2019

WATER FOR A HUNGRY WORLD: Innovation in Water and Food Security: Proceedings of the 2019 Water for Food Global Conference. Lincoln.

Daugherty Water for Food Global Institute

WATER FOR A HUNGRY WORLD:

INNOVATION IN WATER AND FOOD SECURITY

PROCEEDINGS

2019 WATER FOR FOOD GLOBAL CONFERENCE
LINCOLN, NEBRASKA, USA | APRIL 29-30

Water for Food
GLOBAL CONFERENCE
at the University of Nebraska

Proceedings fo the 2019 Water for Food Global Conference, April 29-30
Lincoln, Nebraska, USA.

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Corn silks in a field in Albion, Nebraska, USA.

LETTER FROM THE EXECUTIVE DIRECTOR

Peter G. McCornick, Executive Director, Daugherty Water for Food Global Institute

The Daugherty Water for Food Global Institute at the University of Nebraska (DWFI) hosted the 2019 Water for Food Global Conference, April 29-30, at Nebraska Innovation Campus in Lincoln, Nebraska, USA. We explored the cutting-edge work being done around the world, across the country and here in Nebraska to address one of the most urgent global issues of our time – ensuring we have enough

youtube.com/waterforfood
Full presentations from the conference are available on our YouTube channel

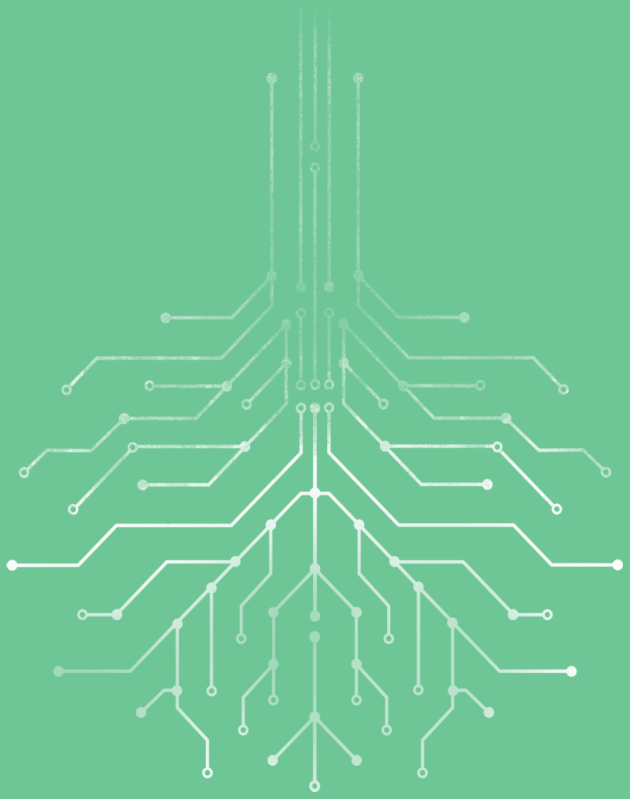
nutritious food and clean water to sustainably support nearly 10 billion people in the next 30 years.

The conference convened leading international experts and organizations – more than 400 participants from 15 countries – to discuss "Water for a Hungry World: Innovation in Water and Food Security," focusing on the next generation of research, smart technology, policy development and best practices that are achieving breakthroughs in this vitally important mission. The conference included 30 sessions and headlined a week of water and food security-related presentations, exhibits, side events, networking opportunities and tours.

To build more resilient, water smart and productive agricultural and food systems, we need to harness the entrepreneurial spirit of farmers, scientists, companies, philanthropists, investors, government agencies and nonprofit organizations that are at the forefront of change. The 2019 Water for Food Global Conference spurred conversations among a spectrum of stakeholders who understand that feeding our growing world population, while ensuring sustainable water resources, requires new approaches to overcome a host of interconnected challenges, such as climate change, water scarcity and pollution, economic disparity, shifting food preferences, food waste, soil degradation, ecosystem threats and competing demands for resources. We need a focused commitment to developing sustainable solutions for water and food security, leveraging the skills and experience of a diverse and talented network of stakeholders.

It will take time to realize the real impact of this knowledge-sharing event, but we have already received excellent feedback from our participants, with more than 92% of survey responders rating it as a "valuable" conference. We will conduct another follow-up survey in the fall to see how our participants are using the information gained to develop new projects and partnerships, build capacity and develop new solutions to this global challenge of ensuring water and food security for our world. Thank you all for your participation and support. We have begun the process of planning for the 2020 Water for Food Global conference and welcome your thoughts and inputs as to how we can use this event to deliver on the vision of a water and food secure world.

Peter G. McCornick, Ph.D., P.E., D.WRE
Executive Director
Daugherty Water for Food Global Institute



PROCEEDINGS

Water for Food
GLOBAL CONFERENCE
at the University of Nebraska

Rice fields in Indonesia.

DAY ONE

Welcome and Opening Remarks

April 29 | 9 a.m.

Speakers:

Mike Boehm, Vice President and Vice Chancellor of Agriculture and Natural Resources, University of Nebraska

Peter G. McCornick, Executive Director, Daugherty Water for Food Global Institute at the University of Nebraska

"How can we take the ideas we've shared and translate them into impact to move the needle on the water for food challenge?"

This is the question put to attendees at the opening session of the 2019 Water for Food Global Conference by Mike Boehm, vice president and vice chancellor of Agriculture and Natural Resources at the University of Nebraska.

Boehm's question reflects a universal desire on the part of water for food stakeholders to transition from research and discussion to practical solutions. During the conference, from classrooms to halls and dining tables, many conversations could be heard revolving around this idea. The conference's theme, "Water for a Hungry World: Innovation in Water and Food Security," was designed to encourage a tangible transition from ideas to action. It is innovative new technology that will help make this possible in the coming years to take more action.

Mike Boehm, Vice President and Vice Chancellor of Agriculture and Natural Resources, University of Nebraska

Boehm warned, however, that the challenges and obstacles examined and discussed at previous conferences remain in play. Water is more important than some of us ever suspected. He pointed out that water is intertwined with aspects of life at many levels: politics and government policy, hunger, poverty, gender issues and more. "Water scarcity

can lead to civil unrest or make it worse," Boehm said. "It can reduce agricultural products, precipitate population shifts, worsen the spread of disease, and undermine economic development."

The Water for Food Global Conferences have focused on many innovative solutions in the past nine years. So, how are we doing? In some ways the news is not good. In his address to conference attendees, Robert B. Daugherty Water for Food Global Institute (DWFI) Executive Director Peter McCornick shared a warning that world hunger levels have risen since the last conference in 2017. "Our target to improve food security is backsliding a little," he said. Water sources continue to degrade, and water quality remains a challenge. Extreme weather events, such as droughts and floods, are increasing. Even Nebraska experienced an unprecedented flood shortly before the conference.

> **Water scarcity can lead to civil unrest... It can reduce agricultural products, precipitate population shifts, worsen the spread of disease, and undermine economic development.**
>
> - Mike Boehm

On the other hand, there *is* good news. Professionals in water, agriculture, energy and government policy have been working diligently in many parts of the world to solve this global problem. Nebraska is right in the thick of this work, because the state's scientists, farmers and natural resources officials have become experts in irrigation, groundwater management, sensing technology and water markets.

Research has advanced the discussion, especially in the areas of human health and diet. Water governance policies are improving. "We are seeing interest at the policymaking/political level," McCornick said, "but it has to be translated into the local context." He challenged conference participants – as they share insights and ideas on innovations in technology, practice and viable policies – to consider how to strengthen partnerships and get solutions in front of the right people. That's how we take ideas, he said, and turn them into impact.

Plenary Session I *April 29 | 9:30 a.m.*

How the Irrigation Industry is Driving the Future through Efficient Technologies

Speaker: **Deborah Hamlin**, CEO, Irrigation Association

Innovation in food and water security often focuses on irrigation, which offers opportunities for new technology to help increase agricultural efficiency. However, it's not simply a matter of researching and developing new equipment or techniques. The challenges facing agricultural water management are complex.

The primary challenge of irrigation is the fact that the world's agricultural lands are shrinking, said Deborah Hamlin, CEO of the Irrigation Association. During Plenary Session I, Hamlin shared research demonstrating that the amount of land available for agricultural production worldwide has increased slightly, but the population of the world has grown substantially. In the United States, she said, the amount of land available for agricultural production has decreased by 800,000 acres. In effect, Hamlin said, worldwide there is now half the cropland available per person to grow food than there was a few decades ago.

Other challenges affecting irrigation include the fact that many young people don't want to farm, so more people are selling farms. "Commodities pricing and tariffs are also giving us trouble," said Hamlin.

The irrigation industry suffers from another interesting obstacle: public perception. Hamlin shared media

Deborah Hamlin, CEO, Irrigation Association

examples showing that some believe agriculture uses too much water. One large American restaurant chain, Chipotle, printed a message on its cups saying more than 80 percent of the nation's water is consumed by agriculture, then proudly stating the restaurant buys onions from drip irrigators – implying drip irrigators use less water.

"The message should have been about how efficient irrigation is," Hamlin said. "It's a misunderstanding

that we are using up water for irrigation. How can we change the message, so these corporations are not driving the message?" That is a goal the Irrigation Association works toward every day.

Hamlin pointed out that the irrigation industry has come a long way thanks to new technology. Irrigation is helping farmers increase yields and meet agricultural needs without wasting water. Cutting-edge irrigation technologies support vertical farming, drones, irrigation controllers that provide more data than ever, and Internet of Things (IoT) technology that makes it possible for homeowners and farmers to adjust water application using smart phones.

"Variable-rate irrigation puts water exactly where it's needed," Hamlin explained. There has been a transition from less gravity irrigation methods to greater pressure irrigation which tends to be more efficient. "Total input over 60 years has stayed level, and agricultural output has risen greatly," she confirmed. Hamlin attributes this to the shift from gravity to pressure irrigation systems.

The irrigation industry is working to drive a positive message with targeted ads and public relations initiatives such as Smart Irrigation Month, a new Vanguard award recognizing companies' successful irrigation projects, and an educational effort including books, classroom curriculum and a certification program.

The Irrigation Association publishes a free magazine that goes to 8,000 farmers, promotes new irrigation technology at an annual trade show and conducts public affairs campaigns. They also guide policymaking by being the voice of irrigation and its challenges in Washington, D.C. They promote efficient irrigation and represent 1,400 companies in two market segments, landscape and agriculture.

> **Total input over 60 years has stayed level and agricultural output has risen greatly.**
>
> - Deborah Hamlin

Farmers are not using too much water, Hamlin said. In fact, they are the original environmentalists and work with others to drive conservation. We need irrigation to help us put water in all the right places, because Mother Nature doesn't always do it, she explained. "Irrigation *is* conservation."

Some participants disagreed with this comment, emphasizing the importance of other agricultural management practices to support rainfed farming, such as planting drought-resistant crop varieties and improving soil quality through conservation practices, such as the use of cover crops.

Sustainable Solutions for Water and Food Security — Business Perspectives

Speaker: **Mark Edge**, Director of Collaborations for Developing Countries, Bayer

Although we tend to think of science and research leading the way in water and food innovation, it may be commercial enterprises that help the world create practical, sustainable solutions. Mark Edge, director of collaboration for developing countries at Bayer said *collaboration* is the key to dealing with the complexities and challenges we face. Edge said drought is the biggest global challenge, causing 67% of crop losses.

"As a commercial enterprise, we can deliver world-class innovation and a huge amount of research," Edge said. "We can be pioneers in digital transformation and set standards in sustainability." But solutions always should be tailored to fit each location's unique challenges, he said – another theme that emerged through many sessions at the conference.

Bayer helps achieve water security at the intersection of three technologies: biotech, agronomic practices and plant breeding. Agricultural practice improvements include reducing tillage, managing water supply in soils, and improving planting rates. The company also collaborates with others on irrigation research.

Edge said that to better manage water, we need to look below the surface and understand what is going on with the plant roots. This is currently being studied by Bayer through their DroughtGard corn lines at the Gothenburg Water Utilization Learning Center that features an innovative rainout shelter to simulate drought situations.

Mark Edge, Director of Collaborations for Developing Countries, Bayer

The Midwest Row Crop Collaborative, one example of a successful public/private initiative, was created to protect air and water quality, and enhance soil health. Future goals are to ensure crop acres, reduce nutrient loading and reduce water quality stress. "There won't be one way to approach this," Edge suggested. "It's really about a holistic approach and public and private sectors coming together."

Because precision is increasingly important in agriculture, Edge said, we should be pursuing more precise data to help producers make better decisions. The Climate Corporation, a Bayer subsidiary, believes in using data to optimize decision-making and increase productivity. The organization is using data and machine learning to create value. It has met with irrigation consortium participants to understand what practices work, so decisions can be driven by evidence.

> **There won't be one way to approach this. It's really about a holistic approach and public and private sectors coming together.**
>
> - Mark Edge

Other examples of Bayer public/private projects:

- Crop water-use maps that create a visualization of the amount of water being used in fields to help reduce the tendency to put more water on than needed.
- Joint research involving irrigation pivots and equipment sharing.
- Plant breeding projects examining the importance of roots to productivity.
- Technology development to help separate environmental variation to get better data.

Edge has been involved with efforts to get food technology into Africa. The project began 10 years ago, funded by the Bill and Melinda Gates Foundation and USAID and managed by African agricultural technology foundations. It is focused on increasing drought tolerance, improving native plants, developing better fundamental policies, and bettering the livelihoods of smallholder farmers.

"Being able to conduct good research in Africa is a challenge," Edge said. "Remote sites lack supervision and even elephants are an issue." He stressed that Africa is 54 different countries with different conditions and needs, and efforts to improve water and food security must address widely varied environments with solutions coming from the people who live in each region.

Edge said Bayer has overarching goals to reduce their ecological footprint, be carbon neutral and reduce inputs using a triple bottom line: social, environment and economic metrics. In the end, Edge said, "Sustainable solutions must be economically viable, and the private sector can help with that to make water and food security a reality."

Value of Water *April 29 | 11 a.m.*

Concurrent Session

Speakers:

Dustin Garrick, Associate Professor and Co-Director of the Smith School of Enterprise and the Environment at the University of Oxford

Tom Iseman, Director of Water Scarcity and Markets Strategy, The Nature Conservancy, Global Program

Richael Young, Co-Founder and CEO, Mammoth Trading

This conference session brought together water thought leaders to provide a variety of perspectives on the value of water and insights to help develop innovative solutions for water scarcity. Session speakers offered insights from nonprofit, business, and academic perspectives. Nick Brozović, director of policy at DWFI, kicked off the session by touching on the rising interest in using incentive-based management tools such as water markets to reallocate water between different users and sustain and enhance environmental flows.

Tom Iseman, director of water scarcity and markets for the Global Freshwater Program at The Nature Conservancy, explained how working with the agricultural sector to provide food and water sustainability is a key part of the global organization's work to protect land, water and life. One-third of the world is currently facing water scarcity impacting humans and the natural environment. Because three-quarters of all irrigated land is in danger of losing productivity, he said, sustainably managing water is more important than ever.

Tom Iseman, Director of Water Scarcity and Markets Strategy, The Nature Conservancy, Global Program

Iseman emphasized The Nature Conservancy's four strategic pillars for achieving the goal of a resilient water supply in the Northern United States: 1) Water Markets, 2) Investment in Water Innovation and 3) Infrastructure, Agricultural Supply Chain, and 4) Water Policy and Governance. Case studies show

well-defined water rights can help balance the needs of farmers and communities. "Think broadly. It is not just about markets. It is about users, value and presence," said Iseman.

Richael Young, cofounder and CEO of Mammoth Trading, focused her presentation on the potential for using water markets as a tool to value water and achieve multiple objectives for diverse water users. Young stressed the need to understand whether a local region is ready to implement water transfer systems effectively – or not. There is growing recognition that water markets have the potential to reduce the impact of regulations, monetize conservation and increase the value of water. As a result, there has been an increasing interest in how to scale water markets to increase their impact. However, no comprehensive tools currently exist to assess the market readiness of a region, including evaluating legal, biophysical, economic and administrative considerations.

> **We need to not just focus on the successful models, but also what has struggled, and how to learn from those challenges.**
>
> - Dustin Garrick

Young is developing a Water Market Transfer Toolkit with DWFI, supported by USDA, to provide key metrics to determine market readiness in any region. Metrics gathered include: severity of water risk, legal readiness, administrative readiness, heterogeneity in values of water, and infrastructure readiness. Each metric is scored as low, medium or high. After considering scores and other qualitative factors, stakeholders can decide whether water markets are an appropriate management tool in a given region. The toolkit was demonstrated using information for some of the newly-formed California Groundwater Sustainability Agencies.

Dustin Garrick, associate professor and co-director of the Smith School of Enterprise and the Environment at the University of Oxford, presented a global view on conflicting water values as they impact allocation. He said conflicts generally arise as stakeholders try to balance water between human and environmental needs, between agriculture and growing cities, and between different jurisdictions across borders.

Garrick shared several case studies to illustrate his points. "We need to not just focus on the successful models, but also what has struggled," he said, "and how to learn from those challenges."

(L-R) Tom Iseman, Richael Young and Dustin Garrick

In the city of Monterrey, Mexico, the increasing population caused the government to extend the city boundary to make the city a part of the urban-rural system. As a result, over time, water management improved between urban areas and downstream farmers.

An example from Melbourne, Australia, showed increased water recovery when water was reallocated through irrigation modernization. One Australian project showed how important it is to prepare for crises across boundaries, so areas are ready with financing, data, technical analyses, engagement and a plan when they occur. A case study from Kenya showed how embracing informality of water supply is sometimes a pragmatic way to achieve water security.

Garrick emphasized that the processes of developing water markets and solving water conflicts often take a long period of time. He concluded with the need to explore scalable solutions to freshwater scarcity by providing a variety of incentives for sustainable water use, including water markets, incentives for conservation, and new policy and planning approaches.

In a lively discussion with the speakers, audience questions included asking for practical advice for water managers, addressing the role of trust in building formal or informal institutions, how the water profession could be coupled better with public health, and who should be responsible for incentivizing water transfers.

The key takeaway messages remind us to inform all users about the full range of threats and opportunities related to water scarcity. It's important to not just talk about markets, but to keep working toward a set of better incentives and address misconceptions about markets and water allocation. For example, consumers don't always trust public utilities, so informal markets can be helpful in filling the gap and should not always be seen as threats, advised Garrick. The federal government can help facilitate conversations, demonstrate commitment and show action by investing money in infrastructure.

It's also important to remember there is no single silver bullet approach; there are many lessons to be learned from one another locally, nationally and globally. As Young put it, "Don't do it by yourself. There is already a wealth of information on water management and we need to learn from lessons of success and failure and leapfrog forward."

(L-R) Rob Bertram, Jennie Barron, Selamawit Damtew, Regassa Ensermu Namara, Petra Schmitter, Ariana Constant and Montaha Hassan

Supporting Profitable & Sustainable, Farmer-led Agriculture *April 29 | 11 a.m.*

Concurrent Session

Moderator: **Montaha Hassan**,
Associate Operations Officer, International Finance Corporation, World Bank Group

Speakers/Panelists:

Jennie Barron, Professor of Water Management in Agricultural Landscapes, Swedish University of Agricultural Sciences

Rob Bertram, Chief Scientist, Bureau for Food Security, USAID

Ariana Constant, Director of Programs, Clinton Development Initiative, Clinton Foundation

Selamawit Damtew, World Bank, Africa Fellow

Regassa Ensermu Namara, Senior Water Economist, World Bank Water Global Practice

Petra Schmitter, Research Group Leader, Agricultural Water Management, International Water Management Institute

To support farmer-led irrigation development in sub-Saharan Africa, we must work together and take an integrated, holistic approach — working in silos does not work. This was the main theme of the conference's session on profitable and sustainable farmer-led agriculture led by moderator Montaha Hassan, associate operations officer of the International Finance Corporation, World Bank Group.

This is important because most of the world's more than 570 million farms are small and family-run. Smallholder farms, those measured as less than 2 hectares, operate about 12% of the world's agricultural land and most rely on rain for soil moisture.

Selamawit Damtew, a young World Bank Africa Fellow explained the multiple benefits of small-scale irrigation: crop diversification, higher incomes, better nutrition and reduced climate shocks. She said we must engage women and youth to provide them with more opportunities and integrate small-scale irrigation with other watershed management activities.

Jennie Barron, professor of water management in agricultural landscapes at the Swedish University of Agricultural Sciences, continued the theme of irrigation integration. She said small-scale irrigation offers a low-cost way to use water efficiently compared to large-scale irrigation. Accessing water is a challenge, as is accessing better seeds and markets.

