GROWING A WATER AND FOOD SECURE FUTURE

Water for Food
DAUGHERTY GLOBAL INSTITUTE
at the University of Nebraska

ANNUAL REPORT

FY2019 (JULY 1, 2018 TO JUNE 30, 2019)

DWFI Executive Director Peter G. McCornick addresses attendees of the 2019 Water for Food Global Conference.
Photo: Chuck Zimmerman | ZimmComm New Media

LETTER FROM THE EXECUTIVE DIRECTOR

Ensuring water and food security for our growing world is an audacious goal – exactly what Bob Daugherty sought to achieve by creating the Daugherty Water for Food Global Institute (DWFI) at the University of Nebraska nearly 10 years ago. He, along with leaders and supporters within the University of Nebraska, the state and well beyond, understood that a collective and committed effort on wise water management was essential to producing enough food to feed the world while sustaining our valuable and limited water resources.

For decades, many dedicated people around the world have striven to overcome the challenges of ensuring water and food security. There isn't a "silver bullet" that will quickly address the complex, interconnected and evolving issues, including climate change, rising demand for more water-intensive foods, soil and water degradation, conflict over and competition for water resources, and, in many developing countries, the low levels of investment in supporting facilities and services.

In collaboration with our dedicated partners, DWFI is making valuable contributions to meeting these challenges. As you'll read in this year's annual report, the institute is conducting innovative research, informing policy, convening stakeholders, sharing knowledge, cultivating new leaders and communicating our work to millions of stakeholders across the U.S. and around the world. Most importantly, our work is advancing our mission to ensure food and water security for nearly 10 billion people by 2050.

The progress towards these outcomes was fittingly demonstrated at the 2019 Water for Food Global Conference, which focused on innovation in water and food security. More than 400 partners – including farmers, scientists, companies, philanthropists, investors, government agencies and nonprofit organizations – convened to explore practical actions to help stakeholders build more resilient, water-smart and productive agricultural and food systems. New partnerships and ideas generated during the conference sessions and networking are now under development.

Here in Nebraska and neighboring states, it has been a year of far too much water, dominated by historic floods and a wetter-than-usual planting season that left many acres fallow. The impacts on

people and communities, infrastructure, and crops and livestock have been enormous. Much has been done to restore the affected communities, though full recovery will take much longer. Stakeholders across the state are reflecting on lessons learned and exploring ways to strengthen the resilience of communities, including bolstering water and food systems.

The results from the recently completed Nebraska Water Productivity report reflect remarkable improvements in yield per drop of water used (water productivity or WP) for crops, livestock and biofuels over the past three decades. This underscores the importance of long-term investments in crop and livestock breeding, enhanced management systems and new technologies. The challenge is how to sustainably achieve similar water productivity advancements in other agricultural landscapes.

With our friends at the Institute of Agriculture and Natural Resources (IANR) and a number of Faculty Fellows and partners, we have catalyzed our efforts to better understand and address water quality challenges here in Nebraska and further afield. A notable example is the Bazile Groundwater Management Area (BGMA) in Northeast Nebraska, where we are working with four Natural Resources Districts (NRDs) to mitigate and manage nitrate contamination.

DWFI is part of a strong alliance of international partners working to expand development of local solutions for irrigated agriculture in sub-Saharan Africa and other emerging regions of the world. These collaborations amplify our individual strengths and create powerful new approaches to achieving water and food security. Directly contributing to this ambitious initiative, the institute and IANR are assessing existing irrigated agriculture business models in Rwanda. The results from this research are expected to inform new investments in sustainably scaling intensive agriculture in other sub-Saharan countries.

While it will still take time to fully achieve our vision of a world without hunger or water scarcity, we are witnessing accelerated progress. As we close in on the institute's 10th anniversary in 2020, we are pleased to share the impacts we've made. We greatly appreciate the support of our Board of Directors, staff, University of Nebraska leadership, Faculty Fellows, Global Fellows, International Advisory Panel, donors and friends who help make these important breakthroughs possible.

Peter G. McCornick, Ph.D., P.E., D. WRE
Executive Director
Robert B. Daugherty Water for Food Global Institute at the University of Nebraska

RESEARCH AND INNOVATION

A paddy field on a rice farm in Bali, Indonesia. Photo: Mush Labs | Flickr

The Niobrara River in the Nebraska Sandhills.

Improving water productivity

The world is facing a balancing act: working to feed more than 9 billion people by 2050 while being good stewards of our limited natural resources. To achieve this balance, we must understand how our water is allocated and how well we are using it. To date, there hasn't been a standard methodology for measuring water use in crops, livestock or ethanol production. DWFI is working on a series of "living" reports that provide water productivity insights for important food-producing regions of the world. To begin with, we looked at data in our own backyard.

Nebraska is a national leader in agricultural production, which contributed about $23 billion to the state's economy in 2016. The state is the nation's third largest producer of corn and second largest in cattle production. It is also the second largest producer of ethanol and distillers' grains (DGs). Corn is a major input in the ethanol industry, which uses it for fuel production. DGs, a by-product of ethanol production, are used as livestock feed, forming what the Nebraska Corn Board refers to as "Nebraska's Golden Triangle:" corn, ethanol and livestock.

Irrigation plays a vital role in Nebraska's agricultural prominence. The state ranks first in the nation in total irrigated

An ear of corn ready for harvest. Over the last 24 years, the WP of corn in Nebraska has increased by 71%.

cropped area with 3.4 million hectares. The expansion of irrigated agriculture has intensified competition for limited water resources, which is why measuring – and improving – WP is so important.

Nebraska has one of the most highly productive cropping systems in the country and world. Over the last 25 years, the state's corn and soybean yields have grown considerably. This significant increase in grain yields, combined with the adoption of improved farm-level management, advanced irrigation systems and regulatory limits on irrigation pumping, has helped sustainably improve the WP of crop production in the state. From 1990 to 2014, the WP of soybeans and corn increased by 79% and 71%, respectively, while groundwater levels have largely stabilized.

The irrigation application rate in the three NRDs studied (Central Platte, Lower Niobrara and Tri-Basin) has dropped by 20% on average for cornfields and by 8% for soybean fields between 2004 and 2013. When applied irrigation is reduced, farmers benefit in the form of lower pumping costs and less leaching of fertilizer and chemicals.

The livestock sector is an important part of Nebraska's economy as well, contributing about 54% of the total economic value of the state's agricultural sector in 2016. Livestock production has increased considerably in the last few decades, matched by a large increase in livestock productivity, which has helped to minimize the rate of increase in livestock feed requirements. The use of the DGs as livestock feed improves the WP of livestock products and reduces pressure on freshwater resources.

The issue with livestock is how to further increase and sustain higher WP. Unlike the studied crops, livestock products lack standard benchmarks that could be used as a yardstick to measure progress in WP. Therefore, potential future research areas in the livestock sector include setting benchmarks, estimating WP gaps and identifying the critical factors affecting consumptive water use for livestock.

The study revealed that, despite tremendous improvement in agricultural WP, the water footprint of biofuels is considerably larger than that of fossil fuels, a factor policymakers should consider when developing biofuel policies.

The current study does confirm earlier findings that bioethanol from corn generates more energy than is required for production. Bioethanol from corn contains 2.1 times more energy for every unit of fossil fuel input. It also reduces the GHG emission by 53% compared to gasoline.

Nebraska is leading the way in precision water management for agriculture and livestock productivity. Great strides have been made in improving WP, but there is room for continued improvement. The Nebraska Water Productivity Report is an excellent benchmark for future research and sets the standard for global WP efforts.

View the report:
go.unl.edu/waterproductivity

Flux network making waves

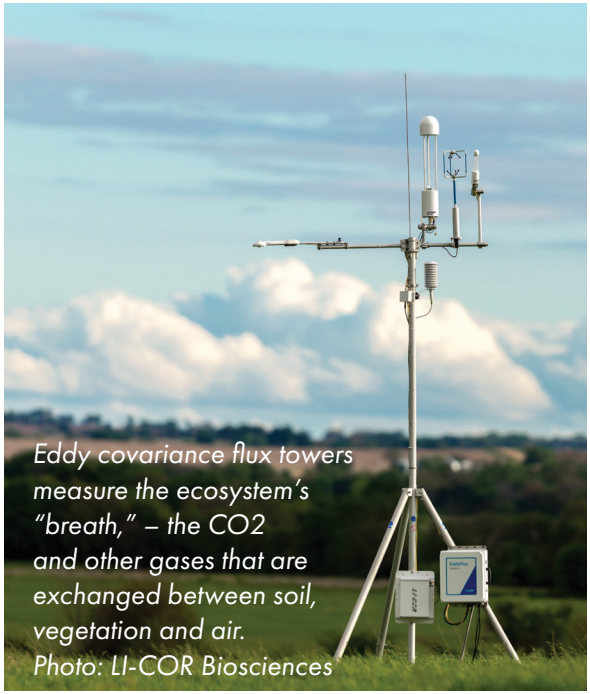
DWFI's network of eddy covariance flux towers across the central U.S. is starting to provide valuable data. The Parallel 41 Flux Network measures evapotranspiration (ET= total plant evaporation and transpiration into the atmosphere), which is a key measurement for determining a plant's unique daily water needs. ET data helps growers precisely apply the amount of water a plant needs, when it needs it, to achieve the best possible yields. While ET can be difficult to measure directly, it is effective for assessing water budgets, water productivity, plant stress and drought.

