Bittleman, Robert Bonnie, Barbara Bramble, Tony Cavalieri, Roger Claassen, David Cleary, Chuck Conner, David Darr, Jed Davis, Adam Drewnowski, Kristin Duncanson, Lorin Fries, Tom Gallagher, Pierre Gerber, Dan Glickman, Christine Hamilton, Hal Hamilton, William Hohenstein, Diane Holdorf, Eric Holst, Molly Jahn, Gene Kahn, Bruce Knight, Stewart Lindsay, Jerry Lynch, Michael Mack, Marty Matlock, Michael McCloskey, Andrew McElwaine, Frank Mitloehner, Donald Moore, Jim Mulhern, Mark Murphy, Wendy Powers, Debbie Reed, Beth Sauerhaft, Mary Shelman, Jeff Simmons, Rod Snyder, Kim Stackhouse, Anna Swaithe, Ellen Terpstra, Robert Thompson, Jan-Kees Vis, Suzanne Walker, Arlin Wasserman, Jason Weller, Jim Werkhoven and Doug Young

Note: Refer to the Appendix for additional details.

EXECUTIVE SUMMARY

The challenge of feeding a global population sustainably arises from an alarming array of numbers: some that are rapidly increasing, others that are dropping dramatically—and that static “one” that is our planet.

The increase of more than 2 billion people globally by 2050 will be accompanied by higher incomes and greater demand for not only more food, but more livestock-based foods such as beef, pork, poultry and dairy. Agriculture already uses vast amounts of natural resources, with significant environmental impacts across the globe. Increased production to meet growing needs must be done in ways that optimize the use of scarce resources within the carrying capacity of the planet, that protect and enhance ecosystems, and that are resilient to the impacts of climate change.

It is widely agreed that food and agricultural systems must increase production sustainably to feed the global population. Nonetheless, consensus on the collective actions required to bring about transformative change is still needed. Significant opportunities exist for the food and agricultural sectors to meet the challenges ahead, as many current efforts are demonstrating. But the real challenge is to amplify those efforts and accelerate adoption of effective solutions system-wide; in other words, it is about working together and picking up the pace.

To spur such action, the Sustainable Food for the 21st Century project aims to contribute to the transformation of US food markets towards environmentally sustainable production systems, with a focus on the role of the US dairy industry. WWF and the Innovation Center for US Dairy began working together in 2009 based on a shared commitment to creating a more environmentally sustainable dairy industry. Through the US Dairy Sustainability Commitment, the dairy industry has been working together precompetitively to reduce the environmental impact of dairy foods and beverages across the entire value chain. Efforts have inspired consensus building, knowledge sharing and initial steps towards greater sustainability. It is critical now to take bolder strides and encourage broader participation to advance progress industry-wide—and, in doing so, respond to growing global demand responsibly and demonstrate solutions for other food sectors.

As part of the project, this paper acts as an important bridge to identify approaches and spark action. It shares insights gathered in interviews with 52 experts and thought leaders working in food and agriculture. The shared themes and unique perspectives will provide the basis for a blue ribbon panel to propose next steps and recommend actionable solutions, as outlined on page 6.

Summary of Key Themes

An encouraging finding from the interviews is the high degree of agreement that arose across diverse responses to open-ended questions. These areas of shared views and common themes point to a readiness for collective action. In addition, topics with a wider range of opinions highlight areas that require further research and consideration.

Defining Sustainable Food and Agricultural Systems

Although varying in the details, there were strong areas of agreement across the interview responses on the definition of a sustainable food and agricultural system. The top themes resulting from the interviews overall emphasized the importance of meeting the needs of a global population while integrating environmental, social and economic considerations.

From an environmental perspective, sustainable systems would provide food security by increasing yields while conserving resources, promoting soil health and protecting biodiversity. Resilience to the impacts of climate change is another critical characteristic. Social attributes include nutrition, food choice, affordability and accessibility along with fair labor practices and animal welfare. A strong economic foundation is needed to ensure sustainability; therefore, profitability across the value chain, including financial viability for farmers, and fair and open markets are integral components. Furthermore, crosscutting attributes such as public policy, transparency, standard metrics and the use of technology play key roles in sustainable food and agricultural systems.

Moving towards Sustainability: Opportunities, Breakthroughs and Key Drivers

The following key themes arose from responses to a range of open-ended questions about opportunities, potential breakthroughs and key drivers for building sustainable food and agricultural systems.

Sustainable food and agricultural systems are continuously improving.

Although identifying breakthroughs was an objective of the interviews, many respondents mentioned the need to continue incremental efforts across all stages of the food system in areas such as efficiency, productivity and environmental impacts. Such steps, when taken by many, can contribute to significant improvements.

This paper acts as an important bridge to identify approaches and spark action. It shares insights gathered in interviews with 52 experts and thought leaders working in food and agriculture.

Significant opportunities for improvement and breakthroughs exist.

System-wide change calls for strategies that promote continuous improvement while encouraging breakthroughs that trigger exponential advances. There was general agreement that the focus today should be aimed at deploying existing solutions on a broader scale. Thinking about how to move forward, it was noted, is not just a matter of determining where breakthroughs are needed, but also determining what breakthroughs have already occurred and need further support and dissemination.

Of the solution exploration areas discussed in the interviews, the following were seen as holding significant opportunities for ongoing improvement and breakthrough change:

- **On-farm practices:** Multiple key areas were identified for potential breakthroughs with on-farm practices, beginning with education, information sharing and data gathering to inform producers about effective practices and drive adoption. The other areas zeroed in on nutrient management, manure management, practices that improve soil health and prevent erosion, and animal welfare and productivity.
- **Precision agriculture:** Many technologies exist or are emerging today that are extremely useful for measuring, monitoring, and improving efficiency and production. Precision agriculture, discussed on page 16, was mentioned as one of the key approaches for achieving improved efficiency and increased yields with improved environmental results.
- **Soil health:** Effective soil management practices improve soil composition and structure, promote soil health, and restore organic matter in soil, which is essential to environmentally sustainable food production. This supports agricultural productivity and provides ecosystem services. In addition, healthy soil's natural ability to capture and sequester carbon presents an opportunity to develop soil carbon credit trading markets, which would provide economic incentives to drive adoption of improved practices.
- **Waste reduction and resource recovery:** Reduction of waste at all points in the food system must be a priority. Where waste cannot be eliminated, opportunities for the recovery and reuse of resources such as nutrients and energy need to be maximized. Manure management and the use of anaerobic digesters with nutrient management technology were cited as top areas for potential breakthroughs.

Research, science and technology are critical components to achieving sustainable food and agricultural systems.

Scientific research is widely recognized as a key driver for innovation and change as well as one of the top opportunities to explore now. Technology plays an essential role in supporting sustainable intensification—producing more with fewer resources and less environmental impact—as well as in the collection and use of data for making informed decisions based on science. Technology discussions also included the role of genetics in supporting increased productivity and resiliency to a changing climate (page 17).

Information sharing and learning based on science must be emphasized.

Sharing information that is grounded in science is a critical component in motivating change. Expanding farmer education and open access to information and data on sustainable on-farm practices regionally and globally can increase adoption rates. Consumer education and awareness about food production and sustainability efforts are needed to foster understanding and build trust in the food system.

Standard measures are needed to define progress in terms of productivity, environmental impact and nutrition.

Collaboration and agreement on measurement and reporting frameworks was noted as a key milestone in building more sustainable systems. Metrics are needed that incorporate a food's nutrient composition with measures of productivity, resource use and environmental performance.

Public and private investment and market opportunities are needed to drive the economic viability of environmentally sustainable agriculture.

Increased public and private funding in agricultural research is needed to accelerate the discovery, development and adoption of solutions. Furthermore, market opportunities and financial incentives must help promote positive environmental outcomes.

These key themes along with other insights from the interviews provide useful guideposts for identifying the best paths forward.

PROJECT VISION

Resilient US agriculture and food markets meet the nutritional needs of a growing global population while conserving natural resources and protecting habitat for species.

PROJECT OBJECTIVE

Through dialogue with experts and thought leaders, the Sustainable Food for the 21st Century project aims to contribute to the transformation of US food markets towards greater environmental sustainability, in collaboration with the US dairy industry.

ABOUT THE PROJECT

Finding practical, flexible solutions to environmentally sustainable food production that are grounded in science is a complex and difficult task, one that requires collaboration among experts from a wide range of professional, disciplinary and geographic backgrounds. That's why WWF launched the Sustainable Food for the 21st Century project, an interdisciplinary approach to identifying the visions, innovations, investments and economic drivers needed to effect meaningful change towards environmentally sustainable food systems.

While its vision is broad, the project focuses on the US dairy industry to help narrow the scope and promote sector-wide transformation. Dairy is one of WWF's 11 priority global agricultural commodities and sectors, which are identified as those that most impact WWF's priority places for biodiversity conservation and contribute significantly to humanity's footprint. Because the dairy value chain involves more than milk production—including feed production, processing of dairy foods and beverages, and retail and consumer stages—many of its key sustainability issues and challenges are not unique to dairy. As such, solutions have the potential for broader application and benefits of environmental sustainability to other agricultural sectors.

Although the project objective and the expertise of the individuals interviewed for this project have a US agricultural focus—including US dairy production—the overall context and scope for the project, the challenges faced, and the views on environmentally sustainable food and agriculture are global and span agricultural commodities.

About This White Paper

This white paper serves as an important bridge. It brings together multiple voices from agriculture, food production, economics and environmental science to help target action areas and next steps forward.

The first phase of this project involved structured interviews to gather insights and approaches for addressing sustainable food production challenges from 52 individuals selected for their demonstrated leadership or academic expertise in environmentally sustainable agricultural systems. The respondents represent industry (including 10 within the dairy industry), academia, government, NGOs and others (grant foundations, consultancies and retail). Refer to the Appendix for additional information on the interviewees and interview process.

A prominent—and promising—finding from the interviews is the high degree of agreement that arose across diverse responses to open-ended questions. The shared views and key themes point to opportunities that are ripe for collective action. In addition, the more distinct perspectives identified provide a fuller picture and, in some cases, new concepts or ideas to explore further.