Petra Schmitter, research group leader of agricultural water management at the International Water Management Institute, offered two examples of potentially productive small-scale irrigation investments: rehabilitating and repurposing small reservoirs as multiple use water systems, and harnessing groundwater while using natural infrastructure to recharge aquifers.

Schmitter focused on the potential offered by solar power for irrigation and the need to design solutions that preserve the water resource, reduce upfront costs and enhance social inclusion. She described pilot studies underway that include both on- and off-grid solutions. India's program enables farmers to sell power back to the grid, but the likely impact on groundwater levels remains unclear. In sub-Saharan Africa, off-grid solutions are a cost-effective way for farmers to access water, but managing the water

(L-R) Ariana Constant and Montaha Hassan

resource will be a challenge. Schmitter said we must integrate multiple sectors to achieve sustainable solutions.

Ariana Constant, director of programs for the Clinton Development Initiative of the Clinton Foundation, shared smallholder farmer training experiences in Rwanda, Malawi and Tanzania. The program facilitates farmers forming cooperative groups and then trains them in agronomy and marketing. Constant emphasized four challenges: access to quality training, quality inputs, financing and markets. She explained that any effort to train and support farmers must include attention to soils, seeds, and access to warehouses as well as to irrigation – again emphasizing a holistic systems perspective.

Regassa Namara, senior water economist at World Bank Water Global Practice, focused on the enormous irrigation potential in sub-Saharan Africa and the critical role farmer-led irrigation can play. World Bank is partnering with multiple institutions, including DWFI, and trying to learn from experiences in India and China. According to Namara, the World Bank is following two tracks: knowledge sharing and advocacy to make farmer-led irrigation development more acceptable to African policymakers, and mainstreaming farmer-led irrigation in its own investment pipeline. He said the World Bank is focused on making financing more easily available, reducing transport costs and improving access to technical training to scale-up successful smallholder farming operations.

Rob Bertram, chief scientist in USAID's Bureau for Food Security, explained that USAID is reorganizing itself to integrate its agriculture work including irrigation, nutrition, water and sanitation and increasing resilience. Farmer-led irrigation development is water-knowledge- and employment-intensive: If we get it right, he said, it can help reduce poverty and improve nutrition. Bertram emphasized the potential in the "hinterlands": Solar pumps for irrigation and livestock water can be a "leapfrogging technology." As Bertram put it, "Even some water can be transformative." But we must do this sustainably and not "blow it," he said. Simply distributing solar panels without understanding socioeconomic drivers, behavior change and finance could lead to disaster.

> **Farmer-led irrigation development is water-knowledge- and employment-intensive: If we get it right, it can help reduce poverty and improve nutrition.**
>
> - Rob Bertram

(L-R) George Burba, John Kastl, Val Kovalskky, Deborah Hamlin, Aric Olson, Albert Maurin and Sally Rockey

Innovations in Irrigation *April 29 | 11 a.m.*

Concurrent Session

Moderator: **Sally Rockey**, Executive Director, Foundation for Food and Agriculture Research

Presenters:

Jay Ham, Colorado State University

Cathie Lavis, Kansas State University

Christopher Neale, Daugherty Water for Food Global Institute

David Zoldoske, Fresno State University

Panelists:

George Burba, Science & Strategy Fellow, LI-COR Biosciences

Deborah Hamlin, CEO, Irrigation Association

John Kastl, Sr. Director of Innovation and Intellectual Property, Valley Irrigation

Val Kovalskky, Lead Remote Sensing Scientist, Geospatial Team of The Climate Corporation

Albert Maurin, Sales & Tactical Marketing Manager, FieldNET & FieldNET Advisor, Lindsay Corporation

Aric Olson, President, Jain Irrigation

This session began with four technical presentations representing the work of Irrigation Innovation Consortium (IIC) partners. The IIC is a joint initiative between private, public and university organizations addressing growing water scarcity in the western U.S. and worldwide.

Jay Ham, professor of environmental physics and micrometeorology, Colorado State University, is using Artificial Intelligence (AI) and machine learning to help farmers make integrated irrigation decisions. With this work, Ham said, it may be "possible to get a 30% increase in crop productivity and a 30% decrease in water use over the next 30 years." He said modern irrigation – Irrigation 4.0 – is the quintessential Fourth Industrial Revolution system, which means it combines mechanical, digital and human inputs and tools.

According to Ham, AI is going to completely transform the irrigation industry just as it is transforming many other industries. "The approach we used in the past has worked well," he said, "but when, how much, and where to irrigate will be transformed." In addition to making irrigation more efficient, AI reduces the price point of irrigation technology by 10% or 20%, he said, which makes it a disruptive technology. AI advancements in irrigation include:

- *Internet of things (IoT).* Narrowband IoT helps farmers get a reliable Internet connection in the field. They can set and transmit data to their phones for about three dollars a year.

> **Modern irrigation — Irrigation 4.0 — is the quintessential Fourth Industrial Revolution system, combining mechanical, digital and human inputs and tools.**
>
> - Jay Ham

- *Weather data and forecasts.* This technology is very accurate compared to a decade ago. Improvements allow weather forecasts two to three days ahead, which is ideal for irrigation management.
- *Machine learning.* There are so many developments in this area it's hard to cover them all, Ham said. Essentially, the benefit of machine learning is that data gathered over many years can be used to improve systems quickly.

Overall, Ham said integration of data streams is important to optimize irrigation. The beauty of the IIC, he said, is that the organization can cover different crops, areas and types of organizations. "Democratization of technologies is important," he said. "Data should not only be available to big

companies but also accessible across the spectrum to everyone."

According to Christopher Neale, director of research at DWFI, precipitation is the ultimate water source. However, it's a challenge to manage water along the gradient represented by areas with different amounts of rainfall. This is a struggle facing Nebraska as well as many other areas of the world that must deal with variable precipitation.

Neale shared information about the Parallel 41 Flux Network, a project funded in its first year by the Irrigation Innovation Consortium (IIC), which is designed to help overcome this challenge. When it is complete, the system will consist of a network of eddy covariant energy balance flux towers, that measure real-time evapotranspiration. These ground data will validate satellite-based estimates of ET made using the visible infrared imaging radiometer suite (VIIRS). The towers also measure gradient precipitation, then serve the data to stakeholders.

The Parallel 41 network, when paired with satellite spatial ET products, will help calculate crop water use and drought indices with increased accuracy to help producers and others make growing decisions. Project partners currently are testing the satellite based evapotranspiration product in Brazil. "We can downscale the VIIRS product to 30 meters and look at smaller regions and irrigated areas" Neale said. "The challenge is that in parts of Africa and Asia, the agricultural field sizes are small."

In Nebraska, the EC flux towers currently exist in seven locations. The goal is to distribute more towers all along the gradient over the next three years. Each tower is equipped with new technology from LI-COR, a Nebraska biosciences research and manufacturing company.

> **Democratization of technologies is important. Data should not only be available to big companies but also accessible across the spectrum to everyone.**
>
> - Jay Ham

The LI-COR software, FluxSuite, works on smart devices and computers, which improves timing and reduces costs, because human beings do not have to travel to towers in remote areas for continuous maintenance. The towers' gas analyzer also measures CO2 fluxes, which can be used for carbon balance studies in different ecosystems. The actual ET values can be compared to reference ET to get real-time crop coefficients for a given time of the year.

Cathy Lavish, professor and extension specialist with Kansas State University, said joining the IIC allowed

Kansas State University to expand its study of soil moisture sensors and recruit a high-quality PhD student, as well as collaborating with another study at the university to look at cool-season grasses and stressing them with 0% to 50% water.

The study is designed to help end-users correctly implement research discoveries. "Education is really important, and research is critical," Lavish said, "but if the end-user is not doing things correctly it doesn't work."

The objective of this study is to look at sensors, lab analysis, soil texture, soil moisture curves, and then take that information to the field and determine trigger thresholds. "We will be able to compare data from the sensors to traditional irrigation," Lavish explained. The comparison will help researchers determine the best turf grasses to use and then devise best methods of controlling water application with the help of moisture sensors, flow meters and rainout shelters.

"Much of the 20 million hectares of turfgrass in the United States is irrigated, and most turf people ignore soil moisture," lavish explained, "but much water can be saved by properly using soil moisture sensors."

In the past, many faculty and universities developed new technologies, but the technology tended to never make it to market. According to David Zoldoske, director of the Center for Irrigation Technology at Fresno State University, the university has developed a network to "bring people out of university to improve irrigation water management" by getting programs and services from concept to product. The ultimate goal is to develop a national network supporting irrigation industry startups and get products to market faster with an accelerator program.

"It's a three-month program that is all about getting people together with experts so they can start to generate some sales, then double and triple their sales in a short period of time," Zoldoske explained. The benefits include creation of jobs – about 300 so far.

Zoldoske said the California Energy Commission set up four regional accelerator clusters, tapping local expertise as well as experts from the University of California system and other resources critical to business startup. The project has gone as far as Kansas and Colorado to gain resources and expertise needed.

IRRIGATION INNOVATION CONSORTIUM

The Irrigation Innovation Consortium (IIC) is a joint initiative between private, public, and university organizations, addressing growing water scarcity in the western U.S. and worldwide.

"We looked to the world to find solutions," Zoldoske said. "We want to keep California competitive and productive, so we need to look worldwide to increase our success rate."

Panel Discussion: Creating a Gateway to Reach Common Goals

Following the presentations, Sally Rockey, executive director of the Foundation for Food and Agriculture Research, moderated a panel discussion. The mission of the Irrigation Innovation Consortium (IIC), according to Rockey, is to transfer successful irrigation techniques from one place to another to make sure water is available for future generations. "We are working on tailored situations, and we know we can't do it alone," she explained. "IIC is a gateway to help us reach common goals ... and figure out how to translate ideas into products."

> **The greatest benefit of vetting products in a precompetitive space is having the opportunity to look at issues together — even when stakeholders are competitors.**
>
> - Albert Maurin

Albert Maurin, sales and tactical marketing manager, FieldNET & FieldNET advisor of the Lindsay Corporation, explained that collaborations in agricultural technology have increased so much that it is obvious no one can be the expert in everything. Panel members discussed the benefits of creating a "precompetitive space to look at crosscutting issues." The greatest benefit of vetting products in a precompetitive space is having the opportunity to look at issues together — even when stakeholders are competitors.

Several panel members stressed the need to make technology easy to use. "Producers have the ability and desire to use technology, but it has to be in a package that is usable for them," Maurin explained. John Kastl, senior director of innovation and intellectual property, Valley Irrigation, added that "growers are starting to drown in data layers," which further emphasizes the need to make products easy to use. Automation may be part of the answer. For example, data input often can be automated rather than requiring farmers to enter data manually.

Panel members touched on ways their companies are helping make new technologies accessible

throughout the world, not just to U.S. farmers. Several companies produce products, such as irrigation scheduling software, that don't require large capital investments or are free to smallholder farmers.

There is a substantial cost for the hardware and gear to obtain satellite imagery and calculations, but it can be very low-cost or free for producers to access the resulting data.

Aric Olson, president of Jain Irrigation, stressed that different regions have different approaches to irrigation, and we can accomplish a great deal when representatives of many regions come to the table together. For example, he said, just as manufacturers are coming together to tackle the problem of plastic in oceans, "we can come together under one umbrella to tackle the environmental issue of nitrates using technology."

Encouragement for organizations to work together was echoed by Valeriy Kovalskyy, a remote sensing scientist on the The Climate Corporation's geospatial team. "We work with growers and others to match opportunities with solutions," he said. "This helps us keep our radar on solutions that will make their way to the customer. We need partners to make tailored solutions for irrigation goals."

Through a lively question-and-answer session, the panel and attendees addressed a number of challenges facing scientists, administrators, funders and producers as they develop irrigation innovation:

- Over-irrigation and water waste
- Recharging water below the root zone
- Irrigators making decisions they shouldn't make, in spite of industry education
- The need to produce standards across the industry

One of the most challenging issues in irrigation innovation is adoption by producers. "A small percentage of people are taking advantage of the technology we have right now," one panel member suggested. "Could we do research on the behaviors of farmers and consumers ... and then figure out what we need to do to help them and change their behavior?"

> **We can come together under one umbrella to tackle the environmental issue of nitrates using technology.**
>
> - Aric Olson

Lunch Keynote *April 29 | 12:30 p.m.*

"It's Irrigation, Jim, But Not as We Know It"
Insights From a Synthesis Report, DFID-ESRC Growth Research Programme

Speaker: **Bruce Lankford**,
Professor of Water and Irrigation Policy, University of East Anglia, United Kingdom

Farmer-led irrigation *is* succeeding. Hundreds of thousands of hectares are beginning to be developed by farmers, and it's showing up on the research agenda. The problem, according to Bruce Lankford, professor of water and irrigation policy, University of East Anglia, United Kingdom, is that "researchers, policymakers and service providers don't see farmer-led irrigation as sufficiently different. We treat it as any other [type of] irrigation."

A project in which Lankford participated in Africa included two activities that helped define the nature of farmer-led irrigation. The first was a wetting front detector to manage over irrigation. The second, the River Basin Game, used marbles to help farmers see how overwatering happens and its effects.

"[These activities] support what I consider to be the true scarce resource, which is collective farmer knowledge on how to maintain systems at scale," Lankford said.

In his luncheon speech, he suggested small-scale farmer-led irrigation is efficient and methods are suited to the catchment. However, government officials, media and others often believe farmers waste water, and that leads government and experts to say farmers need irrigation training.

Bruce Lankford, Professor of Water and Irrigation Policy, University of East Anglia, United Kingdom

According to Lankford, the truth is that the efficiency of all irrigation types continues to be under-researched, which fosters inaccurate views and policies. He encourages policies that fit different stages of irrigation, from adoption through development. Part of the problem, Lankford said, is that national irrigation policies "omit an entrepreneurial facilitation of irrigation by the state." Instead, irrigation is approached via engineering ideals. Lankford suggested a shift to four principles governments can use to add an entrepreneurial approach:

1. Modernize irrigation away from gravity to drip, solar, pump/pressurized
2. Focus on meeting a country's entire irrigation potential
3. Use consultants to help deliver irrigation plans to the country
4. Conduct highly specified studies on those irrigation plans

Lankford saw these principles successfully applied in northeast Rwanda over 16,000 ha of drip irrigation in an area where there was no irrigation experience and no electricity supply.

How do we create a national irrigation entrepreneurial approach? Lankford suggests:

- Create transparent legal-institutional framework to allow irrigation services to operate (incl. artisanal)
- Locate services within/oversight by district councils; closer to farmers and service users; lease out equipment
- Rather than fulfilling irrigation potential, work with existing farming systems and trends
- Discern optimal types and levels of studies (e.g. dry season bottlenecks)
- Collate data on irrigation services as well as resource issues; to support farmers' & national questions
- Allow hybrid and iterative irrigation development (e.g. small areas initially, gravity, pumped, intakes only)
- Determine levels of subsidies (e.g. to support irrigation adoption, grid electricity use)
- Explore resource & system ownership (Who owns the infrastructure, land, water? What are tenure arrangements?)
- Remove (political) marketing and input obstacles (including cross-border exports)
- Embed learning from testing and mistakes (National Master Plans appear to have no space for this)
- Work early on rates of water consumption (community engagement & by-laws re: irrigation expansion)

It's tempting to default to familiar problem-narratives and solutions, Lankford said. Even though farmer-led irrigation *is* on the agenda, "we need a diversity of assessments, reform and support approaches, so we can spend wisely."

> **Researchers, policymakers and service providers don't see farmer-led irrigation as sufficiently different.**
>
> - Bruce Lankford

Sally Rockey, Executive Director, Foundation for Food and Agriculture Research

Plenary Session II *April 29 | 1:45 p.m.*

Harnessing Innovation for Sustainable Water Management

Speaker: **Sally Rockey**, Executive Director, Foundation for Food and Agriculture Research

As Executive Director of the Foundation for Food and Agricultural Research (FFAR), Sally Rockey has a unique opportunity to see how agriculture is developing. At this time, she said, "Data and technology are converging to make things happen at a breathtaking speed, and we need to take advantage of this incredible time in science."

FFAR's mission is to build unique partnerships to support innovative science that addresses today's food and agriculture challenges. FFAR works to provide access to affordable, nutritious food grown on thriving farms.

Rockey said agriculture adopts new technologies fast and we need to ride that wave, but we have so much data we practically don't know what to do with it. "We've generated more data in the last two years than in all the years of humankind," she said. Rockey used DNA sequencing as an example — it can be done 1 billion times faster and cheaper than 25 years ago.

The result is that science can have an impact on productivity in as little as two years. Science in many cases is shifting to proprietary R&D, which means scientists and companies must work together and

research must be available to everyone. For that reason, Rockey and others are focusing on working in precompetitive spaces, where "whatever we learn, when we're together, it will benefit all."

> **The next 30 years are not just the most important years in agriculture, but the most important years there will *ever be* in agriculture.**
>
> - Sally Rockey

This means there are different people sitting at the table with a broad group of ideas. FFAR decided to categorize its efforts based on the ideas of its funding partners. For example, Rockey said her organization now says they work on "sustainable water management" rather than simply "water scarcity," because they've learned it's not just about scarcity, it's about water use efficiency.

It's important to make things clear, so everyone will understand. It doesn't mean much to say "agriculture accounts for 70% of global freshwater withdrawals." It means more to show a photo of the decimated Aral Sea, once the world's fourth largest freshwater lake, which was diverted for agriculture – it's now completely gone because it wasn't managed sustainably.

One of the foundation's most important projects currently is the Irrigation Innovation Consortium, which funds new innovators. Researchers have to become entrepreneurs and find funding for their work, Rockey said, and they often will change to another discipline just to get funding; from agriculture to health for example. "If we capture them early, we can keep them in agriculture," she said.

Offering monetary incentives, Rockey said, can help researchers find answers. For example, the foundation's Egg-Tech Prize is helping improve the sexing of chicks on the day an egg is laid to save time and money. Rockey believes we could create similar prizes for water – a worldwide competition – and she asked conference participants to come to her with ideas. "It's crowdsourcing on steroids," she said. "Anyone could come up with an answer to this water dilemma."

The point is, Rockey said, we always talk about the year 2050, but we need to be concerned about what's happening right now. "The next 30 years are not just the most important years in agriculture, but the most important years there will *ever be* in agriculture. We need all the best minds at the table."

Developing Strategic Framework for Drought Risk Management and Improving Drought Monitoring Tools for Africa

Speaker: **Tsegaye Tadesse**, Research Associate Professor, University of Nebraska–Lincoln, Climatologist and Remote Sensing Expert, National Drought Mitigation Center

Drought is killing millions and is expected to increase in frequency and severity, particularly in Africa. A major challenge of managing drought is getting governments to help reduce drought impact and plan for the future. "People only do things when the drought is happening, then the efforts stop when the drought is over. We need to plan ahead *before* drought," said Tsegaye Tadesse, research associate professor/climatologist and remote sensing expert, National Drought Mitigation Center, University of Nebraska–Lincoln.

In a paper published last June by the United Nations Food and Agricultural Organization (FAO), Tadesse and colleagues mapped out a strategy for future drought risk management and improving drought monitoring tools for Africa. They challenged Africa to make drought a priority, looking at it from past, present and future perspectives to build a strategy framework.

"We also need a strategy so countries can help each other," Tadesse said, "and the role of women is still limited – we need to close that gap." He said people are migrating from drought-prone areas, and any drought strategy needs to help protect displaced citizens. Furthermore, that help should start from within those countries.

Tsegaye Tadesse, Research Associate Professor, University of Nebraska–Lincoln, Climatologist and Remote Sensing Expert, National Drought Mitigation Center

Tadesse's paper shared three drought management pillars that have been adopted in many places:

- drought monitoring early warning system
- drought vulnerability and impact assessment
- drought mitigation and response

Tadesse said other important factors that need to be considered include:

- politics/governance
- drought awareness/knowledge
- reducing underlying factors
- gender inclusion

- innovative financial solutions
- strong partnerships
- Africa leadership

"There is no money, but they [governments] have to start with whatever they have and show the seriousness of the programs," Tadesse said. "New leadership in Africa is important." He suggested next steps should involve putting tools in place to implement the pillars of drought management. This work is already underway through projects such as the NASA Greater Horn of Africa project.

> **People only do things when the drought is happening, then the efforts stop when the drought is over. We need to plan ahead *before* the drought.**
>
> - Tsegaye Tadesse

Tadesse said drought is not only accompanied by economic losses, but life losses, too. There have been a large number of deaths in Africa related to drought. At the global scale, more than 50% of people affected by drought are found in Africa.