PAGE 9

Eddy covariance flux towers are the most accurate method of measuring ET. They do so by measuring the movement and speed of eddies, or three-dimensional circular patterns, to determine movement of water vapor and other gasses. The variance in this movement and the composition of the air helps measure ET more exactly.

The Parallel 41 Flux Network is situated to represent different climate conditions and crop types. With support from the Irrigation Innovation Consortium (IIC) and LI-COR Biosciences, six of the existing flux towers have been upgraded in the past year using new software, which provides data in real time, greatly enhancing the utility of the network.

Daily ET measurements from these flux towers are freely available to farmers, NRD managers, scientists and others through the Parallel 41 website. The real-time data can help these stakeholders better control water usage for maximum productivity.



Eddy covariance flux towers measure the ecosystem's "breath," – the CO2 and other gases that are exchanged between soil, vegetation and air. Photo: LI-COR Biosciences

A young Indian girl carries water from a well.

Developing composite drought index and other drought management tools in India

> India has experienced 21 large-scale droughts in the last 100 years; three of which were classified as severe. In 2016, a severe drought left at least 330 million people without enough water for daily needs.

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A composite drought index (CDI) is a drought monitoring tool that uses newly-developed remote sensing products to assess drought impacts on various components of the hydrologic cycle. A CDI provides weekly maps showing drought status and can enable a government to respond with short-term aid and reparations, as well as long-term infrastructure and policy.

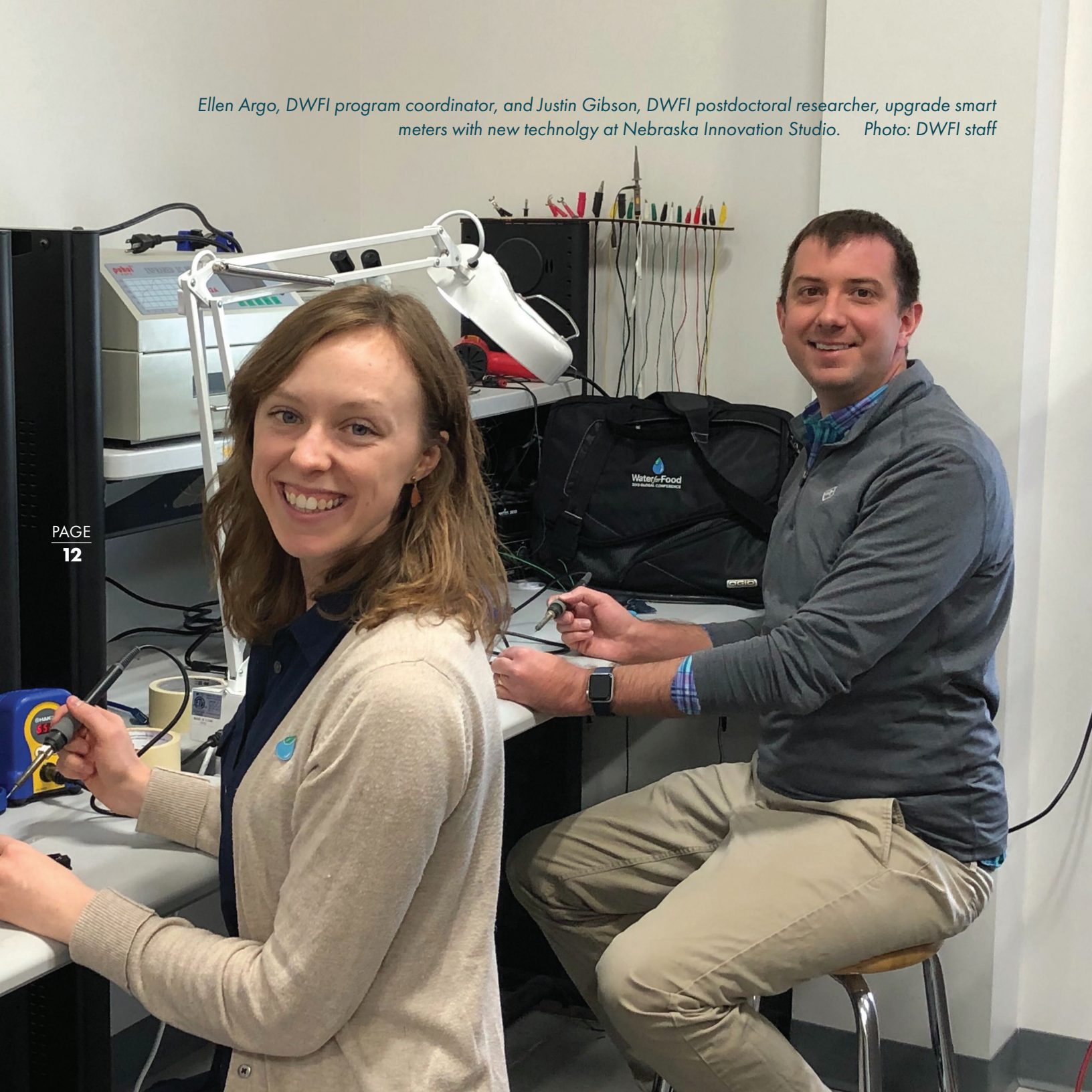
DWFI has partnered with the NDMC and the Indian Agricultural Research Institute (IARI), in a project funded by the United States–India Education Foundation (USIEF), to develop a CDI for Indian states.

The three-year grant-funded project, which began in 2017, includes three objectives:

1. Develop a CDI for India
2. Advance irrigation technology in India
3. Monitor water productivity in India

The work has included two technical workshops held in India. The first workshop was held in July 2018 with high-level government officials and scientists and focused on the application of spatial data infrastructure for irrigation management. The CDI was also unveiled for two Indian states. The progress was well received and resulted in USIEF extending it for an additional year at a no-cost extension.

The capacity building workshop held in January 2019 highlighted the progress and results made so far to develop India's CDI, collected feedback from stakeholders for modification and identified next steps for the project, which included developing CDI for additional Indian states and continuing research on handheld thermal sensor for smallholder farmers in India. By integrating soil moisture sensing and canopy temperature sensing techniques using low cost sensors, farmers can better determine optimal irrigation for different crops.



Ellen Argo, DWFI program coordinator, and Justin Gibson, DWFI postdoctoral researcher, upgrade smart meters with new technolgy at Nebraska Innovation Studio. Photo: DWFI staff

Partnerships advancing hardware, software solutions

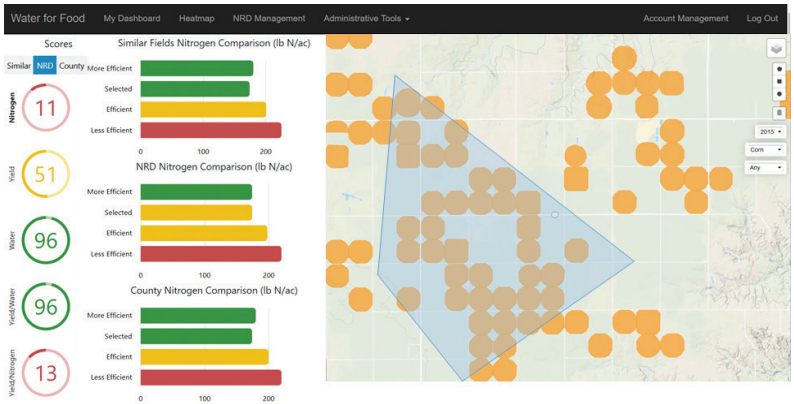
> Agricultural data collection has grown enormously over the last few years because of the advancing ability of technologies to retrieve data from environments ranging from soil to space. Data enable agricultural producers to grow more crops with fewer inputs, saving money and conserving limited resources. However, challenges associated with collection, transmission and interpretation of agricultural data persist.

Over the last few years, DWFI has been developing hardware and software solutions to improve the usefulness of agricultural data for producers and water managers alike. These projects also provide an opportunity for DWFI to work with UNL computer science students and to educate them about agriculture and agricultural technologies.

Benchmarking and comparing crop performance

DWFI's agricultural database project continued development, engaging for a third time with a student team from the UNL Raikes School Design Studio program. During the last year, the student team built a mobile app to allow producers to complete their required annual reporting digitally rather than with the current system of hand-collected paper forms.

With the software, agricultural producers can anonymously compare the performance of crops in their fields to other nearby fields with similar soils, weather and crops. Water managers can use tools to manage data, visualize trends, track the impacts of policies and more. The DWFI team is working with local partners and NRDs to put the dashboard in the hands of water managers and agricultural producers.



