Water for Food
DAUGHERTY GLOBAL INSTITUTE
at the University of Nebraska

IMPACTS

ANNUAL REPORT

FY2018 (JULY 1, 2017 TO JUNE 30, 2018)

Front Cover Photo: Getty Images

FOREWORD

One in nine people goes to bed hungry each night, according to the U.N. World Food Program. That's **795 million people** on the planet who do not have access to enough nutritious food.

The challenge is growing. Global drivers like climate change, urbanization and increasing demand for water-intensive agricultural products are altering landscapes, increasing soil erosion, and degrading water resources and soils in important food producing regions around the world. We must figure out how to feed a global population projected to reach 10 billion by 2050, with the same amount of water and arable land – and quickly.

This was the thinking behind the creation of the Daugherty Water for Food Global Institute at the University of Nebraska. Since 2010, the institute has drawn on expertise in Nebraska and elsewhere – including more than 110 multidisciplinary faculty fellows, 18 global fellows, visiting scholars and a wealth of external partners – to develop technologies, practices and policy solutions to address one of the most urgent challenges of our time.

As you'll see in the following pages, with your help, we are making important progress. This year, the Institute convened a Water for Food International Forum on farmer-led irrigation held in partnership with the World Bank, the U.S. Agency for International Development and the U.S. Department of Agriculture in Washington, D.C. We also took a leadership role in the 8th World Water Forum in Brasilia, Brazil, where we co-organized the water for food security track in partnership with the Food and Agriculture Organization of the United Nations, and hosted a high-level panel on water for food.

The institute developed innovations to advance water and food security, from cutting-edge research using drones to capture real-time crop moisture data, to smart water meters that inform

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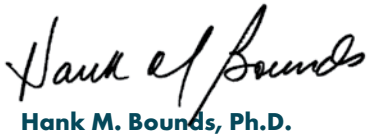
Executive Director, Robert B. Daugherty Water for Food Global Institute at the University of Nebraska

farmers of the energy costs of irrigation. We have shared policy research and best practices, as shown in a new publication we co-authored with the Environmental Defense Fund that provides a toolbox of resources and case studies on water management solutions. And, we're building capacity through educational opportunities for the next generation of water and food security leaders, like the master's level Nebraska field study course we offer in partnership with IHE Delft, The Netherlands, to students from Nebraska and countries around the world.

Particularly with a challenge of this scale, tangible impacts can take years to achieve. But we are proud that DWFI is making a difference through focused research, education, collaboration and communication. That progress is possible because of the generosity of the Robert B. Daugherty Foundation and other donors, the guidance of our board of directors, and the involvement of partners who share our vision for a water and food secure world – including the recently launched Irrigation Innovation Consortium, an important new partnership with the Foundation for Food and Agriculture Research, four other universities and key private sector companies.

Thank you for helping to put dinner on the table for nearly 10 billion people by 2050.



Hank M. Bounds, Ph.D.
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Arid landscape in Morocco.
Credit: valkyrieangie / Flickr

RESEARCHING SOLUTIONS FOR A WATER AND FOOD SECURE WORLD

The Robert B. Daugherty Water for Food Global Institute (DWFI) at the University of Nebraska is working at the global, national and state levels to address the complex and intertwined challenges that threaten our ability to feed our growing world and sustain our scarce water resources. In fiscal year 2018, the institute continued to make significant progress toward our mission with notable outcomes from our technical and policy research, as well as education, outreach and communication efforts.

With projects in more than 75 countries, DWFI and its strong network of partners and affiliated faculty around the world are developing solutions to the challenges of achieving water and food security. The institute draws on the talents of 114 Faculty Fellows from across Nebraska's four university campuses; 18 Global Fellows, comprised of academic researchers from other universities and organizations whose geographic locations and areas of expertise enhance the institute's global reach and effectiveness; as well as our visiting scholars, postdoctoral researchers, students and interns. The institute benefits from the complementary support of partners within the University of Nebraska system, including the National Drought Mitigation Center (NDMC); and draws on the strengths of many national and international partners in the private and public sectors.

In Nebraska, much of DWFI's work is advanced by the Nebraska Water Center (NWC) and the Water Sciences Laboratory (WSL), which focus on water management, quality and public/ecosystem health. The NWC and WSL are integrated with the institute and provide valuable water research and management experience throughout Nebraska, working closely with the state's 23 Natural Resources Districts (NRDs), Nebraska Extension, producers and others.

Center Pivot irrigating a crop field in Nebraska.
Credit: Getty Images

The institute's research and policy program is focused into five areas to best maximize the expertise of DWFI staff, Faculty and Global Fellows, and the University of Nebraska:

Enhancing high productivity agriculture

Closing water and agricultural productivity gaps

Improving groundwater management for agricultural production

Supporting freshwater and agricultural ecosystems and public health

Managing agricultural drought

Education, communication and donor development are also important pillars of DWFI's work. Through educational events, donor engagement and targeted communication, we are working to build tomorrow's leaders and the stakeholder support needed to achieve our mission.

ENHANCING HIGH-PRODUCTIVITY IRRIGATED AGRICULTURE

Irrigation Innovation Consortium

The IIC is accelerating the development and adoption of water and energy efficient irrigation technologies and practices to help producers, water managers, government agencies and private industries improve management and policy decision-making that lead to enhanced water and food security.

A major new partnership this year has been the formation of the Irrigation Innovation Consortium, a strategic collaborative research effort designed to accelerate development and adoption of water and energy efficient irrigation technologies and practices through public-private partnerships. Consortium members matched a $5 million grant from the Foundation for Food and Agriculture Research (FFAR) for a total initial investment of $10 million to support research and collaboration costs over five years (2018–2023).

The consortium is composed of the following initial founding university members:

- California State University, Fresno
- Colorado State University
- Daugherty Water for Food Global Institute at the University of Nebraska
- Kansas State University
- Texas A&M AgriLife Research

Founding industry partners include the Irrigation Association, Jain Irrigation, Lindsay Corporation, Northern Water and Rubicon Water.

Public sector researchers and industry partners will co-develop technology and information systems designed to equip "farms of the future," with cutting-edge strategies to enhance irrigation efficiency. Participants are working to create a platform for other universities, federal agencies and the private sector to work together on the critical water challenges facing agriculture, municipalities, and industry. The goal is to dramatically advance water and energy efficiency in irrigation, ultimately creating greater resiliency in food and irrigated landscape systems.

Expected outcomes include:

- Developing technology for improved irrigation hardware and software, decision support systems and big data applications
- Filling research gaps using the diversity of expertise from university partners and collaboration with industry and federal research agencies
- Leveraging existing irrigation and demonstration facilities at the participating universities to advance new technologies and irrigation management approaches in the pre-competitive space
- Developing a network of multi-state sites for irrigation technology demonstrations and hands-on training
- Convening multiple public-private participants for technology transfer, multiplying the FFAR investment
- Transferring knowledge to farmers and the public through land grant university extension networks

Through its work in the consortium, DWFI is developing a network of research and production farms that allows on-farm technology evaluation and provides in-field training and education. Researchers established the first eddy covariance system (Smart Flux) southeast of Grant, Nebraska. The system measures crop evapotranspiration, providing the data needed to model soil water content and irrigation water demand of various cropped fields. In the coming months, researchers will upgrade and install a next-generation of Smart Flux equipped towers in central Iowa, as well as in eastern and northwestern Nebraska.

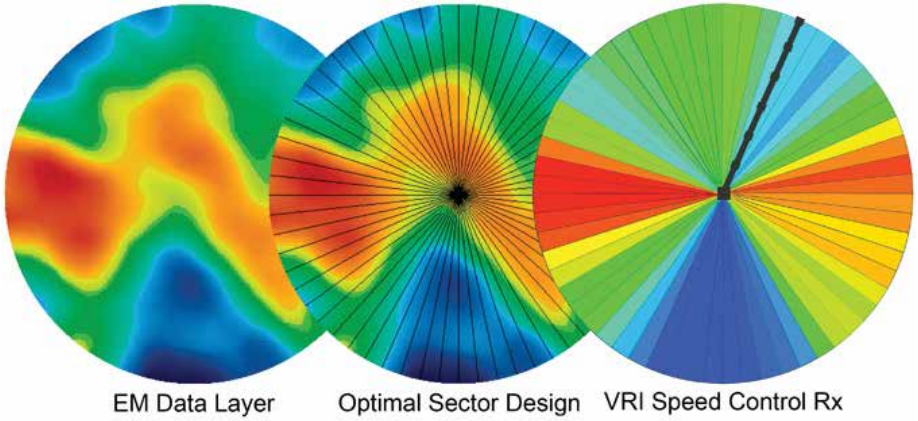
As a result of their work, consortium partners expect to see significant advances in water and energy efficiency to benefit society and the environment.