DWFI funded a seed project involving a University of Nebraska-Lincoln team working in Ethiopia in two drought-prone areas. Researchers surveyed 351 households to get base data to help them understand the area's crop production, nutrition/health and anthropometry. Findings included:

- there is a high incidence of malnutrition among children
- water is a limiting factor for irrigation
- a simple manual treadle pump had a big impact
- any solution has to be holistic, involving everything from economics to nutrition
- farmers watched techniques, then used whatever tools they had to do it themselves — this shows farmers can experiment independently and develop solutions to meet specific needs

Tadesse said local community involvement is very important and can help implementation. "We can't give them a prescription and say 'This is for you.' They have knowledge no professional can have. Listening to them could make us more efficient." He said future efforts must include local perspectives in implementation of strategy documents, research, and improvement of drought monitoring tools using state-of-the-art technology.

Tadesse recommended that stakeholders begin helping drought susceptibility via small, holistic, economical, healthy and nutritious efforts – all while taking advantage of current innovations and technologies to accelerate results.

(L-R) Harkamal Walia, Yufeng Ge, Sruti Das Choudhury, Ayse Kilic, John Gamon and Tala Awada

Close-range and Remote Sensing Technologies and their Role in Mitigating Drought Stress

April 29 | 3 p.m.

Concurrent Session

Moderator: **Archie Clutter**, Dean, Agricultural Research Division, University of Nebraska–Lincoln

Speakers:

Tala Awada, Associate Dean, School of Natural Resources; Physiological Plant Ecologist; University of Nebraska–Lincoln

Sruti Das Choudhury, Image Analysis Specialist, School of Natural Resources, University of Nebraska–Lincoln

John Gamon, Quantitative Remote Sensing Scientist, University of Nebraska–Lincoln

Yufeng Ge, Assistant Professor, Biological Systems Engineering, University of Nebraska–Lincoln

Ayse Kilic, Professor and Remote Sensing Expert, School of Natural Resources, University of Nebraska–Lincoln

Harkamal Walia, Associate Professor, Department of Agronomy and Horticulture, University of Nebraska–Lincoln

Recent and emerging technologies play an increasing, critical role in our ability to accurately investigate and forecast plant traits important for growth, yield stability/increase, resistance to stresses and ecosystem resilience. This ability is critical for mitigating and adapting to unpredictable future growing conditions. The conference session, moderated by Archie Clutter, dean of the Agricultural Research Division at the University of Nebraska–Lincoln, explored six innovative, noninvasive proximal and remote sensing approaches that can help us address food security in the face of a changing climate and dwindling water resources.

Adoption of High-Throughput Plant Phenomics for Assessing Drought Stress in Plants

High-throughput plant phenomics have been conducted for thousands of years, but it has been laborious, expensive and destructive said Tala Awada, a physiological plant ecologist and associate dean of the School of Natural Resources at the University of Nebraska–Lincoln. New technology is making phenomics more efficient, and it's a tool that could speed yield improvement by 2050. A new genotype is expected in just a few years. The international genomics network is still new but has been growing through information sharing, Awada said.

The University of Nebraska recently invested in several systems supporting phenomics studies on topics ranging from small plants to feeds. The systems complement existing investments in technology such as satellite imaging. Researchers developed a system that automates plant imaging to extract important

Tala Awada, Associate Dean, School of Natural Resources; Physiological Plant Ecologist; University of Nebraska–Lincoln

information, including leaf shape, texture and count, stem tilt to measure wilting, etc. This is done through artificial intelligence and ground validation.

Another modeling system manipulates genes and predicts and simulates plant growth. The team is measuring indices from remote-sensing groups to derive physiologic characteristics, such as chlorophyll, with varying levels of success. Adoption is slow, because the systems are still expensive, but adoption should improve as costs decrease.

Deep Learning for Detection in Temporal Propagation of Drought Stress Using Hyperspectral Image Analysis

Sruti Das Choudhury, image analysis specialist, School of Natural Resources, University of Nebraska–Lincoln, described a project that analyzes plant images in different light spectrums

with plants under different types of stress as they grow. The plants are imaged from different angles to help researchers understand how plants react physiologically to different conditions for the ultimate purpose of mitigating drought stress. The study addresses two different aspects of plant of drought stress mitigation: (1) a data-driven approach to detecting drought using hyperspectral imaging and (2) drought stress quantification using three-dimensional plant phenotypes.

The team conducted two experiments involving segmentation based on image subtraction – for pixels responding to the plant and for wavelengths. The researchers looked for four different distinct types of clusters of pixels showing different levels of drought conditions. In resulting diagrams, green pixels indicate unstressed portions of plants and red pixels show stress.

The research is expected to result in a pending plant analysis toolbox, including algorithms designed for hyperspectral analysis and the clustering technique, as well as an automated process for camera calibration.

Improving Drought Responsive Phenotypic Diversity in Wheat from Wild Alleles

One way to improve the yield of cereals is to make crops more drought resilient. This research was based on the question of whether researchers could go back into the wild with phenomics tools and revisit plant breeding and traditional tools to determine what makes a plant drought resistant, said Harkamal Walia, associate professor, Department of Agronomy and Horticulture, University of Nebraska Lincoln. He explained that the study is based on the premise that crop selection narrows generic diversity and reduces drought resilience. Researchers wanted to find novel sources that would make wheat more resilient.

An experiment was set up using wild emmer wheat – a vintage strain of wheat known to have higher diversity, a richer gene pool and higher drought resistance. Researchers developed imaging methods to precisely measure the water plants take up every day, so the amount of biomass they are gaining can be predicted. The amount of water applied was gradually reduced and results were compared with control plants.

Through this experiment, Walia said the team believes it has identified a gene that could help develop plants that grow well under stress. The project has confirmed that image phenomics can be used to create a detailed map of drought responses and underlying genes for completing detailed molecular analysis.

Solar-Induced Chlorophyll Fluorescence as a Tool for Predicting Drought Stress in Plants

Researchers have known about chlorophyll fluorescence for many decades said John Gamon, quantitative remote-sensing scientist, University of Nebraska–Lincoln. Scientists discovered by accident that satellites monitoring for gasses could also see chlorophyll fluorescence, but it was difficult to pick up through sunlight. With spectrometers, researchers can see this otherwise invisible signal.

Fluorescence follows photosynthesis from day to day (although it is different if measured hourly) – so it offers a new way to detect stress in plants, including drought stress, Gamon explained. A wide range of technologies are being tested and compared to spectrometer results to see what the signal really tells us. He said the benefit of this method is that it measures photosynthetic signals directly rather than indirectly as other sensors do.

This work is being done at Mead, Nebraska, in an area that is on the edge of a hotspot for measuring fluorescence. Researchers are using aircraft to obtain the images through spectrometry. The uniqueness of this method of measurement is important, because it adds information not currently present in research, Gamon said. Different methods and instruments yield different results, so more work is needed to standardize the technology.

Sensing and Modeling Plot Scale Crop Water Evaporation at Very High Temporal Resolution

The University of Nebraska is making great strides in phenotyping, including advances in instruments and systems that allow breeders, crop specialists and even computer scientists to do the work they need to do. Yufeng Ge, assistant professor of biological systems engineering, University of Nebraska–Lincoln, shared two examples of systems being used to support phenotyping for water-use-related crop traits at high spatial and temporal resolution, which is important for crop improvement in the context of plant breeding and also for water/irrigation management in the context of production.

The first example Ge shared is an imaging system used to extract pixels to get estimated plant biomass. The system includes a precision water station and cameras. Plants are placed on a conveyor belt that takes them through watering, weighing and imaging stations to accurately track the amount of water consumed during the day and across the entire lifecycle of the crop. Results show plants are stressed for some time before biomass data changes. "It's really surprising," Ge said. "The plant is actually doing something to conserve the water."

The second example of a cutting-edge system in the UNL phenotyping center is a spidercam field phenotyping facility. Four posts are placed at plot corners, with a cable robot sensing platform attached to them. By pulling the cables, the automatic system can precisely position sensors at any point in the plot. The system can go over plants hundreds of times a day, which helps fill a gap in phenotyping data. "This is the first time we've been able to capture the temperature distribution of a plot at very high spatial resolution, as well as very high temporal resolution," Ge explained. "[This allows us] to do better modeling regarding energy balance and evapotranspiration from the surface."

Evapotranspiration at field and residential scales from Google EEFlux and GEARUP apps and transformation into irrigation scheduling by GEARUP and ETM apps

The University of Nebraska's evapotranspiration monitoring system, EEFlux (Earth Engine Evapotranspiration Flux) system runs on the Google

Earth operating system with data from the Landsat satellite. The system is being used to develop maps for a local Natural Resources District (NRD) to show variation from field to field, said Ayse Kilic, professor and remote-sensing expert, School of Natural Resources, University of Nebraska–Lincoln. "Being able to see water consumption on a large scale for an entire NRD is very important," she said. The data maps, which provide several layers of information for users, are available in seconds to anyone. They measure plots of land about 100 miles in size every 16 days, and the archive goes back to 1985 when data first became available through Landsat.

> **Being able to see water consumption on a large scale for an entire NRD is very important. The data maps, which provide several layers of information for users, are available in seconds to anyone. They measure plots of land about 100 miles in size every 16 days, and the archive goes back to 1985 when data first became available through Landsat.**
>
> - Ayse Kilic

A second application measures residential water use through the National Agriculture Imagery Program (NAIP) because it shows one-meter resolution and can image everything in a homeowner's yard. The app runs every two weeks and provides a binary code estimating irrigation needs — yes or no, do owners irrigate today or not, and how much. The information can be received on a smart phone or iPad.

Kilic said UNL researchers also have been working on developing a real-time, on-the-fly scheduling system for agriculture based on EEFlux and other tools the university has developed. The primary motivation is to make data available to the farmer's smart phone. "Others, such as government and natural resources districts and scientists can see this. Why can't we make this available to the farmers so they can look at their own farms?" Kilic explained. She stressed that the systems are not costly, but there are only two satellites in orbit now, and to do it right the system needs 16. "We need to put pressure on state and federal officials to make sure we have the resources to do this."

Water: A War Game Scenario *April 29 | 3 p.m.*

Concurrent Session

Facilitators: **National Strategic Research Institute** and **Daugherty Water for Food Global Institute**

A war game scenario was conducted in this session to allow participants to examine the value of water through role-play. Attendees behaved as various actors (e.g., countries, aid organizations, tribal groups, etc.) in the scenario to simulate a conflict over water and food security.

Kate Gibson of the Daugherty Water for Food Global Institute leads participants through a war game secenario.

Throughout the game, water and food were used as currency in exchanges between the actors. The simulation and discussions following the role-play revealed the differing values placed on water by each actor and how this relates to real-world water resources management, conflicts over water, and water transfers.

The session was facilitated by staff from the National Strategic Research Institute.

Participants enjoyed the hands-on approach to working through water issues and concepts surrounding the value of water. Some inquired about bringing the scenario to their own organizations.

(L-R) Martha Rhoades, Mik Schulte, Graham Christensen, Jesse Bell and Martha Mamo

Water Quality, Nutrition and Climate Change

April 29 | 3 p.m.

Concurrent Session

Moderator: **Claudia Ringler**, Deputy Director of Environment and Production Technology Division, International Food Policy Research Institute

Speakers:

Jesse Bell, Claire M. Hubbard Professor of Health and Environment, University of Nebraska Medical Center

Martha Mamo, Department Head, John E. Weaver Professor of Agronomy and Horticulture, University of Nebraska–Lincoln

Martha Rhoades, Research Manager, Xenobiotics Laboratory, University of Nebraska–Lincoln

Claudia Ringler, Director of Environment and Production Technology Division, International Food Policy Research Institute

Panelists:

Graham Christensen, President, GC Resolve, LLC

Mik Schulte, Operations Analysit, Water in Agriculture Global Water Solutions, World Bank of Environment and Production Technology Division, International Food Policy Research Institute

Water provides a connection between a wide variety of issues and challenges throughout the United Nations' Sustainable Development Goals (SDGs), said Claudia Ringler, deputy director of the environment and production technology division at the International Food Policy Research Institute. To successfully address these challenges, improve synergies and help avoid negative consequences, she explained, we need to better understand these linkages.

> **Key linkages in nutrition include increasing food production, access to clean water and improving health so nutritents can be absorbed.**
>
> - Claudia Ringler

Key linkages in nutrition include increasing food production, access to clean water and improving health so nutrients can be absorbed. Water contamination is directly linked to poor health outcomes. The good news is that poverty, hunger and ecosystem health can all be addressed by improving irrigation, but coordination is needed Ringler said.

The presentation began with climate change. It is a significant threat to the health of all people, and all are vulnerable, but some are more vulnerable than others, said Jesse Bell, Claire M. Hubbard Professor of Health and Environment at the University of Nebraska Medical Center. Climate drivers lead to exposure (to climate-related risks), which leads to health outcomes, which are governed by environmental, institutional, social and behavioral context.

In rural communities, extreme heat is the largest killer. Another health concern is air quality — Nebraska has the sixth highest air-quality-related death rate in the United States. Extreme weather in Nebraska has become more common, with 14 floods occurring within the last 10 years, and the fifth highest flood disaster declarations of any U.S. state. More extreme weather disasters mean more mental health concerns and challenges associated with the spread of disease. Bell suggested that education, research and a continued dialogue will help us better understand climate impacts and prepare the public.

Martha Rhoades, research manager of the Xenobiotics Laboratory at the University of Nebraska–Lincoln discussed water pollution and health. She said research is showing that combinations of agricultural pollutants are causing increased adverse health outcomes. For example, atrazine and nitrate combine to form nitrosamines, a known carcinogen in animal models. In Nebraska,

those who drink water with both chemicals present are two-and-a-half times more likely to develop Non-Hodgkin's lymphoma. Further studies are looking at the connection between drinking water wells that test positive for agrichemicals and county birth defects, which are also high in Nebraska: https://bow.unl.edu/

Martha Mamo, department head and John E. Weaver Professor of Agronomy and Horticulture at the University of Nebraska–Lincoln, discussed irrigation and nutrition during this conference session. In research looking at two drought-prone areas in Ethiopia, she said, 81% of farmers purchased grain with money earned by selling livestock. This highlights the seasonal shortages of food, which leads to stunting and underweight children. Thirty percent of the area has irrigation, which reduces the number of severely underweight children. One project bought treadle pumps for farmers in stressed areas, which decreased irrigation labor, increased output and doubled income. The treadle technology spread widely in the region after the first project was launched. The increase in income allowed the residents to add more protein to their diets.

Mik Schulte, coordinator for water in agriculture solutions for the World Bank shared a snapshot of diet diversity and education from the World Bank's Human Capital Project. Researchers found we are reaching only 57% of our potential in this area worldwide, and just 41% of the potential in sub-Saharan Africa. One potential solution is geographic targeting, which can help improve diet diversity and education in certain areas. For

Claudia Ringler, Director of Environment and Production Technology Division, International Food Policy Research Institute

example, in Uganda, farmer-led irrigation, nutrition monitoring and education are improving climate resiliency. In Somalia, an even more fragile area, there is exponential risk, so Schulte said the focus should be on multi-use systems, water storage and demonstration farms.

Graham Christensen, president of GC Resolve, LLC, discussed groundwater contaminants. His organization has partnered with the University of Nebraska¬–Lincoln's Department of Civil Engineering to track contaminants in surface and groundwater in Eastern Nebraska using citizen science. The first year, the program had 190 participants and it grew to 600 participants this year.

At his home farm, Christensen said, the average nitrate level was 12.8 ppm (10 ppm is the safe

drinking water standard). He suggested that all stakeholders need to use more precautionary principles. The solution lies in soil, he said. More carbon in the soil leads to more water-holding capacity, greater filtration, reduced farming inputs and greater value added. According to Christensen, regenerative farming is one way nitrate levels can be improved – this includes no-till, cover crops, crop rotations, adding livestock and intercropping with trees. On his own farm, soil carbon increased from 2.6% to 6.9% in 10 years.

During the question and answer segment of the presentation, one person asked what kinds of policies can lead to solutions. Christensen said we need to target the value chain and support soil health. He said the U.S. Farm Bill makes it challenging to get regenerative agriculture into conservation programs, but the Nebraska Legislature approved the healthy soils initiative and action plan this year, which supports conservation and soil regeneration efforts.

One attendee inquired about research covering multiple water contaminants. Rhoades said there is great interest in studying exposure to mixtures of contaminants, and her lab is studying 20 different chemicals.

When asked if no-till strategies raise yield, Christensen answered that the main benefits of no-till are erosion control, improved water-holding capacity, increased organic matter and labor reduction. An increase in productivity could be achieved by adding more plant diversity, he said.

(L-R) Mik Schulte, Graham Christensen, Jesse Bell, Martha Mamo, Claudia Ringlers and Martha Rhoades

When asked which types of education are needed in Ethiopia, Malmo cited more education in "building extension workers' capacity, school systems, university, multisector [solutions] and doctors." She added that we need to meet people where they are in their understanding of the issues and capacity to address them and bring people "into the room" to discuss these topics.

Water Reuse, an Untapped Resource for Food Production

April 29 | 3 p.m.

Concurrent Session

Moderator: **Yulie Meneses**, Research Assistant Professor, Food Science and Technology Department, University of Nebraska–Lincoln; Water for Food Processing Specialist, Daugherty Water for Food Global Institute

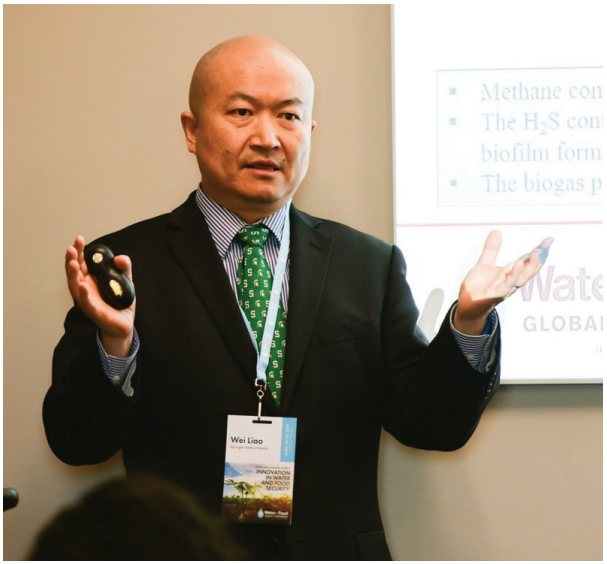
Speakers:

Wei Liao, Director of the Anaerobic Digestion Research Education Center, Michigan State University

Bahman Sheikh, Independent Water Reuse Consultant

Kurt Schwabe, Professor of Environmental Economics and Policy, University of California Riverside

Kristan VandenHeuvel, Research Manager, Water Research Foundation



Wei Liao, Director of the Anaerobic Digestion Research Education Center, Michigan State University

The United Nations' Sustainable Development Goals for 2030, among other things, target global reduction of untreated wastewater and increased safe reuse. Water reuse is the best way to secure new water supplies for food production. Research has shown water reuse can be implemented safely and cost-effectively. However, several concerns related to public health risks and community perceptions impose constraints on moving forward with implementation. In this session, stakeholders from academia and the private sector discussed how to face these challenges and understand opportunities offered by new technologies, ongoing research and evolving regulations.

> **By integrating solar thermal collection, bilogical conversaion and non-reverse-osmosis, we could provide a self-sustainable and scalable organic waste and wastewater use solution to reclaim water. Through this, we can generate renewable energy for both agriclutural and municipal operations.**
>
> - Wei Liao

A self-sustaining wastewater utilization integrating solar-bio-nano-technologies

Wastewater and organic wastes have great potential to satisfy the demand for chemical and energy resources through the system of biological, solar power and nano-technology, said Wei Liao, associate professor and director, Anaerobic Digestion Research Education Center, Michigan State University.

By integrating solar thermal collection, biological conversion and nano-reverse-osmosis, we could provide a self-sustainable and scalable organic waste and wastewater use solution to reclaim water. Through this, we can generate renewable energy for both agricultural and municipal operations.

Anaerobic digestion can produce biogas containing 65% methane and the wastewater produced can be cleaned to drinkable levels through nano-membrane filtration and reverse osmosis membrane filtration. Anaerobic digestion also can work with sand filters and wetlands to treat wastewater.

Liao described a pilot-scale, solar-biopower generation system used to treat organic waste in Central America. He said the hybrid solar/bio unit can provide sufficient energy to power the integrated system to sustainably treat and use organic wastes and wastewater.

Reuse of treated municipal wastewater for local food production: opportunities, conflicts and cost-effective irrigation

While voluntary reduction of water consumption has not shown promise in the past, water reuse has increased by 300% since 1970, said Kurt Schwabe, professor of environmental economics and policy, University of California-Riverside.