Next Steps

The key themes and unique perspectives from the interviews informed the selection of action areas for the next phase of the project. In early 2015, WWF and the Innovation Center for US Dairy will convene a blue ribbon panel of 10 to 12 renowned experts in the fields of environmentally sustainable food and agriculture. The panel will work over the course of the year to develop recommendations on next steps to achieve scalable, actionable solutions regarding environmentally sustainable food production in the five areas listed below. While the panel will focus on opportunities with the US dairy value chain, its work and recommendations will be crosscutting and, as such, will provide a model for other agricultural sectors and generate positive spillover effects.

- **Better management practices and technology:** Identify ways to overcome the barriers that US dairy farmers and grain growers face in using existing, feasible practices and technologies to conserve water and improve water quality.
- **Knowledge sharing:** Recommend the actions, stakeholders and investments needed to leverage existing tools and expand knowledge sharing and learning among producers and growers with respect to environmental sustainability.
- **Genetics:** Identify the gaps in scientific studies on genetics, selective breeding and genetically modified organisms (GMOs) and develop agreement areas for acceptable technologies that can support the sustainable production of dairy and dairy feed crops. Develop an outcome-based study that considers the opportunities, barriers and drawbacks for these agreement areas and proposes potential acceptable solutions. Identify key stakeholders and set an engagement strategy.
- **Metrics:** Explore ways to incorporate measurements of environmental impacts and nutritional value into standard metrics of sustainable production.
- **Waste:** Identify concrete actions needed to reduce waste and maximize resource recovery, reuse and recycling at all stages of the food chain.



WHERE TO GO: DEFINING SUSTAINABLE FOOD AND AGRICULTURAL SYSTEMS

"A sustainable food and agricultural system is one in which we have highly productive farmers who can continue their work with the goal of feeding nine billion people, while still getting good environmental outcomes. It is a system that can produce the base quantity of food we need for sustenance and growth as a global population but still can provide local and regional choices to meet the cultural ethics and values of those consuming it."

DAVID DARR

Vice President, Sustainability and Member Services | Dairy Farmers of America

ABOUT FOOD AND AGRICULTURAL SYSTEMS: In the interviews and in this white paper, “system” is meant in the broadest sense and encompasses the interrelated components and sets of systems worldwide, from agricultural food production to food processing and packaging, distribution, trade, retail, consumption, use of coproducts, resource recovery and disposal. Within this value chain perspective, the interview discussions lean towards the production side as the area with greatest impacts and opportunities for significant sustainability-related improvement and transformation, while also exploring areas such as waste and consumption dynamics.



We asked the experts and leaders to define a sustainable food and agricultural system for the 21st century and to describe its principal characteristics. The intent of the questions—and therefore this paper—was not to propose a single definition but rather to understand shared and divergent views for continued dialogue.

Although specific definitions and descriptions varied, similarities in underlying concepts and areas of overlap were prominent. Not surprisingly, the areas of agreement also aligned with many widely recognized definitions such as the US legal definition for “sustainable agriculture.”

Consensus on the general principles regarding sustainable food and agriculture will be an important milestone. Based on the interviews, it seems we are quite close to reaching this consensus, which will provide a basis for increased efforts towards achieving this common vision.

Respondents recognized the value of and need for shared understanding to drive collective action towards greater sustainability. In fact, respondents identified agreement on common language as one of the top opportunities to pursue now.

KEY THEMES AND CHARACTERISTICS

Many of the responses to defining a sustainable food and agricultural system built on the definition of sustainable development from *Our Common Future*: that we must meet the needs of the present without compromising the ability of future generations to meet their own needs.¹ The definitions provided by the respondents also integrated environmental, social and economic dimensions, while addressing the unique aspects and considerations of food and agriculture.

The following descriptions reflect the prominent themes across the definitions and characteristics:

- Food produced by the system is safe, secure, affordable, accessible and nutritious.
- The system increases yields to meet the needs of a growing global population while using natural resources in a highly efficient or “superefficient” manner and protecting ecosystems.
- Technology’s role in farming and its deployment are greatly increased in the system.

- The system has appropriate mechanisms and incentives in place to encourage farmers to achieve optimal production and environmental outcomes.
- The system is resilient to the impacts of climate change as well as to market changes.
- Responsibility applies to areas such as fair labor practices and animal welfare.

The system is profitable across the value chain and supports the financial viability of farmers. Additional characteristics provide valuable insight. Many respondents discussed the need for a food and agricultural system to be adaptable to consumer preferences; the system would ensure access to all types of food to all people, including affordable and culturally relevant choices. From a resource utilization perspective, some respondents foresaw the expanding role of plant-based diets.

The role of policy was also discussed. Respondents saw food and agriculture policy being better connected to link production and trade with societal nutrition and public health. And many pointed to the importance of fair and open trade as a key component to supporting global needs.

Overall, a prominent view, which applies to most of the characteristics, is the recognition that sustainability is a process of continuous improvement.

“A sustainable food and agricultural system is efficient in the way it uses natural resources, is well integrated into ecosystems, is profitable and responds to ethical and cultural considerations. The system provides food that is good for the consumer: balanced, nutritious, enjoyable and safe.”

PIERRE GERBER
Senior Policy Officer | *Livestock and the Environment*
FAO, Animal Production and Health Division (AGA)
Livestock information, sector analysis and policy branch (AGAL)

“A sustainable food and agricultural system is one in which the livelihoods of the growers are sustained and met, natural resources are optimized and not exceeding their capabilities over the long term, and the biodiversity/ecosystem in which the crops are grown is also sufficiently support ed.”

DIANE HOLDORF
Chief Sustainability Officer and Vice President of Environment, Health, and Safety
Kellogg Company



Role of US Dairy

Respondents recognized the US dairy industry as an agricultural sector leader in environmental sustainability and indicated that it can and should continue to play that role in the future, especially as the industry responds to growing global demand. Under the leadership of US dairy farmers, dairy industry leaders came together precompetitively in 2007 to launch the US Dairy Sustainability Commitment, which aims to continuously improve the industry's contributions to a socially responsible, economically viable and environmentally sound food system for current and future generations.

Respondents discussed the nutrition and health benefits that milk and dairy foods contribute to diets worldwide. However, they also pointed to environmental impacts that must be mitigated and managed more sustainably. In particular, respondents noted the important role the dairy industry must play in greenhouse gas emissions reduction,² waste reduction and resource recovery. The reduction of water pollution from nutrient runoff from manure and fertilizer use is another area of concern.

US dairy farms have shown continuous improvement in efficiency and milk production in the past decades: compared with 1944, average milk yield per cow in 2007 increased by more than 400% while resource use per unit of milk produced decreased (90% less land, 77% less feed and 65% less water).³ Still, more work is needed to conserve natural resources and reduce environmental impacts of an expanding industry. In doing so, dairy farms have the opportunity to demonstrate improved models of closed-loop systems for livestock agriculture (see page 21).

“The dairy industry is in a position where we can, and should, be leading regarding environmental sustainability. We have integrated livestock and cropping operations on our farms that produce manure for energy. We have taken a comprehensive look at agriculture so that what we learn can be applied to other crop and livestock systems.”

DOUG YOUNG
Dairy Producer | Spruce Haven Farm



“The dairy industry has shown a lot of leadership related to sustainability—such as on energy use, greenhouse gas emissions, methane digesters and water quality. The great thing that the dairy industry is doing is looking at approaches that are not only sustainable but also addressing the social and economic issues. Dairy has already stepped out in an important way and can be a beacon of agriculture.”

ROBERT BONNIE
Under Secretary for Natural Resources and Environment | US Department of Agriculture





HOW TO GET THERE: IDENTIFYING OPPORTUNITIES, SOLUTIONS AND DRIVERS

"I think we need a new deal of farming—a new deal between industry and farmers, regional or state governments and research institutes. This 'new deal' would include much more collaboration and connection between food sector and agriculture. A new deal like this is about creating an integrated economic, low-carbon development plan for a region and how to plan for agriculture, industry, housing, recreation and all of the resource needs that come along with the different activities. It is about creating a new view of how we manage the economy and natural resources within a certain region."

JAN-KEES VIS
Global Sustainable Development Sourcing Director | Unilever

GLOBAL PERSPECTIVE, LOCAL APPROACHES: Although the focus of the interviews was on US food and agricultural systems, most of the respondents emphasized the importance of taking a global perspective when thinking about opportunities and solutions. Demand is global, but farming is local: agricultural practices vary based on specific farm and regional attributes. At the same time, knowledge sharing and technology transfer can promote application of effective solutions and practices across countries and regions with similar characteristics. In addition, broader challenges must be viewed through a wide lens that incorporates aspects of global trade and distribution.



A range of opportunities and practical, evidence-based solutions need to be pursued now to achieve sustainable food and agricultural systems. And the right drivers need to accelerate progress. Respondents explored these topics to help identify where efforts should be focused.

TODAY'S OPPORTUNITIES

We asked the experts and leaders to pinpoint opportunities to pursue today to achieve the sustainable agricultural systems they envision. Across the responses, the following areas of opportunity were most commonly recommended (in order of most frequently mentioned):

- farmer behavior and practices
- data and tools
- research and science
- manure management
- soil health
- genetics

The top three opportunities—farmer behavior and practices, data and tools, and research and science—are broad and therefore apply across the approaches, solutions and key drivers discussed throughout this paper. The more specific on-farm opportunities with soil health and genetics, about which respondents were specifically asked, are discussed in separate sections.

Other opportunities include reducing the yield gap between the highest- and lowest-performing farms, increasing feed efficiency (the conversion of feed into desired output in livestock), minimizing food waste and improving human nutrition. In addition, communications opportunities exist to reach agreement with common language and standards and to foster understanding about food production and practices with consumers and other stakeholders, as discussed further on page 25. Respondents also noted that there were opportunities for public policy, government subsidies, and incentives to promote more sustainable practices and outcomes, and for trade policy to support fair and open markets.

AREAS FOR IMPROVEMENT AND BREAKTHROUGHS

To expand the discussion, we also asked the experts and leaders to identify possible breakthroughs that can be made in the following areas to drive sustainable agriculture: on-farm practices, efficiency through technology, soil health/soil carbon, genetics, waste, land use, property rights and consumption dynamics. Refer to the Solution Exploration Areas table on the following page for additional context about these areas and top opportunities identified.