Drone research project. Credit: Morgan Spiehs

Eddy covariance system, which measures crop evapotranspiration data to help evaluate soil water content.

Improving variable rate irrigation efficiency

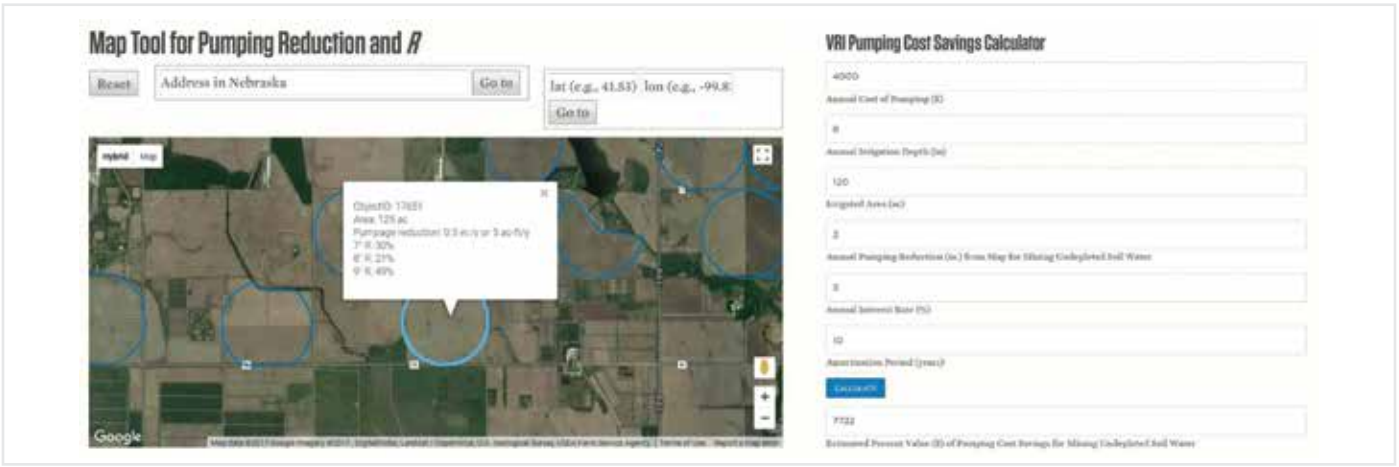
Variable rate irrigation (VRI) gives producers using center pivot irrigation the ability to customize water management of specific areas within a field instead of applying uniform watering across the entire field. DWFI is supporting research to improve VRI functionality with customizable speed and flow controls, along with software to create prescription maps specifying irrigation for each zone within a field. These technologies can help farmers better control water application and inputs for their crops, resulting in reduced water use, less nitrogen leaching and improved productivity.



Irrigation prescription maps for a center pivot. Credit: The Crop Site

A typical center pivot covers 136 acres. Traditionally, irrigation water is applied in an even quantity across an entire field. It's possible for the soil within a given field to vary significantly, so uniform irrigation can lead to different areas being irrigated more or less than needed. Overwatering can lead to leaching of fertilizers, such as nitrate, and yield loss. Underwatering can result in plant stress and decreased yields.

Farmers, pivot manufacturers, government agencies and groundwater managers are interested in how VRI technology can improve water usage in agricultural production. With funding provided by USDA NIFA, and in partnership with NWC, Lindsay Corporation and the Eastern and Western Nebraska Research and Extension Centers (ENREC & WCREC), DWFI Faculty Fellows are studying VRI applications and associated technology such as unmanned aerial systems, known more commonly as "drones." Drones provide



Screenshots of the online map tool for VRI pumping reduction.

high resolution multispectral and thermal infrared imagery for determining in-field variability, including water holding capacity, soil water content, canopy growth and temperature. With this information, producers can make effective management decisions, applying water only when and where needed for maximum yield and profit.

DWFI supported Faculty Fellow development of an online mapping tool (heeren.unl.edu/map), which provides estimates of potential pumping reduction and cost savings that could result from the use of VRI.

To share knowledge regarding the use of drones for agricultural information gathering, DWFI sponsored the event, "Flight to Maps: An Introduction to Unmanned Aircraft Remote Sensing," at the Eastern Nebraska Research and Extension Center in April, in conjunction with the Mid-America GIS Consortium.

DWFI will continue research on VRI technology to help producers and others adopt best practices to improve water and energy use in agriculture. This research aims to influence a change in producer behavior, shifting from viewing crop water management as a bulk, uniform decision for the entire field to increased acceptance of water management based on in-field spatial variability and sensor measurements.

DWFI provides irrigation expertise to assist smallholder family farmers in Bahia, Brazil

Understanding water availability and land use helps policymakers and farmers efficiently use water to increase yields, reduce energy use, protect ecosystems and public health and increase drought resilience. In Brazil, Nebraskans are helping stakeholders gain knowledge and tools needed to achieve these goals.

Grain storage facility in Fazenda Decisão

The Western region of the state of Bahia, Brazil, has great unmet potential for irrigated agriculture from the Urucuia groundwater aquifer. This aquifer is as large as the Ogallala Aquifer in the United States. However, it has less than three percent of the number of pivots as Nebraska. By working with the active Association of Farmers and Irrigators of Bahia (AIBA) and influential state government officials, as well as the Federal University of Vicosa, Minas Gerais, DWFI seeks to apply lessons learned from agriculture in Nebraska. DWFI is helping develop effective surface and groundwater monitoring and management programs, while sustainably expanding and intensifying irrigated agriculture in Bahia.

This program has five key components, which are complementary to creating holistic and long-term change within farming communities. The program's pillars are: modeling, monitoring, governance, shared center pivots, strengthening irrigation districts and capacity building. The research goals include developing a prototype water quality and quantity monitoring system and a prototype governance system for western Bahia. AIBA group is reviewing Nebraska's system of administering water locally through NRDs as a model for effective, stakeholder-led water governance.

DWFI leaders and Faculty Fellows join farmer members of AIBA at a farm in Bahia, Brazil

The project partners have already launched a Water Leaders Academy, based on a similar program in Nebraska, to create self-sustaining and long-term change by building capacity through practical learning, internships and international opportunities. Thirty farmers and other stakeholders, such as government staff and private sector employees, will begin the course in Brazil in late fall of 2018. The training will focus on solving real-world problems and include significant fieldwork and site visits.

This research partnership is administered and funded in part by AIBA, representing more than 1300 farmers and 2.25 million hectares of land in Bahia. Other partners include the State of Bahia, the Federal University of Viçosa, Nebraska NRDs, and agribusiness owners, including smallholder farmers in the region.

A Nebraska delegation of university and DWFI leaders and faculty visited Bahia in early 2018, participating in two workshops organized by AIBA. Delegates met with technicians, researchers, farmers, water users and civil society representatives, policymakers and the media. Workshop activities involved 300 professionals from 111 organizations with heavy media coverage.

The AIBA/DWFI collaboration is focused on achieving a significant economic impact and improved water and food security in Bahia by introducing a new form of groundwater governance and intensifying agricultural production.

NEBRASKA FARM DATA DASHBOARD EXPANDS TO INCLUDE DECISION-MAKING TOOLS FOR WATER MANAGERS

DWFI is working with students in the Raikes School Design Studio at UNL to develop new data analysis and visualization tools in a farm database dashboard. When completed in early summer 2019, the dashboard will enable water managers to monitor the impact of management strategies and assess potential new policies. The dashboard allows easy identification of emerging water use trends and helps focus stakeholder outreach and education.

The Nebraska farm database dashboard allows agricultural producers to anonymously benchmark irrigation water use, nitrogen fertilizer use and yield against fields with similar weather and soils. In the second year of development, the project team focused on providing Nebraska's NRD water managers with tools needed to make better use of on-farm data.