Schwabe posed the question of whether efficient action in one area of water is leading to inefficiencies in other areas and what can be done through policy to operate the system more efficiently. For example, when someone conserves water as a result of a state mandate, wastewater treatment costs may increase and recycling opportunities for water may be reduced.

Water Research Foundation agricultural water reuse research

Kristan VandenHeuvel, research manager at the Water Research Foundation, said the foundation is conducting research to promote water reuse in the agriculture, food and beverage, and power and manufacturing industries. She has found that instead of negative public perception, the high cost of wastewater reuse is surprisingly the biggest concern of the public, despite agricultural reuse for food crops gaining momentum.

Agricultural use of recycled water: impediments and incentives

Only about 10% of wastewater is treated around the world, said Bahman Shiekh, independent water reuse consultant. Some areas have attempted to irrigate with untreated wastewater (raw sewage), resulting in huge public health risks, including diarrhea. While Shiekh made the point that all water is recycled water via the natural hydrologic cycle, quality matters. Despite a negative public perception, wastewater is an untapped resource for irrigation and food production, and the safety of wastewater use has been demonstrated, said Shiekh. A member of the audience added that the lengthy distance between wastewater treatment plants and farming fields has been the main obstacle for this in Nebraska.

Entrepreneurship Marketplace *April 29 | 4:30 p.m.*

Concurrent Session

Participants:

John Gates, Chief Science Officer, CropMetrics

Ramsay Huntley, Vice President and Clean Technology and Innovation Philanthropy Program Officer, Wells Fargo

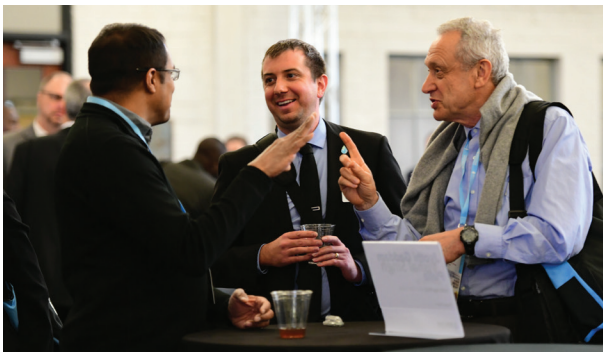
Neil Johnson, President and CEO, SmallData Tech

Oren Kind, Chief Commercial Officer and U.S. General Manager, Phytech

Vishal Singh, CEO and Founder, QuantifiedAg

Monty Teeter, CEO, Dragon-Line

Steve Tippery, President and CEO, RealmFive Agriculture



Attendees network and learn about agricultural start-ups in the Entrepreneurship Marketplace.

The High Plains of the U.S. is home to intensive irrigated agriculture and produces some of the world's highest crop yields. Thanks to millions of hectares of cropland and the occurrence of both abundant and stressed water resources, this region can serve as the perfect incubator for agricultural innovation and a testing ground for new technologies.

This session featured presentations from several agricultural startups headquartered or working in the High Plains of the United States. The startups, which ranged from irrigation system providers to entrepreneurs seeking to improve rural data transmission, shared information about their water and food related projects to inspire and inform conference attendees.

SmallData Tech: Internet of Things Data Analysis

The Internet of Things (IoT) is the extension of Internet connectivity into physical devices and everyday objects. This technology has permeated all types of industries. SmallData Tech is a start-up that installs and manages gateways in different counties throughout Nebraska. These gateways listen to and read the data from various IoT devices on agricultural lands, measuring everything from soil moisture levels and irrigation pump performance to water levels in wells and stock tanks. The company provides advanced solutions to growers and specializes in precision irrigation management.

CropMetrics: Precision Irrigation Solutions

This company develops and supplies a full precision irrigation solution for growers to help them optimize profits while increasing efficiency in water, nutrient and energy use. CropMetrics works to understand the real needs of each of their farmer customers, then combines the best in-field sensors with data science and field support to provide the best solution for that farmer. The unique value of the CropMetrics product and service is providing in-season expert support by a certified irrigation agronomist who is familiar with the area of the crops studied.

Dragon-Line: Efficient Water Use Through Drip Technology

This innovative pivot and linear irrigation technology transforms irrigation through drip technology to make every drop count. The mobile drip irrigation system applies water and nutrients directly to the soil rather than to the plant, which avoids the loss of water through evaporation. The unique design also allows for precise chemical/fertilizer application and crop germination.

RealmFive Agriculture: Wireless Sensor Hardware and Software

Modern producers need a cost-effective wireless sensor connectivity platform to make use of the all data available to them. RealmFive's platform combines robust, long-range, wireless hardware designed for difficult in-field environments with intuitive software that enables its customers to easily access their data. The company focuses its technologies in five market verticals: agronomy, irrigation, livestock, operations and inventory. RealmFive's connectivity platform is scalable for installations containing one or many types and brands of sensors.

Phytech: Plant Stress Data Analysis

Micro-variations of stem diameter are scientifically proven stress indicators. Phytech's sensors on selected plants monitor stem diameter, then transmits data in real time to the Phytech cloud for further analytics. Phytech applies patented algorithms to transform raw data into a crop-specific plant status. The product's predictive analytics and plant intelligence capabilities provide meaningful alerts and scheduling recommendations to help producers make effective decisions. The ultimate outcome of the data fusion and algorithmic analysis is a simple and easy to understand plant status indicator; keeping plant status in the recommended range (green) is designed to help farmers achieve optimal yield with minimal resources.

QuantifiedAg: Precision Livestock Analytics

This precision livestock analytics company offers "Fitbits" for the cattle industry. QuantifiedAg's system electronically monitors cattle health and identifies illness early, which helps pen riders be the best they can be. The smart cattle ear tag — "Quantified AG® Tag" — pulls behavioral and biometric data from the cattle, alerting managers to the specific animals that need attention to health issues. The system allows feedlot managers to get faster, more insightful data on the performance of their operations.

Irrigation in a sugar cane field in Brazil.

DAY TWO

Welcome and Opening Remarks

April 30 | 8:30 a.m.

Speakers:

Ronnie Green, Chancellor, University of Nebraska

Mike Boehm, Vice President and Vice Chancellor of Agriculture and Natural Resources, University of Nebraska

"Nebraska, due to its location, has a vast array of groundwater and surface water resources Water and food are inextricably linked in the DNA of Nebraska," said Chancellor Ronnie Green, University of Nebraska—Lincoln.

"Robert B. Daugherty believed that bringing together policymakers, scientists, entrepreneurs, and producers into a dialogue and conversation would allow us to confront the major challenges that present themselves in our ability to have a water and food secure world for the long term," he said.

Green joined the university as vice chancellor in 2010 and has had the opportunity to see the Daugherty Water for Food Global Institute grow into the leading institute it is today, he said. Green has traveled the world and helped develop relationships to shape the institute and remembered in gratitude all of the people who worked to make the institute what it has become.

Ronnie Green, Chancellor, University of Nebraska

Recapping the previous day of conference activities, Mike Boehm, the university's vice president and vice chancellor of agriculture and natural resources, said science and research will only get us so far. We need the collective expertise of a variety of partners to solve our water and food security challenges.

Boehm also recapped Nebraska's recent water event: "It was an extremely cold winter in Nebraska. Then we got word from the national weather service that there was a bomb cyclone heading our way –

think of a hurricane with rain and hurricane force winds mixed with two or three feet of snow, all happening at the same time," Boehm said. "The saving grace of this was that forecasting models have gotten better over the years and we had a few days' warning." The panhandle of Nebraska was in the eye of the bomb cyclone, and the cyclone moved north and east, so it affected several other states.

Many Nebraska farmers and ranchers had cattle in the early stages of calving, and the new calves were out on the prairie, susceptible to the storm. After the snow, the rain came, forming ice and exacerbating the problem. The entire upper Midwest was being impacted. "The scale was enormous," he said.

Boehm shared slides showing swollen rivers and tributaries that had gushed well beyond their borders, as well as photos of very thick ice. A 99-year-old dam broke and sent ice sheets three or four tons in weight and eight feet in depth flowing down rivers, through homes, through cities and taking out bridges. The flood was devastating – it claimed three human lives and thousands of livestock. Bridges moved off their moorings and were pushed downstream taking out whatever was in the way. Entire communities were completely flooded. Many of those living in river valley areas lost everything. More than 500,000 acres were impacted, with 350,000 of them being farmland and rangeland.

Nebraskans received an outpouring of support from across the country, Boehm said. There are some complexities to the response to this disaster: understanding the water dynamics and soil health – some fields have as much as six feet of sand and sediment and tons of debris buried in the sediment.

"Our railroads and highways were also impacted," he said. "Our natural system of feeding cattle and DDGs (distillers' grain) – moving that around – it's all been disrupted. The mental well-being and public *health needs are tremendous."*

> **Robert B. Daugherty believed that bringing together policymakers, scientists, entrepreneurs and producers into a dialogue and conversation would allow us to confront the major challenges that present themselves in our ability to have a water and food secure world for the long term.**
>
> - Chancellor Ronnie Green

Plenary Session III *April 30 | 8:50 a.m.*

A Water Secure World For All: Sustaining Water Resources, Delivering Services, Building Resilience

Speaker: **Jennifer Sara**, Senior Director, Water Global Practice, World Bank Group

Jennifer Sara, senior director of the Water Global Practice for the World Bank Group, encouraged conference attendees to think carefully about the interconnectedness of global food security and water security, emphasizing that the effects of a long-term drought do not grasp the same headlines as disastrous water-related events. Everyone knows nine of 10 disasters worldwide are water related, for example. But it is also important to realize that food production is increasing water stress over time.

At the same time, Sara said, water pollution is increasing, and the problems are being exacerbated by population growth, which leads to greater demand and more pollution. And growing agricultural needs are expected to exacerbate the quality and quantity of groundwater and surface water problems.

On top of that, Sara said, we have to look at a much less often talked about issue: more than a third of food produced is wasted each year, $680 billion worth. "Wasted food is wasted water," Sarah suggested. However, in some parts of the world people are hungry or malnourished. "About 3 billion people, close to half the world's population, are either not eating enough or eating the wrong type of food, resulting in debilitating illnesses and high costs to public health."

In fact, water is so important that a recent study by the World Bank indicated that ALL of the world's 17 Sustainable Development Goals (SDGs) can only be achieved with sufficient water. Water's importance is reflected in a recent updating of the World Bank Group's water strategy, which highlights how

Jennifer Sara, Senior Director, Water Global Practice, World Bank Group

countries can manage water resources in a more holistic manner. The organization has always made a commitment to water across public and private sectors, but now, for the first time, it will provide financing and technical assistance under one Water Global Practice. The new strategy is focused on moving toward a water secure world using three pillars: sustaining water resources, delivering services, and building resilience.

> **Wasted food is wasted water.**
>
> - Jennifer Sara

The World Bank believes partnerships with academia are important to help the World Bank provide policy advice based on evidence and analysis of sound methodologies. Sara encouraged conference attendees to take into consideration the lesser-known aspects of water in their work, including valuing user needs when valuing water, looking at issues of both quality and quantity, addressing water for the environment as well as social and economic purposes, looking at storage options which are becoming more important, and looking into building water resilience to address issues such as climate change, jobs and political conflict.

A holistic system of water within a global hydrological cycle, she emphasized, must include water markets, regulation and policy. There is a need for better legal structure, data, enforcement mechanisms, water and land rights, wastewater reuse, and environmental treatment standards. "It's really important for us to look at public policies in the farm sector, and the agriculture sector, and the water sector, together." However, Sara stressed that sector financing must fundamentally change. "Public resources will not be enough to ever reach this goal."

The biggest question, she suggested, is how to get everyone involved. Speaking directly to students at the conference, Sara said, "The senior people in the room have begun this, but you are the ones who are going to have to take this forward, so we need to think about how we educate and empower the next generation."

As it relates to the conference's topic of innovation, Sara said we must help governments formulate public policy that supports innovation. Data must be equally available to everyone in developing countries. "It's not just putting systems in place, but also the institutions that manage the assistance," she explained. "How do we bring technologies to scale with policies?"

Furthermore, she suggested Internet delivery models are very important. "We can leapfrog ahead by sharing these innovations. It will take all of us to create food and water secure world."

Christopher Neale, Director of Research, Daugherty Water for Food Global Institute, translates for Leonardo Góes Silva.

Water and Food Security in the State of Bahía, Brazil

Speaker: **Leonardo Góes Silva**, Secretary of Water Infrastructure and Sanitation, State of Bahía, Brazil

The state of Bahia in Brazil is two-and-a-half times the size of the state of Nebraska in the United States. Like Nebraska, Bahia is known for its expertise in water. In this session, Leonardo Góes Silva, Secretary of Water Infrastructure and Sanitation, State of Bahia, Brazil, described the management policies and tools Bahia uses to protect and administer water. Brazil contains 12% of the world's freshwater, including 12 major river basins, with much of Bahia's freshwater contained in the Amazon basin. Brazil contains three major aquifers: the SAGA, Guarani and Urucuia. The Urucuia aquifer, located in the western state of Bahia, is similar in size to the High Plains aquifer in Nebraska.

Overall, Silva said, it is important to know that policies of food, environment and water must work together. Water governance in Brazil is based on a 1997 water law, which controls federal and state rivers and deals with the integration of surface and groundwater. A national water agency was created in 2000. The government structure includes tools such as a permitting system, water fees, incentive-based payment for environmental services and information provided to stakeholders and users.

Bahia is moving toward a shared vision of water involving a variety of stakeholders from different sectors of society. Silva shared some of the main food security and rural development policies that complement water policy in Bahia. This includes programs to strengthen family farming with rural financing, purchase food from family farms and provide school meals to make sure children go to

school. A large World Bank program provides funds to help smallholder farmers and develop the rural sector, as well as assist in the sustainability of water resources. Bahia is one of the states in Brazil with the largest number of smallholder farmers in Brazil. The state's environmental policy follows Brazil's new environmental forest law designed to help preserve native forests. Some components of this policy call for farmers to register their properties.

Brazil's Secretary of Agriculture Lucas Teixeira Costa is working on a master plan for irrigation in the state. There are five growing seasons in Bahia over a two-year period, with crops including soybean, cotton, fruit, vegetables and bio energy. The state has plenty of sunlight and good temperatures to grow agricultural products on its more than 500,000 ha of irrigated land.

The recent Urucuia Aquifer Project is a partnership designed to study and improve water availability in Western Bahia. The many partners include agricultural associations, government and universities. Completed sub-projects include hydrological modeling of the aquifer, a study of water availability in river basins and an analysis of land use change. Approved projects that will take place over the next two years will address governance/monitoring and small-scale farming. To view a database representing Brazil's groundwater and surface water, visit obahia.dea.ufv.br.

Leonardo Góes Silva, Secretary of Water Infrastructure and Sanitation, State of Bahia, Brazil

> **Food security and rural development policies that complement water policy in Bahia include programs to strengthen family farming with rural financing, purchasing of food from family farms and providing school meals to make sure children go to school.**
>
> - Leonardo Góes Silva

Flash Talk Presentations *April 30 | 9:30 a.m.*

Technology and Resilience in Irrigated Row Crop Systems

Speaker: **Hannah E. Birgé**, Water and Agriculture Program Manager,The Nature Conservancy in Nebraska

According to Birgé, it's important to take a systems approach to research, because understanding the parts of a system provides a better understanding of the problem and is more likely to lead to successful results. However, she explained, there is an inherent uncertainty in systems. Rabbit population growth dynamics show that for a while you can predict how many rabbits will result if you leave them to reproduce and live on three different islands, but as time goes by it becomes impossible to predict population. The question, Birgé said, is how to reduce that uncertainty. That's what The Nature Conservancy is trying to do as it applies systems principles to understanding groundwater level changes. All of this is the context within which The Nature Conservancy projects are designed.

Birgé described the Central Nebraska Irrigation Project, which helps growers schedule irrigation closer to crop needs, so farmers aren't irrigating based on arbitrary factors such as how the soil looks or when the family is going on vacation. Tools given to farmers through this project include flow meters and telemetry so they can turn water on and off using cell phones. The project will involve 50 producers over three years, and it is expected to conserve more than 9 billion gallons of water, with additional positive impacts on water quality, soil runoff and greenhouse gas (groundwater tends to be saturated with methane).

Hannah E. Birgé, Water and Agriculture Program Manager, The Nature Conservancy in Nebraska

Through this project, Birgé said, her team learned that we can't eliminate uncertainty, but we can manage "for change," using technology in the "messy" system to embrace and plan for surprises, which is more likely to lead to beneficial outcomes.

Nebraska Strong: Rebuilding After Historic Flood

Speaker: **Steve Nelson**, President, Nebraska Farm Bureau

Steve Nelson, President, Nebraska Farm Bureau

In the recent flood event in Nebraska, more than 75% of the state was affected, Nelson said, including almost every river basin. The storm that led to the floods was very unusual. "We aren't used to having storms that cover this much of the state," he explained. The weather event included a rare "bomb cyclone" with both snow and rain. A major dam broke, sending an 11-foot wall of water and slabs of ice up to two feet thick speeding down the river and into fields and towns, where they destroyed roads and buildings. Nebraska Farm Bureau conducted more than 100 interviews with Nebraskans across the state to determine the extent of the damage.

The cost of the storm was calculated to be more than $1.4 billion, with crop damage accounting for billions more. Many farmers won't be able to plant this year. Livestock losses included deaths, poor feed conversion and delays to market. In addition, the state infrastructure was destroyed in many places and will need to be rebuilt. "This doesn't include losses to railroads and costs of clearing land of sediment one to five feet deep. It doesn't include the cost of farm buildings or indirect losses from compromised feed supply and having to move cattle earlier," he added.

Nelson shared a video interview with one Nebraska family whose land had not flooded in 120 years. The farm was immaculate before the storm, and completely devastated afterwards. "There are many others like them," he said. "There was a huge financial toll, but also a significant personal toll." The Nebraska Farm Bureau website includes a public place where people can list their needs, and a disaster relief program has raised a significant amount to help them. "Red Cross tends to go to populated areas first," Nelson explained, "so we worked from rural areas first. We are looking at years to recover, not just months."

Malawi — USA via The Netherlands: How My Career Path Changed My Perspective

Speaker: **Mavuto Banda**, double masters degree graduate, University of Nebraska–Lincoln and IHE Delft Institute for Water Education (The Netherlands)

Sometimes a simple internet search can change a whole life trajectory. In the case of Mavuto Banda, it took him from Malawi to the Netherlands to Nebraska through a unique partnership between IHE Delft in the Netherlands, the University of Nebraska-Lincoln and the Daugherty Water for Food Global Institute.

"This has been one of the best opportunities I've had. It's changed the way I look at life, and the water issues that we face," said Banda. "I've come across people from more than 50 countries, made connections, shared ideas. Although we all face the problem of water, each part of the world needs a different approach, different solutions."

Agriculture, especially smallholder farming, is the economic mainstay of Malawi. While there has been rapid growth in the sector, the east African nation still faces challenges of food and nutrition insecurity.

According to Banda, Malawi, which is in southeastern Africa, and shares borders with Zambia and Mozambique, is rich in water resources. "The people are known to be cheerful, and the land is beautiful," he said. Banda studied irrigation engineering has an undergraduate, then went online and found the double master's degree sponsored by

Mavuto Banda, double masters degreee graduate, University of Nebraska–Lincoln and IHE Delft Institute for Water Education (the Netherlands)

the University of Nebraska-Lincoln and the IHE Delft Institute for Water Education (The Netherlands). "I knew I wanted to study water," he said. "Each part of the world needs different solutions, and it changed the perspective I had about water," Banda said. "Water is a common denominator ... and the effort needs all of us."

During his research project, Banda completed a thesis analyzing the economic benefits of sugarcane farming with deficit irrigation. Because Lake Malawi has had low water levels for the past 20 years, it has resulted in lows in sugarcane production. "We established that we can grow a crop with optimum level of water for growth of sugarcane," he said. "The state will be happy, because we will grow more with less water."

(L-R) Azariah Lawal, Shivam Gupta, Marco Ugarte and S. Sajeesh

Policy Strategies for Agriculture Supply Chain Management

April 30 | 10:30 a.m.