Measuring energy-water linkages with smart meters

One of the largest costs of irrigating with groundwater is the cost of energy used to pump water to the surface. It's currently difficult for producers to understand in detail the energy costs of their irrigation and whether these are reasonable. During FY2018 and FY2019, DWFI staff installed 73 custom energy meters in Nebraska and Wyoming. Where cellular connections are good, these meters provide real-time information on energy and water use. Where cellular connections are poor – as is the case in much of rural Nebraska – it's impossible to transmit and capture agricultural data from the field. DWFI saw this as another opportunity to engage a team of UNL Raikes School Design Studio students. We charged them with developing a solution for poor data connectivity in agriculture.

The students designed a device that connects to in-field sensors and logs and stores the data it reads. They also developed a mobile app that communicates with the device to sync the data and store it on a producer's mobile device until the producer can reach a reliable wireless or cellular signal. Then, the producer uses the app to send the data to the cloud server, which can be accessed by DWFI. The solution was elegant and well-executed – and won the Raikes School Platinum Project award for best project. The DWFI team is now installing the new devices on energy meters across the state with positive initial results, allowing increased coverage of our project support.

Ellen Argo installs smart meter technolgy on a Nebraska Farm. *Photo: DWFI staff*

Researching irrigation in Rwanda

Over the past year, DWFI developed a new multifaceted research, teaching and engagement program in Rwanda. The institute's policy team has been working to understand different approaches to irrigation service provision for smallholder farmers. A goal is to determine what types of irrigation service are currently present, how they're functioning, and whether they will be able to scale from a business and sustainability perspective.

Additionally, the team surveyed the broader landscape of agricultural entrepreneurship in Rwanda to understand the nascent community's needs. DWFI also developed and tested multiple experiential learning programs to allow University of Nebraska students to gain an understanding of the challenges of farmer-led irrigation and smallholder agriculture in Rwanda and elsewhere in sub-Saharan Africa. The DWFI team was able to hit the ground running with their work in Rwanda by leveraging existing connections through University of Nebraska programs.

PAGE 15

DWFI staff visit a farm cooperative in Rwanda to learn about their irrigation practices. Photo: DWFI staff

Naisi Dave, DWFI research associate, and John Krohn, a farmer from Albion, Nebraska, discuss irrigation prescriptions for Krohn's cornfield. Photos: DWFI staff

Writing new irrigation prescriptions

For the second year, DWFI and The Climate Corporation (TCC), with support from the Nebraska Water Balance Alliance (NEWBA), collaborated on a research project to better understand the field-level application of ET research. Despite spring flooding in the state, DWFI successfully worked with 11 partner farmers in central and western Nebraska to gather field data throughout the 2019 growing season.

The fields of partner farmers were divided into three sections — one-half of each field was irrigated based on regular grower management, one-quarter was irrigated according to data from TCC's proprietary software, and the other quarter's irrigation was prescribed by DWFI researchers.

DWFI made its calculations using weather data, satellite thermal imagery, past irrigation data, soil mapping, soil water monitoring and the Spatial Evapotranspiration Modeling Interface (SETMI).

To achieve high yields, farmers must use stored soil water, precipitation and irrigation to satisfy a crop's total water requirement after ET.

The DWFI/TCC project hopes for two results: (1) compare the three prescription techniques after harvest and (2) ground truth ways of measuring ET through satellite imagery. The mostly open-source measurement methods used by DWFI are available anywhere in the world. If they prove accurate as a way to effectively prescribe irrigation, they could be used in the future to determine irrigation needs for crops in the Middle East and North Africa (MENA) region or other high-potential areas, as opposed to using solely on-ground, in-field measurements.

Dusty plains during a drought in Sudan.

Bringing drought monitoring and early warning systems to the MENA region

The percentage of the planet affected by drought has more than doubled in the last 40 years, and drought has affected more people worldwide than any other natural hazard, according to FAO. Severe episodes of drought can have a devastating impact, leading to famine, migration, natural resource degradation and weak economic performance, or exacerbating social tensions and civil unrest.

While drought can't be stopped, it can be forecasted and its impacts substantially reduced. DWFI and its international and regional partners, including the National Drought Mitigation Center (NDMC), University of Maryland, NASA, United States Department of Agriculture (USDA) Agricultural Research Service (ARS), Independent Community Bankers of America (ICBA) and International Water Management Institute (IWMI), with funding from United States Agency for International Development (USAID), are helping countries in the MENA region predict future drought and devise drought mitigation plans for implementation. The project delivers new insights, management plans and drought resilience strategies at the national and local levels to reduce drought impacts on the food supply and on the quantity and safety of the water supply in vulnerable communities.

In the last year, DWFI updated its GloDET spatial datasets with 2013–2017 data and continues to work toward its goal of real-time ET mapping. The GloDET portal provides free access to ET data calculated by the ALEXI two-source energy balance model. ET represents daily crop water use and can be used to determine the amount of plant stress. If remote sensing shows that a plant's ET is decreasing while its temperature is increasing, it can be a sign that the plant is stressed by a lack of adequate water, and an early indicator of drought.

DWFI and NDMC, along with local partners, have already conducted needs-analysis in several countries in the MENA region, including Jordan, Lebanon, Morocco and Tunisia. Following the introduction of real-time data to GloDET, the two organizations will host technical workshops in those areas of the region to train decision makers to use the data with a composite drought index (CDI). Combined data from the two systems captures the nature and characteristics of current drought conditions at regional and country levels.

With a drought mitigation plan already in place and the capability for early detection of drought potential in a region, a community can be more resilient in the face of drought's adverse ecological and humanitarian effects.

See the database:
glodet.nebraska.edu

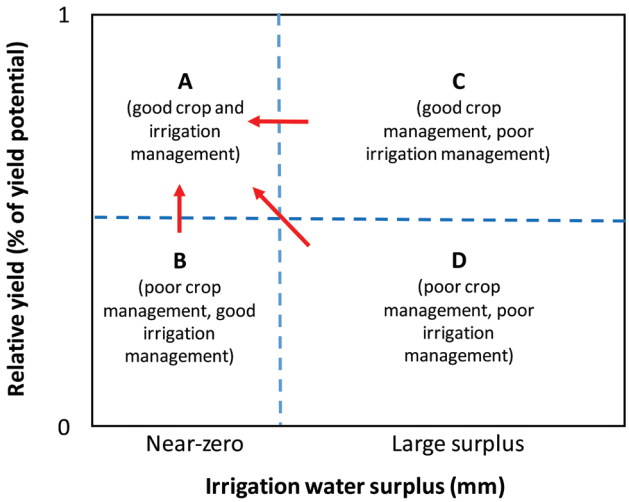
A field of wheat is nearly ready for harvest.

It pays to follow the rules

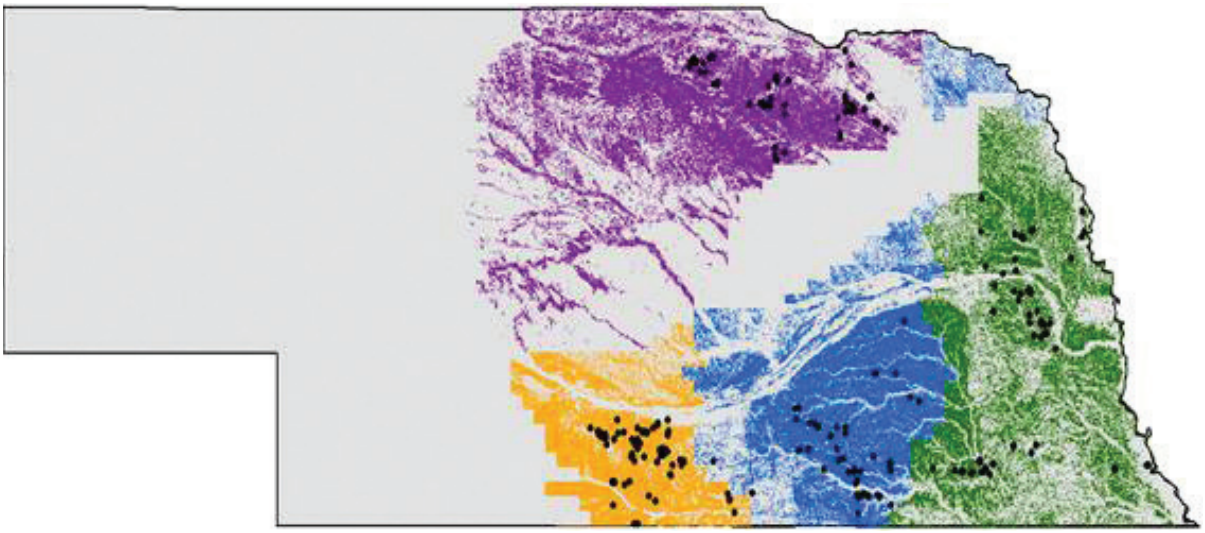
In a new study published in Environmental Research Letters, researchers from DWFI and the University of Nebraska–Lincoln found that about a third of producer fields studied successfully achieved high yields within benchmarked irrigation water requirements. This shows that achieving nearly full yield potential and staying below established irrigation water requirements are compatible goals for actual fields in the state. Irrigation water requirements are defined seasonal amounts of irrigation water expected to achieve full yield potential. Yield potential is the maximum yield attained when water and fertilizers are not limited. The authors of the study noted that, in the case of U.S. corn, reaching 80% of yield potential is a reasonable goal.