Given that identifying specific breakthroughs in some topics can be challenging, many respondents instead identified areas where, given conditions and constraints today, there may be the potential for breakthroughs or where breakthroughs are possible. They also noted breakthrough solutions that already exist but would require widespread implementation to bring about transformative change. There was general agreement that the focus now should be aimed more at deploying existing proven solutions on a meaningful scale by identifying and removing barriers to adoption.

Many mentioned that, in lieu of breakthroughs in some areas or in addition to breakthroughs, there is a need to continue incremental improvement efforts across all stages of the agricultural system. Respondents felt that such steps, when taken by many, can indeed add up to significant improvements. This reinforces a key theme from the interviews: sustainable food and agricultural systems are continuously improving.









Both approaches—the measured strides of continuous improvement and the giant leaps of innovative breakthrough change—need to be pursued in tandem to address pressing and converging challenges by 2050. The following subsections provide an overview of the interview results across the solution exploration areas and highlight the opportunities and solutions discussed.



Solution Exploration Areas

Solutions for building sustainable food and agricultural systems will come from many areas to address a range of challenges and considerations. The solution exploration areas used in the interviews were adapted from the strategies that Jason Clay, WWF senior vice president, markets and food, has proposed in earlier publications and at worldwildlife.org/stories/freezing-the-footprint-of-food.

To foster creative ideas, the interviewers did not define the solution exploration areas; rather, the respondents were given the opportunity to define these topics from their perspective and expertise. The following descriptions provide an overview of the scope of the discussion within the interviews and present some additional considerations.

SOLUTION EXPLORATION AREAS	
 ON-FARM PRACTICES	<p>Improve the production of farms by sharing, adopting and adapting better agricultural management practices at local, regional and global levels. Focus on closing the production gap between the poorest-performing and best-performing farms.</p> <p>Discussions in this area were broad, covering increased productivity, optimization of resources, animal welfare and reduction of adverse environmental impacts. As such, they overlapped with conversations on efficiency through technology, soil health and genetics.</p>
 EFFICIENCY THROUGH TECHNOLOGY	<p>Advance the efficiency of input and processes in order to increase food production and reduce the environmental and financial costs of farming.</p> <p>Discussions included availability of and access to technology as well as related cost considerations.</p>
 SOIL HEALTH/ SOIL CARBON	<p>Restore organic matter in soils to improve water and nutrient retention, reduce inputs and erosion, and store carbon.</p> <p>Discussions included carbon sequestration strategies and potential for carbon trading markets.</p>
 GENETICS	<p>Harness breeding technology to select favorable traits needed to increase productivity, nutritional value and resiliency while reducing inputs and environmental impacts.</p> <p>Discussions of genetics also occurred under Efficiency through Technology and covered traditional methods of plant and animal breeding as well as genetic engineering.</p>
 WASTE	<p>Reduce waste across the food system by identifying and eliminating factors that contribute to waste. Where waste cannot be completely eliminated, expand opportunities for the recovery and reuse of nutrients and energy.</p>
 LAND USE	<p>Minimize conversion of habitat to farmland to prevent loss of biodiversity.</p> <p>In the interviews, land use was mentioned primarily in context with optimizing resources to increase productivity without increasing land requirements. Land rehabilitation, which addresses reversing erosion and degradation of underperforming land, was not directly mentioned within the interview questions but offers solutions to land use challenges.</p>
 PROPERTY RIGHTS	<p>Pursue strategies that protect land and secure property rights in order to ensure that lands are sustainably managed to optimize their long-term production potential.</p>
 CONSUMPTION DYNAMICS	<p>Consider the role of consumers through food preferences and purchasing decisions in contributing to a sustainable food system.</p> <p>Another aspect of this topic, which was not directly part of the interview discussions but needs attention, is the promotion of sustainable diets for all. The interviews and broader project are aimed more specifically at sustainable production of food.</p>

NOTE ON SUSTAINABLE INTENSIFICATION: The phrase “sustainable intensification” can be understood in different ways, which makes it a source of concern for some. Within this paper, it is used simply to describe increasing food production in ways that are sustainable by reducing key environmental consequences, being socially responsible and economically viable, and protecting ecosystems and the services they provide. The phrase is not used to indicate particular practices or systems.



“Great opportunity lies in the fact that within each production system we find a large variability in environmental performance. We need to better understand the drivers and obstacles that shape this heterogeneity in order to narrow the environmental performance gap.”

PIERRE GERBER
Senior Policy Officer | *Livestock and the Environment*
FAO, Animal Production and Health Division (AGA)
Livestock information, sector analysis and policy branch (AGAL)

SUSTAINABILITY THROUGH EFFICIENCY, RESILIENCY AND ADAPTATION

The respondents characterized a sustainable food and agricultural system as efficient, resilient and adaptive. In other words, a sustainable food and agricultural system is one that uses natural resources in a “superefficient” manner, increases yields to meet needs, has an increased use and deployment of technology, and is resilient to the effects of climate change.

To feed a growing population sustainably, agricultural practices must be as efficient, productive and environmentally responsible as possible. This sustainable intensification of agriculture—producing more with less—must integrate better practices, optimization, adaptation and technology.

Identifying and adopting the most effective on-farm practices and agricultural technologies that are appropriate for each farm and region can help close the gap between what a farm produces and what it could produce. Opportunities to close this yield gap exist in developed and developing countries alike.

For example, a 2012 study of 17 major crops representing three-quarters of the world’s harvested cropland found that fertilizer use, irrigation area and climate account for 60% to 80% of the yield gap for these crops.⁴ The study concluded that better management practices suited to a particular region and crop—particularly nutrient and water management practices—could increase yields of most crops by 45% to 75%.⁵

In looking at the global dairy industry, 31 member countries of the Organisation for Economic Co-operation and Development account for only 20% of the world’s dairy cows, but they produce 73% of global milk production.⁶ A dairy cow in the US produces, on average, four times more milk than the average dairy cow worldwide.⁷

Similar performance gaps and opportunities for improvement apply to environmental impacts as well. For example, data from the US dairy industry’s 2009 Greenhouse Gas Life Cycle Assessment for Fluid Milk suggest that if all US dairy farms adopted the manure management practices of the top 10% most-efficient farms, total greenhouse gas emissions across the US dairy supply chain would drop by an estimated 14%.⁸

Many of the solutions areas discussed in the following sections—on-farm practices, efficiency through technology, genetics and soil health—support sustainability characteristics of efficiency, resiliency and adaptation.

“A sustainable food and agriculture system has four core principles that are applicable at every scale: soil health, input efficiency, resiliency in the face of climate change, and integration of natural habitat.”

DAVID CLEARY
Director of Agriculture | The Nature Conservancy



“One area where information sharing is critical is at the farm or producer level. Farmers are very competitive because they manage to the level of pennies per bushel. They are always looking for the next best solution: call it an innate sense of continuous improvement. As in all cases, information sharing with producers about environmental best practices has to be done in a relevant way—i.e., very practical to their situation—and from a source who is both credible and trusted.”

JERRY LYNCH
Chief Sustainability Officer | General Mills



ON-FARM PRACTICES

Not surprisingly, respondents identified on-farm practices as a top area for incremental change and one in need of breakthroughs to drive greater sustainability in food production. Similarly, farmer behavior and practices ranked as the top opportunity that should be explored now.

One respondent summarized breakthroughs in this area as “getting more output with less input,” which captures the sentiments of many of the experts and leaders. Specifically, respondents mentioned precision agriculture’s breakthrough potential for achieving greater efficiencies through technology, as discussed in the following section. In addition, they noted four key areas where there is potential for breakthroughs with on-farm practices:

- **Education, information and data:** The use of data and information to improve practices was noted as a potential breakthrough. At the same time, many respondents emphasized the importance of acceptance and adoption of practices on the ground. They indicated that more education and peer-to-peer learning to share information and data on environmentally effective practices, including cost-benefit analysis and outcomes, may drive farmers towards adopting approaches that increase yields in sustainable and economical ways. Refer to the Critical Role of Information Sharing highlight for further discussion.
- **Crop nutrient management:** Nutrient management and manure management are key areas where breakthroughs are possible to improve water quality and reduce environmental impacts from nutrient runoff into groundwater and waterways. To minimize nutrient losses, better management practices incorporate the “four Rs” of fertilizer management: the right fertilizer source, applied at the right rate, at the right time and in the right place. Adoption of these practices also helps maintain high yields. Refer to discussions on precision agriculture (page 16) and waste (page 20) for more information.
- **Soils:** Practices that improve soil health and prevent erosion are essential for sustainable food production. The Soil Health section on page 19 covers the discussion on this topic.
- **Animal welfare and productivity:** Animal health, welfare and productivity were identified as ripe for breakthroughs in areas such as cow comfort, animal housing and reductions in enteric emissions (methane emitted from cows’ digestion process).

CRITICAL ROLE OF INFORMATION SHARING



One of the most repeated topics across the interviews was the importance of information sharing and its essential role in fostering the types of changes needed to build sustainable food and agricultural systems. Education and information

sharing for farmers, as noted in this section, is needed to disperse better practices, technologies and data. Respondents underscored the importance of information and data that are credible and based on science. They also stressed the need for information sharing to be open and precompetitive, while respecting and protecting confidential information. Access to open data in a useable format supports decision making, collaboration and innovation. For example, the Climate Data Initiative (Climate.Data.gov) makes available the US federal government’s extensive open data resources, including the Food Resilience theme, a collection of data sets related to the effects of climate change on the food system. The LCA Digital Commons Project, described on page 27, is another example.

A specific knowledge sharing solution discussed by the respondents is the expansion and/or replication of the US land-grant extension program model to a global scale for better practices and knowledge to be accessible to farmers worldwide. One respondent noted that the eXtension.org site—the Internet-based public educational network that complements the community-based Cooperative Extension System in the US—is already visited by users in other countries, an unexpected result that can be leveraged further for greater reach and impact. The eXtension site features content providers from US land-grant universities who deliver educational resources and provide credible expertise on a wide variety of topics. The 24/7 availability of resources such as eXtension and other digital and mobile technology can increase access to information and help accelerate the adoption of better practices around the globe.

“A key milestone will be to come to some common understandings about the role of technology and farming practices. Farm size, whether small or large, is not good or bad by definition. Technology is not bad or good by definition as well. Modernizing farming practices [is] about embracing beneficial technologies as much as we embrace technology in other areas, like modern communications. It is about learning in one place and taking it to another place.”