Concurrent Session

Presenters:

S. Sajeesh, Assistant Professor, Marketing Department, College of Business, University of Nebraska–Lincoln

Shivam Gupta, Assistant Professor, Supply Chain Management and Analytics Department, College of Business, University of Nebraska–Lincoln

Marco Ugarte, Sustainability Consultant, Antea Group

J. Kalu Osiri, Director of International Business, College of Business, University of Nebraska–Lincoln

Kelechi Chibuikem, Graduate student, Community and Regional Planning, University of Nebraska–Lincoln

Azariah Lawal, Graduate student, School of Natural Resources, University of Nebraska–Lincoln

Jacob Monti, Mechanical Engineering, University of Nebraska–Lincoln (Alum)

Theo Udeigwe, Director of Research, Institute for the Advancement of Developing Economies

How can businesses be more sustainable and respond to a dynamic global environment? This session focused on supply and demand along a value chain as it relates to food marketing and pricing, strategies to collaborate with farmers to conserve water in food and beverage production, and efficient irrigation system design.

S. Sajeesh, assistant professor of marketing at University of Nebraska–Lincoln, presented a Turkish case study about global childhood obesity and health policy. The project began as a collaboration between University of Nebraska–Lincoln and the university in Ankara, Turkey. Results showed consumer preferences and perceptions change when consumers become more health conscious. In fact, consumers can be motivated to select higher-quality, more nutritious foods through policies that limit the consumption of unhealthy junk foods and impose high taxes on those types of foods.

Sajeesh explained, "We wanted to build on data collected in a country with an emerging economy and use it as a basis for building a model to understand how firms should adopt strategies where policy interventions are taking place and where consumer perceptions are evolving over time." The resulting model helped researchers understand consumer behavior and policy strategies that support the selection of healthy food products.

"The question becomes what sort of changes in product quality should firms be offering to consumers given that consumers want to be healthier and given policy interventions such as taxes on junk food and banning of unhealthy products," Sajeesh said. The study looked at how market mechanism factors such as social welfare and taxation can influence public policy initiatives and how that sort of influence forms strategic decisions in terms of what kind of quality to offer, what prices to charge, what level of social welfare to seek and what level of advertising should be used for products the firms are marketing to consumers. "So, you can see this is a fairly complex problem we are trying to analyze using a mathematical framework and hoping to come

> **The question becomes what sort of changes in product quality should firms be offering to consumers given that consumers want to be healthier and given policy interventions such as taxes on junk food and banning of unhealthy products.**
>
> - S. Sajeesh

up with nominative solutions to guide marketing strategies," he said.

The consumers (parents and children) interviewed for the project agreed that junk food should be taxed at a higher rate and agreed that educational messaging would be helpful in encouraging healthier food selections. An audience member asked if there were in-depth questions about organic and inorganic food or environmental issues. According to Sajeesh, the survey only asked questions about the impact of unhealthy food consumption either by imposing higher taxes on those types of foods or through increased communication promoting the advantages of healthy food.

The study found that there are nonlinear effects in terms of profits. As the importance of healthfulness messaging increases for consumers, company profits actually increase. He discussed other aspects of health messaging, taxation, consumer skewedness on quality product characteristics, pricing and profits, product differentiation, and social welfare. Sajeesh emphasized how important it is for firms to keep in mind that consumer characteristics are changing and governments are instituting new policy interventions.

Shiyam Gupta, assistant professor in management and analytics at the University of Nebraska–Lincoln presented factors that influence distressed produce prices in India. By definition, distressed prices are when a farmer sells produce at a much lower price than the guaranteed government support pricing. The problem has become prevalent enough in India that the media has been covering it regularly.

Azariah Lawal, Graduate Student, School of Natural Resources, University of Nebraska–Lincoln

In India, farmers must bring their produce to government procurement centers to be purchased in order to receive support prices. Distressed selling occurs because the procurement centers have limited capacity to purchase farmers' produce, and the farmers feel they must find other places to sell their products, in many cases before they spoil. Very often, farmers turn to traders/agents who are supposed to purchase the produce at the same price the government would pay; however, because the practice is not carefully monitored the agents and traders get away with offering 15% to 20% less than the government price.

Gupta said there are three main reasons this happens: (1) the government procurement system is poor and transactions are slow, (2) there is a lack of storage space, and (3) the farmers lack the resources to hold onto the produce until it can be sold to the government. Other disruptions that interfere with the

system include uncertain government procurement center.

Among other things, the study allowed researchers to quantify both the amount of distressed sales and the impact of public policies. Results showed that each of two approaches — increasing the capacity of government procurement and providing affordable loans — likely would result in 4% improvement in the farmers' welfare. "With the help of this kind of decision-making tool," Gupta said, "policymakers can begin with some targeted level of improvement, and then see which policies will result in that targeted improvement, and then do a cost-benefit analysis. If one thing is more beneficial in terms of its cost, then they can implement that policy."

> **The true cost of water includes how much you're paying for water, but also all the other elements you find in a detailed mass balance assessment.**
>
> - Marco Ugarte

Gupta's key message was that, to improve the farmers' welfare, the Indian government should provide and ensure access to affordable loans at low interest rates. The government also should improve support prices to ensure a fair income, he said.

Marco Ugarte, a sustainability consultant from Antea Group, discussed policy strategies for agriculture supply chain management – specifically the business of water. He said there is a lack of transparency in supply chains that deliver consumer goods, and he shared lessons learned in the food and beverage industry. Specifically, he discussed reasons for companies to disclose and be more transparent, to make goals and communicate those goals. He said many companies are looking to reduce risk by being more compliant and determine what kinds of environment and social elements are significant. One of the problems, he said, is that many global companies cascade down global goals into local areas without considering all the important local factors.

Walmart is one example of a large company that began looking into its own carbon and water footprints about a decade ago. "They realized 10% of their environmental impact was due to them [internal corporate factors]," he said, "90% was due to others in the supply chain." BlackRock recently sent a letter to many suppliers saying "the triple bottom line is here to stay." In other words, it's no longer just about finance. It's also about environment

> **We are creating the right conditions for companies to move foward and use different initiatives to incentivize farmers to do the right things.**
>
> - Marco Ugarte

and the social implications. A company's corporate procurement policy should accordingly change and evolve, Ugarte said.

The United Nations SDG 6 includes water availability, Ugarte said, and companies need to manage risks associated with water, including flooding. It's a common mistake for companies to look at themselves and their impact on water issues, without considering what of their own operation is embedded in the supply chain. It's important to address not only procurement but also change management — and, as a part of that, he suggested companies must actively engage with the community. Some companies have formed coalitions to look at challenges in manufacturing operation. "The true cost of water includes how much you're paying for water, but also all of the other elements you find in a detailed mass balance assessment," he said.

Ugarte said companies are starting to focus on efficiencies, including formulating white papers in the interest of self-regulation and getting ahead of the curve. "Many companies are trying to be more responsible," he said, "and they should do it based on what exactly are the conditions of the market." He referred to the new Alliance for Water Stewardship (AWS) standard that has been around for almost 2 years. Two months ago, Ugarte said, both the Nestlé and the Nestlé Waters subdivision, as well as PepsiCo, announced they will be AWS-standard-certified in all their plants across the globe by the year 2025. It will take time and money, he said, implying that these companies deserve credit for working toward water stewardship goals in spite of the costs.

"We are creating the right conditions for companies to move forward and use different initiatives to incentivize farmers to do the right things," Ugarte said.

Kelechi Chibukem, a graduate student at the University of Nebraska–Lincoln, shared information about a multidisciplinary team's attempts to design an affordable center pivot system for sustainable food production within a small community in Nigeria. He said most sub-Saharan African countries are faced with the challenge of food insecurity due to fast growing population, political instabilities and conflicts, and poor irrigation management practices. He believes this problem can be tackled by

introducing affordable irrigation systems in farming communities with proper water management systems.

Chibukem said because the Midwest region of the United States, including Nebraska, has become one of the most productive regions of the world with the introduction of center pivot technology, the team began looking at the same technology in a downscaled solar version as a possible solution. Chibukem said the project is exciting because there is an 80% yield gap in rainfed maize in his country, which provides a great opportunity for improvement. The ultimate goal is not just to feed people, he said, but to stimulate economic growth in the region.

The research team has considered span length and land area, crop selection, water demand, location of water sources, waterproofing of electricity, and other factors. They are looking at irrigating a one-acre farm using lessons learned in irrigation of much larger farms in Nebraska.

The team has been tackling multiple challenges as they arise. One key consideration, Chibukem said, is the battery, which is valuable enough that they must find ways to make sure it cannot be stolen. They've looked at other power alternatives, including diesel fuel, which presents a concern about creating a carbon footprint. Wind power is just as expensive as solar power.

Because costs were a concern with most of the alternatives being examined, the team began focusing on ways to cut costs. They considered manufacturing the pivot in-country instead of importing it from Nebraska, which would reduce expenses for materials, labor and transportation. But the cost was still prohibitive, and they are still looking for solutions.

The work of the team will culminate in Chibukem's final thesis. A member of the audience asked why the team looked at center pivot irrigation as a solution if they knew it would be costly, and Chibukem replied that the U.S. success with center pivot irrigation is too compelling not to look into it and see what lessons can be learned for Africa. Furthermore, he said, with the exploding population it is important to begin thinking big in addition to coming up with small solutions.

Water Footprint: How Light Are We Treading

April 30 | 10:30 a.m.

Concurrent Session

Moderator: **Christopher Neale**, Director of Research, Daugherty Water for Food Global Institute

Speakers:

Galen Erickson, Animal Science Professor, University of Nebraska–Lincoln

Landon Marston, Assistant Professor, Kansas State University

Mesfin Mekonnen, Post-doctoral Research Associate, Daugherty Water for Food Global Institute

Christopher Neale, Director of Research, Daugherty Water for Food Global Institute

Pasquale Steduto, Regional Strategic Program Coordinator, Food and Agriculture Organization of the United Nations

A complete understanding of a region's hydrologic system, current level of water productivity and water productivity gaps can be used to support producers in managing water, as well as decision-makers in developing scientifically sound, economically efficient and socially acceptable policies. Christopher Neale, director of research at the Daugherty Water for Food Global Institute led this conference session, which explored the use of local, regional and global data to estimate spatial and temporal variations of crop water productivity. "The genesis of this session was a realization that research is needed to better understand energy and economic efficiency," Neale said. "Farmers typically strive for the highest yield, but not the sweet spot for economics and water use."

Mesfin Mekonnen, a postdoctoral research associate with DWFI, discussed the water footprint of crops in

Christopher Neale, Director of Research, Daugherty Water for Food Global Institute

the context of the recently completed Nebraska Water Productivity Report. To provide context, Mekonnen shared that total irrigated area in Nebraska is the largest in the U.S. and almost equal to Spain and Egypt. Almost all the state's water comes from groundwater, and there are more than 100,000 irrigation wells. Nebraska's economy is dependent on the groundwater that supports agriculture. Because groundwater is so important, Nebraska producers have taken action to control groundwater depletion and pollution, and in most places in the state, groundwater drawdown has stabilized.

> **The genesis of this session was a realization that research is needed to better understand energy and economic efficiency. Farmers typically strive for the highest yield, but not the sweet spot for economics and water use.**
>
> - Christopher Neale

The report uses data from 2,000 Nebraska fields in three different natural resources districts within the state, illustrating farmers efforts to reduce irrigation application rates from 2004 to 2011. Farmers were successful in dropping rates by almost 50% due to a shift from surface irrigation to center pivot irrigation, as well as close control of soil moisture and irrigation application. The main objective of the report was to assess water productivity of crops and livestock at different spatial scales and use this as a learning tool for a future water productivity series covering other regions in the United States and the world.

There are three interconnected work components to the report that have become known as "Nebraska's Golden Triangle": (1) crop water productivity, (2) livestock water productivity, and (3) water, energy, carbon footprint of bioethanol from corn compared to sugarcane. The Nebraska Water Productivity Report used FAO's model to analyze productivity of crops with data coming from more than 200 weather stations.

The interesting thing about Nebraska, Mekonnen said, is that precipitation is highly variable, dropping from east to west, and soil also changes from east to west. In other words, farmlands are more fertile in the eastern part of the state than they are in the western part. This has an indirect effect on water productivity. In addition to this variability, he explained that

> **Everything is connected. The action we take on crops will help livestock and the system as a whole.**
>
> - Mesfin Mekonnen

different people use different indicators when talking about water productivity, and this must be considered in any study or decisions made.

In Nebraska, water productivity has increased significantly on average due to two factors: yield and evapotranspiration (ET). Yield has increased significantly over the last 30 years, and ET has not showed any decline. "The question is whether this water productivity will continue," Mekonnen said. "Everyone expects a yield plateau where we reach maximum yield."

According to Mekonnen, one thing is clear across the state with the two crops that were studied for the report — irrigated crops have a higher water productivity as opposed to rainfed crops. This differentiation is also an opportunity to increase water productivity through agricultural management. This can be done, he said, by setting a benchmark to help identify water productivity gaps. He explained, "We need to identify different agro-productivity zones depending on agro-climatic conditions related to soil, precipitation, and other aspects of the different regions."

During the question-and-answer period, Mekonnen said that much of the yield increase we have seen is due to completely different crop varieties than farmers were using in the 1990s. Also, plants are planted closer together compared to earlier periods, for example, which reduces ET. A member of the audience pointed out that plant breeding has even improved yields through changing biomass in the plants from leaf to grain.

Overall, there is a need to compare what is possible with what is existing in the different zones (the water productivity gaps). There are larger gaps for rainfed crops than irrigated crops, and closing the gap means either "increasing yield at a given ET or reducing ET at a given yield." Mekonnen said we need to close water productivity gaps without putting additional pressure on water resources if possible. As a segue to the second presentation, he pointed out that reducing water productivity for crops also reduces the water footprint of beef due to the water the animals consume. "Everything is connected," he said. "The action we take on crops will help livestock and the system as a whole."

Galen Erickson, an animal science professor at the University of Nebraska–Lincoln, shared information about the water productivity of livestock. This is important, he said, because it speaks to how farmers can make better feed choices, reduce feed waste,

increase productivity, and reduce the water footprint. In the livestock industry, pork and poultry have a higher water use efficiency than beef by far, and producers realize consumers might choose pork and poultry over beef. Overall, since the 1960s, according to Erikson, beef producers are getting more efficient.

Galen Erickson, Animal Science Professor, University of Nebraska–Lincoln

Erickson presented graphs showing that beef takes significantly more water per unit of beef production than other agricultural livestock products when looking at both human edible and inedible products. When looking only at human edible products, beef becomes much more competitive from the perspective of water footprint. However, when it comes to water productivity, beef doesn't do well. "And that's why I wanted to look at this to see what we can do," he said.

According to Erickson, one problem in studying these conditions is that available literature includes a high number of variations in conditions that lead to water productivity. "Most people won't go look at the variations and why they are different," he explained. Some of the variations in water productivity of beef he cited included grazing versus pen feeding versus a combination, including different times spent in each combination; the water footprint of different feed ingredients; and different definitions of animal products. "It's not uniform," he said.

Erickson provided a detailed view of the complex and segmented beef industry. Beef is much more diverse than pork and poultry, he said. There are many different ways to raise cattle, including grass-fed and grain-fed animals, and many different considerations go into understanding what helps or hurts the water footprint. Some of the findings are surprising. For example, he said most people believe the feedlot is the worst phase of cattle production in terms of energy used, greenhouse gases, etc. "But this is the most important phase in reducing the water footprint," he said. In the end, the goal is to increase production without increasing the number of cows.

The project Erickson and his colleagues have been working on calculated a water efficiency scenario

for beef production around a system where cows are grazed on ranches in the Nebraska Sandhills. Results were segmented between different phases of raising cattle: for cow and calf together on the ranch, raising the calf after weaning, and providing a finishing diet. Based on trial work at the university, water used during these three phases adds up to about 1.75 million liters, resulting in animals with a 420 kg carcass. The research group will use this as an example to calculate all the feed input and run hundreds of other scenarios looking at different ways beef can be produced. Again, it's important to remember livestock water productivity is closely linked with crop water productivity, especially in so far as cattle are often fed on corn stock residue.

Erickson reminded participants that this study considers meat products only — there are many more products that come from the raising of cattle. In fact, he said during the question-and-answer section that he believes many changes will not come about until food companies change what they are doing. According to Erickson, producers have addressed sustainability as far as water and air quality, but water use efficiency has not been on the radar of most beef producers yet.

So, the next natural question is, how can producers use data such as that in the Nebraska Water Productivity Report to make decisions. Pasquale Steduto, former FAO regional strategic program coordinator and a researcher involved in the FAO AquaCrop modeling framework, explained a proposed grading system that is designed to express crop water productivity (CWP) in a standardized

Pasquale Steduto, Regional Strategic Program Coordinator, FAO

way: the Water Productivity Score (WPS). The WPS provides normalization criteria to address variability and thus allowing comparisons between 'zones' within different scales (local, national, global), in a relative ranking.

He presented details of the methodology, including the key measure for meeting increasing food demand and coping with water scarcity: the combined increase of productivity per unit of land and per unit of water consumed. In the end, so far, the scoring has shown that, because of variabilities of many types, you can produce the same yield with different amounts of water consumed, as well

as producing different yields while consuming the same amount of water. The point, he said, is to be able to understand the variabilities and sources (e.g., evaporative demand of the atmosphere, yield, soil type, crop variety, pests and disease, fertilization, etc.) on local, farm and global levels and then make decisions on how to respond.

"We thought one of the first things we should do across different climatic zones was normalize for climate," Steduto said. With normalization, the study showed that different crops are similar in crop water productivity. Using a minimum and maximum of variability that represents two extremes of a variation that has been observed, the team proposed a grading system of 1 to 10, with 1 being poor and 10 being excellent. The scoring can be adjusted to fit the situation, and it's useful for setting baselines and targets – also for benchmarking and monitoring. "It can identify hot/bright spots with both low and high CWP for a focused diagnosis of constraints and best practices," Steduto explained. "It's a robust instrument for monitoring over time and for facilitating discussion between stakeholders and decision makers."

During the question and answer period, Steduto shared his opinion that reporting water productivity at a high level of aggregation (e.g., GDP/water withdrawals) is not appropriate because of the confounding effect of variability. He suggested disaggregating the data and going back to look at it more carefully. However, the point of the scoring system (WPS) even with aggregated data, he said, is to provide a basis for analysis and debate, to take into consideration the different variables and understand them.

Landon Marston, an assistant professor at Kansas State University, shared information about a current project that looks at what would happen if water users adjusted their water productivity to match a calculated benchmark. The question is how much water could be saved and how it would be saved. A study published last year used data from hundreds of sources to synthesize a spatially explicit and distinct industry mapping of the U.S. economy's water consumption. Findings showed that agricultural products have a tremendous amount of water usage and agricultural industries are the only industries that use more water than the national average. However, as the other speakers in this section emphasized, there is a large amount of variability in data between sectors and also within sectors.

The study also looked at how economic water use varies across the country. Marston shared a diagram showing the top water user in every county in the United States. In seven out of every 10 counties, agriculture was the top water user, and he said the ratio might be even greater if we aggregated all agricultural industries together. Interestingly, only about 300 counties consume about three-fourthsof the water used.

The data also provides insight into whether industries depend on water use directly (within their operations) or indirectly (through their supply chain vendors). "Ninety-three percent of sectors we studied use more water indirectly than directly,"

Marston said. For this reason, he explained that some larger companies such as Coca-Cola and Kellogg's are working with suppliers to reduce their water footprint through the supply chain.

The original question posed by the study related to how much water could be saved if all water users adjusted to a benchmark. Researchers looked at drivers of variability in public water supply water use across the contiguous U.S., and they found several factors that could lead to variations in water use. One of the causes they inferred was climate, and they used NOAA climate data to constrain the analysis. For crops, they used a little different approach based on a paper published around 2012 about closing yield gaps with different inputs.

In summary, Marston said the greatest water savings can be achieved in the agricultural sector. "Looking at it by region, you can see the greatest amount of water savings, and see how crops could be changed in water stressed regions to achieve greater water savings." The study also looked at how much water would be made available for other uses, such as for reservoirs and environmental purposes.

> **We need to talk about incentive structures that may be used, different industries' pricing structures, and different management practices — to explore the inherent trade-offs involved in improving water utilization.**
>
> - Landon Marston

Marston said. "A lot of times when you hear these research projects, it's doom and gloom, but there is still a significant water savings available through the U.S. and the areas of the most potential savings are also where there is the greatest amount of water stress."

Future research is needed, he said, because we know water savings can be achieved but we don't know quite how producers, manufacturers and others are achieving it. "We need to talk about incentive structures that may be used, different industries' pricing structures, and different management practices — to explore the inherent trade-offs involved in improving water utilization."

(L-R) Jesse Bell, Ravinder Kaur, Rachael McDonnell, Eduardo Martins and Mark Svoboda

Drought Early Warning and Risk Management: Provision of Tools and Services for Informed Decision and Policy Making

April 30 | 10:30 a.m.