Researchers collected data for the study from NRDs and through producer surveys. They then developed a framework to diagnose current irrigation water use as it applies to grain production in producer fields. While previous related studies have relied primarily on data from simulations or research farms, the new study used actual producer data from more than 500 corn and soybean producers' fields in Nebraska.

A striking finding of the study was the fact that yield did not differ between fields using different types of irrigation scheduling. One type of scheduling included methods and technologies that enable more efficient irrigation, including soil water balances, soil moisture sensors and computer irrigation-aid tools, such as CornSoyWater. Another type of scheduling involved "soil feeling," or visual assessment of plant status. The last type included rudimentary methods,



With good crop and irrigation management, growers see high yields with little irrigation water surplus.



This map of Nebraska shows the locations of fields used in the study.

such as basing irrigation on fixed calendar dates or a neighbor's schedule.

Actual yield of fields in the study averaged 86% of full yield potential across all three scheduling methods. However, fields that used best available technologies to schedule irrigation saw very little water surplus, especially compared to the other two methods, but the fields using best available technology only represented 22% of the total fields. This finding indicates a substantial opportunity to save irrigation water and potentially increase farm profit through adoption of new technologies.

Researchers also found actual irrigation in more than half of the study's fields to be similar to estimated irrigation water requirements. According to lead researcher and author Kate Gibson of DWFI, this means those producers are doing quite well at achieving high yields with little water surplus. But there is still a lot of potential for reducing water use in the remaining half of the fields studied.

Funding for the work presented in the new publication came from DWFI, Nebraska Corn Board and Nebraska Soybean Board.

Full article:
go.unl.edu/irrigationwater

Video recap:
go.unl.edu/irrigationvideo

POLICY AND PARTNERSHIPS

DWFI Director of Research Christopher Neale signs a memorandum of understanding with Minister Mirzagaliyev, minister of ecology, geology and natural resources of the Republic of Kazakhstan. *Photo: Republic of Kazakhstan*

From Scarcity to Security:

Managing Water for a Nutritious Food Future

PAGE 24

Ertharin Cousin and A.G. Kawamura
Cochairs

Mark W. Rosegrant
Principal author

March 2019

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THE CHICAGO COUNCIL ON GLOBAL AFFAIRS

From scarcity to security

DWFI Executive Director Peter G. McCornick worked with a diverse leadership task force to develop a new report from the Chicago Council on Global Affairs' Global Food and Agriculture Program.

The report, entitled "From Scarcity to Security," focuses on a U.S.-led strategy to ensure water, food and nutrition security for a 2050 global population of nearly 10 billion. It is estimated this future world population will need 30 to 50 percent more water for food, sanitation, environmental purposes and other uses than the world is using today. The report brought together farmers, policymakers, researchers and the private sector to discuss the future of both water and food security.

The report included recommendations, many of which DWFI is actively pursuing through research and policy development, including:

1. improving overall water resource governance through institutions that are transparent, accountable, efficient, responsive, sustainable and geographically contextualized;
2. allocating water more efficiently through water rights, regulations and quotas, water pricing, water trading and subsidy reform;
3. improving crop and livestock productivity per unit of water and land through agricultural research, development, technology, extension and financing;
4. shifting diets and diversifying agriculture to reduce the demand for water; and
5. increasing the supply of managed water and expanding irrigated areas through investment in infrastructure.

In addition, the report suggests that expanding urban and peri-urban agriculture and focusing on effective international agricultural trade policies, including "virtual" water trading, will further support water productivity. Ensuring that these solutions reach smallholder farmers, and that women and girls are empowered in the process, is not only essential to increasing water productivity but will improve livelihoods and contribute to greater water, food and nutrition security.

Read complete report:
go.unl.edu/scarcitysecurity

(L-R) Rob Bertram, Jennie Barron, Selamawit Damtew, Regassa Ensermu Namara, Petra Schmitter, Ariana Constant and Montaha Hassan at the 2019 Water for Food Global Conference.
Photo: Brett Hampton | Brett Hampton Photography

Supporting irrigation methods for smallholders

> Millions of smallholder farmers in developing regions of the world struggle to feed their own families, much less have enough harvest to market for profit. DWFI and partners explored the topic of scaling up sustainable and locally driven solutions for irrigated agriculture for smallholder farmers at the 2017 Water for Food Global Conference, which led to a special Water for Food International Forum (WFIF) held at the World Bank in January 2018 to generate interest in "farmer-led irrigation."

Subsequently, DWFI has continued to work with and support partners in further developing the concept on-the-ground and sharing knowledge. Examples to date include the following events.

- The Chicago Council on Global Affairs' Taskforce on Water and Nutrition, mentioned earlier, embraced farmer-led irrigation as a key emphasis of their 2019 influential report "Managing Water for a Nutritious Food Future." The council further explored and promoted the concept during their Food Security Symposium in Washington, D.C., in March 2019.
- Alliance for a Green Revolution in Africa (AGRA) co-organized a session on farmer-led irrigated agriculture at the 2018 African Green Revolution Forum (AGRF), along with the World Bank and African Development Bank. The declaration from this event, which drew on the outcomes from WFIF, was included in the plenary session. A follow-up session on the topic was included in the 2019 AGRF.

Irrigated land in Nebraska.
Photo: Nebraska Department of Natural Resources

Report sheds light on complexities, benefits and challenges of agricultural water transfer rights in the Western U.S.

> A 2019 report coproduced by DWFI and Mammoth Trading offers insight into the use of water transfers as a way to reduce water scarcity risk and meet competing demands among agricultural, environmental and urban interests.

A 2019 report coproduced by DWFI and Mammoth Trading offers insight into the use of water transfers as a way to reduce water scarcity risk and meet competing demands among agricultural, environmental and urban interests.

Most water rights trading is done at a local level without standardized regulations or documentation. This report helps define the different forms of water markets in play and how they are being used to provide value and risk management.

The report includes input from dozens of water practitioners and policymakers throughout the Western United States, as well as data collected from a number of published research papers. The authors used these resources to identify the types of water transfers that are occurring, the challenges around transfers, the policies for monitoring and enforcing transfers and the methods of data collection and reporting.

Since agricultural irrigation accounts for more than 60% of freshwater use in the Western U.S., understanding how water transfers are working – or not – can have a tremendous impact on both food and water security. This report sheds light on how farmers and water managers can use water transfers to better manage the resource and mitigate risk.

Read complete report:
go.unl.edu/watertransfer

The Platte River at sunrise. *Photo: Brett Hampton | UNL Communications*

Researchers verify ways to preserve Ogallala Aquifer waters

The High Plains Aquifer, one of the largest freshwater aquifers in the world, supports nearly 30 percent of U.S. irrigated agriculture. The area exemplifies groundwater challenges found worldwide, namely how to sustainably manage an aquifer at a time of increasing demands from food production, drinking water consumption, urbanization and climate change.

Achieving better aquifer management in the future will require a comprehensive understanding of the region's climate, soils, agronomy, hydrology, socioeconomics and water governance. For this purpose, in 2015 the USDA provided a $10-million, four-year grant for the Ogallala Water Coordinated Agriculture Project (OWCAP), led by Colorado State University with the Nebraska Water Center (NWC) and the University of Nebraska among project partners, including Kansas State University, Oklahoma State University, New Mexico State University, Texas Tech University, West Texas A&M University, Texas A&M AgriLife and the USDA ARS.

The USDA funding is being used to develop and share practical, science-supported information about best practices for irrigation, crop and soil management, and economics, policy and decision-making. The NWC, part of DWFI, leads the University of Nebraska's efforts in this project.

In FY2019, NWC postdoctoral research associates contributed groundwater and crop modeling expertise that strengthened the project. Their models for corn, soybean and winter wheat helped project economists run scenarios to understand the impact of future management decisions on groundwater levels.

Team members are sharing findings through published articles that become a part of permanent scientific scholarship.