MARY SHELMAN
Director | Agribusiness Program, Harvard Business School



EFFICIENCY THROUGH TECHNOLOGY

Respondents across all sectors represented in the interviews—industry, NGOs, academia and government—noted the need for “superefficient” production and increased yields. And they felt that many technologies exist or are emerging today that are extremely useful for measuring, monitoring, and improving efficiency and production. The use of every agricultural input, including water, energy, fertilizer and pesticides, needs to be optimized to maximize output and minimize environmental impacts.

Focus on Precision Agriculture

Consistently described as a tremendous breakthrough area, precision agriculture was mentioned as one of the key approaches for achieving both improved efficiency and increased yields.

Precision agriculture recognizes that attributes such as soil composition and moisture, nutrient levels, pests, air quality, crop maturity and microclimates vary. Precision agriculture helps farmers optimize agricultural inputs, such as nutrients and water, through precise and appropriate application based on the capability of the land and crop at any given time. Also called “as-needed” agriculture, this approach promotes increased productivity and soil health (discussed further on page 19), while minimizing environmental impacts. At the same time, implementation of certain technologies involves investments in machinery, software, crop consultants, etc., which must also be considered.

Agriculture not only uses 70% of the world’s fresh water, it also wastes more than half of its water use annually.⁹ Inefficient field application methods contribute to that waste. Monitoring and automation systems can better control water use by applying water when and where it is needed and in the precise amounts the crops need. Similarly, precision agriculture techniques can closely manage fertilizer application to avoid overuse and reduce nutrient runoff.

A Range of Simple to Complex Approaches

The basic premise of precision agriculture is observation and response based on current and anticipated conditions in a given area of the farm; therefore, specific practices range from simple to complex. Some respondents called out the importance of recognizing these differences.

Simple, accessible approaches to precision agriculture can include weather reports and investments in basic equipment. In developing countries, practices such as field scouting and spot application of pesticides are considered precision agriculture practices. Respondents thought that providing access to and increasing availability of basic equipment and information to developing countries would move us further along the path to sustainable food and agricultural systems.

In developed countries, precision agriculture typically incorporates the following components: background data, specialized implementation equipment, a recordkeeping system, a decision-making process, evaluation and revision.¹⁰ Some respondents mentioned the need to continue working to improve more sophisticated technologies for use in precision agriculture. For example, one respondent was beginning to see a growing number of proposals to establish regional and national information systems that use unmanned aerial vehicles (also referred to as drones) to track crop development and nutrient deficiency. He also discussed the potential of large-scale data sets that are being built from global positioning system monitors already installed on large-scale farm equipment.

Increasing Adoption

Many respondents pointed to precision agriculture as an example of a proven solution that needs greater adoption and implementation in order to effect large-scale change. Investments in technology, knowledge sharing and education, as discussed in the Key Investments section on page 27, will help realize the significant potential of this approach in developing and developed countries.

“There are three characteristics that are a big part of a more sustainable food and agricultural system in 2050: seed varieties that produce more yield on less land with less waste; chemical inputs that reduce the loss and wastes on the field as well as after harvest; and better recycling of nutrients to bridge disconnect between consumption in cities and production in rural areas.”

MICHAEL MACK
Chief Executive Officer | Syngenta



GENETICS

Genetics, discussed broadly within the context of developing and using better variants of plants, animals and microorganisms through a range of approaches to enhance desired genetic traits, was among the most frequently mentioned opportunities to pursue today.

Many respondents see genetics as a critical tool to help improve productivity, efficiency, resilience and nutrition—all recognized characteristics of a sustainable food and agricultural system. As such, genetics was identified as a top solution area for both incremental improvement and breakthrough change. Several respondents explicitly pointed to potential breakthroughs in genetics as a means towards reaching greater efficiencies through technology. Additional areas for potential breakthroughs include crop resistance to changing climate conditions, such as drought and extreme weather patterns, and nutrient efficiency. Livestock breeding was also noted as a potential breakthrough area, where herds could be improved for their health, protein content, production and ability to convert feed to milk efficiently with different total mixed rations (feed efficiency).

Because respondents were asked to consider this topic through their own perspective without a formal definition of “genetics,” the interview discussions were high level and did not exclude any particular approach (selective breeding, propagation or genetic engineering). Several respondents acknowledged the use of GMOs as a contentious issue and one with growing consumer acceptance challenges, but they did not delve into the current debate. Rather, they presented their views on the overall role of genetics in sustainable food and agricultural systems.

Although the debate about the use of GMOs is outside the scope of this white paper, this important and complex topic has been identified as one of the action areas that the blue ribbon panel for the Sustainable Food for the 21st Century project will explore further, as described in the About the Project section on page 6.

Role of Genetics in Sustainability

Although respondents discussed different aspects of genetics, there was much alignment in how genetic technology—whether through breeding, propagation or genetic engineering—could contribute to addressing several key sustainability objectives:

- **Increase productivity:** Respondents frequently pointed to the contributions that genetics have made towards the current productivity of agriculture, particularly in the US. For example, a 2006 study of US dairy estimated that of the 3,500 kilogram increase in lactation yields since 1980, 55% can be attributed to improved genetics, including improved genetic evaluation procedures for selective breeding.¹¹ Between 1900 and 2007, US corn yields increased from an average of 28 bushels to 147 bushels per acre. While many factors contributed to this increase, a good share of this growth is attributable to genetic research and development of new corn varieties, particularly hybrid corn.¹²

Respondents noted that continued research and development of genetic traits and breeding programs are important to enable further improvements and breakthrough changes in productivity. Further research is also needed to evaluate productivity gains of genetically engineered crops. A recent US Department of Agriculture (USDA) Economic Research Service report found that the adoption of insect-resistant (Bt) crops increases yields; however, there was mixed evidence of an increase in yield for herbicide-tolerant (HT) crops.¹³

- **Enhance resiliency and adaptation:** Many interviewees stressed the importance of continuously improving crop resiliency and adaptation through advanced breeding and genetic engineering to counter the disruptive impacts of climate change such as drought, extreme heat and cold, and changing or severe weather patterns. At a time when food production must increase, these effects will likely decrease crop yields by up to 2% per decade from 2030 to 2100.¹⁴ To prepare for and mitigate these impacts and associated impacts on pests and weeds, public and private investment in research is needed to better understand the potential impacts of changing conditions and develop more resilient and adaptive crops.

“Agriculture is necessarily focused on productivity—we need more food to meet the needs of current and future populations. Many breakthrough opportunities exist to produce more environmentally sustainable and high yielding varieties that are more resistant to insects and disease and require fewer inputs to produce, but we also need to invest in the quality of food and nutrition in the breeding of farm crops.”

GENE KAHN
Head, Global Market Development | HarvestPlus



- **Improve nutrient and feed efficiency:** Some of the respondents pointed to GMOs as a key solution for optimizing plant processing of nutrients to improve nutrient efficiency and minimize water quality impacts. Several extended the discussion to livestock genetics, pointing to potential breakthroughs in improving the protein content and feed efficiency, which measures how effectively feed is converted into desired output, such as milk for dairy cows or increased body mass in beef cows, pigs or chickens.
- **Enhance nutrition:** A few of the respondents noted the global health benefits that biofortification—improving the nutritional quality of food crops through conventional plant breeding and/or the use of biotechnology—can deliver. This underscores the importance of food quality that is needed along with productivity gains. For example, one respondent discussed breeding micronutrients such as zinc and iron into staple crops most frequently eaten by the poor and undernourished.

Across all these areas, continued research and development is necessary. Many respondents identified investments in genetics as one of the key technology investments needed today. At the same time, others indicated that the focus should be on implementing the genetic technology that already exists to bring solutions to scale. To do so, we need to identify current barriers and determine ways to overcome them, while seeking to understand the consequences and risks of broader adoption. The identification and adoption of appropriate management practices related to the use of genetic technology are also essential. For example, the adoption of HT crops with a parallel reduction in the diversity of weed management practices has contributed to a global problem with herbicide resistance in weeds. Of the 372 herbicide-resistant biotypes confirmed worldwide, the US has 139.¹⁵ Wider use of better management practices for weed control may mitigate the development of such weeds and sustain the efficacy of HT crops.

“Some milestones include that we have had public investment in agricultural research, consumer acceptance of technology and a growth in production to meet demand.”

CHUCK CONNER
President and Chief Executive Officer
National Council of Farmer Cooperatives





SOIL HEALTH

Respondents identified soil health as one of the top improvement opportunities for sustainable food production to pursue today. Discussions focused on effective soil management practices and the development of carbon markets and sequestration strategies to promote wider use of better practices.

Although there are different views on the meaning of “soil health,” healthy soil includes having appropriate structure as well as hosting a vital ecosystem of minerals, nutrients and microorganisms. Healthy soil helps absorb and regulate water flows, and it can filter and buffer potential pollutants and store, transform and cycle nutrients such as carbon, nitrogen and phosphorus.¹⁶

Topsoil contains the majority of carbon-based organic matter that keeps soil healthy and productive. Approximately half of the world’s topsoil has been lost in the past 150 years.¹⁷ Topsoil loss from erosion and winds lowers productivity and the efficient use of inputs such as fertilizer and water.¹⁸ In addition, soil health is greatly diminished by overgrazing and compaction, over- or under-application of water and nutrients, regional air and water pollution, clear-cutting, and other factors.

Promoting Better Soil Management Practices

Although regional soil types have inherent qualities such as “sandy” or “clayey,” management practices can improve soil’s composition and structure, promote soil health, and restore organic matter in soil. Respondents cited soil health and carbon-friendly farm practices such as conservation tillage, cover crops and rotational grazing as existing solutions that contribute to conservation of soil carbon. In addition, precision agriculture technologies and practices, discussed on page 16, can contribute to soil health through the appropriate application of nutrients and water based on real-time soil assessments.

Because much work has been done on soil health and many scientifically recognized practices are in use today, several respondents recommended prioritizing the widespread implementation of these practices to drive breakthrough change.

Sequestering Carbon in Healthy Soils

Respondents pointed to soil carbon sequestration and carbon trading markets as one of the top potential breakthrough areas to support improved soil health.