Concurrent Session

Moderator: **Mike Hayes**, Professor, School of Natural Resources, University of Nebraska–Lincoln

Speakers:

Jesse Bell, Claire M Hubbard Professor of Health and Environment, University of Nebraska Medical Center

Ravinder Kaur, Principal Scientist, Indian Agricultural Research Institute

Eduardo Martins, President, FUNCEME, Brazil

Rachael McDonnell, Principal Researcher, International Water Management Institute

Mark Svoboda, Director, Associate Research Professor, National Drought Mitigation Center, University of Nebraska–Lincoln

According to Mark Svoboda, director of the National Drought Mitigation Center and research professor at the University of Nebraska–Lincoln, drought is a globally wicked issue. Although much progress has been made over the past decade in helping to transform science into useful and usable information, the question is now what? How do we provide drought-related services that better inform decision makers and policymakers?

In this panel session, researchers shared case studies of drought monitoring and mitigation projects, tools, information and services being provided in arid regions around the world, such as the Middle East/North Africa (MENA) region, Brazil, India and the United States. The session was moderated by Mike Hayes, Professor, School of Natural Resources, University of Nebraska–Lincoln.

Case study: National Drought Mitigation Center

Svoboda said the purpose of the National Drought Mitigation Center is to translate science to the public, making it understandable and not just useful but usable. The center was founded in 1995 with a mission of applying services throughout American states and around the globe, having worked with over 60 countries the past 20 years. Work has been done following three pillars of drought risk management: 1) monitoring and early warning, 2) policy and planning, and 3) vulnerability and risk assessment. The center works in partnership with many different groups to develop these three pillars.

The U.S. Drought Monitor (USDM) was one of the first products developed by the NDMC in partnership with the U.S. Department of Agriculture (USDA) and the Climate Prediction Center at the National Oceanic and Atmospheric Administration (NOAA). More than 425 people contribute drought monitoring information each week for the USDM and many use the monitor to assist them in early warning and policy. "We let science drive decision-making," Svoboda said, "and our overall purpose is preparedness." Only 4% of the U.S. is in drought right now, according to Svoboda, which is historically low. He said it usually runs around 10% to 15%.

Planning tools are part of the services provided by the drought center. Drought planning tools are available at all scales for a variety of users, from an individual producer to a community to water planners, as well as states and countries. In addition, the center is working in MENA and southern Africa helping governments turn hotspot maps into policy and planning. "We want to help locals run with it themselves and sustain operational monitoring and drought planning as they go forward," Svoboda said.

Case study: Mapping drought in Brazil

According to Eduardo Martins, president of FUNCEME in Brazil, Brazilian states are not seeing as much drought severity as they have previously. Just 30 of its 108 cities are still in high-risk areas. The organization is setting up a drought monitoring network and reaching out to stakeholders, working with the agricultural secretary to provide information.

Eduardo Martins, President, FUNCEME

This network started with a few states in the northeastern part of the country and they are now working to bring the whole country together.

The organization uses information on a regional scale to provide benefits. For example, states are automatically included in the national civil defense water truck program. There is also a harvest insurance program. Martins said Brazil has a great number of small reservoirs for which they have no information – there are more than 30,000 small water areas in total. "The remote sensing folks could help us with monitoring that," Martins said.

He stressed that it's important to come up with drought diagnoses that account for downstream needs. "We have to work at the scale of sector," Martins explained. "We have to work with the sector itself and help them map it as best we can." The organization is conducting a new study to help. Martins emphasized that it's important to get the right players to start the process and to build a strategy with those who are already involved. Among other things, it is critical to demonstrate to those players why it's important to have this information.

Case study: Monitoring drought and building resilience in the MENA region

The International Water Management Institute is bringing drought monitoring and management solutions from Nebraska to MENA (Middle East and Northern Africa). It can be a challenge, because

> **We are preparing plans now in a calm, nonpolitical way, because when drought comes there is a lot of finger pointing and we need to be able to agree where to turn off water when needed.**
>
> - Rachael McDonnell

drought in each MENA country is very different, according to Rachael McDonnell, principal researcher for the institute. McDonnell is working on a project with Nebraska's NDMC and Daugherty Water for Food Institute to tackle drought risk management in the MENA region. The project's first pillar is to set up an operational Composite Drought Index (CDI)-based drought monitoring system for each of the four countries. "Now we have to validate it by working in the countries and asking if it is how they are experiencing drought in that year," McDonnell said. The Institute is drawing from the U.S. Drought Monitor experience to set up validations.

> **We need to understand both personal and government social costs. We need to be able to put this in front of the Minister of Economy and say 'This is how much we can save if we do this.'**
>
> - Rachael McDonnell

The second pillar of the project is looking at vulnerability and impact assessments – what is being impacted and why. It's political, according to McDonnell. All four countries in the project have received numerous refugees, and the organization is looking at what the challenges are, including local policies, and how they are going to complete assessments. "We need to understand both personal and government social costs," McDonnell said. "We need to be able to put this in front of the Minister of Economy and say, 'This is how much we can save if we do this'."

The project's third pillar involves mitigation, preparedness and response. In some places there is no declaration of drought. In others, farmers are using crop species that are not resilient. It can be a challenge to get ministers to agree what each will do in a next drought and how to get financing. "We are preparing plans now in a calm, nonpolitical way, because when drought comes there is a lot of finger-pointing, and we need to be able to agree where to turn off water when needed." She said it is important to build slowly and make sure they are building strong foundations.

Case study: Drought monitoring, policies in India

In 2008, India drafted a standard drought protocol manual and began monitoring drought throughout different areas based on available data. However, it was difficult to monitor, and it could take a long time for the funds to be released. In addition, the

data was unreliable, because technology had not advanced enough to show actual conditions in small areas. Part of the problem, said Ravinda Kaur, principal scientist for the Indian Agricultural Research Institute, is that drought in different areas of India doesn't follow standard criteria.

> **Floods kill people, but droughts destroy civilizations more than any other climate or weather-related disaster.**
>
> - Jesse Bell

Also, according to Kaur, "The standard [for the protocols] was set by stakeholder participation and there was a lot of subjectivity, which limited practical applications across the states." The drought protocols called for money to be given to states before action was taken. Then, the protocols were sometimes dropped or taken too casually, and states were not following the guidelines.

In 2016, the Indian government decided to create a less-subjective India drought monitor through a memorandum of understanding with the University of Nebraska–Lincoln. The protocol was implemented in 2018. States were required to follow the protocols and only then receive the money. On-the-ground descriptions of drought were verified using advanced sensor technology that could show actual conditions in small areas. "The new protocol shows this with remote sensing, so people get funding according to their real need – that is the goal."

Case study: Drought as a public health threat

In the United States, we don't think of drought as a human health threat, said Jesse Bell, Claire M. Hubbard Professor of Health and Environment at the University of Nebraska Medical Center. "But we know it has economic impact in communities and states," he said. "Floods kill people, but droughts destroy civilizations more than any other climate or weather-related disaster."

Bell shared several diagrams showing how drought causes human health outcomes. For example, drought causes an increase in dust storms, which impacts health. Behavioral contexts are important as well, he said. Populations in crisis are vulnerable, and it is important to try to understand what they are going through. Drought can cause alarming mental health and behavioral issues, such as suicide.

Bell was involved in a series of public health interventions, during which researchers attempted to understand some of the links between drought and public health. He helped provide materials to community leaders, including a guide for preparing for drought at different stages on a local level. The

data were presented in an easy-to-access fashion, so local government officials could easily understand it and really use it. Bell urged researchers and policymakers to produce better drought information on a state and local level.

Panel Discussion

After the presentations, Hayes asked a series of questions to gain additional insight into the organizations and projects.

What is one big obstacle that stands in the way to your next steps?

Several answers related to communication: sharing information, working across political boundaries, gaining access to data, and creating awareness so people know when a drought is coming. In India, accuracy of data is a challenge, and Svoboda said it can be difficult to understand the "hydro-ILLOGICAL" cycle that happens during a crisis. "That's why we are preaching a proactive crisis-mode response," he explained.

What are innovative ways people can contribute and share data?

Panel members offered the following ideas for data collaboration.

- The hashtag "#drought2017" was used in North Dakota and South Dakota to give people affected by the drought a voice. It is now possible to look at tweets and survey activity on smart phones to examine agricultural and environment conditions over time. (Svoboda)
- We are looking at how to put data into a form insurance companies and crisis funds can use to make payouts. In part, this means sending people who are trained in drought to do the assessments in the field – assessments currently are sometimes done by untrained assessors, such as military personnel. This is also important because if we can get funding out quickly farmers can buy the seed and fertilizers they need for the next season, so the drought doesn't also impact the next season. (McDonnell)
- In India, it is a dream to consolidate data in one place. That's easy to say but difficult to make a reality. How do we accommodate all the diversity and vastness of the country, but have an exceptionally good organizational structure, one that is based on credible data? (Kaur)
- We are looking at other data networks to learn how others are handling volunteers who provide the data. We also are doing some text mining, but we have to be careful how we use that kind of data. (Martins)
- Large data sets for health are rare, so we are working to try to pull out better insights. One way is examining multiple data sets to show relationships between them. Surveys were done of public health officials to hear what is really going on and then compare those answers with the available data. (Bell)

Data collection can be useful for understanding the past, but it's difficult to project into the future. How do we make projections into the future, and is it even possible?

- We are looking at current hotspots for climate change, such as consecutive dry days, that can help researchers create models for the future. We are also looking at crop models to try to build in resilience. (McDonnell)
- Health is hard to project, but we need to focus more on it. The EPA has been projecting things like wildfire and dust, which are associated with drought but don't have direct health impacts. We can learn from that and are excited to see where it will go. (Bell)
- We have been doing studies on climate change and how it impacts water and agriculture. We don't use those models to predict drought, but we determine the correct basis of droughts. We can look at things like the increasing number of consecutive dry days and how it relates to crops. (Martins)
- It's hard to see drought before it becomes a big problem, but we need to monitor it. Baselines are changing and the signs are here, but people often ignore them. We have to keep fighting the good fight. Some are including drought in other planning activities, and we can provide references and guides to help them. (Svoboda)

What is the social aspect of drought? How can we make society more aware?

- Although some places in the world might not have much social intervention in regard to drought, some places do have cell phones where they did not previously have them, and that is a powerful tool for sharing information. People are providing info from their cell phones with pictures – and also posting on social media. Private companies and NGOs are monitoring these things and seeing how it's affecting crops and livestock. (Svoboda)
- We are working with farmers unions, for example, and working with the media to understand what drought is. We are also working with insurance companies and banks to persuade them to work with farmers who cannot make payments during droughts. Communication about drought is good. (McConnell)
- We are working with policymakers, and they are taking it seriously and responding to us, because we're giving them hope that is provided by technology. (Kaur)
- We want to reach out to hospital associations this year to bring them aboard and help them understand the impacts of drought. (Bell)

Business Models for Smallholder Irrigation

April 30 | 1:30 p.m.

Concurrent Session

Presenters:

Samuel Adewole, Co-Founder, Volta Irrigatio

William Shyaka Bakunda, Entreprenuer and Farmer, Rwanda

Charles Kwarteng, CEO and Co-Founder, Volta Irrigation

Grace Mukarusagara, Irrigation Consultant, Daugherty Water for Food Global Institute

Fabien Ngoga, Rwanda Project Coordinator and Country Representative, European Cooperative for Rural Development

Petra Schmitter, Research Group Leader, Agricultural Water Management, International Water Management Institute

This conference session was in a "world café" format, showcasing early-stage business models and technology options for expanding African smallholder access to irrigation. DWFI has been working with several of the featured presenters on an analysis of entrepreneurial approaches to smallholder irrigation service provision in Rwanda. The focus of this work is to understand from a business perspective the key constraints to scaling irrigation quickly, as well as how alternate business models generate value for smallholders.

Volta Irrigation: Mobile battery-powered pump – and loans

Charles Nana Kwarteng and Samuel Adewole explained the business model of Volta Irrigation, an agritech start-up launched by five young entrepreneurs in Rwanda. Volta uses a mobile battery-powered pump charged through a bicycle-like unit to provide irrigation services. It pairs this with loans for farming inputs to ensure a profitable harvest and receives a share of the revenue after

Attendees participate in round table discussions about business models for smallholder irrigation.

harvest. Interestingly, Charles is from Ghana and Samuel from Nigeria – they met in Rwanda and saw the gap in finance for irrigation as a business opportunity.

AgriRain: Irrigation equipment and mobile service

Jyoti Gaddam Pulla described a similar model that AgriRain is planning to implement in western Ethiopia, where her family lives. This area usually has good rainfall. Farmers grow only maize, but they are introducing a second, nitrogen-fixing pulse crop that uses residual moisture and only one to two irrigations. AgriRain is an Indian irrigation equipment manufacturer that also offers a mobile irrigation service. The company trains local youths to operate the machines and collect yield, temperature and soil moisture data, which is fed into an app to calculate irrigation requirements.

IFC and EUCORD irrigation service subsidies

Fabien Ngoga described another irrigation service business model being tested in Rwanda: supporting farmer cooperatives with financing, combined with extension services and management support. The Rwandan government offers a 50% subsidy for small-scale irrigation technologies, but even with this support, irrigation remains too expensive for most smallholders. The International Finance Corporation (IFC) has partnered with the European Cooperative for Rural Development (EUCORD) to build on the government subsidy by offering a loan covering 40% of the cost, leaving just 10% to be paid upfront. The partners are testing multiple irrigation technologies in a pilot program including sprinklers, rain guns, drip equipment and hoses. Ngoga discussed how large-scale adoption will depend on being able to reduce costs, as well as understanding which technologies work best for participating farmers.

International Water Management Institute solar irrigation pump business models

International Water Management Institute (IWMI) researcher Petra Schmitter described recent work identifying three possible business models to scale

Grace Mukarusagara, Irrigation Consultant, Daugherty Water for Food Global Institute

up the use of small solar irrigation pumps. The three models are: (1) provision through cooperatives or by an agribusiness through an outgrower arrangement; (2) linking the technology-supplier to a credit institution using pay-as-you-go to recover the cost; and (3) linking the purchase of a pump to credit insurance to reduce risks. IWMI plans to pilot these models in Ghana and Ethiopia.

Changing perceptions of farming in Rwanda

William Shyaka Bakunda is a Rwandan who grew up in Switzerland. He returned to Rwanda in 2014 to start a business. He purchased 15 ha and developed an irrigated farm producing mangos, citrus and avocados. His goal and passion is to change the current negative perceptions of farming in Rwanda. He described the challenges and opportunities of agricultural entrepreneurship in Rwanda.

Grace Mukarusagara, currently a DWFI consultant, described an entirely different pilot: in 2014, the Rwandan government purchased 37 center pivots, which irrigate about 500 ha cultivated by about 500 farmers. Each pivot has 1 to 60 farmers, depending on holding size (most are under 1 ha). Mukarusagara said farmers are not paying the full operational costs, which can be very high. Some with larger holdings are doing well and beginning to rent land from smaller farmers. Outcomes in terms of agricultural productivity and profitability have been highly variable, with some irrigated fields integrated successfully into international export markets and others struggle to produce any crops.

Case Study: Smallholder Irrigation in Rwanda

The Daugherty Water for Food Global Institute (DWFI) at the University of Nebraska and its partners are working to find the best models for sustainable irrigation in Rwanda, while looking for potential opportunities to scale these models in other African countries.

DWFI's research includes case studies of the following business models:

- Irrigation as a Service
- Small-scale Irrigation Technology Subsidy
- Government Funded Irrigation
- Cooperative-Owned Irrigation

Cost-effective scaling of smallholder irrigation could unlock increased crop production and result in a more stable income for the bulk of the population. DWFI is helping develop the next generation of farmers and entrepreneurs to make this bold dream a reality.

(L-R) Brian Krienke, Martha Kauffman, Richard B. Ferguson, Matthew Helmers and Chittaranjan Ray

Keeping It Fresh: Protecting Fresh Water Quality and Mitigating Pollution

April 30 | 1:30 p.m.

Concurrent Session

Moderator: **Mike Hayes**, Professor, School of Natural Resources, University of Nebraska–Lincoln

Panelists:

Richard B. Ferguson, Vice Chancellor, Rwanda Institute for Conservation Agriculture

Matthew Helmers, Director, Iowa Nutrient Research Center, Iowa State University

Brian Krienke, Assistant Extension Educator, University of Nebraska–Lincoln

Martha Kauffman, Managing Director, Northern Great Plains, World Wildlife Fund

This session featured case studies of regions where agriculture has had significant impact on water quality. Brian Krienke and Matthew Helmers spoke about their work in Nebraska and Iowa, respectively, sharing recent advances in nitrogen management that rely on both technology and policy. Martha Kauffman, Managing Director, Northern Great Plains, for the World Wildlife Fund, talked about the

importance of grasslands and the benefits of converting crops back to grasslands. Richard Ferguson spoke about his recent work in setting up the Rwanda Institute for Conservation Agriculture, which will teach and eventually research and extend conservation agriculture principles that impact water quality, including soil erosion and loss of productivity. The session was moderated by Chittaranjan Ray, Director of the Nebraska Water Center.

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>
> - Brian Krienke

Challenges in reducing nitrate contamination in Nebraska

According to Brian Krienke, an extension educator with the University of Nebraska–Lincoln, nitrate contamination is in some areas of Nebraska's groundwater due to commercial nitrogen fertilizer applied to irrigated acres. Determining factors of nitrate contamination include management, cropping systems and soils. Corn requires nitrogen to grow, and water has to be added; nitrogen fertilizers leach even more with some corn types. The eastern part of the state requires more irrigation and is more likely to leach because of the type of soil, so there are more danger zones in the eastern part of the state.

Krienke said the level of nitrate is lowering due to efforts to reduce contamination, but the levels are beginning to plateau, and producers are not achieving additional gains in corn production.

"It's a guessing game — you have to make choices," Krienke said. "And there are lots of aspects to determining when to apply fertilizer and how much to use. Expected yield generally exceeds actual yield, and we are over-applying but not gaining efficiency – supply is not aligning with demand." He added that farmers are applying nitrogen sometimes when it's most vulnerable, such as when rain is falling. Early warning systems using sensors can help detect when the plant is stressed and nitrate content is decreasing to help farmers better synchronize.

Krienke shared information about two projects Nebraska Extension is working on related to water quality and mitigating pollution. In the first project, sensors improved nitrogen efficiency and also increased profitability for the producer. A model showed this would happen 62% of the time. The second project, a fertigation research project, involved a pivot irrigation system with split application. Researchers used an algorithmic

approach to determine how much nitrogen was needed, then used a suite of different fertigation treatments. A computer approach, with a predictive model, shows that fertigation methods were more profitable than "the old standby."

The conclusion was that cropping system changes would have the largest effect on nitrogen contamination reduction. "The system needs to take the nitrogen off the land for a period of time," Krienke said. "We also need to stop all fall applications and we must maintain cover crops." The department is establishing several standardized long-term irrigation management studies across the state, and Krienke said the team will be constantly embedded in the communities to accurately validate results.

Nitrate reduction plateaus in Iowa studies

In Iowa, there is a great deal of focus on surface water and private drinking wells that show high levels of nitrate contamination. According to Matthew Helmers, director of the Iowa Nutrient Research Center at Iowa State University, there is increasing concern about both urban and rural wells. The Des Moines Waterworks, for example, recently filed suit against counties in Iowa in an attempt to get them to reduce nitrate levels, and an effort was made to reduce nitrate loads on the Mississippi River by 45%, but that goal was not reached. There was a call within the state to come up with state-level strategies to meet those goals.

Helmers discussed different opportunities the state of Iowa may have to reduce nitrate levels:

> **We would almost have to go to no nitrogen at all to reach 45% reduction. No one single practice will get us there, unless we convert all acres back to a perennial system.**
>
> - Matt Helmers

- Tile drainage and subsurface drainage in some places deliver water directly to surface water bodies. New technologies may be used to remove nitrate from runoff before it reaches the water bodies.
- More diversified cropping could help with nitrate loss. In Iowa, soybeans have replaced some secondary crops, such as alfalfa
- The state began looking at nitrate management strategies that include edge-of-field practices.
- Some producers tried applying nitrogen in the spring as close as possible to when the crop needs it. But, Helmers said, in Iowa they have not seen the benefit of this.
- Lower nitrate levels have been seen with the use of subsurface drainage bioreactors, carbon filled trenches with woodchips.

- Wetlands used specifically for nitrate removal purposes may help. Water is routed through the wetlands to capture flow. "Taking 1% of the land to reduce nitrate 50% is attractive," Helmer said.
- Drainage water recycling reuses nitrate-saturated water for other crops.