More information:
ogallalawater.org

PAGE 31

A man flyfishing for trout in Veridgre Creek in the Bazile area.
Credit: brookiesandbrowns.blogspot.com

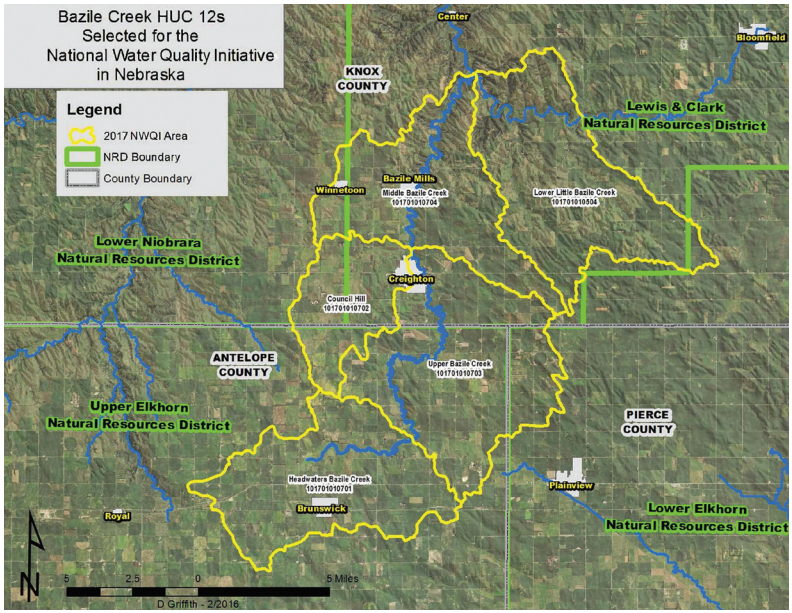
Implementing nitrate solutions: Bazile Groundwater Management Area

Nitrogen is an essential fertilizer for growing productive crops. However, when it enters into water it becomes a risk. For decades, Nebraska's NRDs and the Nebraska Department of Environment and Energy (NDEE) have been monitoring the state's water quality. With the help of University of Nebraska research, a 756-square mile area of Antelope, Knox and Pierce counties has been identified as having high groundwater nitrate levels. With groundwater supplying much of this area's drinking water, homeowners and small communities must treat water but often find it cost-prohibitive.

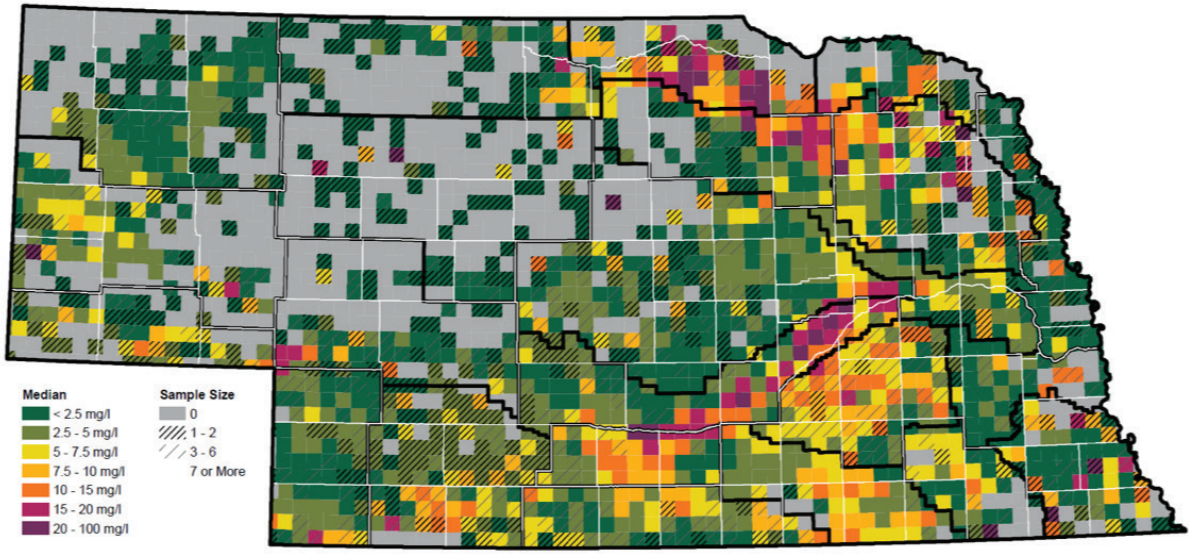
PAGE 33

To help solve the problem, six years ago area NRDs and NDEE teamed up with local, state and federal partners to create the BGMA Plan. Partners include the NWC and its Water Sciences Laboratory (WSL) — and University of Nebraska Extension. This work is critical for the health of more than 7,000 Nebraska citizens in the area. A number of the communities have exceeded Environmental Protection Agency (EPA) maximum nitrate levels for drinking water.

BGMA leadership is taking action through jointly funded research, outreach and incentivization of best practices to help lower nitrate



A Nebraska map shows the amount of nitrate in groundwater (average by township). Credit: NDEE 2018



levels, improve groundwater quality and mitigate nitrogen loss in the soil.

Last year, a jointly funded extension educator position was established to perform BGMA-specific on-farm research and demonstrations. The extension educator is developing educational programs and field demonstrations.

Through a Nebraska Environmental Trust (NET) grant, the NWC expanded its Know Your Well program into five BGMA high schools. This program teaches students to sample and test community wells. The NET grants provide BGMA-related support of more than $820,000 over the next three years.

Crystal Powers, research and extension communications specialist through the NWC, has been leading NWC engagement within the BGMA. She said the end goal is bigger than Nebraska. "Once we know the best combination of best management practices, the university's large faculty and extension group, including DWFI with all its international connections, is well-positioned to expand this knowledge throughout the state and other places in the world that are experiencing similar challenges."

On October 9 and 10, 2019, the NWC hosted its annual conference in Norfolk, Nebraska, with a specific focus on water quality in the BGMA and Northeast Nebraska. More than 40 speakers presented their knowledge of how community engagement, innovative methods and public health can be applied to create a clean water future.

More information about nitrates and the BGMA team's work: ***water.unl.edu***

CULTIVATING FUTURE WATER FOR FOOD LEADERS

Faculty Fellow Derek Heeren works with graduate students, researching electromagnetic soil moisture sensors to develop irrigation prescriptions. Credit: Morgan Spiehs

Students in the UNL SEEDS learning community visited a coffee farm on their experiential study trip to Rwanda.
Photo: DWFI Staff

Seeds of success

DWFI hosted an upperclass learning community at UNL focused on global entrepreneurship, agriculture and sustainable development. In late July and August 2019, DWFI staff led eight students from the learning community on a three-week experiential study trip to Rwanda. The students, a mix of American and Rwandan UNL students, traveled across the country, meeting with farmers, local entrepreneurs, nongovernmental organizations and agribusinesses to learn about the agricultural landscape in Rwanda.

DWFI also provided financial and professional development support to the Future Agriculture Leaders (FAL), a student-run organization of UNL students aimed at helping Rwandan youth develop an interest in solving agricultural issues through entrepreneurship and innovation. In July, DWFI co-sponsored FAL's inaugural entrepreneurship workshop and pitch competition in Kigali, Rwanda. About 50 high school students representing 13 different schools across Rwanda participated in the workshop.

DWFI's engagement in Rwanda includes capacity building for local entrepreneurs and other nongovernmental organizations through informal mentoring. DWFI staff has developed relationships with start-ups such as Volta Irrigation, a small agribusiness company providing irrigation through a fuel-free system to smallholder farmers across the country. DWFI's support for Volta Irrigation even helped the company land a start-up contract from One Acre Fund (an international NGO) to develop and manufacture innovative planting tools, as well as building 100 irrigation systems to support 1,000 smallholder farmers across Rwanda.

Future focus

In the coming year, the DWFI policy team will release a report with case studies and key findings of their business model analysis in Rwanda. Engagement and mentoring will also continue with entrepreneurs, as well as current and graduated scholars from the College of Agriculture and Natural Resource (CASNR) Undergraduate Scholars Program (CUSP), to develop business strategies that could sustainably scale irrigation efforts in Rwanda.

A water canal in Europe. *Photo: Julie Fowler | UNL*

UNL students learn about European water management through IHE-Delft partnership

In May 2019, nine UNL students in the National Science Foundation (NSF) National Research Traineeship (NRT) program traveled to The Netherlands, France and Spain to participate in a two-week course to compare ancient and modern water structures in the three countries with those in Nebraska.

UNL students from the NRT program on their trip to Europe. Photo: Julie Fowler | UNL

The program dates back to 2012, when the IHE Delft Institute for Water Education and DWFI established a biennial two-week field course in Nebraska for students studying water- and food-related topics. The course emphasized hands-on learning, including laboratory work and field research. The partnership has evolved to include an annual field course each year, hosted in Nebraska in even-numbered years and Europe in odd-numbered ones.

UNL students in the NRT program began their trip in summer 2019 with a few days of instruction at IHE Delft, where students from Africa and Asia joined them as they journeyed first to France and then to Spain for seven days each.

Participating students said the program will help them with their future careers, bringing a more well-rounded perspective to solve complex problems related to the water, energy and food security nexus.

WARI leadership program advances worldwide water quality and human health solutions

Since 2016, DWFI and NWC have teamed with several university departments in a unique joint initiative with some of India's best academic institutions. The program fosters leadership in addressing global water quality challenges, such as ecological and human health impacts caused by pollutants and contaminants, groundwater quality assessment and management, and remote sensors that monitor and measure water quality. According to the World Health Organization, almost 100 million Indians lack access to safe water.