Nebraska's NRDs collect a large amount of farm data, but they don't always have access to data analysis and visualization tools. Researchers from DWFI and UNL's Department of Agronomy and Horticulture

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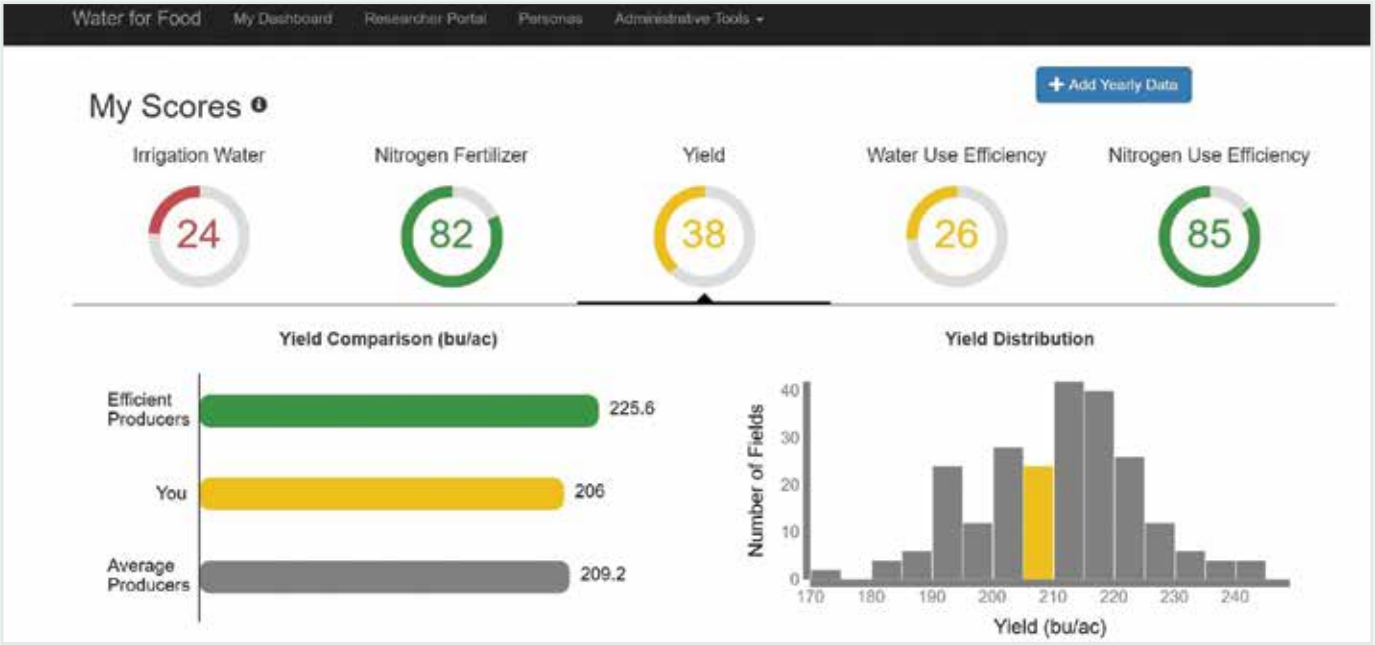
collaborated this year with students from UNL's Jeffrey S. Raikes School of Computer Science and Management (Raikes School) to make field-level data more useful to water managers. It was the second collaboration with Raikes students during the life of the project.

The student development team worked closely with several NRDs to understand their data analysis needs and ensure data confidentiality. The new NRD dashboard allows water managers and producers to compare resource use and yield for a group of fields with other fields in the district. The dashboard also displays easy-to-understand "heat" maps showing resource and yield results for historical growing seasons.

The dashboard makes it easier to illustrate the impact of policies over time and manage data. For example, NRD staff can create individual reports demonstrating that fields with similar soil and weather are getting the same or higher yield with less irrigation water, which can help them easily communicate with producers about ways to improve input efficiency. The project has earned the highest level award at the Raikes School Design Studio Showcase the past two years.

Upcoming work will include testing products and gathering feedback from intended users of the database. The DWFI team will work with the Raikes' School Design Studio program again in the fall of 2018 to incorporate real-time water use data into the dashboard. Future goals include building tools to streamline collection of new data, providing automatic importing and updating of data and allowing interfacing with other data collection devices and platforms.



The Nebraska farm database dashboard

CLOSING WATER AND AGRICULTURAL PRODUCTIVITY GAPS

Nebraska Water Productivity Report

"Water productivity" measures the efficiency with which water is converted to food, providing valuable information to farmers and others who are working to maximize food production while ensuring water sustainability for our world. The institute has made significant progress on preparing an annual Water Productivity Report (WPR), which is expected to become one of the flagship publications of the institute.

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Corn in drought conditions in Serbia.
Credit: Getty Images

The Nebraska WPR examines resource use efficiency of corn and soybeans, livestock (beef cattle, milk cow, swine, and poultry), and ethanol production. The report identifies historic trends and future goals for water consumption used in crop and livestock production. Additionally, WPR researchers assess the water, energy and carbon footprint of ethanol from corn.

This work develops and tests methodologies that may be applied globally to determine the gaps between actual and attainable water productivity in both crops and livestock. The Nebraska WPR is a pilot project, leading to the publication of a Global WPR.

Preliminary results show that between 1990 and 2014, water productivity of irrigated and rainfed corn and soybeans increased significantly. This was largely due to improved high-yielding hybrid varieties with good tolerance to water stress; effective fertilizer, soil and water management; and improved weed control. The concurrent shift to more efficient irrigation systems has reduced the water applied. Also, research data show water productivity of livestock products in the state has increased considerably between 1990 and 2016, largely due to improvement in livestock productivity (output per head).

The report is scheduled for release in late fall 2018, and results will also be published in refereed academic journals. DWFI plans to partner with UNL Extension to share the information with Nebraska farmers, local government and industry partners for more informed decision-making in agriculture and livestock management.

Nebraska cattle. Credit: Getty Images

Supporting smallholder farmers with irrigation in Ethiopia

> ***What are the most effective ways to empower smallholder farmers to feed themselves and their family for a lifetime, rather than a day? DWFI researchers and Faculty Fellows learned some important lessons about this while working with several communities in eastern Ethiopia.***

Beginning in 2010, DWFI and UNL faculty partnered with iDE, Haramaya University, and Wollo University to work in two of the most drought-prone regions of Ethiopia: South Wollo and East Harerge. Researchers conducted a comprehensive food production and health survey in this study area, which determined that nearly 30 percent of children in South Wollo and more than 40 percent of children in East Harerge were underweight, and many of them experienced stunting as a result of food insecurity. Smallholder farmers in these drought-prone areas typically pursue irrigation by excavating huge, open pits to reach groundwater. The dirt walls of these pits are often unstable, posing a danger to those collecting water.

Selected community members were trained on construction and maintenance of the treadle pump (TP) system, including drilling boreholes and installing well casings. Credit: Teshome Regassa

Also, because a single pit has multiple users, most farmers have to pump water a considerable distance or travel to collect water. Other challenges to expanding irrigation include the limited practical skills of farmers in irrigated agriculture; lack of technical expertise to maintain generators, pumps and electric lines required for pumping water from deep wells; shortage of agricultural inputs; limited availability of improved irrigation facilities; and rugged topography not suitable for furrow irrigation.

This project sought to implement a low-cost technology using shallow wells with a narrow diameter. Between 2012 and 2013, iDE drilled 38 successful wells in East Harerge and installed inexpensive treadle pumps. At the same time, DWFI and iDE faculty and staff trained community members on the construction and maintenance of the treadle pump system. In the following two years, from 2013 to 2015, more than 100 new systems were constructed by trained community members. During a preliminary impact assessment, some farmers reported doubling their crop production and more than doubling their revenue.

The most significant impact of the treadle pump technology was the introduction of a special excavating technique that now has become widespread. The communities themselves used this new technique to modify the initial excavation method. Young entrepreneurs recognized the potential of this technique and went on to establish well drilling businesses. Local craftsmen also developed new and more efficient excavating tools.

Previously, smallholder farmers had paid as much as nearly one year's income to excavate traditional water pits. Installation of new shallow well irrigation systems now costs 75 percent less. This new technology made irrigation accessible to a higher number of households than the project anticipated.

The South Wollo and East Harerge regions of Ethiopia.

INTERNATIONAL JOURNAL PUBLISHES PIONEERING GAP-ANALYSIS PROTOCOL

Calculating gaps between potential and actual water productivity at local to regional scales can help agricultural producers improve crop production. The question is, how do you reliably calculate water productivity and determine gaps between actual and potential yields? DWFI has supported UNL's Department of Agronomy and Horticulture and partners in an international study designed to help solve this problem and contribute to the world's ability to optimize crops, minimize water usage and feed the rapidly growing populations of the world.

In June, the international Journal of Agricultural and Forest Meteorology published a multi-country study that establishes a unique protocol for estimating water productivity gaps across spatial scales. In addition, the study confirmed water productivity variations among regions with different soils and climates, and it revealed that non-water-related factors, such as nutrient deficiencies, pests and diseases often limit crop yield more than water supply.

The study was conducted by researchers from the United States, France, Australia and The Netherlands and was supported by the Bill and Melinda Gates Foundation, DWFI, Wageningen University & Research, and the CGIAR research program on Climate Change, Agriculture, and Food Security (CCAFS).