Helmers revealed that nitrate levels remained similar, even when nitrogen was not applied at high levels. "We would almost have to go to no nitrogen application at all to reach 45% reduction," he said. "No one single practice will get us there, unless we convert all acres back to a perennial system." He was referring to the fact that there is less nitrate loss in prairie than in corn, and researchers are wondering what we may be able to learn from that.

Helmers pointed out that the benefits of nitrate reduction go beyond mitigating pollution. "It could pay off in other ways that might be worth it: improved local water, protected soil, employment opportunities, [and] more diverse landscapes," he said.

Studies in limiting grassland conversion to conserve freshwater

Grasslands are a critical part of conserving freshwater in the Mississippi basin where nitrogen pollution is mostly coming from cropland areas. In the Northern Great Plains, the root systems of prairie plants are holding everything together. "The benefits of this prairie ecosystem include CO2 storage, wildlife habitat, filtering and storing water, food (beef) and livelihoods," Martha Kauffman said. She is managing director, Northern Great Plains, for the World Wildlife Fund. The biggest threat to the system is conversion from native grasslands to croplands. "Grasslands are going away fast, exceeding the rate of the Amazon, so we started tracking it."

The correlation between soil quality and conversion is important, Kauffman said. In marginal soils, the amount of nitrogen required goes up, and so does the potential impact on water. Impacts include released CO2, habitat loss, increased nutrients, decreased diversity, and shrinking communities.

The World Wildlife Fund asked the question, "What if remaining soils of the Missouri River Basin were limited in conversion?" They ran two scenarios to test conversion of cropland: (1) a crop and grassland mix, and (2) a grassland conversion. They found that good-quality soils could be converted back to grasslands or a crop/grassland mix successfully.

> **The benefits of this prairie ecosystem include CO2 storage, wildlife habitat, filtering and storing water, food (beef) and livelihoods.**
>
> - Martha Kauffman

Drivers of conversion are likely to be economics of farming versus ranching, a policy safety net for farming versus ranching, and other human dimensions such as age, lifestyle, etc.

Kauffman said possible solutions are varied, but, no matter what we do, we need to remember the importance of grasslands. She urged a leveling of the policy playing field with initiatives such as communicating recognizable benefits and costs, providing technical assistance, establishing easements, and working on a conversion-free supply chain.

The new Rwanda Institute for Conservation Agriculture

Rwanda is one of the smallest countries in Africa and would fit inside the state of Nebraska. However, there are 1,200 people per square mile in Rwanda and only 12 people per square mile in Nebraska. In Rwanda, people are simply trying to survive day to day. "People still farm on slopes and everywhere to survive," said Richard B. Ferguson, vice chancellor at the Rwanda Institute for Conservation Agriculture. There is some terracing in the country, but erosion is something they just have to live with. Rainy seasons are their growing seasons, and they can add a third growing season with irrigation – but rainy seasons also are the peak of erosion. In addition to nitrate concerns, the country is challenged by soil erosion and sewage/manure discharge.

"These are nutrient starved systems and sediment loss causes not just health issues but also impacts the ability to grow crops to meet food needs," Ferguson said. He explained that constructed rock drains carry water away with sediment in it, which causes urban soil erosion and sediment loss, which equates to a loss of livelihoods. There is also a loss of capacity to handle human and livestock waste. For example, in a milking parlor livestock waste is swept onto an apron, then it goes down a ditch into the stream. "You go several miles down and people are getting water out of the stream," Ferguson explained.

Ferguson is helping to launch the Rwanda Institute for Conservation Agriculture near Kigali, Rwanda. He shared slides showing the beginning class with 84 students. The hope is that education will help maximize productivity and profit, as well as impact environmental quality. Students will likely live and work on farms. The campus is currently under construction. Even on campus, the students are building dikes in drains to prevent erosion.

Panel Discussion

What about the soil biology piece in Iowa and Nebraska?

Crop rotation could help improve soil health and also could take up nitrate. In one no-till site, we saw almost the same nitrate loss, even though there are a lot of other benefits to no-till. Some of the practices we have can be beneficial for mitigating pollutants, but not for other factors in soil health. (Helmers)

Brian Krienke, Assistant Extension Educator, University of Nebraska–Lincoln

Sweden struggles with water quality near the marine environment. How do you intend to do these things to scale?

We have tools to make measurable gains, but the question is how do we accelerate the level of adoption? We need to go faster. Incentives and cost share programs have helped, but that will not be enough. We will have to look at different mechanisms integrating livestock and cover crops. For example, we might have livestock grazing and cover crops as incentive to participate. (Kauffman)

Natural Prairie is used to protect the Mississippi River watershed. What is the incentive for landowners who want to plant those areas and get a profit?

We are focused less on restoring and changing what people are doing and more on keeping what's left in grass. There's an argument against restoration in low-quality soils and there is also a financial incentive possible for native seed. We need to do something to help some people stay in business and do things like protect the habitat of birds. Some are partnering with large companies that will pay producers for ecosystem benefits they can measure. It's a big challenge, which is why there are not many of them. (Kauffman)

We're working on developing prairie strips over a small portion of fields with cost share programs. We're also looking at ROI on parts of the field such as depressions. We continue to input there, even though we are losing money – maybe putting some of those areas into native vegetation would have benefits other than subsidies. (Helmers)

What are the main lessons Rwanda can learn from Nebraska? What is the university doing?

They are not that different from farmers in Nebraska. One problem is that major projects come with subsidies. It's valuable for new ideas, but it's not good for sustaining agriculture over the long term. Farmers will always keep doing what impacts them and is good for them – or on some level they will do what helps the environment. We are trying to set up ways to make extension effective, conveying knowledge in ways that are meaningful and understandable. (Ferguson)

View From the Field *April 30 | 3:30 p.m.*

Concurrent Session

Moderator: **Leticia Obeng**, International Advisory Panel member, Daugherty Water for Food Global Institute

Panelists:

William Shyaka Bakunda, Entreprenuer and Farmer, Rwanda

Dean Eisenhauer, Professor Emeritus, University of Nebraska–Lincoln; Farmer, Nebraska

Grace Mukarusagara, Irrigation Consultant, Daugherty Water for Food Global Institute

Jerry Stahr, Farmer, Nebraska

Elisa Zancanaro Zanella, Farmer, Brazil

This unique conference session allowed farmers and those who work directly with farmers to share their perspectives on using technology and innovative practices to improve resilience and sustainability. The session included farmers from Nebraska, Rwanda and Brazil. The session was moderated by Letitia Obeng, International Advisory Panel Member, Daugherty Water for Food Global Institute

Presenting farming in Rwanda as a valid entrepreneurial choice for youth

William Shyaka Bukunda is just shy of 25 years old. When he was young, he was sent to Switzerland during Rwanda's political upheaval. During that time, he visited many farms in Europe. Now back in Rwanda and working his own farm, Bukunda is a strong advocate of younger people farming. He encourages young Rwandans to become involved in agriculture, not as a way to reduce poverty or help women, although those are respectable causes

William Shyaka Bakunda, Entrepreneur and Farmer, Rwanda

and many of his employees are women who are trying to make life better for themselves. Instead, it is important, he said, to view success as an entrepreneur. Showing that one can have prestige

and economic success as a farmer is crucial to attracting youth to become involved.

"This is a business and is something I can do to help my own family," he explained. He also believes promoting farming as a business in Rwanda is a good way to improve the country's image.

Rwanda has some of the highest population in Africa per capita, and the people are very poor, Bukunda said. There is not enough land for everyone. Most farmers in the country irrigate by gravity, but some fields use water pumped from lakes up the hills to farms. Bukunda said he knows how much water is being applied to his fields by gauging how many minutes the tap is open. Recently, he learned about soil conservation using cover crops.

Nebraska hobby gardener learns the power of labor and marketing

Before retirement, Dean Eisenhauer was a hobby gardener and a professor who worked with DWFI and Delft University. After retirement, he launched an organic market gardening business called Arbor Grove Produce, located on his farm that has been in the family for 128 years. He has enjoyed his farming business but admits there are a host of problems that must be dealt with, even for a small farmer. In the process of transitioning from a hobby farmer to a producer at a larger scale, he used cover crops and experimented with different types of irrigation from drip to sprinkler.

His challenges have included:

- Maintaining the farm's organic status. He began organic gardening with alfalfa to maintain his status.
- Labor supply as the farm gets bigger. "High school kids did not want to do the work," Eisenhauer said. He first sold his products at a farmer's market, and then sold to a couple of grocery stores. He also provided produce for the Food Bank of Lincoln. It was a lot of work to harvest, sort and load, and he could not keep up with this on his own.
- Spray drift. It can be a problem to overcome the effects of surrounding commercial agriculture. "If you put one acre of produce out, you are an island in the middle of commercial agriculture in Nebraska – basically corn and soybeans. You even have [farming] renters to worry about," he said.
- Water management.
- Perishable products. You only have a matter of days to use the product.

> **This is a business and is something I can do to help my own family.**
>
> - William Shyaka Bakunda

- Irrigation. Because Eisenhauer was a water management specialist during his career, he used a surface drip system. However, his one-acre plot needed a drip line for every row, and it had to be set up manually for the season each time. Because he was working on his own, he moved to a sprinkler system, which took one-tenth of the labor needed. "It's not ideal, always wetting the leaves, but it solves the labor problem," he said. He admits he has to deal with some parts of the field being overwatered and some being underwatered. "We irrigate weeds sometimes, so we now use a cover crop – a mixture of oats, turnips and radishes. The oats didn't survive," he said. He likes the idea that his field is a laboratory that can be used for educational purposes to demonstrate furrow irrigation.

According to Eisenhauer, marketing is key to the success of a market gardening business. "Make sure the market is established before you get into it," he said. Part of the reason he still farms is that he wants to show young people they can be successful, that there is a market, and that you have to respond to the market's needs.

Exploring creative solutions in the demanding farmlands of Rwanda

Grace Mukarusagara, a DWFI consultant from Rwanda, has been working with farmers in her country, exploring different farming behaviors in different parts of the country. She began with smallholder farmers growing a variety of crops. "It was quite a challenge to work with farmers with the new technology in their country." She said. "They gave us training in center pivot [farming], and after one year we came up with a system for growing maize, beans, soybeans and vegetables."

Over the course of working with government-sponsored shared irrigation schemes, she noted the success of cooperatives and water use associations to share best practices, challenges, and for developing innovative solutions. According to Mukarusagara, most farming challenges in Rwanda are related to cost. Farmers are first and foremost learners, she said, but posed the question of knowledge transfer to the older generation. Some older farmers have no access to markets in the cities. It is also a challenge to transfer knowledge to older farmers about center pivots and new technologies. She said it helped that local farming cooperatives gave everyone an opportunity to share and explain the problems they were seeing growing with the center pivot.

The team visited farms and asked farmers what they could do to help. The challenges can be daunting. "One pivot is shared by 60 people, "Mukarusagara explained. "People become sick and can't follow through when they are supposed to. One farmer was too old and couldn't do it." She said the government is trying to come up with things to help. For example, they are helping farmers leave their own land and work on other farms. They are researching models with smallholder farmers, including using irrigation as a service. In another model, the government is subsidizing irrigation to farmers – paying 50% of

the farming costs. In some places, she said, the government provides irrigation for free.

A four-decade farmer wrestles with irrigation, conservation and other growing challenges

Jerry Stahr, a Nebraska farmer, has been farming for more than 40 years. He began after leaving the Navy. During his first years, the farm used small equipment, including an open-station tractor that was very dirty and cold in the spring. As his farm grew, he went to bigger six-row equipment, and then eight. He now has 16-row equipment. He is a vocal proponent of no-till after a start using a great deal of tillage. "I hate to disc anything, and I love the no-till idea," he explained. "Disked land seems like the worst place to plant anything." He stressed that farmers like himself do all they can to maximize efficiency with inputs, but particularly water.

Stahr now farms 1,200 acres. He is looking into retiring, and his son is becoming interested in it. "But he likes a steady paycheck and insurance," Stahr laughed.

Stahr began irrigating with siphon tubes, then used pipe which helped with ridge till. Now he primarily uses center pivot irrigation. "We try to do everything we can to conserve water, and it's good for us too. Water is a precious resource, and we want to be very careful with it. We can do things cost-effectively," he said.

> **Farming is not what we do. It is who we are.**
>
> - Eliza Zancanaro Zanella

A lifetime of farming in Brazil: From child to agricultural student to adult advocate

After graduating with a degree in biology, Eliza Zancanaro Zanella began working on the family farm as a professional. However, she shared photographs of herself and her brother and sister as children on the farm with their father, grandfather and cousins. The family has been farmers for as long as anyone can remember, going back many generations. "Farming is not what we do," she said. "It is who we are."

The farm's main crops are soybeans, cotton, beans, and corn. They irrigate, because rain is not regular. They capture irrigation water from a nearby river, store it in trunk lines, and then push it to pivots. They are licensed to use the canal for a certain amount daily. They had to remove farmable land to use the canal, and now operate 21 pivots over about 6,000 planted acres. The family uses IRRIGER water management software to determine crop water needs based on equipment, soil, and water data.

Most irrigation in the Brazilian state of Bahia is surface water. To improve both surface water and groundwater, the irrigation association in Bahia (AIBA) partnered with several universities, including the University of Nebraska, and the Bahia state government to develop methodologies that provide

reliable estimates of the physical behavior of surface water and groundwater, including determining the potential of the Urucuia Aquifer. Zanella has contributed to this work. She is also a board member of the river basin committee of Rio Grande, one of several committees created after decentralization of water management in Brazil. She has been involved with the committees since 2010. Water management technology and the river basin committee help producers use the resource most efficiently, she said.

Panel Discussion

Is there something you learned at the conference that is useful? What would you like to hear about that we did not discuss?

Bukunda: I learned a lot about technology. People are thinking about technology, but we are far away from this in Rwanda. In Africa, we have mostly rainfed farming. We need some inspiration. Connecting farming to poverty and gender is one of the worst things you can do for us. Connect it to business – make agriculture cool to attract young people who might be in the field. To be a farmer can be sexy!

Mukarusagara: I am learning a lot from the sessions. Everyone is talking about water. Back home, water is important, and we must use it efficiently. I call upon the students who are here to think about where you will go and what you will do. We have a lot of jobs for you. I would like to know more about the use of groundwater in irrigation.

Zanella: What is amazing in Nebraska is how many pivots you have here. The technology, sustainability and how you manage water – this is what was important to me here [at the conference]. I would like to know more about the energy system and how farmers [use it to] manage the water here.

Eisenhauer: It really struck home to me that a lot of land is not irrigated in Eastern Nebraska, and evapotranspiration is a bigger player here, and I need to be mindful of that with my own system. However, the reason [my own land] doesn't get mulched as it should is because of labor. I'm one of those old farmers, and I don't get as much done as I used to. We still need to be concerned about groundwater sustainability — we still have groundwater depletion even in wet years, and we need strategies to deal with that.

Stahr: Farmers are a brotherhood. We got an invitation to go to Brazil with the Daugherty Water for Food Institute, and we were treated like royalty. It's all about family; that's why I have done what I've done. I appreciate the work that's being done in Rwanda. I respect the work that's being done by the NRDs in Nebraska, and I know Brazil is looking at that, and I think that is a positive direction.

How can you help with involving youth and the fact that farming is seen as not cool? What are you doing to help that?

Bukunda: Show young people that farming is a great profession. I'm making money in farming. I'm making a business. It's not the worst thing you could do. To make it attractive, we need more success stories.

Peter G. McCornick, Executive Director, Daugherty Water for Food Global Institute

Closing Remarks *April 30 | 4:45 p.m.*

Speaker:

Peter G. McCornick, Executive Director, Daugherty Water for Food Global Institute

Peter G. McCornick, executive director of the Daugherty Water for Food Global Institute, closed the conference, noting a recurring question that had been asked in many of the sessions: "How do we get people into these sectors who can actually manage all the variables and the things we have been discussing for the last couple of days?"

McCornick said one of his colleagues told him during a break that the energies and partnerships are really starting to come together. "We saw a lot of discussions and disagreements from different perspectives," McCornick said, "but certainly a lot of energy around the key areas we are trying to explore. We need to tease out some of those outcomes and see what real progress is made over the next few months."

One of the biggest complaints from participants, McCornick said, was that people wanted to be in concurrent sessions. He himself tried to be in two at the same time and it didn't really work! He reminded the audience that recordings of all sessions are available online at

waterforfood.nebraska.edu/explore-our-conferences/2019-water-for-food-global-conference.

"My final measure for what we've achieved is that Dean Eisenhauer learned something in a conference after 45 years in his career," he laughed. For the most part, McCornick said, he felt DWFI had been successful in getting the right people to the table at the conference.

> **The energy has been fantastic. I look forward to following up, really pushing toward outcomes and working together in partnerships going forward.**
>
> - Peter G. McCornick

He added, "It was also really pleasing to see in the View From the Field closing session, three young people who were very enthusiastic about this sector and the challenges of water and food and getting a lot of inspiration from us all meeting here today."

McCornick invited Hank Bounds, president of the University of Nebraska, and Mogens Bay, chairman of the Robert B. Daugherty Foundation, to join him at the podium where he presented the Water for Food Champion Award to Bounds for his unwavering support and board leadership with the institute. Bounds is stepping down from his role as university president and will be leaving late in the summer of 2019 but will continue as a member of the DWFI board. "He has been a tireless supporter," McCornick said.

McCornick thanked DWFI and the University of Nebraska for their support of the conference. He also thanked the partners and sponsors. He recognized the board of directors, which includes Bounds and Bay, as well as James B. Milliken, Chancellor of The University of Texas System, and former president of the University of Nebraska; Howard W. Buffet, author and lecturer at Columbia University; and Mike Johanns, a former Nebraska senator who recently had to step down from the board. He thanked the strong DWFI advisory committee, many of whom were very involved in the conference.

In addition, McCornick thanked the staff of DWFI, the volunteers including students, friends and family and the Lincoln Convention and Visitors Bureau, as well as vendors, all of whom helped pull the event together.

He closed the conference on a positive and encouraging note, saying, "The energy has been fantastic. I look forward to following up, really pushing toward outcomes and working together in partnerships going forward."

Mark Rosegrant, Research Fellow Emeritus, International Food Policy Research Institute

Managing Water and Agriculture for Sustainable Food Security

April 30 | 5 p.m.

Heuermann Lecture

Speaker: **Mark Rosegrant**, Research Fellow Emeritus, International Food Policy Research Institute

The power of water and food security is that it contributes to many pathways that address the challenges we face, said Mark Rosegrant, research fellow emeritus for the International Food Policy Research Institute. For example, irrigation contributes to increased production and therefore farm income, which makes food more affordable. Irrigation also reduces risk through improved resilience against weather variability, which is increasingly important with climate change. Irrigation also increases agricultural diversification, which improves dietary diversity for human health. Improvements in proximity and cleanliness of water sources and technologies for water extraction support women's empowerment through time-saving health gains.

However, he explained, irrigation is not the only side of water that's important. We also need a high-performing water, sanitation and hygiene (WASH) sector, which is important for achieving food security and nutrition goals. For example, access to safe water can reduce infection and disease, as well as reduce maternal and neonatal mortality rates, especially when it comes to in-house piped water which is not common in some parts of the developing world. "An important new pathway we should try to

be opening is enhanced cooperation and integration between the agricultural water sector and WASH sectors.

Hunger and undernutrition still persist in the world, and there also is an alarming rise in over-nutrition (overweight children) worldwide. Rosegrant said a great deal of this is driven by increasing population, and demographic shifts, along with migration from rural to urban areas. "The huge increase in population in Africa is scary, and Asia has the second largest increase in population – those are places that have food insecurity!" he said. According to Rosegrant, Africa is expecting its population to increase by 2.5 billion from 2010 to 2100, and the next closest population increase will be in Asia, which is expecting an increase of 432 million.

Although undernourishment is decreasing in Asia, it is increasing in Africa. Worldwide, undernourishment was decreasing noticeably until a few years ago, when it began to rise again. Both rising incomes and hunger are causing diet changes, changes in patterns of consumption, and changes in tastes. "A larger and more urban population will demand more and better food," he explained. "It also puts a lot of demand on water to produce food." He said demand is increasing for meats, such as poultry, as well as dairy, oils and sugar, much more than staples such as rice and wheat. Rosegrant said demand for cereals and grains will increase by about 37% to 2050, meat by 66%, and fruits and vegetables as high as 85%. In other words, we are likely to see dramatic increases in higher-value commodities as compared to staples.