PAGE 40

The WARI program provides Indian Ph.D. students and early-career faculty with advanced water research and mentorship opportunities at the University of Nebraska and includes a reciprocal exchange component for Nebraska students to conduct water research in India. WARI program partners include the Indian government and its Department of Science and Technology, the Indo-U.S. Science and Technology Forum, the University of Nebraska–Lincoln (UNL) and the University of Nebraska Medical Center (UNMC).

In 2019, the program was renewed for an additional three years by program partners in India. To date, 39 WARI Fellows from more than 25 Indian institutions have participated. In November 2018, WARI alumni and Nebraska faculty jointly organized a major workshop in India on water, energy and climate.

Big plans are in place for the program in 2020. A Nebraska-led consortium will expand WARI to satellite programs at the University of Idaho, Texas Tech University and Purdue University. Each school will host one or two fellows, introducing them to a wide range of water-related topics and expertise. UNL will continue to host the majority of the scholars.

More information:
go.unl.edu/wari

CONVENING AND COMMUNICATING

Federal Communications Commission (FCC) Chairman Ajit Pai, meets Nebraska farmers on a DFWI-coordinated visit. Photo: DWFI staff

Farmers and agriculture experts from the United States, Brazil and Rwanda share their personal perspectives and hands-on experience during the "View from the Field" session at the 2019 Water for Food Global Conference. Photo: Chuck Zimmerman | ZimmComm New Media

2019 Water for Food Global Conference

> "Water is life," said Deborah Hamlin, CEO of the Irrigation Association. It was a sentiment shared by 400-some participants who gathered from across Nebraska, throughout the U.S. and from more than a dozen countries to learn how the power of water can sustainably grow enough food for our world's rapidly increasing population. The participants were part of DWFI's ninth Water for Food Global Conference (WFGC) held April 29–30 at Nebraska Innovation Campus.

"It was inspiring to see the enthusiasm and energy of people from all over the world sharing innovative ideas and perspectives on water and food and rising to the challenge of transforming these into impacts," said Peter G. McCornick, DWFI executive director.

The conference title, "Water for a Hungry World: Innovation in Water and Food Security," highlighted the focus on emerging breakthroughs in research and technology that are fueling the future of agricultural water management and increased productivity.

In the course of two days, scientists, government agency directors, nonprofit leaders, entrepreneurs, water managers, policymakers, farmers, students and private industry executives listened to experts share their perspectives and attended a selection of 20 sessions.

Sessions covered a wide range of important topics, such as supporting sustainable farmer-led agriculture, innovations in irrigation technology, an entrepreneurship marketplace, water reuse in food processing, and predicting and mitigating drought, as well as the intersection of water quality, nutrition and climate change.

The conference closed with a Heuermann Lecture by Mark Rosegrant, IFPRI research fellow, who spoke about the recently released report "From Scarcity to Security: Managing Water for a Nutritious Food Future," sponsored by the Chicago Council on Global Affairs with input from DWFI Executive Director Peter G. McCornick.

A "Women for Water" side event was held the following day, May 1, with more than 100 participants discussing a variety of topics related to agricultural water management and the opportunities for women in this field.

Recorded conference sessions on YouTube:
youtube.com/waterforfood

Conference proceedings and agenda:
go.unl.edu/proceedings

DWFI-supported students, Faculty Fellows and staff network at the annual DWFI Faculty and Student Research Forum. Photo: Nebraska Water Center staff

Students share research and outcomes at annual Faculty and Student Research Forum

> Recipients of DWFI's Student Support Awards presented their innovative work in food and water security at the annual Faculty and Student Research Forum on April 4, 2019, at the Nebraska Champions Club.

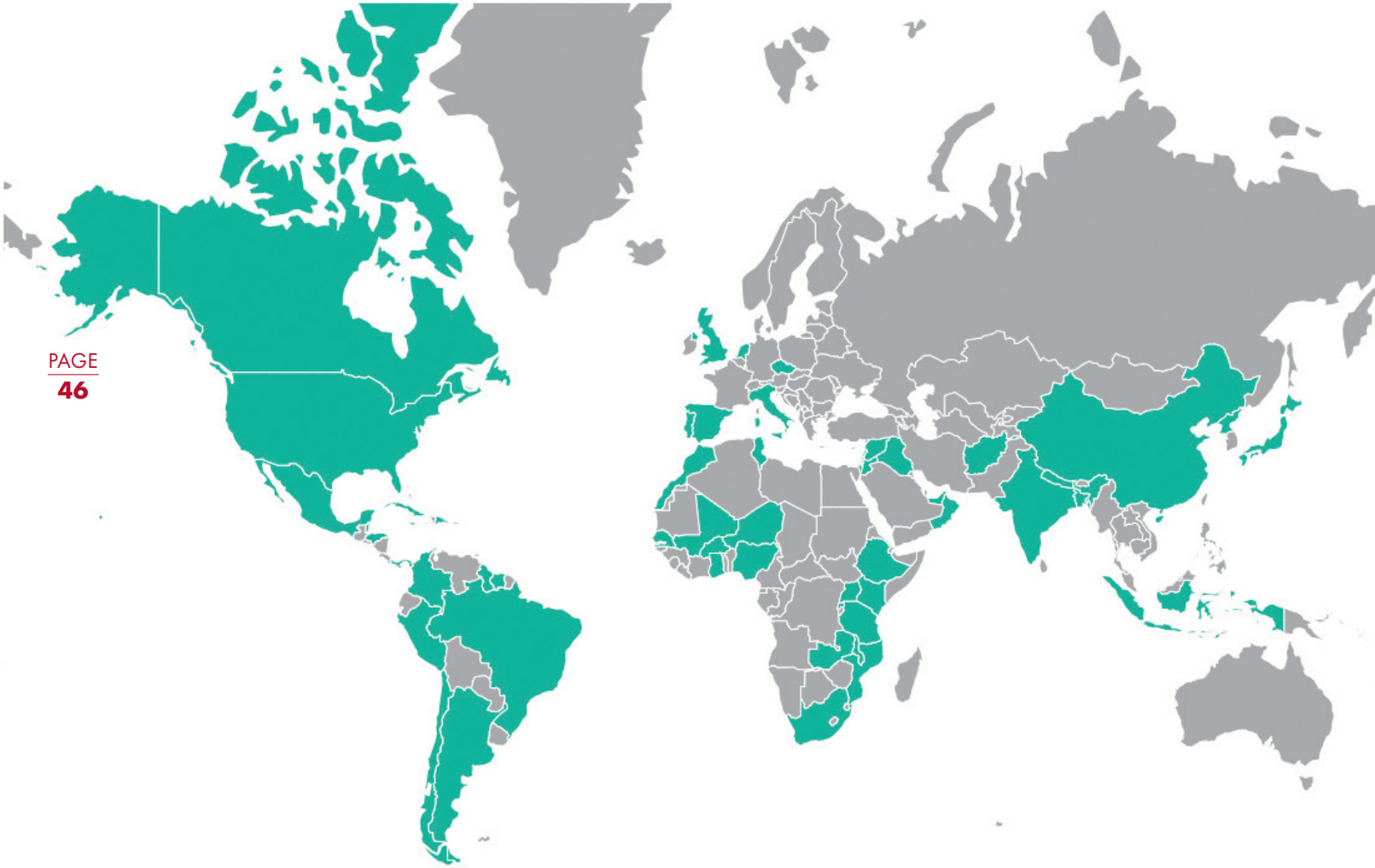
The annual event serves as a culmination of the program's yearly activities. This year's event showcased short graduate student presentations and a student poster session, as well as a science communication mini workshop.

The first five years of DWFI's Student Support Awards program funded 47 projects. With an investment of approximately a half-million dollars annually as of 2018, this is the institute's largest program area. The award amount from DWFI is matched one-to-one with faculty funds, ensuring a student can be supported full-time through a master's or Ph.D. program.