Healthy soil’s natural ability to capture and sequester carbon presents an opportunity to include soil improvement practices as eligible carbon offset projects in current and future carbon credit trading markets. To earn “credit” for restoring soil carbon, third-party verifiers measure on-farm soil carbon before and after farmers implement practices such as no-till farming, direct seeding and crop rotations. The soil carbon improvements are measured in carbon credits, which are sold on carbon credit trading markets. Soil carbon credit trading can provide economic incentives for wider adoption of better soil management practices.

Some respondents noted that the technology, knowledge and efforts to restore soil carbon already exist; they just need to be brought to scale. Additional research needs to occur to reach consensus about the best soil carbon sequestration strategies, third-party credit verification methods and trading market structures needed to drive breakthrough change.

“For agriculture as a whole, the issue of inputs— as a driver of water quality degradation and soil quality—is extremely important. The tradition of farmland preservation is soil conservation, which is absolutely essential to create new opportunities. We tend not to focus on soil health because the perception is that the dust bowl is over—but the data do not support that. We need to make smart, short-term decisions to not farm in our wetlands, on stream banks, or on highly erodible soils in order to save our topsoil from eroding into the Gulf of Mexico and other bodies of water.”

ANDREW MCELWAIN
President | American Farmland Trust

FINDING SOLUTIONS TO MULTIPLE ISSUES: When discussing water quality impacts of manure at concentrated animal feeding operations, some respondents pointed to innovative solutions designed to reduce nutrient discharges into the Chesapeake Bay watershed. One effort aims to use agricultural manure to rebuild soil quality at reclaimed coal mine sites in Pennsylvania. Once restored, the land would be used to grow biomass crops to create renewable energy.²⁶ Another initiative is a proposed bay-wide nutrient credit trading program, which would provide market-based incentives for farmers to reduce nutrient runoff to the bay.²⁷ Projects such as these can address multiple problems and deliver added benefits.



WASTE

In hearing the general topic of “waste,” respondents identified two main areas of focus: the reduction of waste overall and the optimization of its reuse, particularly food waste and post-consumer waste. In addition, manure management and the use of anaerobic digesters were identified as areas of possible breakthroughs.

Building a sustainable food and agricultural system requires a reduction of waste at all points by identifying and eliminating factors that contribute to waste. Where waste cannot be eliminated, opportunities for the recovery and reuse of resources such as nutrients and energy need to be maximized.

Reducing Food Waste

Of those who mentioned waste as a breakthrough opportunity, most noted that food waste, and post-consumer food waste in particular, was a core issue that must be addressed to meet growing food needs.

The numbers surrounding food waste are staggering. Globally, approximately one-third of all food produced for human consumption is either lost during production or wasted by retailers or consumers.¹⁹ In the US, the retail value of avoidable food waste in 2009 was \$197.7 billion, with consumer waste representing nearly 63% of all wasted food.²⁰

But the statistics also underscore the benefits to be gained by addressing this challenge. According to the Food and Agriculture Organization of the United Nations, the uneaten food produced globally would be enough to feed 2 billion people. A recent World Resources Institute report estimates that reducing current food loss and waste by half would reduce the amount of additional food production needed in 2050 by approximately 22%.²¹

In high-income countries, food waste occurs mostly at the retail and consumer stages. Education and awareness efforts can promote behaviors and practices that minimize food waste. In low-income countries, most food loss occurs at the storage, transport and processing levels, which requires different approaches to address storage and infrastructure needs.

Although the perishable nature of food implies food loss and waste will never be completely eradicated, there is tremendous room for reducing food loss and waste across the globe.

“There is a huge opportunity in food waste that we need to address. Up to 40% of our [nation’s] food is wasted. We have to make a societal shift to reduce the amount of the food we throw out.”

KIM STACKHOUSE
Director of Sustainability Research
National Cattlemen’s Beef Association

Focus on Manure Management

Respondents across all sectors identified manure management as one of the top opportunities to pursue today.

The storage and processing of manure in livestock operations impacts air and water quality and contributes approximately 10% of the sector’s total greenhouse gas emissions.²² Global methane and nitrous oxide emissions from manure management are projected to increase 17% from 2005 to 2030²³; therefore, effective management practices need to be used more widely to help reverse this trend.

Nutrient-rich manure has long been used to fertilize cropland; however, intensive animal production generates manure that contains nutrients in excess of what is needed for regional crop production. Runoff of excess nutrients and pathogens from manure into waterways is a key source of water pollution. Manure from livestock contributes 19% of the nitrogen and 26% of the phosphorous entering the Chesapeake Bay²⁴ and 5% of the nitrogen and 37% of the phosphorous entering the Gulf of Mexico.²⁵

Implementation of appropriate waste management systems can limit discharges by storing and managing facility wastewater and runoff. Additionally, one respondent identified the need for transportation systems for manure to help address the challenges with concentrations of manure.

Most respondents emphasized that manure is a valuable resource that should be fully utilized in ways that are environmentally and economically sustainable. In support of that view, many noted that the dairy industry has been a leader at turning waste into a profit center while minimizing environmental impacts, as discussed further in the following subsection.

“There are opportunities to reduce risk while addressing agriculture’s role in greenhouse gas emissions. The livestock and dairy industries in particular have opportunities in manure management and renewable energy generation.”

WILLIAM HOHENSTEIN

Director of Climate Change Program | United States Department of Agriculture



Maximizing Resource Recovery

Respondents overwhelmingly felt that breakthroughs were possible not only to reduce waste overall but also to use it for maximum benefit by taking a resource recovery approach.

Several discussed the need to move towards closed-loop, zero-waste systems. This would involve bringing more technology to waste recovery systems and finding alternative uses and markets for waste products. They pointed to anaerobic digesters as a solution for reusing food waste, livestock manure and other organic waste to generate renewable energy while capturing nutrients and other coproducts.

Anaerobic digesters recover energy and nutrients from organic waste by “digesting” it in an oxygen-free environment. The process captures biogas (methane) for use as a renewable source of energy for heat generation, electricity production and vehicle fuel. Digesters also recover the nutrients embedded in the waste for use as a nutrient-rich liquid fertilizer to grow more crops. The leftover fiber is used as soil amendment or livestock bedding.

Germany is a leader in the use of digester technology with 7,800 of its 9,945 biogas plants converting agricultural waste from crops and livestock manure.²⁸ In the US, there are more than 2,000 sites producing biogas, including 239 digester systems at livestock operations.²⁹ Although the current number of digester systems at US livestock sites is low, the potential for growth is substantial: more than 8,000 according to a US Environmental Protection Agency (EPA) AgSTAR report.³⁰

The use of digesters at livestock operations addresses many environmental issues, resulting in greenhouse gas reductions and improved water and air quality.³¹ It can, with adequate technical, financial, policy and regulatory support, be an economically viable solution for waste issues for farmers, businesses and communities.

Overcoming Barriers

Respondents see anaerobic digesters as an existing breakthrough technology that is already proven but needs greater support to remove barriers to promote the widespread adoption needed for meaningful progress.

Financing these capital-intensive projects is a significant challenge. To help secure funding and deliver a steady return on investment, the system needs to operate at optimum capacity, which requires a long-term, affordable supply of organic waste to produce the maximum amount of energy and other products. It also requires robust markets for the digester outputs: energy, nutrients, compost and bedding. A number of promising public and private efforts to address many of these barriers are already under way:

- The US White House released a Biogas Opportunities Roadmap in July 2014 highlighting the economic and environmental benefits of and potential for biogas systems in the US. USDA, EPA and the Department of Energy will take steps to promote the development of biogas systems by fostering investments, strengthening markets and promoting biogas utilization.
- The US dairy industry is working to promote the widespread adoption of anaerobic digesters and nutrient management systems. For example, the Dairy Power™ project is focused on resource recovery—harvesting the value in manure and creating viable business models that will lead to a more sustainable food system.
- Retail grocers and food processors are increasingly turning to digester systems to avoid sending food waste to landfills, often through co-digestion with manure in systems on dairy farms (which increases energy production).
- Well-coordinated public and private initiatives and actions are accelerating the adoption of digesters in Massachusetts, as described in the case study on the following page.

TAPPING THE VALUE OF WASTE THROUGH PUBLIC-PRIVATE PARTNERSHIPS

The Massachusetts Commonwealth is gaining widespread recognition for its 2014 commercial organic waste ban, which aims to divert food and other organic waste from landfills and put it to better use. The ban mandates entities that generate a ton or more of organic waste per week—universities, hotels, food processors, supermarkets and others—to donate consumable food to feed the hungry and send non-consumable food and other organic waste to composters and anaerobic digester systems.

Organic waste, of which a large percentage is food waste, occupies a quarter of the state's landfill space, where it releases greenhouse gases as it decomposes. This waste has commercial value in the form of energy, nutrients and coproducts, which can be captured when the right supporting elements are in place.

After years of work, those elements have been established in Massachusetts. Agencies have created policies, revised regulations, streamlined permitting and created \$4 million in loans and grants to help bring digester technology to scale. Utility incentives create a market for digester-sourced electricity. Massachusetts is well positioned to meet its environmental reduction goals and foster a clean energy economy.

Prior to the commercial organic waste ban, two Massachusetts dairy farms—Jordan Farms and Barstow's Longview Farm—were already co-digesting cow manure with food waste from many of the state's food processors and retailers. The combination of manure and food waste boosts the biogas production.

The business model for these two early adopters has been key to their success. Both farms partner with third-party operators, which enables each partner to do what it does best: dairy farmers focus on managing farm operations, while digester operators focus on running the system at optimal capacity. The third-party operators also manage the food waste supply contracts and maintain the utility purchase agreements and renewable energy credit sales.

Now that the right policies, funding options and incentives have been established to support digester systems such as these, more are under development. Broader adoption will provide organizations with organic waste disposal options needed to comply with the ban and benefit both the community and environment.

Interagency collaboration and public-private partnerships have been central to fostering the adoption of digester systems in Massachusetts. These efforts demonstrate an effective, replicable strategy for turning sustainability challenges into multiple opportunities.





LAND USE AND PROPERTY RIGHTS

How land is used and who owns it impact agriculture in a number of important ways; as such, land use and property rights play an essential role in building sustainable agricultural systems. When asked to identify opportunities for breakthroughs in the areas of land use and property rights, respondents felt both were complex topics that vary greatly based on societal and geopolitical factors. Consequently, these topics were not discussed in as much detail as those previously addressed. Still, respondents recognized some potential opportunities to explore.