Rosegrant said irrigation plays a key role in supporting agri-food systems, and with all these trends water stress is increasing worldwide, which compromises food security. "Thirty-six percent of the [world's] population is in regions with water stress," he shared. "The stress is going to cause more and more problems in the future."

This presents a list of challenges for water policy, including:

- increasing costs of developing and delivering water
- waste
- depletion of sources
- declining water quality with pollution
- increased variability in precipitation and streamflow due to climate change

- pollution
- billions of people without access to safe drinking water, hygiene and sanitation
- increased competition among water users

> **Less than one-third of the world's harvested land is irrigated, but irrigated crop areas generate 40% of global food production.**
>
> - Mark Rosegrant

Rosegrant said it's increasingly difficult to mobilize resources and finance both irrigation and WASH. There are low rates of return and high financial risks, as well as difficulty estimating needs under climate change. "It's important for both public and private to work together to undertake this funding, but there remain deep suspicions between the two sectors in much of the world," he explained. The private sector sees political interference, and government sees the private sector selling to industries rather than agriculture or domestic water suppliers. In the WASH sector, over time, challenges include underpriced services with subsidies maintained for many urban users, cost recovery risks, and relatively low ROI.

There are also serious challenges in terms of losses in value chains, Rosegrant said. Post-harvest loss (PHL) averages about 30% to 40% worldwide. Value chains from farm to retail show much lower losses: 8% to 20%. However, there is still significant potential to reduce food losses and water losses, which are embedded in those value chains. In developing countries, PHL is caused by constraints in harvesting methods, lack of storage/cooling facilities, and poor marketing and roads. In developed countries, the problems exist at the retail and consumption level.

"That's all a pretty tough set of challenges to deal with," Rosegrant admitted. He offered a "lightning tour" of what he believes are the key policies and strategies to address water and food security: water rights, technology, incentives and subsidies, agricultural research and development, governance, investment and finance, nontraditional sources of water and food, agricultural trade, and balanced diets.

In his presentation, Rosegrant discussed the benefits, challenges and details of each of these key strategies. Some of the most important takeaways:

- Water rights are a cornerstone of management because they empower users and incentivize individuals to do things differently, such as investing in farm improvement.
- Real system-wide water savings from technology are much more difficult to achieve and

more limited than people think. Some new technologies actually result in using more water rather than saving water.

- Subsidies should be specific rather than generalized, if they are used at all. High subsidies cause overuse and distort production decisions. Subsidies for R&D, farmer compensation and smart technologies are effective without costing much money.
- Agriculture research and investment in irrigation, sanitation and sewage services are going to have to increase. Governance, finance and planning, value chains, and pollution enforcement will have to improve. There is an under usage of things like green and blue bonds, payment for ecosystem services, and blended public/private finance. New technologies will help reduce PHL (listen to video for specifics).
- Meetings and treaties between nations have been effective, while pushes within countries have been less valuable. Water user associations have not worked well, but they can encourage members to become involved in water delivery service improvement, rather than just focusing on farmer allocations and fee payments.
- We need to expand nontraditional sources of water, such as urban irrigated croplands, but there are challenges that constrain growth in this niche. Five to 20 million hectares of land globally could be irrigated with treated wastewater as opposed to raw and diluted wastewater. Other nontraditional sources are recycled wastewater and desalination, but total impact is low.
- Trade barriers need to be reduced for water and food security, because with climate change developing countries will require greater imports of food. Short-term imports also will be needed due to weather-induced production shocks.
- Promoting balanced diets can improve both health and sustainability including reduced

> **Small-scale irrigation look much more promising [than large-scale irrigation]. As climate change proceeds and rivers change course and rainfall changes patterns, these flexible new pumps can be moved along with that. You can't just pick up a dam and move it.**
>
> - Mark Rosegrant

water usage.

Farmer-led irrigation was a common theme during the conference, and Rosegrant said it will be important in the future to invest in expanding irrigation, especially in sub-Saharan Africa. However, large-scale irrigation in that part of the world faces serious challenges, so small-scale irrigation is more promising. Small-scale irrigation is more flexible to meet farmers' needs and changing hydrology, can be rapidly deployed at a lower cost, is spurred by technological development, contributes to women's empowerment and is more environmentally benign.

Rosegrant said we need to promote technological innovations (digitization, remote sensing, solar) and institutional innovations (water rights, governance), as well as supporting infrastructure (fewer energy subsidies, better roads, providing farmer credit) for farmer-led irrigation. These are provided initially by government, but we need to figure out a way to make them profitable without a lot of subsidies. And we need highly profitable technologies scaled up relatively soon – and we need to manage them carefully.

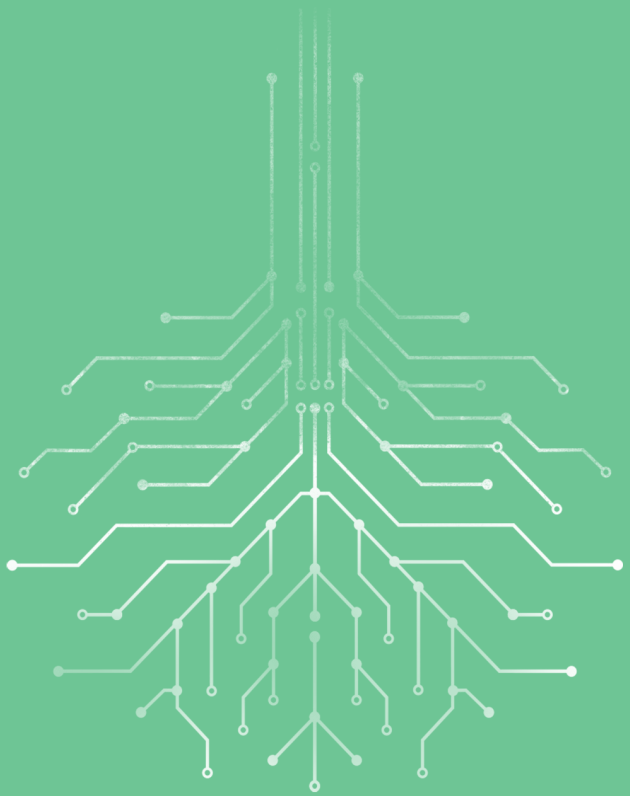
Water use policies need to be region specific, he suggested. There will be different priorities in different regions, depending on the underlying conditions. "The solutions are difficult and will take time, political commitment and money, and we need to move forward quickly because of the growing challenges," he contended.

Rosegrant said the U.S. government can do a few things to promote international outcomes on water and food security. First, it can strengthen the environment for cooperation and communication between water development and food/nutrition security. One example is that the government is already moving to link the Water for the World Act more closely to the Feed the Future Initiative, and it's encouraging the new USAID initiative to merge water and food under one roof for very high payoffs.

He believes the government needs to ease the challenges that hinder greater private-sector investment in order to expand sustainable water development for food and nutrition, including using levers in the government in addition to USAID, such as USDA and the new Development Finance Corporation (DFC).

We can also leverage U.S. expertise and influence to improve water resource governance and sustainability," he suggested, "focusing on technical expertise and educational opportunities available in this country to share technical expertise overseas."

Finally, Rosegrant urged the government to strengthen support for agricultural R&D and interdisciplinary research at the nexus of water, food and nutrition. It is important to invest additional research funds in breeding for yield per unit of water and land, such as breeding crops with more efficient transpiration and photosynthesis, with drought and heat tolerance. We should look to the vast expertise of land grant universities such as the University of Nebraska, he suggested, and take advantage of other educational opportunities to enhance research and the development of solutions.



WOMEN FOR WATER

Water for Food
GLOBAL CONFERENCE
at the University of Nebraska

Niobrara River in Nebraska, USA.

WOMEN FOR WATER

A Side Event of the Water for Food Global Conference

May 1 | 9:30 a.m.

A new addition to the Global Conference, the Women for Water Gathering brought more than 100 participants to explore women's unique contribution to ensuring abundant, clean water for future generations. The half-day event featured leaders in policy, culture, science and engineering who shared their inspiration, challenges and expertise. They also led discussions on how to engage in next steps for local action.

One of the overarching themes that emerged during the event was how women's passion for water is often driven by an intersection of professional expertise and an ethic of caring for families, community, and the world. Talks showcased women in key positions, making decisions, and a network of resources for guidance on how to handle projects related to water.

As one attendee shared, "This event was a 'watershed' moment for me, in helping define a dialogue and align myself with other women who are working within traditional frameworks to protect our critical resources and enhance community resilience while also developing our own reserves of professional and personal resilience."

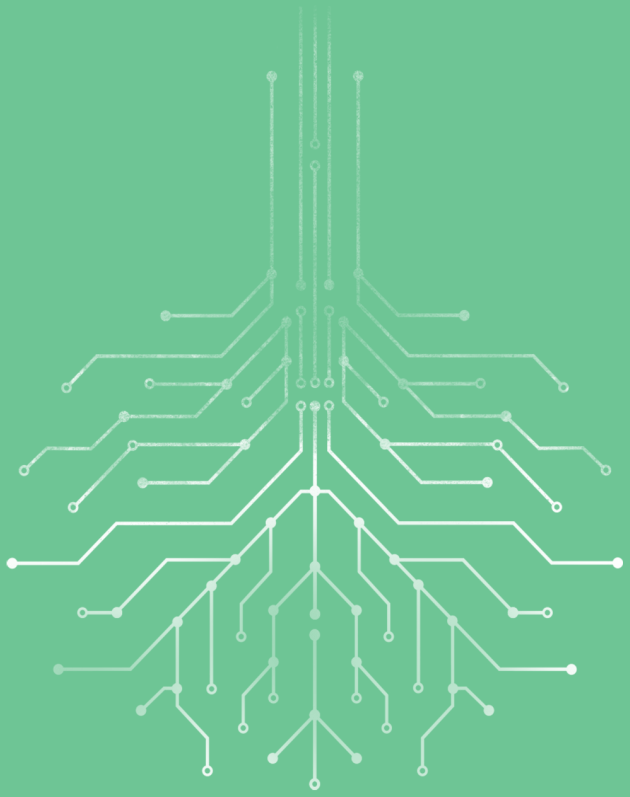
(L-R) Jennifer Schellpeper, Marty Link and Alisha Bartling.

The Women for Water Gathering was an inspiring first step to bringing more women into water leadership, and there are plans to continue this side event in future global conferences.

Attendees network during the Women for Water Gathering.

Speakers:

- Karen Amen - Lower Platte South Natural Resource District
- Jennie Barron - Swedish University of Agricultural Sciences
- Shannon Bartelt-Hunt - University of Nebraska – Lincoln, Civil Engineering
- Alisha Bartling - Santee Sioux Nation
- Saptashati 'Tania' Biswas – Nebraska Water Center Water Sciences Laboratory
- Jane Griffin - Groundwater Foundation
- Karen Griffin - Ollson
- Rachael Herpel & Crystal Powers- Daugherty Water for Food Global Institute and Nebraska Water Center
- Chelsea Johnson – Nebraska Conservation Voters
- Marty Link – Nebraska Department of Environment and Energy
- Mariah Lundgren - Platte Basin Timelapse
- Gina Makin - University of Nebraska–Lincoln, Agricultural Leadership, Education & Communication
- Kim Morrow - Verdis Group
- Renee San Souci - Omaha Tribe of Nebraska
- Jennifer Schellpeper – Nebraska Department of Natural Resources
- Annette Sudbeck – Lewis & Clark Natural Resource District
- Donna Woudenberg – University of Nebraska–Lincoln, School of Natural Resources & Gender Studies
- Elisa Zancanaro Zanella – Fazenda Decisao Group



POSTERS

Water for Food
GLOBAL CONFERENCE
at the University of Nebraska

Solar panels power an irrigation system in Rwanda.

POSTERS

Peter Rogers Memorial Student Poster Competition

The conference featured a juried poster competition for graduate students, along with a "people's choice" award based on votes from attendees at the conference, and an online competition.

Monetary awards were sponsored by Distinguished Fellow and former Valmont executive Bob Meaney and his wife Angenette in honor of DWFI International Advisory Panel member Peter Rogers, who passed away last year. Peter was a Harvard professor and author and highly respected throughout the global water for food community for his leadership in water research.

Online Competition Winners

First Place

▶▶ $1,000 cash + conference registration

Ear Formation Issues in Corn: a Field Survey. Osler Ortez.

Second Place

▶▶ $750 cash + conference registration

Pesticide Application Practices And Knowledge Among Small-Scale Local Rice Growers And Communities in Rwanda. Ben Ndayambaje.

Third Place

▶▶ $500 cash + conference registration

Effect of Chlorination on Treatment of Meat Processing Wastewater Using Immobilized Co-culture of Microalgae and Activated Sludge. Xinjuan Hu.

Online first place winner Osler Ortez with Associate Vice Chancellor Ron Yoder.

On-site Competition Winners

First Place

▶▶ $1,000 cash

Improving Aquifer Characterization through Integration of Airborne Electromagnetics (AEM) and Well Hydrographs. Jacqueline Polashek.

Second Place

▶▶ $750 cash

Predicting Crop Yield Losses Due to Soil-Water Alinity: Comparison of Traditional and Alternative Approaches. Ansley Brown.

Third Place

▶▶ $500 cash

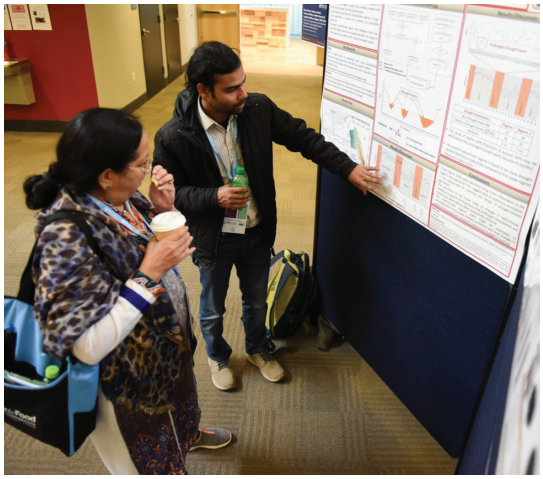
Sustainability of Safe Foods: An Integrated Life Cycle Assessment of Antimicrobial Systems during U.S. Beef Processing in the Food-Energy-Water Nexus. Shaobin Li.

People's Choice

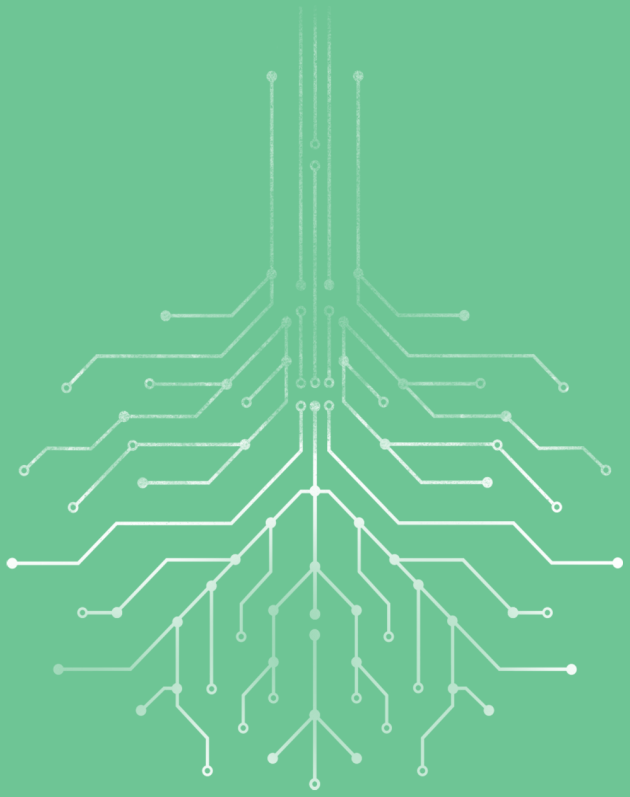
▶▶ $300 cash

Soil Structure and Soil Texture Effects on Soil Water Content Measurement by a Capacitance-Based Electromagnetic Sensor. Jasreman Singh.

On-site first place winner Jacqueline Polashek with Associate Vice Chancellor Ron Yoder.



Attendees review student posters during a break.



METRICS

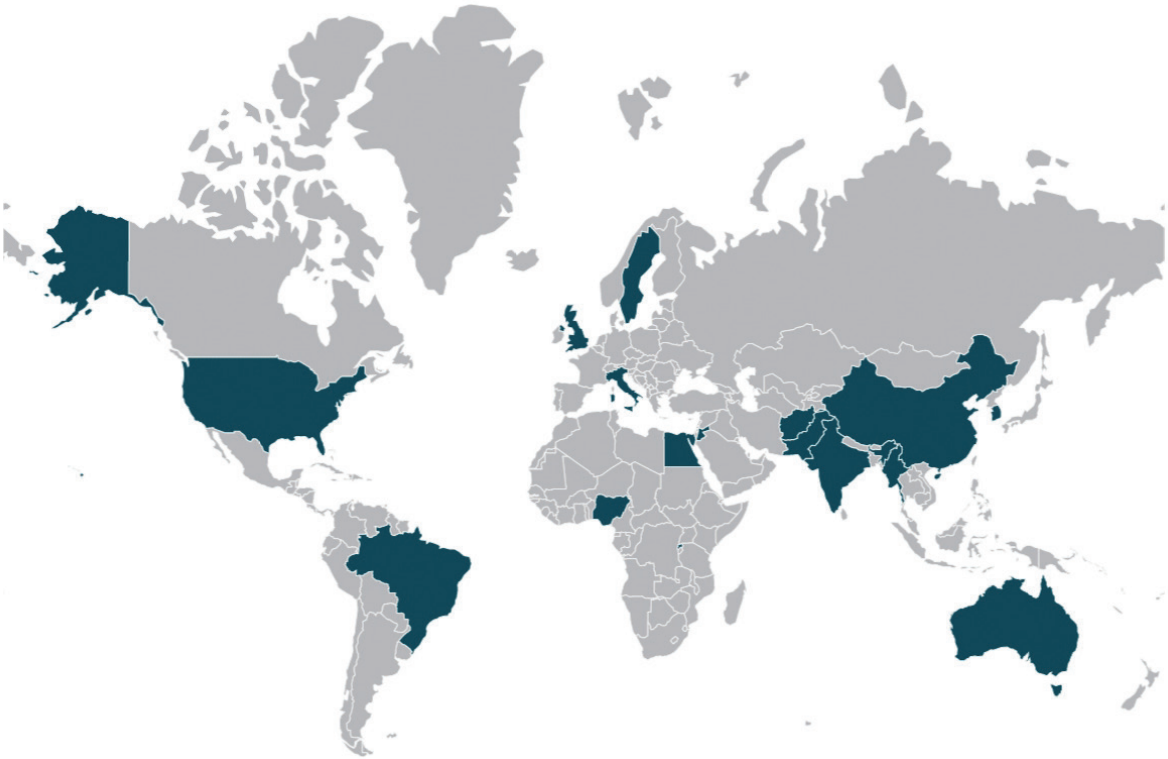
Water for Food
GLOBAL CONFERENCE
at the University of Nebraska

A soybean field in Nebraska, USA.

BY THE NUMBERS

400+ Attendees
16 Countries
25 U.S. States + Territories

Attendees included farmers, students and those from academia, non-governmental organizations, government agencies, non-profits, and private sector organizations.



Post-Conference Survey Results

79 attendees complete the survey sent via email several days after the conference concluded.

Satisfaction of networking opportunities

Out of possible 5

4 = Very Satisfied 5 = Extremely Satisfied

Responded that they learned valuable information at the conference.

Responded they were satisfied, very satisfied or extremely satisfied with the conference.

"This conference was perfect — long enough, large enough without being too long or too large. Well done to all."

"Knowledgeable, compassionate people coming together to find solutions globally for water and food issues.

"Great talks and networking opportunities."

"The quality of the speakers [was valuable]. There were many experts in attendance and they were very approachable between lectures."

PHOTOS

Conference attendees converse with exhibitor Dragon-Line, a mobile drip irrigation provider from Kansas.

Conference participants enjoy a reception at the University of Nebraska State Museum.

DWFI International Advisory Panel Member Martin Pasman networks between sessions.

DWFI staff members network with conference attendees between sessions.

A session attendee asks a question during the Question + Answer period.

DWFI Events Coordinator Amber Poythress checks in attendeees at the registration table.

DWFI Executive Director Peter G. McCornick (left) and Robert B. Daugherty Foundation Chairman Mogens Bay (right) present University of Nebraska President Hank Bounds (center) with the Water for Food Champion Award.

Closing keynote speaker Mark Rosegrant networks at the conference.

Conference attendees attend the closing reception featuring the music of Darkwood.

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