CIMMYT international wheat nurseries growing in Ecuador. Credit: CIMMYT / Flickr

Researchers proposed an estimation approach based on information in the Global Yield Gap and Water Productivity Atlas (GYGA; yieldgap.org) an initiative sponsored by DWFI and developed by a team at UNL to quantify potential and actual water productivity and associated gaps.

The approach introduced in the study has the potential to help agricultural producers, researchers and policymakers across the globe more accurately formulate benchmarks for monitoring and mitigating water productivity gaps and improving crop yields within defined geographic areas.

IMPROVING GROUNDWATER MANAGEMENT FOR AGRICULTURAL PRODUCTION

Smart technology for smart water management

Measuring the energy used to pump water for irrigation will help producers understand how much they pay to irrigate. With a better understanding of their energy costs, producers may choose to make different irrigation choices that could result in water savings and reduced energy consumption.

DWFI partnered with Smart Water Metering, Inc. to design smart energy and water meters specifically for this research project. The meters connect to electric irrigation pumps and measure the electrical energy that irrigation pumps use. After calibration with flow meters, researchers can determine the amount of water used and combine the energy data with water use data to determine the cost of the water pumped.

DWFI Program Coordinator Ellen Emanuel calibrates a smart water meter during installation at a Nebraska farm.
Credit: Molly Nance

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Producers often comment that energy costs have a significant impact on their bottom line; however, many producers do not have a way to accurately calculate their real-time energy costs for pumping.

Producers may know the cumulative total of the amount of water pumped, but they likely do not know how much their water costs as they pump it onto their fields during the growing season. Sometimes producers will not receive an energy bill until they harvest their fields, and at that point it is too late to use the information to affect their irrigation decisions. Through the use of energy meters, DWFI aims to give producers pumping cost data during the irrigation season, so they can make more informed decisions about when to irrigate their crops.

In FY2018, DWFI received 200 meters from Smart Water Metering and installed 57 throughout Nebraska and seven in southeast Wyoming. DWFI plans to have all meters installed by the end of the project.

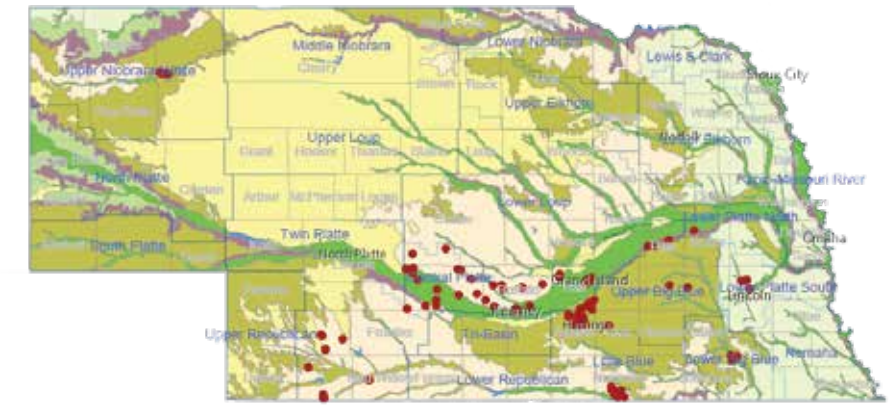
The institute is working with Smart Water Metering to set up a server to collect meter data, which will be analyzed and shared with participating producers, helping them make effective water management decisions to maximize production while minimizing water energy costs.

Nebraska Vadose Zone program provides soil chemical data to help water managers, producers and policymakers make informed soil and water management decisions

The Nebraska Vadose Zone database provides historical and ongoing vadose zone agrichemical data to Natural Resources Districts and municipalities. The one-of-a-kind database serves as an early warning system to help manage and improve groundwater and drinking water quality.

In Nebraska, groundwater provides four of every five Nebraskans with drinking water. Unfortunately, nitrate concentrations in groundwater in some parts of the state are rising. Additionally, naturally occurring elements, such as uranium, further complicate groundwater quality. While state and local agencies have conducted regular groundwater monitoring, more work is needed to characterize the vadose (unsaturated) zone.

The vadose zone is the space below the land surface and above the groundwater table, where a mixture of air, water, and other chemical and biological microorganisms fills the spaces between rock and soil particles. The zone acts



Vadose zone map showing areas where core samples were extracted. Credit: nebraskavadose.unl.edu

as the "skin" of the earth, regulating groundwater recharge and chemical movement. Substances present in the vadose zone can eventually appear in the underlying aquifers.

If these compounds are found in public water systems in excess of regulated limits, a utility must either treat the water or find an alternate supply. Thus, natural resources managers, city planners, treatment plant operators, regulators, researchers, and others have an interest in monitoring the vadose zone to anticipate if and when these substances will reach the groundwater supply and in what amount.

The cost of removing nitrates can be prohibitive for small communities. This has led to a pressing need to better understand and manage the vadose zone, the soil just under the earth's surface. The Water Sciences Lab and Nebraska Water Center, with support from DWFI, are working with selected communities and NRD water managers to collect and analyze vadose zone soil core samples and upload the information into a public database.

The project will standardize data collection, analysis and validation methods, and serve as a repository of information to help stakeholders learn more about how nitrates move through the subsurface. The project will also help communities predict future water quality changes so they can plan ahead to optimize groundwater sources and ensure safe drinking water.

The City of Hastings, Nebraska, and the Little Blue and Upper Big Blue NRDs are already using project information to determine how nitrogen and irrigation water management changes are affecting nitrate stored in the vadose zone near the city's wells. The information will help them promote effective management practices.

The project has already digitized soil cores and uploaded information from nearly 300 locations to the online database and GIS-linked map. Cores have been collected and processed from almost 100 new locations. Last year, researchers tested a new hydraulic profiling tool for rapid assessment of vadose zone properties affecting nitrate transport.

Goals for the coming year include completion of two monitoring studies, collection of additional historical data and doubling the number of cores in the database.

The project is supported by grants from the Nebraska Environmental Trust, Department of Environmental Quality and several municipalities and NRDs. See the database and project information at nebraskavadose.unl.edu.

Promoting effective, integrated aquifer management to support water for food security

> ***The Ogallala Aquifer region accounts for 30 percent of total crop and animal production in the United States, and more than 90 percent of the water pumped from the aquifer is used for irrigated agriculture. The water table is relatively stable in Nebraska; however, the aquifer in parts of Kansas and Texas are rapidly being depleted and climate change could make the situation worse.***

In the past, Ogallala Aquifer research focused on quantifying problems. Now, the focus has moved to developing tools to help manage and adapt to water-related challenges, as well as helping sustain agriculture and communities dependent on the aquifer.

DWFI, through the Nebraska Water Center, is participating in a special USDA Coordinated Agricultural Project titled, "Sustaining Agriculture through Adaptive Management to Preserve the

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Lake McConnaughy, Nebraska. Credit: Getty Images

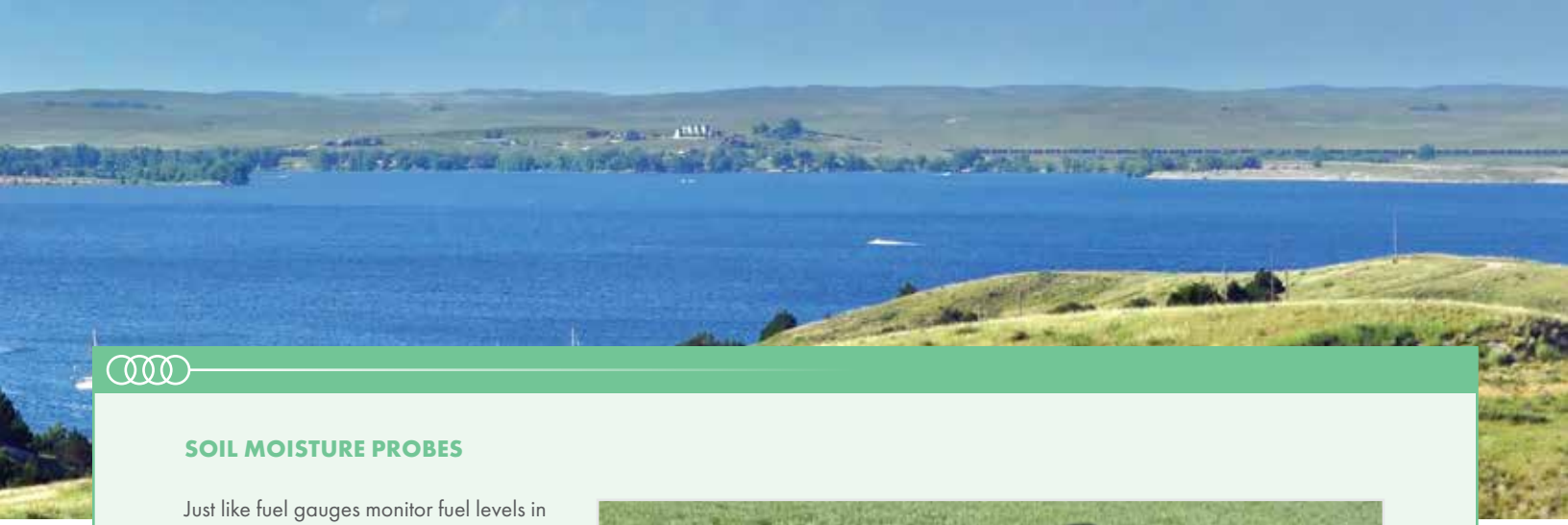
Ogallala Aquifer under a Changing Climate," which involves nine institutions in six states and more than 70 researchers. The project is designed to bring stakeholders together to optimize water use and sustain food production, as well as provide a global model for groundwater management. More information is available at ogallalawater.org.