Land Use

Land constraints, population growth and land-use changes limit the amount of new land available for expanded agricultural production. Globally, an estimated 70% of the land that is suitable for growing food is already in use or under some form of protection.³²

It is commonly agreed that global agricultural yield needs to increase sustainably without expanding the current footprint of agricultural land. (Refer to discussion on precision agriculture on page 16.)

Respondents discussed land use primarily in the context of sustainable intensification: optimizing resources to increase productivity without increasing land requirements. Minimizing conversion of habitat to farmland will also help prevent loss of biodiversity and ecosystem services such as efficient nutrient and water cycling.

The issues and challenges related to land use vary by region. In the US, for example, although cropland used for crops remained constant between 1964 and 2007, it increased by 11 million acres in the Corn Belt and Northern Plains and decreased by 17 million acres in the remaining regions.³³ Furthermore, from 2006 to 2011, rates of grassland conversion to corn and soy across a significant portion of the US Western Corn Belt (North Dakota, South Dakota, Nebraska, Minnesota and Iowa) were 1.0% to 5.4% annually, which are comparable to deforestation rates in Brazil, Malaysia and Indonesia.³⁴ This conversion is concentrated in close proximity to wetlands, posing a threat to waterfowl breeding in the Prairie Pothole Region.³⁵

“Land has to be treated like every square foot counts if the system is to be more sustainable.”

BARBARA BRAMBLE
Senior Program Advisor, International Affairs
National Wildlife Federation

Most of the respondents viewed land use in the US as a top candidate for incremental improvement. Additionally, many stressed the importance of keeping existing farmland in production rather than transitioning it to other uses. Current efforts to improve the land's productive capacity and to share and implement better on-farm practices should be continued.

Many felt that breakthroughs in land use are needed in developing countries to support sustainable intensification of production without losing valuable ecosystems and habitat. They also acknowledged that challenges such as politics, culture and gender issues in many regions present difficult barriers.





Property Rights

Protecting land and securing property rights help ensure that lands are sustainably managed to optimize their long-term production potential. Because land ownership can influence the way land is used and how a farmer tends it, land use and property rights are related. When farmers do not own their land, or when their property rights or ownership are not recognized, they may be less likely to make long-term investments in more sustainable practices and technologies.

Most respondents viewed property rights as an issue of greater importance in developing countries than in the US or other developed countries. Productivity differences between leased and owned lands, however, were noted as an issue in both.

In discussing developing countries, some linked property rights issues to community rights, water rights and the rights of women farmers as barriers to sustainable production. In fact, one respondent suggested reframing the issue as “property rights and gender equality” because women in many developing countries tend to work the land, but their husbands or the landowners typically reap the financial benefits. Addressing property rights was noted as having potential to improve biodiversity and water quality and even support the development of ecosystem services markets.

Some of the respondents saw little to no potential for breakthroughs in this area due to geopolitical, cultural, and gender inequity and other issues; however, others could envision the potential for significant change if policy and cultural aspects evolve to provide opportunities for poor or disenfranchised farmers.

“The biggest driver will be to allow agriculture to monetize the social and environmental benefits of conservation agriculture for long-term success. This will require a combination of markets and public policy. We need to change the attitudes and perceptions towards managing farmland and create structured investment vehicles that will orient farm practices towards patience and a long-term perspective.”

ANDREW McELWAIN
President | American Farmland Trust

WWF DEGRADED LANDS RESEARCH

WWF recently explored six global agricultural commodities (cotton, cocoa, beef, bamboo, oil palm and wheat) to better understand the actions needed to incentivize investments in underperforming or degraded lands. The team focused on lands that were currently in production but were underperforming. Across all six commodities, researchers found a fundamental gap in the services that farmers need to access in order to boost productivity and thus reduce the need for additional land. These services include access to information and technical knowledge, access to inputs such as fertilizers and seeds, and access to financing and markets. The cases also underscored what has been widely reported—that farmers have a low risk tolerance for changing on-farm practices that could increase production and restore lands. For those farmers who want to invest in new technologies and practices, the lack of a proven business model presents additional barriers. WWF is looking at ways to address some of these issues and lower barriers to restoring underperforming agricultural lands.

“In 2050 a sustainable food and agricultural system will allow us to meet consumer demands, such as food security and food preferences, through different production systems with different production characteristics and attributes. This will not require one specific production system, but a combination of agricultural systems.”

WENDY POWERS
Professor, Director of Environmental Stewardship for Animal Agriculture
Michigan State University



CONSUMPTION DYNAMICS

Consumers are key players in the development of sustainable food and agricultural systems. Consumers' values, preferences and buying decisions as well as their understanding and acceptance of production practices and technology influence what is produced and how it is produced.

Many of the experts and leaders underscored the importance of consumers both domestically and globally having access to healthy, nutritious, affordable and culturally relevant foods that are sustainably produced. Most agreed that the breadth of consumer preferences, needs and behaviors merit thoughtful inclusion when considering solution options. Overall, respondents felt that if breakthroughs were going to occur in consumption dynamics to drive sustainable food and agricultural systems, they should occur through changing consumer perceptions of agriculture.

In the US, although taste is the most important influence on food choices, followed by cost, wider considerations about nutrition, health, safety, and environmental and social impacts are increasing.³⁶ Globally, as income and middle classes grow in emerging economies, consumption patterns shift from carbohydrate-rich staple foods towards more expensive and resource-intensive food choices such as meat and dairy products.³⁷ This change is resulting in increasing similarities in diets and food delivery mechanisms worldwide.³⁸ To that end, some of the respondents saw the expansion of plant-based diets as an approach to counter the impacts of these trends.

Influencing Factors

Most respondents felt that consumption dynamics hold more opportunities for incremental changes than for large-scale breakthrough changes, primarily due to the unlikelihood of sudden major shifts in consumption patterns. Still, respondents identified factors that would contribute to or help drive improvements or potential breakthroughs (listed in order of those most frequently discussed):

- **Consumer perception:** People are increasingly interested in the source of their food and how it is produced. Many noted that consumer awareness and acceptance of agricultural practices and technologies could drive us towards more sustainable food and agricultural systems. Furthermore, many respondents felt that if breakthroughs in consumption dynamics were going to occur, changing consumer perceptions of agriculture would be a key component.

Reinforcing this view, a key theme in the discussions on the role of information sharing was that consumer education and awareness are needed to build understanding and trust in the system. Connecting the farmer to the consumer and providing information that is grounded in science are important aspects of this theme.

In addition, a number of respondents agreed on the need for more communication and engagement with consumers about the strides the US food and agricultural sector has taken towards more sustainable production practices.

- **Preference for more nutritious food:** Several reports and surveys indicate that health and nutrition are increasingly important attributes in food purchase decisions in the US.³⁹ In line with these trends, several respondents saw consumer preferences as a driver for more nutritious food choices, which is a social component of a sustainable food system.
- **Consumer role in reducing food waste:** Another aspect of consumption dynamics, which several respondents discussed, is the connection between purchasing behaviors and food waste, and consumers' role in helping reduce waste. Refer to the Waste section on page 20 for further discussion.
- **Food price:** An important characteristic identified for a sustainable food and agricultural system is affordable food. Respondents noted that price drives consumer decisions and will continue to do so in the future.

Pursuing opportunities for increased consumer engagement and education tailored to the values and interests of consumers can help build trust in a safe, environmentally sustainable food and agricultural system.

“Key milestones that marked progress would include: inherent support and changes in the broad regulatory framework that incentivize farmers for what they grow and what they are supported for financially; an overhaul to the crop extension education networks; and significant whole-scale changes to on-farm practices.”

DIANE HOLDORF
Chief Sustainability Officer and Vice President of Environment, Health, and Safety
Kellogg Company



KEY DRIVERS

Many external drivers influence the development of sustainable food and agricultural systems. It is important to understand these drivers and leverage their potential to stimulate meaningful, transformative change. Respondents identified the biggest economic drivers and investments that will help accelerate progress. In addition, they discussed the role of information sharing (discussed on page 15), which is widely viewed as a critical component in moving towards more sustainable systems.

Key Economic Drivers

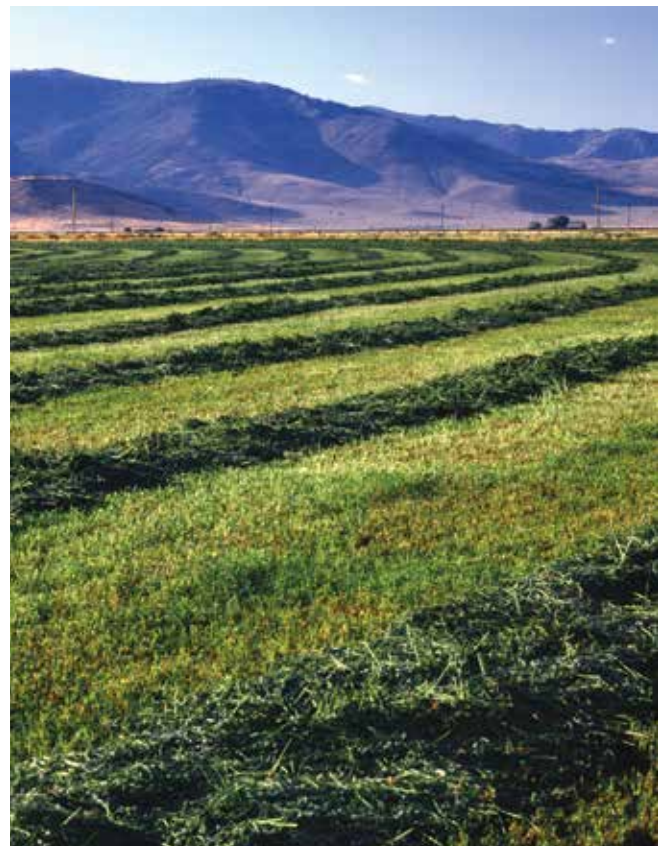
Respondents pointed to the following economic factors that could help fuel the development and adoption of sustainable practices and technology:

- profitable market pricing and trade opportunities
- financial incentives and markets to promote positive environmental outcomes
- public policy and government subsidies to encourage improvement
- appropriate pricing of natural resources and resource availability, including waste streams (Refer to the Waste section on page 20 for further discussion.)
- incorporation of externalities such as water availability, air quality and climate change into financial decision making and pricing models

CULTIVATING EXPONENTIAL CHANGE: One respondent highlighted the power of incentivized prize competitions such as those held by the XPRIZE Foundation to cultivate the type of innovations that can lead to radical change.