DWFI-supported student Luke Monhollon presents his research at the 2019 Faculty and Student Research Forum. Photo: Nebraska Water Center staff

Where We Work

COUNTRIES	PROGRAMS	PROJECTS	PUBLICATIONS	FACULTY	SCHOLARS	GRANTORS
58	15	516	209	118	195	203



Mapping our progress

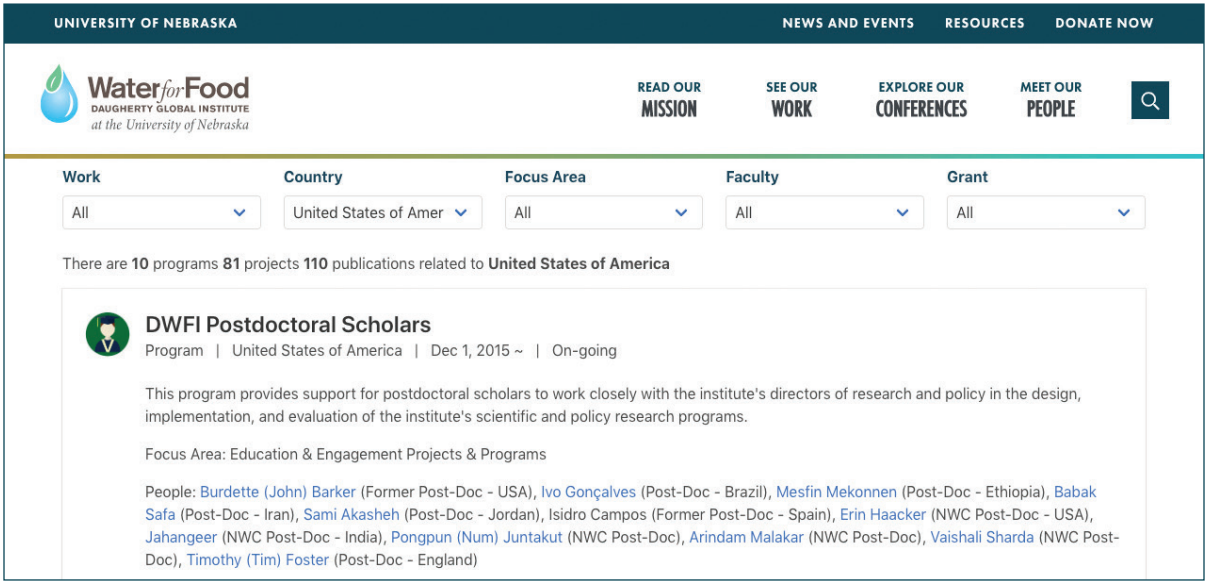
DWFI works with more than 110 associated University of Nebraska Faculty Fellows to achieve water and food security around the world through research, education and communication. Visitors to the DWFI website can quickly view the many university-led research projects and papers related to the institute's mission through a new interactive map.

The map draws from a database named UNDA, the Latin word for "ripple" or "wave," and includes work by DWFI, Faculty Fellows, NWC, WSL and associated staff and scholars. Through the map, high-level information is available about projects, including description, focus area, status, start and end dates, country and people involved.

"We are very excited to add this helpful feature to our website," said Lacey Bodnar, DWFI research project manager and the database project leader. "It showcases the University of Nebraska's leadership in research and practical problem solving, tackling complex challenges, and delivering results to advance water and food security."

Access UNDA: ***waterforfood.nebraska.edu/our-work*** *(scroll down)*

PAGE 47



DWFI growing stakeholders through social media

> Just as today's technology allows us to connect with growers worldwide to produce more food for a growing population, the vast world of social media allows us to bring the institute's mission and expertise to the ends of the earth.

The communications team expanded the breadth of our network this year by adding Instagram and LinkedIn as key platforms in its strategic communications plan. Twitter and Facebook have long been the cornerstones of the institute's social media efforts, reaching both international and domestic audiences, respectively.

Instagram has a more visual message than other platforms and achieves greater reach with youth — those generations on which the great transfer of knowledge and the future of our world will depend. A greater presence on LinkedIn allows us to connect with potential donors, sponsors and collaborators and share our network's research and outcomes in a meaningful way. By tagging our colleagues and Faculty Fellows, our reach far expands beyond our immediate network.

+19%
likes

1,329,555
reach

14,266
engagement

+5%
followers

454,006
impressions

417
mentions

6,919
engagements

+199%
followers

1,000,660
impressions

14,380
likes

+945%
engagement

+48%
followers

+81%
engagement

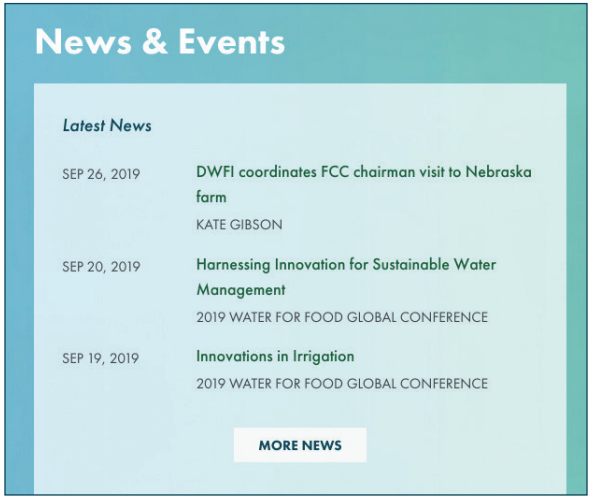
582
page clicks

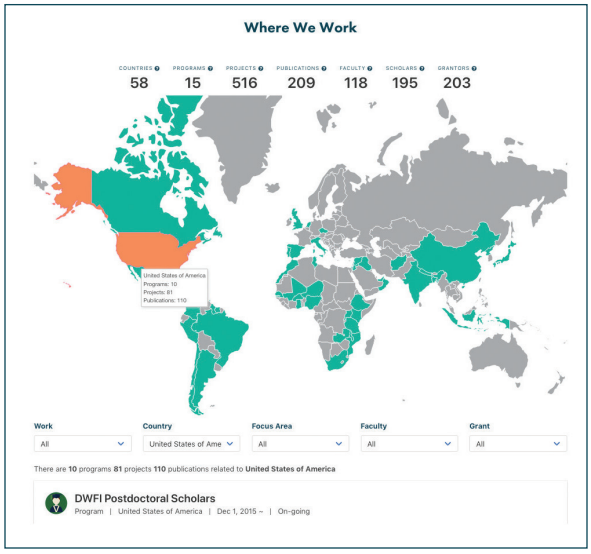
Website Developments

The institute's website was completely redesigned in FY2018 and new enhancements were added in FY2019:

- Updated website imagery to reflect the organization's current work
- Archived resources from the 2019 Water for Food Global Conference
- Added functionality for the UNDA database in the "Our Work" section
- Updated the "News and Events" section to contain all news press releases, blogs, events and media mentions. All current information is now available in one place.
- Rearranged the "Our People" section into collapsible categories and added a page for each Faculty Fellow
- Added an archive page with an updated list of archived Water for Food Digest e-newsletters
- Improved search engine optimization by optimizing imagery and code for the website

Our website is trending, with visitors spending more average time on the site. This means they are engaging in our content for longer periods of time. From July 2018 to July 2019, time spent per visit increased by an average of 45 seconds.





Telling our story

With a focused effort to use more storytelling video, DWFI is now better able to share its successes with its wide online audience. Complex topics are simplified and high-level topics made personal through the use of sounds and visuals. DWFI continues to increase its use of video as a key part of its communications strategy and has had great success over the past year.

A video featuring donors Robert and Karla Baltzell and their Student Innovator Fund garnered more than 8,200 views on Facebook alone, reaching 3,867 unique viewers. Through the video and this story of one couple's passion for paying it forward, we reached other donors who may wish to do the same in the future.

Video also has allowed us to make our researchers' published journal articles easier to digest, and it helped us demonstrate the articles' impact. A video showcasing DWFI Research Project Manager Kate Gibson explaining her research on high yields and irrigated water requirements reached 8,626 views on Facebook.

Sessions from the 2019 Water for Food Global Conference are posted online, so the knowledge can live on and reach a wider audience. Research presentations from DWFI-supported students also were recorded and posted online, so students can share the results of their work.

PAGE 50

New additions to the Water for Food YouTube channel

The DWFI video library has grown to 256 videos and attracted nearly 70,000 views. Here are some of the videos added within the last year:

- Robert and Karla Baltzell Student Innovator Fund
- High yields, staying within irrigated water requirements not conflicting goals
- Working with the Daugherty Water for Food Global Institute
- Airborne Agriculture Technology: The Grit and the Glory
- Drone surveillance for crop productivity
- Rwandan student studies water-food-energy nexus
- Rwandan undergraduate students learn about DWFI's work
- Megan Homolka - Baltzell Student Innovator Awardee
- A New Look at Groundwater through Airborne Electromagnetics
- The Influence of Climate and Agriculture on Groundwater Contamination
- Full video of the 2019 Water for Food Global Conference and Women for Water
- 2019 DWFI Faculty Student Forum Videos

Watch: **youtube.com/waterforfood**

DONORS AND FUTURE SUSTAINABILITY

Past DWFI-supported student Mitch McGuire uses unmanned aerial vehicle (UAV) to monitor drought stress during his research. Photo: DWFI staff

DWFI-supported student Osler Ortez shares his research on formation issues in corn at the University of Nebraska–Lincoln's Holdrege research farm. *Photo: DWFI staff*

Donors support our work and future leaders

> Now entering its fifth year, DWFI's student support program has distributed nearly two-million dollars to support undergraduate, graduate and postdoctoral research across all four University of Nebraska campuses. The awards provide stipends to students working on projects that contribute to the institute's mission of achieving food security with less pressure on scarce water resources.