NWC and DWFI staff are working with the interdisciplinary USDA team to conduct biophysical experiments on reducing crop-water use, modeling surface-groundwater interaction along the Platte River Corridor, modeling crop growth and yield using trial data, and estimating producer profits using hydro-economic tools.

Last year's efforts helped improve communication between farmers, water managers, consultants and researchers to build trust and determine real-world next steps for water conservation that can be used in any region facing groundwater management challenges.

DWFI participated in the 2018 Ogallala Aquifer Summit where a consortium of researchers discussed ways to support improved practices, defined the scope and outcomes of research and enhanced communication for integrated management across groundwater districts and states. Key ideas from the summit are shared at ogallalawater.org.

NWC co-hosted the Platte River Basin Ecosystem Symposium with the Crane Trust, which reached out to researchers and industry professionals interested in conserving the natural resources along the basin, an important part of the Ogallala Aquifer in Nebraska. Additionally, project leaders reached more than 175 producers and industry professionals at the Crops and Water Field Day, a partnership with Nebraska Extension and Nebraska Water Balance Alliance.



SOIL MOISTURE PROBES

Just like fuel gauges monitor fuel levels in a gas tank, soil moisture probes monitor water levels in the soil. Irrigating without using soil moisture probes is like driving without a fuel gauge: you're likely to be overcautious and fill the tank early and often to avoid being stranded. Similarly, a farmer may be using more water and energy than necessary to effectively irrigate crops.

Soil moisture probes enable producers to know precise areas of a field needing irrigation and how much water to apply. With probes, farmers know when to water, which leads to water savings, energy cost savings and improved crop health.

Despite their advantages, many farmers do not use these probes because of expensive hardware and data plans, as well as a lack of understanding of how to analyze and interpret the data into useful information. Additionally, installing and removing the probes every season causes wear on equipment and can be inconvenient for crop producers. Poor cellular or internet connectivity in rural areas can also inhibit data transmission from the probes.

Farmer deploying wireless soil water content sensor in field. Credit: PrecisionAg

Smart agriculture technology can help farmers improve production and reduce costs. As more farmers take advantage of such tools, and challenges to using the tools are addressed, the overall agricultural industry will benefit.

SUPPORTING FRESHWATER & AGRICULTURAL ECOSYSTEMS & PUBLIC HEALTH

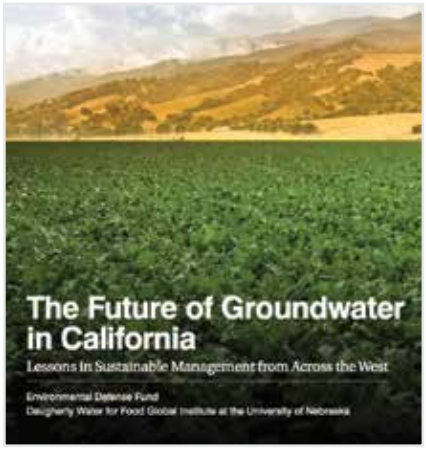
New collaborations advance understanding of informal water markets

Water markets can help reduce economic impacts of water scarcity and help stakeholders attain environmental objectives cost-effectively. DWFI is working closely with the USDA and other partners to improve the applications of these important drought management tools in irrigated agriculture around the world.

Water markets are used to reallocate limited water between users who volunteer to lease, sell or exchange water or water rights.

Water market trading can help even the scales.

Researchers at DWFI have helped expand national and international collaborations on the use of water markets as risk management tools.



Water markets can help reduce risks associated with water scarcity for agricultural, urban and environmental water users. However, most U.S. and international market transactions are occurring informally, have been poorly documented, and are largely ignored in policy debates and decisions. As a result, users and other stakeholders tend to misunderstand the actual and potential value of water markets.

DWFI and its partners are working to clear these misunderstandings with research and analysis on water markets in many locations. By providing educational materials, training and engagement on water market topics to water managers, decision makers and water users, the partners are helping design and implement viable and effective institutions for water allocation. Ultimately, the goal is to influence the adoption of viable water markets across the globe.

Last year, DWFI launched a new global water markets partnership with the World Bank Global Water Practice and the University of Oxford's Smith School of Enterprise and the Environment. The partners are producing a report on the state of knowledge of the efficiency, equity and sustainability of diverse water markets worldwide with a goal to increase understanding of informal water markets, including transfers between agricultural and environmental or urban sectors.

DWFI furthered its role as a thought leader in this area over the past year by co-authoring publications on groundwater trading to support new legislation in California and giving presentations on water markets to water managers and decision makers in France, Morocco and Tunisia. Additional collaborations on water markets are underway or were completed involving the USDA Office of Environmental Markets, the National Drought Mitigation Center, the Environmental Defense Fund and the Nature Conservancy.

Know Your Well program trains students to collect water quality data

> ***As the years progress, the world will need motivated, knowledgeable professionals to help assess water quality and formulate solutions to the growing challenges of water and food security. Nebraska's "Know Your Well" program is preparing future scientists by teaching them about water quality in high school.***

Students in the Know Your Well program learn about well construction and factors affecting drinking water quality, especially vulnerability to nitrate, metals, pesticides and coliform bacteria. Using a web-based mobile app to upload and store the data they collect, students are participating in important real-world water analysis activities, including establishing a crowdsourced baseline of domestic well-water quality across the state – an approach that could be easily replicated beyond Nebraska.

The program is administered by the Water Sciences Laboratory. Through the program, high school students across Nebraska gain hands-on experience properly sampling

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Waverly High School students test samples for their Know Your Well project.

water wells, preparing samples for lab analysis, and reading and interpreting test results. Well owners receive test results and information to help them evaluate their own water quality, so they can identify and remediate contamination. In addition to providing valuable data to their communities, the students may be inspired to pursue water and food related careers.

During the three-year project, UNL graduate students will train more than 100 students from 16 high schools across Nebraska and analyze more than 300 unregulated private wells for a wide variety of substances. The program is entering its second year with the addition of six more high schools, bringing the total to 10 schools that have sampled 35 wells.

Some of the Know Your Well students are participating in a wellhead protection study funded by the city of Hastings, Nebraska, in addition to the state's Little Blue and Upper Big Blue NRDs. The study is part of the Nebraska Vadose Zone project, a collection of several grant-funded projects collectively funded by Nebraska Environmental Trust, Nebraska Department of Environmental Quality, and other NRDs. Learn more at knowyourwell.unl.edu.

One Health: Linking human, animal, plant and ecosystem health

> ***One Health is a worldwide initiative that brings together networks of diverse stakeholders to address complex health challenges at the human-animal-environment interface. Diverse researchers, students, health professionals and communities identify and address health challenges in and beyond Nebraska.***

In December 2017, a DWFI Faculty Fellow joined other key stakeholders from universities, state and federal agencies interested in linking human, animal, plant and ecosystem health at a One Health conference to share ideas on local and global health challenges. The group discussed steps to build more effective partnerships and creative ways to advance One Health research, training and outreach in Nebraska.

Nebraska is one member of many in this movement to achieve optimal health outcomes across the globe. The One Health approach began with the unprecedented global response to the avian flu in 2005 and has grown into a cohesive worldwide approach adopted by a wide variety of local, national and international organizations, universities and countries. Water and food security are at the heart of many One Health efforts throughout the world.