“The biggest economic drivers that would bring about wholesale change would include encoding risk related to resource degradation and depletion and the benefits of more resilient agricultural practices and more resilient food systems into finance and insurance.”

MOLLY JAHN
Professor in the Laboratory of Genetics and
Department of Agronomy | Center for Sustainability and the
Global Environment, University of Wisconsin-Madison
National Initiative for Sustainable Agriculture



“Our big gains in agriculture have been through research, yet funding is declining and, particularly problematic, the basic sciences in agriculture are declining. A big opportunity is in adequately managing and funding research institutions and dollars.”

DAN GLICKMAN
Executive Director | Aspen Institute Congressional Program
former Secretary of Agriculture and Congressman



Key Investments

Several key investment areas to support sustainable food and agricultural systems were identified:

- **Research:** Investment in scientific research is widely recognized as a key driver for innovation and change as well as one of the top opportunities to explore now. Most respondents called for increased public and private funding in agricultural research—including climate change mitigation and adaptation—to accelerate the discovery and development of solutions to environmental problems.

In the US, public spending for agricultural research and development (R&D) as a total of all public spending has declined from 21% to 13% between 1960 and 2009.⁴⁰ Given that investments in agricultural R&D in the US have yielded large returns on investment over the past decades, reductions in R&D funding risk slowing the pace of productivity growth and associated environmental and economic gains.⁴¹

Timing is critical because it can take many years to decades to move from initial research funding to commercialization and widespread adoption of a new solution.⁴² In addition, work is needed to identify current gaps and areas of scientific disagreement to help direct funding to those areas.

- **Technology:** The role of technology to support sustainable intensification was raised throughout the interviews. Continued investment is needed to develop and implement practices that improve yield; in particular, genetics was mentioned as an area for investment. Improved distribution of and access to technology in developing countries to help increase agricultural yields, such as those described in the Efficiency through Technology section on page 16, also requires support.
- **Education:** In addition to the call for increased research funding, respondents emphasized the importance of education for farmers to learn about better practices, technologies, and data and to share with peers within the US and in other countries. Expanding education and access to information and data about the costs, benefits and outcomes of sustainable on-farm practices regionally and globally can cultivate change, as described in the Critical Role of Information Sharing highlight on page 15.

Promoting efforts to engage with consumers, which is discussed further on page 25, is another aspect of education to pursue.

- **Infrastructure:** Investments in infrastructure, particularly in developing countries, will address multiple challenges such as productivity gaps and food loss. Additionally, respondents noted that investments in infrastructure would improve access to markets in the developing world and link the global food system.

Next Steps

To achieve the vision of sustainable agricultural systems, we need to address research gaps and work to understand which investments will deliver the greatest returns. This will enable us to invest in the right areas and with the right focus and to leverage the most effective economic drivers.

SUPPORTING RESEARCH BY SHARING AGRICULTURAL KNOWLEDGE

Agricultural life cycle assessments (LCAs) provide valuable data to understand the environmental impacts of an agricultural commodity at all stages of its production and to identify top opportunities for improvement.

In 2012, USDA, the University of Washington, the University of Arkansas, the USDA National Institute of Food and Agriculture, and the USDA National Agricultural Library created the LCA Digital Commons Project. The LCA Digital Commons is an open-access, comprehensive inventory of peer-reviewed US LCA data.

The project is intended to maximize sustainability research investments and speed new research. Through the submission of LCA data from studies funded by the Innovation Center for US Dairy, the dairy industry was a pilot industry in the project.





HOW TO STAY ON TRACK: MEASURING AND MARKING PROGRESS

“Various tools and metrics are evolving within existing supply chain initiatives, but it remains to be seen whether these initiatives will address sustainability issues in a harmonized way that can be scaled up. We need tools, calculators, systems and metrics that are harmonized and compatible in order to take advantage of and utilize the existing data troves and to create decision-support systems that can drive change in the agricultural sector at a scale that matters. When that happens, we will see where we are making progress.”

DEBBIE REED
Executive Director | Coalition on Agricultural Greenhouse Gases

“Metrics to track productivity, health and nutrition of people globally is an important part. We also need to have a global investment in agricultural research and development.”

ANN BARTUSKA
Deputy Under Secretary for Research, Education, and Economics
US Department of Agriculture



Respondents contributed thoughts on metrics and milestones to help measure and mark progress. Both help track collective efforts and determine whether we are on course.

METRICS

In considering metrics, the experts and leaders discussed not only types of indicators but also the need for standardized metrics to inform decision making and evaluate overall progress. Shared measurements provide a baseline from which goals can be set and progress can be evaluated, such as closing the yield gap or reducing environmental impacts. As such, metrics can be a powerful lever for innovation; they also support comparability over time and among farms, food products and regions. Respondents also indicated the role of measures in information sharing and communications with customers, consumers and other stakeholders.

Although the specific metrics recommended varied, these common “shoulds” emerged (in order of frequency of discussion):

- Metrics should include environmental indicators such as water quality, soil health, biodiversity and greenhouse gas emissions.
- Performance-based metrics should demonstrate productivity and efficiency of the system.
- Metrics should be standardized.

Several respondents brought up the inclusion of a food's nutrient composition into measures of productivity, resource use and environmental performance. There have been several studies and proposed approaches in this area, and more research and work are needed.

Respondents also pointed to the need to evaluate specific metrics in context with other factors and measures—for example, comparing the nutrient density of a food with its carbon or water footprint. Understanding the management practices in use also provides relevant context for assessing results and identifying opportunities for optimizing inputs, reducing impacts and maximizing output. Regional priorities such as water quantity in the western US and water quality in the Upper Mississippi watershed also need to be considered when developing metrics.

“We will need to measure some leading indicators of ecosystem quality. We need to keep it simple: those key attributes that measure basic environmental quality. These attributes—such as air quality, water quality and availability, natural vegetation, soil retention, and wildlife habitat—are different across different geographies but have similarities globally.”

ERIC HOLST
Senior Director, Working Lands | Environmental Defense Fund

Other recommendations include defining process-based metrics that can be flexible as the system evolves to become more sustainable. In addition, building an approach that works from the ground up—meaning it begins on farms of all sizes and carries through the value chain—was recommended.

Balancing Standards with Flexibility

While the respondents stressed the need for consistency, flexibility is also key, especially for on-farm metrics. Within the US, more than 2.1 million farms throughout all 50 states⁴³ represent a wide range of operations within diverse ecosystems. The US dairy industry alone includes nearly 49,000 licensed dairy operations.⁴⁴ This makes the development of a “one size fits all” approach challenging, leading many initiatives to focus on a particular crop or sector, such as those described in the highlight on the following page.

At the manufacturing and retail end of the value chain, a growing number of large food and beverage retailers and brands are asking their key ingredient suppliers to provide information and data about their sustainable farming and sourcing practices, which is further driving the need for standardized measurement approaches.

“A milestone would be to have harmonization across stakeholders on the issues that need to be addressed and have a way to move forward on concrete progress in order to see a more sustainable agricultural system in 2050. Different sectors may have to do different things, but we also may just find those common places to move forward.”

ELLEN TERPSTRA
President and Chief Executive Officer
International Food and Agricultural Trade Policy Council



KEY MILESTONES

Respondents were asked to imagine the year 2050 and then to look back on the key milestones that made their vision for a sustainable food and agricultural system a reality. The most frequently mentioned milestones to achieving success share these traits:

- There is collaboration and agreement on sustainability measurement and reporting frameworks.
- New advances and increased funding for research, technology, data collection and data storage have occurred.
- The developing world has increased its productivity and can now feed itself and export food and agricultural products across the globe in a manner that is environmentally sustainable.

Additional perspectives on key milestones included free and open trade as a component of sustainability. Other markers of progress would be when public-private partnerships break down the mistrust between consumers and the rest of the value chain and when farmers make systemic change from the ground up and reinforce that change through peer learning circles.

Milestones such as these and others will help direct collaboration, investment and progress. Refer to the highlight on the right for two initiatives that are currently doing just that.

“In 2050, if progress is being made in the right ways, then Africa is a net exporter of food. That milestone would tell me that a lot of the right things will have been done.”

MICHAEL MACK
Chief Executive Officer | Syngenta

A LOOK AT TWO MEASUREMENT APPROACHES

Two of the top milestones noted work together: sustainability measurements and reporting frameworks rely on technology and data collection solutions.

A number of approaches and efforts to standardize sustainability metrics and provide measurement tools for food and agriculture already exist. For example, Field to Market®, the Keystone Alliance for Sustainable Agriculture, is a diverse alliance working to create opportunities across the agricultural supply chain for continuous improvements in productivity, environmental quality and human well-being. Field to Market’s Fieldprint Calculator® uses science- and outcomes-based environmental and socioeconomic metrics and free, confidential tools to help corn, cotton, rice, wheat, potato, and soybean growers measure and improve sustainability performance and operational efficiency for each farm’s unique operation. In addition, Field to Market publishes the National Report on Agricultural Sustainability, which comprises 11 agricultural sustainability indicators for six commodities using publicly available data to evaluate trends and progress.

Sector-specific measurement standards have also been developed. The *Stewardship and Sustainability Guide for US Dairy* identifies the topics and indicators that matter most to the dairy industry and its stakeholders. Developed through a precompetitive, multi-stakeholder approach, the *Guide* provides dairy farmers and companies with a voluntary framework to track and communicate their sustainability progress. The Innovation Center for US Dairy also has developed a suite of confidential, science-based tools—Farm Smart™, Dairy Plant Smart™ and Dairy Fleet Smart™—to support measurement, decision making and reporting at various stages of the dairy supply chain. Together these resources provide consistency for the industry while allowing for diverse operations and flexibility for US dairy farmers and processors.



A large center pivot irrigation system is shown in a lush green field under a clear blue sky. The system consists of a long metal structure supported by multiple wheels, with numerous smaller wheels extending from it to water the crops. The structure is positioned diagonally across the frame, receding into the distance.