With a gift to the University of Nebraska Foundation, The Ivanhoe Foundation established a fund that provides fellowship awards and research assistance for international graduate students pursuing careers in water management, especially in economically emerging countries. Two supported graduate students are researching wheat residue management to enhance soil water conservation, and the role of climate information in making agricultural water management decisions in sub-Saharan Africa, respectively.

The grants program supports interdisciplinary faculty research while enriching the education of students who will one day be scientific leaders in water and food security. Thanks to a matching grant from the Robert B. Daugherty Foundation, the institute can double a donor's gift to help even more students conduct research and study abroad, as shown in the following examples:

- Robert and Karla Baltzell's student fund focuses on innovations to improve water usage connected to raising livestock. To date, two undergraduate and two graduate students have received the Baltzell Student Innovator Award for their research in this important area of improving water productivity.
- UNL and UNMC alumna, Dr. Carol Swarts, established the "Exploring New Directions with DWFI and Public Health" student support endowed fund, focusing on medical research, public health and mentoring students. This fund strengthens collaboration between DWFI and the College of Public Health as it relates to water quality and its effects on public health.
- Many students have had the opportunity to pursue advanced research related to improving water use in agriculture, thanks to funding from generous donors, such as Elanore and Dan Decker and Robert and Angenette Meaney. Gifts from these families have supported student research, study abroad experience in Rwanda for the SEEDS Learning Community, and the Rogers Student Poster Competition at the 2019 Water for Food Global Conference, named in honor of International Advisory Panel member Peter Rogers who passed away in 2018.

In collaboration with the University of Nebraska and the Robert B. Daugherty Foundation, the institute has developed a long-term sustainability plan, which will ensure the institute's work will continue well into the future.

Strategic Partnerships

Alliance for a Green Revolution in Africa (AGRA)

Environmental Defense Fund (EDF)

Food and Agriculture Organization of the United Nations (FAO)

Foundation for Food and Agriculture Research (FFAR)

Global Harvest Initiative

Groundwater Foundation

Global Water Partnership

International Food Policy Research Institute (IFPRI)

IHE Delft

International Water Management Institute (IWMI)

Irrigation Innovation Consortium (IIC)

National Drought Mitigation Center (NDMC)

United States Agency for International Development (USAID)

United States Department of Agriculture (USDA)

University of Nebraska–Lincoln Institute of Agriculture and Natural Resources (UNL IANR)

U.S. Water Partnership

The World Bank

World Water Council

World Wildlife Fund (WWF)

Foundations

Anonymous

Ivanhoe Foundation

Robert B. Daugherty Foundation

The Straws Charitable Foundation

Valmont Foundation

Private Funding

Robert and Karla Baltzell

Elizabeth A. Beghow

Ann K. and David D. Bruntz

Blanche Butera

Daniel and Elaine Decker

C.K. Duryea

Richard B. Ferguson

Tiffany Heng-Moss

Gabin Kundwa

Patrick J. Leahy

Melissa Malkovich

Robert and Angenette Meaney

Amy N. Ngo

Justin Z. Spooner

Dr. Carol J. Swarts

Brenda Umutoniwase

Grant Funding

Alliance for Sustainable Energy LLC

Apogee Inc.

Bayer (formerly Monsanto Co.)

Colorado State University

U.S. Department of Interior-GS

Eastern Research Group, Inc.

Electric Power Research Institute (EPRI)

International Water Management Institute (IWMI)

National Cattlemen's Beef Association

National Science Foundation (NSF)

Nebraska Beef Council

Nebraska Department of Environment and Energy (NDEE, formerly NDEQ)

Nebraska Environmental Trust (NET)

Nebraska's Established Program to Stimulate Competitive Research (EPSCoR)

Several Nebraska Natural Resources Districts (NRDs)

U.S. Department of Agriculture-National Institute of Food and Agriculture (USDA-NIFA)

U.S. Department of Agriculture-Office of Community Engagement (USDA-OCE)

University of Wyoming

Corporate Sponsors

Bayer

Valmont Industries

Lindsay Corporation

World Wildlife Fund

Nebraska Corn Board

Wells Fargo/IN2

Mosaic

Credits

The FY 2019 Annual Report is published by the Robert B. Daugherty Water for Food Global Institute at the University of Nebraska. For more information, see the website at **waterforfood.nebraska.edu**.

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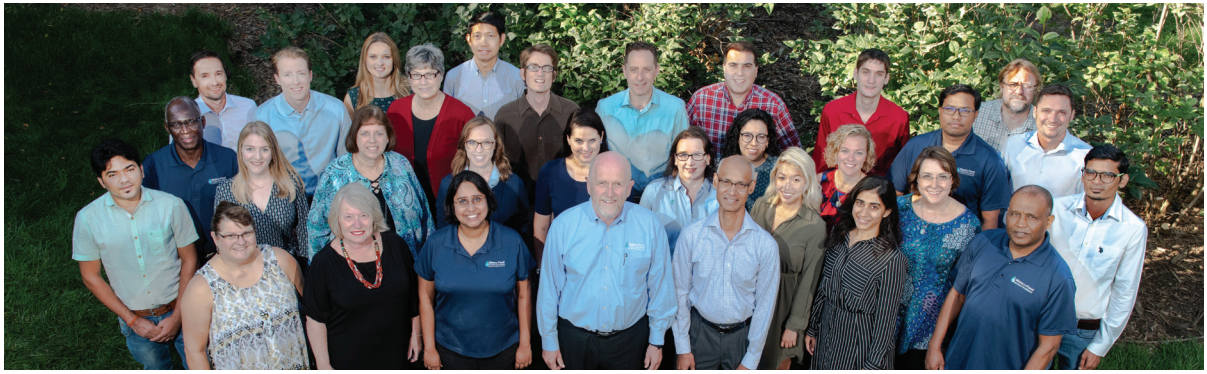

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Acronyms

ACRONYM	ORGANIZATION/TERM
AfDB	African Development Bank
AGRA	Alliance for a Green Revolution in Africa
AGRF	African Green Revolution Forum
ALEXI	Atmosphere-Land Exchange Inverse
BGMA	Bazile Groundwater Management Area
CASNR	College of Agricultural Sciences and Natural Resources at the University of Nebraska–Lincoln
CDI	Composite Drought Index
CUSP	CASNR Undergraduate Scholarship Program
DGs	Distillers' Grains
DWFI	Daugherty Water for Food Global Institute at the University of Nebraska
EDF	Environmental Defense Fund
EPA	Environmental Protection Agency
ET	Evapotranspiration
FAL	Future Agriculture Leaders
FAO	Food and Agriculture Organization of the United Nations
FCC	Federal Communications Commission
FY	Fiscal Year
GHG	Greenhouse Gas
GloDET	Global Daily Evapotranspiration
HA	Hectare
IANR	Institute of Agriculture and Natural Resources at the University of Nebraska–Lincoln
IAP	International Advisory Panel
IARI	Indian Agricultural Research Institute
ICBA	International Center for Biosaline Agriculture
IFPRI	International Food Policy Research Institute
IHE Delft	Institute for Water Education, Delft, The Netherlands
IIC	Irrigation Innovation Consortium
IUSSTF	Indo-U.S. Science and Technology Forum
IWMI	International Water Management Institute
MENA	Middle East and North Africa
MOU	Memorandum of Understanding
NASA	National Aeronautics and Space Administration
NDEE	Nebraska Department of Environment and Energy

NDMC	National Drought Mitigation Center at the University of Nebraska–Lincoln
Nebraska EPSCoR	Nebraska's Established Program to Stimulate Competitive Research
NET	Nebraska Environmental Trust
NEWBA	Nebraska Water Balance Alliance
NGO	Non-governmental Organization
NIC	Nebraska Innovation Campus
NRDs	Natural Resources Districts
NRT	NSF Research Traineeship
NSF	National Science Foundation
NU	University of Nebraska
NWC	Nebraska Water Center
NWPR	Nebraska Water Productivity Report
OWCAP	Ogallala Water Coordinated Agriculture Project
RBDF	Robert B. Daughert Foundation
SEEDS	Service, Engagement, Entrepreneurship, Development, Sustainability
SETMI	Spatial Evapotranspiration Modeling Interface
SWM	Smart Water Meters, Inc.
TCC	The Climate Corporation
UAV	Unmanned Aerial Vehicle
UNL	University of Nebraska–Lincoln
UNMC	University of Nebraska Medical Center
U.S.	United States
USAID	U.S. Agency for International Development
USDA	U.S. Department of Agriculture
USDA-ARS	U.S. Department of Agriculture - Agricultural Research Service
USDA-NIFA	U.S. Department of Agriculture - National Institute of Food and Agriculture
USDA-OCE	U.S. Department of Agriculture - Office of Community Engagement
USIEF	United States-India Educational Foundation
WARI	Water Advanced Research and Innovation
WB	World Bank
WFGC	Water for Food Global Conference
WFIF	Water for Food International Forum
WHO	World Health Organization
WP	Water Productivity
WSL	Water Sciences Lab

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Front Photo: Volcanos National Park looms behind a farm field in Rwanda.