Rather than supporting specific research projects or approaches, Nebraska's One Health funding is earmarked to develop stakeholder connections that enhance research and outreach. Because Nebraska supports a broad range of agriculture systems, the state has the potential to be a leader in developing effective teams and solutions with the capacity to solve global health challenges such as impaired water quality and antimicrobial resistance.

Nebraska One Health plans to build an interactive online stakeholder database, create new online and in-person opportunities for stakeholder discussion, establish a One Health leadership council, and develop a larger One Health research symposium for fall 2018. Nebraska's One Health representatives attend local, national and international conferences, such as the annual global health conference sponsored by the Consortium of Universities for Global Health and the ECOHEALTH Conference in Cali, Columbia.

To learn more about Nebraska One Health, visit nebraskaonehealth.unl.edu.

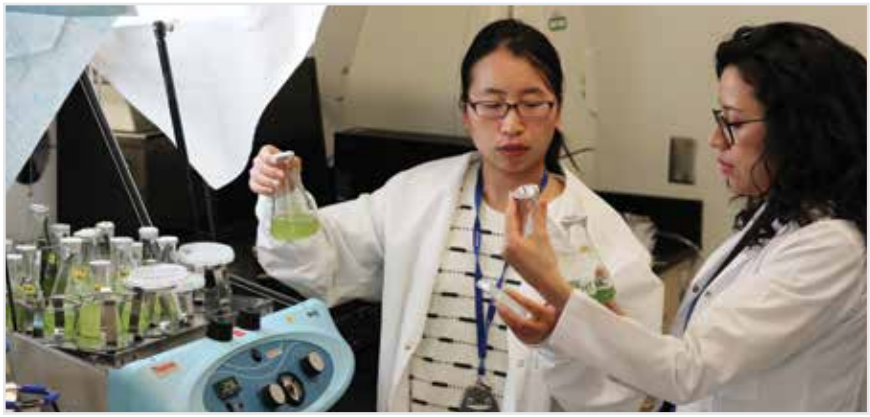
Water re-use in food production

Water scarcity, untreated wastewater and the need to find alternative energy sources for nonrenewable fuels are all global issues impacting food production and quality of life for farmers and society as a whole. Treatment of food-processing wastewater is intended to provide an all-inclusive solution to these challenges by transforming waste into resources that support the long-term sustainability of agro-industrial operations.

DWFI is supporting two projects designed to advance understanding of water re-use in food production:

Treatment of food-processing wastewater with microalgae. This project was developed to engineer and evaluate an optimized algae-sludge immobilized system to treat wastewater in food processing operations. This research will enhance fundamental knowledge related to the operation and performance of an alternative wastewater treatment process (algae/bacteria beads) that offers economic and environmental benefits over and above traditional treatments. The study found three species of microalgae that successfully acclimated and cultivated in the wastewater discharged food processing operation, removing much of the water additives. Results have been submitted for publication.

Reuse of caustic solution (harsh, corrosive chemicals) in Cleaning in Place (CIP) operations. Caustic solution represents about a quarter of the wastewater generated from CIP operations. Reusing caustic solution allows producers to reduce water consumption while extending the shelf life of chemicals, since they are not disposed of after a single use.



Graduate research assistant Xinjuan Hu (left) and Water for Food Processing Specialist Yulie Meneses examine the effect of algae treatment on nutrient removal from food processing wastewater. Credit: Bismarck Martinez Tellez

The food and beverages processing industry requires a huge amount of water. One of the main problems is the amount of wastewater continuously produced in food processing plants. The water is used as an ingredient, a cleaning agent, for boiling and cooling purposes, for transportation and conditioning of raw materials.

Food industry standards specify that spent process water intended for reuse (even for cleaning purposes) must be at least of drinking quality. Regulations for other applications, such as boiler make-up water or warm cleaning water, are even more stringent, so finding new ways to achieve water quality for re-use is an important step toward achieving water and food security.

MANAGEMENT MODEL HELPS FARMERS DECREASE NITROGEN INPUT AND INCREASE YIELDS

Currently, only about 40 percent of the nitrogen fertilizer applied to farm fields is used by plants. The rest leaches off fields and into water bodies, which can compromise drinking water.

If high-yield farmers could save money by using less nitrogen, which also may require less energy and effort, they could increase revenue while improving groundwater and drinking water quality. And, if farmers in developing countries could learn more about maximizing nitrogen use through a reliable cost/benefit analysis, it would help them invest wisely.

DWFI Faculty Fellow Haishun Yang is developing a nitrogen scenario modeling management tool that helps farmers determine the optimal amount of nitrogen to use for a specific field or season. Yang and his team have not only helped develop the model, but are also spreading the word by developing educational materials and making presentations in Nebraska and worldwide. Ultimately, the project expects to promote adoption of new technology and best practices by producers, which could reduce nitrogen use.

Nitrogen scenario modeling can help farmers use the appropriate amount of fertilizer for best production, while reducing leaching. Credit: Laura Thompson

The model is already being used in Northeast Nebraska, through the Nebraska Water Center and the Water Sciences Laboratory, where we are working with the Bazile Groundwater Management Area to help producers in three counties increase nitrogen efficiency. Additional funding is through an Environmental Protection Area grant and support from the U.S. Department of Agriculture/Natural Resource Conservation Service.

Partners and stakeholders of the modeling project include UNL Extension, the Agricultural Model Intercomparison and Improvement Project (AgMIP), and the Beijing ICAN Technology Co. Yang will present the model at the AgMIP global workshop in 2018. ICAN Co. is licensing the model for field testing and use in China, which has the potential to enhance water and food security for the world's most populous country.

MANAGING AGRICULTURAL DROUGHT

U.S.–India Partnership: Improving water management, agricultural production and food security in drought-prone areas

DWFI is using Nebraska's drought expertise in partnership with India's scientists and policymakers to advance drought knowledge and technologies, develop an early warning system and drought mitigation strategies, and help farmers make science-based decisions to improve food and water security.

The worldview of drought is shifting. Rather than seeing drought as an insurmountable problem, the world is collectively viewing it as a manageable risk. New technologies and best practices involving precise applications of fertilizer and irrigation water will help the world improve crop/water productivity and adjust to climate change. India, with its huge population and extreme droughts, is a region that can greatly benefit from predicting and managing drought's impact on water and food needs.

The University of Nebraska plays a national and global leadership role in drought management through the National Drought Mitigation Center (NDMC) at UNL and in water management for food production through DWFI. The institute is collaborating with the Indian Agricultural Research Institute (IARI) on research and capacity-building focused on technology transfer (including remote sensing/geospatial technologies and field sensors), management practices, policy, and planning. The DWFI project, funded through the INDO-US 21st Century Knowledge Initiative, is called "U.S.–India Partnership: Improving Water Management, Agricultural Production and Food Security in Drought-Prone Areas." The project is supported by the United States-India Educational Foundation.

In FY2018, DWFI continued research on development of a Composite Drought Index for India. Two IARI doctoral students spent four months at NDMC working with research staff on this topic. A third doctoral student, a Fulbright scholar, has worked at DWFI since September 2017 on modeling evapotranspiration using satellite remote sensing and comparing data to ground-based scintilometer measurements.

The composite drought index and drought monitoring tools are being developed for two India regions. The goal is to present the tools later this year at a national workshop organized by IARI and DWFI. Other regional governments are invited to participate and help fund a pan-India product.

Over the next five years, DWFI and partners will develop and disseminate information, policy models and tools to build resilience and reduce vulnerability to drought in the agricultural systems of other selected countries and regions, such as East Africa.

Developing a satellite-based daily evapotranspiration product in the MENA region

DWFI is working with partners to develop an online evapotranspiration product that will enable researchers, water managers, policy makers, producers and others to access nearly real time ET data to predict and detect drought conditions in the Middle East and North Africa (MENA) region.

A steer grazes on fall oats (cover crops) in Nebraska. Credit: IANR at UNL

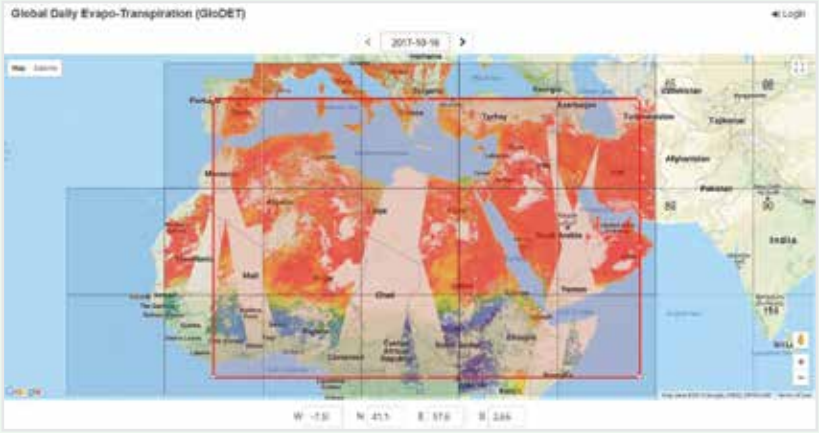
When drought hits water-scarce regions there are significant repercussions for food and water security, as well as broader social and environmental systems' stability. Environmental monitoring and early warning systems to detect the onset of drought conditions can facilitate timely and effective drought management responses from government and private sector stakeholders, empowering decision-makers to plan for and manage the impacts of droughts on food and water security under current and future climate conditions.