HOW TO START: TAKING STEPS TODAY

“One way progress will be seen is as a series of tipping points—where the actors in the food system tip a part of the system towards more sustainable solutions. For example, there are enough farmers in the value chain demonstrating profitable success with a particular solution that it tips towards widespread adoption.”

JERRY LYNCH
Chief Sustainability Officer | General Mills

“In 2050, a sustainable food and agricultural system is one in which we have been able to double our production while at the same time cutting GHG emissions, cleaning up streams and making sure that the food system is as safe and affordable as it is today or better.”

MICHAEL McCLOSKEY
Co-Founder and CEO | Select Milk Producers
Chairman of the Board | Fair Oaks Farms



MOVING FROM DIALOGUE TO ACTION

Navigating the pathways to solutions for environmentally sustainable food and agriculture depends on knowledge sharing and dialogue. And it calls for consensus building, collaboration and bold action. We need everyone who is engaged in the food system to be involved.

Next Steps for the Project

As discussed earlier, the next phase of the Sustainable Food for the 21st Century project will build on the insights in this paper. The blue ribbon panel to be convened by WWF and the Innovation Center for US Dairy will meet in early 2015 and work during the year in the following five areas:

- **Better management practices and technology:** Identify ways to overcome the barriers that US dairy farmers and grain growers face in using existing, feasible practices and technologies to conserve water and improve water quality.
- **Knowledge sharing:** Recommend the actions, stakeholders and investments needed to leverage existing tools and expand knowledge sharing and learning among producers and growers needed for environmentally sustainable production of food.
- **Genetics:** Identify the gaps in scientific studies on genetics, selective breeding, and GMOs and develop agreement areas for acceptable technologies that can support the environmentally sustainable production of dairy and dairy feed crops. Develop an outcome-based study that considers the opportunities, barriers, and drawbacks across the agreement areas and proposes potential acceptable solutions. Identify key stakeholders and set an engagement strategy.
- **Metrics:** Explore ways to incorporate measurements of environmental impacts and nutritional value into standard metrics of sustainable production.
- **Waste:** Identify concrete actions needed to reduce waste and maximize resource recovery, reuse and recycling at all stages of the food chain.

The outcome of the panel's work will be a set of recommendations on steps that can lead to scalable, actionable solutions for sustainable food production in the five areas. While the panel will focus on the US dairy value chain, its work and recommendations will be crosscutting and, as such, will provide a model for other agricultural sectors and generate positive spillover effects.

WWF plans to publish the recommendations on its website at worldwildlife.org/sustainablefood in the later part of 2015.

Steps for Today

While the blue ribbon panel is doing its work, there are many ways that you can contribute to ensuring sustainable food for the 21st century. The following steps are just a sample of actions and initiatives for beginning or continuing your efforts.

Connect. Engage farmers, farm service providers, industry leaders, policy makers, financial decision makers and consumers to identify key issues and explore ways to build an environmentally sustainable food system:

- Share this white paper with your colleagues.
- Join the conversation on Twitter: #21Cfood and online: worldwildlife.org/blogs/on-balance.

Learn. Visit worldwildlife.org/sustainablefood for additional resources to learn more about the topics and solution exploration areas discussed in this white paper.

Participate. Get involved in sustainable food and agricultural initiatives to work towards meaningful change at the industry, food sector or commodity level. The following examples provide some starting points:

- Farmers and growers can work with Field to Market®: The Alliance for Sustainable Agriculture at FieldToMarket.org.
- For those in the dairy value chain, consider joining the Innovation Center for US Dairy's Sustainability Council or using the *Stewardship and Sustainability Guide for US Dairy* and Smart Tools available at USDairy.com.
- Businesses should work together with their supply chains and others on sustainable sourcing. One approach is to take part in third-party initiatives and certifications aimed at transforming commodity markets at bit.ly/1pbWeh7.
- Any business or organization can participate in the EPA Food Recovery Challenge at www.epa.gov/foodrecoverychallenge.

Let's get to work. Together.

A photograph of a cornfield with young plants in rows, overlaid with a semi-transparent green filter. The word "APPENDIX" is written in orange, bold, sans-serif capital letters on the right side of the image.

APPENDIX

ABOUT THE INTERVIEW PROCESS

WWF, in cooperation with the Innovation Center for US Dairy, selected 52 individuals based on their demonstrated leadership or academic expertise in sustainable agricultural systems. Leadership was defined as organizations that actively participate in, fund, guide, innovate and/or develop sustainability initiatives for the food and agricultural sectors. Academic expertise was defined as organizations or individuals who research, advance or innovate science on environmentally sustainable agricultural systems. The interviewees represent a range of perspectives in food and agriculture, as summarized in the following table.

Interviewee Representation

Sector/Area	Number
Industry	22
Academic Experts	7
Government	6
Nongovernmental Organizations	13
Other*	4

Interviewees represent a range of perspectives in food and agriculture.

**Other includes grant foundation (1), consultancies (2) and retailer (1).*

Interview Questions

The interview questions were designed to help identify initial solutions by first exploring what a sustainable food and agricultural system means and then considering how best to achieve such a system. Each interview followed a set of open-ended prepared questions, which varied in the type of response they solicited, from visionary to detailed. To support the development of this white paper, the interview responses were analyzed for common themes and understanding and for unique perspectives.

WHERE TO GO: Defining sustainable food and agricultural systems

- What is your definition of a sustainable food and agricultural system?
- In your opinion, what does a sustainable food and agricultural system look like in the year 2050? What are the salient characteristics?
- What role does the US dairy industry play in your vision?

HOW TO GET THERE: Identifying opportunities and solutions

- What are the opportunities we should explore now if we are to achieve your vision?
- In your opinion, what breakthroughs can be made in the following areas to drive sustainable agriculture? Genetics, On-Farm Practices, Efficiency through Technology, Land Use, Property Rights, Waste, Consumption Dynamics, Soil Carbon
- What are the biggest economic drivers or investments that would bring about wholesale change?

HOW TO STAY ON TRACK: Measuring and marking progress

- How will we know we are on the right track? What are the metrics that are important now and in the future to measure progress?
- Imagine the year is 2050 and your vision has come true. Looking back, what were the key milestones that marked progress?
- From your perspective, what role does information sharing play in achieving sustainable agricultural systems?

INTERVIEWEES

Jon Alby

General Counsel | Leprino Foods Company

Ann Bartuska

Deputy Under Secretary | USDA Research, Education, and Economics

Sarah Bittleman

Senior Ag Counselor | Environmental Protection Agency (formerly)

Robert Bonnie

Under Secretary for Natural Resources and Environment | USDA

Barbara Bramble

Senior Program Advisor | International Affairs,
National Wildlife Federation

Tony Cavalieri

Senior Program Officer | Bill and Melinda Gates Foundation

Roger Claassen

Agricultural Economist | USDA, ERS

David Cleary

Director of Agriculture | The Nature Conservancy

Chuck Conner

President and CEO | National Council of Farmer Cooperatives

David Darr

VP, Sustainability and Member Services | Dairy Farmers of America

Jed Davis

Director of Sustainability | Cabot Creamery Cooperative

Adam Drewnowski

Professor, Epidemiology | University of Washington

Kristin Duncanson

Former American Soybean Association President; current AGree participant | TBL Commodities Producer (corn, soy, pork producer); Producer | Duncanson Growers

Lorin Fries

Senior Project Manager | New Vision for Agriculture, World Economic Forum USA

Tom Gallagher

Chief Executive Officer | Dairy Management Incorporated

Pierre Gerber

Senior Policy Officer | *Livestock and the Environment*
FAO, Animal Production and Health Division (AGA)
Livestock information, sector analysis and policy branch (AGAL)

Dan Glickman

Executive Director | Aspen Institute Congressional Program; former Secretary of Agriculture and Congressman

Christine Hamilton

Association of Agricultural Production Executives (out-going President) | TBL Commodities Producer (cow-calf producer); Producer | Christensen Land and Cattle

Hal Hamilton

Director and Founder | Sustainable Food Laboratory

William Hohenstein

Director of Climate Change Program | USDA

Diane Holdorf

Chief Sustainability Officer and Vice President of Environment, Health, and Safety | Kellogg Company

Eric Holst

Senior Director, Working Lands | Environmental Defense Fund

Molly Jahn

Professor in the Laboratory of Genetics and Department of Agronomy, Center for Sustainability and the Global Environment | University of Wisconsin-Madison, National Initiative for Sustainable Agriculture

Gene Kahn

Head, Global Market Development | HarvestPlus

Bruce Knight

Principal and Founder | Strategic Conservation Solutions

Stewart Lindsay

Director, Global Corporate Affairs | Bunge Limited

Jerry Lynch

Chief Sustainability Officer | General Mills

Michael Mack

CEO | Syngenta

Marty Matlock

Professor | University of Arkansas

Michael McCloskey

Co-Founder and CEO | Select Milk Producers; Chairman of the Board | Fair Oaks Farms

Andrew McElwaine

President | American Farmland Trust

Frank Mitloehner

Professor and Air Quality Specialist | University of California-Davis

Donald Moore

Executive Director | Global Dairy Platform

Jim Mulhern

President | NMPF

Mark Murphy

Director of Corporate Responsibility | Cargill

Wendy Powers

Professor, Director of Environmental Stewardship for Animal Agriculture | Michigan State University

Debbie Reed

Executive Director | Coalition on Agricultural Greenhouse Gases

Beth Sauerhaft

Senior Director Corporate Agro Sustainability | Pepsi

Mary Shelman

Director, Agribusiness Program | Harvard Business School

Jeff Simmons

President | Elanco

Rod Snyder

Executive Director | Field to Market

Kim Stackhouse

Director of Sustainability Research | National Cattlemen's Beef Association

Anna Swaithes

Head of Water and Food Security Policy | SABMiller

Ellen Terpstra

Head of Livelihoods, Land and Food Security | International Food and Agricultural Trade Policy Council

Robert Thompson

Visiting Scholar, Johns Hopkins University | Senior Fellow, Chicago Council on Global Affairs

Jan-Kees Vis

Global Sustainable Sourcing Development Director | Unilever

Suzanne Walker

Director of Sustainability | Kroger

Arlin Wasserman

Principal and Founder | Changing Tastes

Jason Weller

Chief of the Natural Resources Conservation Service | USDA

Jim Werkhoven

Dairy Producer | Werkhoven Dairy

Doug Young

Dairy Producer | Spruce Haven Farm

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