Agricultural drought exists on a spectrum, and various measures of soil moisture, plant water stress, biomass, and yield indicate when a region is moving into and out of drought conditions. Direct, in-field, measurement of these indicators across a large area is often expensive and time consuming. Using satellites to evaluate large swaths of land from a distance, also called remote sensing, provides a consistent, convenient and cost-effective method for science-based decision making in regional drought management.

This project is focused on developing a near real-time global daily evapotranspiration dataset using a satellite-based remote sensing approach. Evapotranspiration (ET) is the sum of evaporation from land surface plus transpiration from plants. The transpiration aspect of ET is essentially evaporation of water from plant leaves. ET is a difficult crop parameter to directly measure and yet is vital for assessing water budgets, water productivity, plant stress and drought.

The project has been initiated in the Middle East and North Africa (MENA) region, with funding from USAID in partnership with the International Center for Biosaline Agriculture (ICBA) and the NDMC to produce a satellite-based daily ET product for use in drought monitoring in the region. The mission of the Middle East North Africa Regional Drought Management System (MENA-RDMS) is to serve as a catalyst to improve the region's drought early warning capabilities and create an environment of proactive drought risk management.

GLOBAL EVAPOTRANSPIRATION (GLODET) WEBSITE WILL ASSIST MENA DROUGHT MITIGATION



New knowledge and insights, management plans and drought resilience tools and strategies at national and local levels will help reduce the negative impacts of drought on the food supply and on the quantity and safety of water within vulnerable communities of the Middle East and North Africa (MENA).

The MENA region already faces a host of challenges from limited water supply, political instability, and desertification. Drought adds intensifying pressure on natural resources, economies, and social development. Tools, knowledge, and drought planning strategies offered by DWFI and its partners serve as an early warning system empowering decision makers in MENA regions – from government officials to smallholder farmers – to monitor, plan for, and manage drought to improve food and water security through current and future climate conditions.

ET satellite monitoring data for the MENA region is now available through a free website along with a web-based mapping tool, allowing users to download information to help them analyze current conditions and plan for better crop yields using less water. In development since late 2017, Glodet.nebraska.edu will be launched in a regional stakeholder workshop in late 2018.

As an extension of this project, the University of São Paulo Institute of Astronomy, Geophysics and Atmospheric Sciences in Brazil and DWFI received funding from the CAPES/ANA Federal agencies of Brazil to verify the daily ET product in different ecosystems. Researchers will use data from a network of Brazilian flux towers. Partners include the Federal University of Rio Grande do Sul and the Federal University of Santa Maria in southern Brazil. Future related project work will expand the daily ET product to India and the central United States.

To learn more, visit Biosaline.org/projects/regional-drought-management-system-middle-east-north-africa.

Water for Food Innovation Fair at the Water for Food International Forum. Credit: Jesse Starita

EDUCATION AND ENGAGEMENT

Water for Food International Forum, Washington DC

As an outcome of the 2017 Water for Food Global Conference, the World Bank, along with USAID and USDA, invited DWFI to partner in producing a new event in January 2018 focusing on the importance of improving smallholder farmer access to irrigation. The international forum, "Farmer-Led Irrigated Agriculture: Seeds of Opportunity," showcased voices from farmer representatives, the private sector, national and regional policymakers and major international financing institutions. The forum galvanized support to advance farmer-led irrigation initiatives, particularly in Africa.

Farmers, NGO leaders and water ministers discuss "Bringing it All Together" at the Water for Food International Forum. Credit: Jesse Starita

While many areas of the world are making tremendous strides toward improving water and food security, farmers in developing countries of the world do not have access to the resources needed, especially irrigation, that could greatly improve their agricultural productivity. Irrigation in agriculture has immense potential to increase crop yields, support crop and livestock value chains, reduce poverty and improve health in rural sub-Saharan Africa and parts of Asia. DWFI first featured this topic at its 2016 Global Conference.

Keynote speakers and expert panelists discussed ways in which stakeholders can work together to improve livelihoods

for smallholder farmers in developing countries by intensifying and expanding sustainable irrigated agriculture. Farmers, water ministers, researchers and leaders from public and private sectors shared their concerns and highlighted successful new approaches to improving access to irrigation. Participants also focused on the importance of creating an enabling environment for sustainability, including strong partnerships; linkages to market support, capacity and technical training; and the role of the private and public sectors.

As summarized in a blog post written by Steven Schonberger and Lauren Nicole Core of the World Bank, the forum confirmed the following key messages about the future of smallholder agriculture:

- Farmer-led irrigation may strengthen climate resilience and inclusive economic growth, particularly because it provides farmers with the agency and autonomy to adopt innovative technologies and access flexible financing;
- Inclusive access to technology has the potential to mitigate the risks of rapid increases in the use of water and other natural resources;
- Policies and approaches should focus on women, youth and vulnerable communities to ensure inclusiveness in supply chains for irrigation technology and services;
- Sustainable groundwater management needs to be strengthened, including developing incentives for collective action in managing irrigation and common efforts to manage negative impacts on groundwater.

World Bank Global Conference Room. Credit: Jesse Starita

Congressman Jeff Fortenberry (R-NE) speaks to forum participants. Credit: Jesse Starita

The forum was an opportunity to bring together stakeholders from around the world, and perhaps more importantly, to ensure the strong voice of farmers and other private sector actors. This combination of ministers, heads of international organizations, global experts, farmers and irrigation and food companies confirmed the role and future importance of farmer-led irrigation as a new paradigm to support food security and water sustainability in the future, and has set a new focus for the World Bank's support to irrigation in Africa and other parts of the developing world.

— STEVEN SCHONBERGER, GLOBAL LEAD FOR WATER IN AGRICULTURE WITH WORLD BANK'S WATER GLOBAL PRACTICE

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Blanche Butera, Rwandan student, University of Nebraska-Lincoln and former DWFI intern shares her perspective.

DWFI developed and distributed a working paper at the forum, "Pathways to Increasing Farmer-Led Investments," which outlines previous research and projects to promote irrigation use among smallholder farmers, as well as trends and prospective opportunities. See "Reports and Working Papers" for the report at waterforfood.nebraska.edu/resources.

The institute convened a side meeting during the World Water Forum in Brasilia, Brazil, in March with partners from IWMI, FAO, the World Bank, USAID, USDA and others to discuss next steps. The group agreed to continue collaboration, promoting the topic at future international conferences and looking for opportunities to upscale promising projects.

DWFI Executive Director Peter G. McCornick, leads the High Level Panel discussion at the 2018 World Water Forum. Credit: Molly Nance

World Water Forum

DWFI's leadership at the 8th World Water Forum in Brasilia, Brazil, brought Nebraska's expertise in water research and policy to thousands of water and agricultural ministers, farmers, NGO leaders, government delegates and private industry executives from around the world.

The challenges to ensuring we have enough water to feed our growing world population are formidable. Poverty, conflict, climate change, soil erosion, lack of technology and training, and increasing demand for meat and dairy products are straining our limited water resources. More than ever, dialogue between organizations, sectors and countries is required to develop innovative solutions through public and private actions to improve water resource quality and sustainability.

The triennial World Water Forum is the largest international gathering to focus on water. With the overarching theme "Sharing Water," the 8th World Water Forum fostered this dialogue to promote cooperation and the exchange of knowledge and perspectives.

The World Water Council invited DWFI to co-lead the conference track "Water for Food" with the Food and Agriculture Organization of the United Nations. Together, the

organizations developed sessions focusing on the exciting new technologies and best practices for improving water and food security in our world.

The institute produced or was involved with seven sessions of the forum and also hosted an exhibit booth and side meetings. DWFI invited leaders from two Nebraska NRDs to share their experiences with the state's natural resources governance system. Many international forum participants were very interested to learn how local governance can help farmers better manage their water usage and increase crop productivity.

"This is just amazing – that we are here sharing the things that work for us in the middle of Nebraska with people from Nigeria, India, Australia and China," said John Berge, general manager of the North Platte NRD.

"No matter who you are or where you're from, it all comes down to building trust," added Scott Snell, public relations manager of the Upper Big Blue NRD. "Our farmers want clean water, too. We work on solutions together so there is transparency in the process."

DWFI Faculty Fellows shared their expertise in water management, climate change monitoring and mitigation, and maximizing water re-use in food production at the international forum. DWFI also held a side event to discuss ways in which organizations can support farmer-led agricultural production, including access to irrigation for small-scale farms. Participants recommended looking at a variety of projects in this focus area, building on successful programs that have the potential to be scaled-up.

Scott Snell, public relations manager for the Upper Big Blue NRD in York (left); Kate Gibson, research project manager, DWFI; John Berge, general manager of the North Platte NRD in Scottsbluff; and Dr. Nicholas Brozović, director of policy, Water for Food Institute. Credit: Molly Nance

The institute produced a global high-level panel on the topic of water and food security. The panel was moderated by DWFI Executive Director Peter G. McCornick and featured Mauricio Antonio Lopes, president of EMBRAPA (Brazilian agricultural research association); Isabel García Tejerina, minister of Agriculture, Fisheries and Food of Spain; Celestino Zanella, farm producer in the state of Bahia, Brazil; and Claudia Sadoff, director general, International Water Management Institute, who shared their insights on advancements being made to improve agricultural production to meet current and future needs while improving water use efficiency through technology and management.

The event raised the global profile of the institute, fostered current partnerships, and set the stage for future projects and programming.

DWFI staff work with experts in Rwanda to learn about local irrigation techniques.
Credit: Gustave Emilien

Growing future leaders

The institute is cultivating future leaders in water and food security through undergraduate and graduate research and education, internships, workshops, seminars, study tours, exchange programs and projects. These young researchers, scholars and entrepreneurs are using their knowledge to advance water and food security in the U.S., as well as in many countries around the world, as they take on new roles at universities, water ministries, NGOs, government agencies, new businesses and farms.

IHE DELFT PARTNERSHIP AND FIELD COURSE

The institute hosted its fourth graduate-level field course coordinated in partnership with IHE Delft Institute for Water Education in Delft, the Netherlands. The field course is composed of field and laboratory measurements and tours. The field tours gave students the opportunity to observe irrigation and hydraulic structures, irrigation schemes, and the manufacturing and application of irrigation equipment, including center pivots, subsurface drip irrigation and vertical turbine pumps. Students also met with water supply, regulatory and water management organizations, such as the Central Nebraska Public Power and Irrigation District and two of Nebraska's Natural Resources Districts: the Upper Big Blue and the Lower Platte South.

Fifteen graduate students were enrolled in the course, including seven Master of Science in water science and engineering students who are specializing in land and water development for food security at IHE. The IHE students were joined by eight UNL graduate students, including one student in the IHE/UNL double-degree program in advanced water management for food production. Between IHE and UNL, the nine international students in the course represented India, Malawi, Nigeria, Rwanda, Zambia and Zimbabwe.

Surveys show more than 90 percent of the students who earn Master of Science degrees at IHE return to their home countries upon graduation to work in water-related industries. The potential impact of this two-week course on water management in the developing world could be very significant over time.

Dean Eisenhauer, DWFI coordinator of the IHE Delft partnership and agricultural engineering professor, leads an experiment with students in the Nebraska Field Course. (Below) Graduate students learn about irrigation technology. Credit: Molly Nance

WARI Scholars discuss water quality research. Credit: Jesse Starita

WARI PROGRAM ROLLS INTO THIRD YEAR

WARI is a joint initiative between the University of Nebraska and several of India's top academic institutions to foster the next generation of water researchers to address global water quality challenges.

A second group of Indian scholars selected for the Water Advanced Research and Innovation program (WARI) conducted research at UNL for some of FY2018, and all of them returned to India by the end of June. WARI is a joint initiative between DWFI, the University of Nebraska, the Indo-US Science & Technology Forum and Govt. of India Department of Science & Technology to help build capacity to address global water quality challenges. The 2017–2018 class included 11 awardees, including one doctoral student from UNL. This second group of Indian scholars selected for the program conducted research at UNL through June 2018.

New this year, the program launched a reciprocal exchange component, which enables Nebraska students and early-career faculty to conduct water research in India. In January, the first Nebraska WARI scholar began a five-month fellowship in India.

Additionally, seven of the 10 total members in the third class arrived during FY2018. This group includes seven doctoral students and three early-career faculty. At the time of this writing, the program is being evaluated for renewal by partners in India, and several indicators point to renewal.

As of FY2018, WARI scholars have authored or coauthored nine papers in international journals, submitted 23 other papers, given 12 poster presentations and seven oral presentations, written four book proposals and been awarded four grants.

The Indo-US Science & Technology Forum awarded funding for a bilateral workshop scheduled in November 2018. The workshop, "Water-Food-Energy-Climate Nexus: A Perspective Toward a Sustainable Future," is the direct result of WARI collaborations. Five NU faculty members and one postdoctoral student will go to India for this weeklong workshop to catalyze international research and student opportunities.

Several YouTube videos are available to learn more about the WARI scholars and their research on DWFI's YouTube channel at youtube.com/waterforfood.

GROWING SEEDS

DWFI is finalizing plans for the UNL Water for Food Global SEEDS (Service, Engagement, Entrepreneurship, Development, Sustainability) undergraduate upper-class learning community. The program has admitted 10 students for fall semester 2018. The learning community will be based in the new Massengale Residential Center on East Campus. During the year-long program, SEEDS students will work with Faculty Fellows and DWFI staff to understand entrepreneurial approaches to improving the use of water in agriculture in Nebraska, the U.S. and around the world.

INTERNSHIPS

Fifteen undergraduate students have benefited from internships at DWFI, where they contributed to communications projects, assisted with website development, contributed to research projects, organized events and assisted with a range of activities focused on advancing the institute's mission. These opportunities provide students with hands-on experience in a variety of subjects related to water and food security, building their interest and enthusiasm for pursuing further study or related careers.

DWFI Intern Will Ruffalo shares his research during the 2017 DWFI Water for Food Global Conference. Credit: Brett Hampton

Mazbahul Ahamad discusses The impact of health education on pastoraltists' water, sanitation, and hygiene behaviors in Tanzania at the Water for Food research forum. Credit: Craig Eiting

DWFI STUDENT/FACULTY FORUM TAKES ROOT

On April 26, more than 125 students, faculty and interested partners attended DWFI's annual showcase of research on advancing water and food security. Dion McBay, global sustainable lead for Monsanto, provided opening remarks focused on the need for innovative solutions to advance food production and ensure effective, sustainable water use.

"All of us are working to provide farmers with the tools and technology they need to cultivate our food while preserving the environment," said McBay. "The research you are doing today will lead to new solutions to help farmers achieve their goals."

DWFI's Director of Research Christopher Neale shared the framework of the institute's research. "Nebraska has a global reputation of excellence in both agriculture and water management. We support over 110 Faculty Fellows across all four NU campuses and the 22 students who are presenting their work today in areas that advance our mission," Neale said.

Faculty and students shared presentations and answered questions throughout the daylong forum, illustrating the creativity and ingenuity of Nebraska researchers at all levels. From plant genomics to software development, drones to groundwater management policies, and high-tech drought monitoring techniques to livestock thermodynamics, the presenters shared a wealth of promising research projects across a wide swath of topics.

"I was very impressed with the quality of research our students and faculty are engaged in," said Peter G. McCornick, DWFI executive director. "It's inspiring to see the innovative approaches and topics our people are pursuing to solve what is truly one of the most important global issues facing our world."

Dr. Nicholas Brozović, DWFI director of policy, speaks during a stakeholder meeting in Kearney.
Credit: Jesse Starita

DONOR DEVELOPMENT

Megan Homolka, senior animal science student at the University of Nebraska-Lincoln, was the first recipient of the Robert and Karla Baltzell Student Innovation Award. The award was established with a gift from Robert and Karla Baltzell and a matching contribution from the Robert B. Daugherty Foundation to provide research support to undergraduate and graduate students studying critical questions at the intersection of water and livestock, animal feed and/or crops. Credit: Jesse Starita

DWFI was founded in 2010 with a generous grant from the Robert B. Daugherty Foundation. The reputation of the institute has grown exponentially, and we are working hard to ensure the momentum provided by the initial investment continues. Support from a growing body of donors will perpetuate DWFI's mission – to achieve water and food security for our world – for generations to come.

In November 2017, DWFI hosted a town hall meeting in Kearney, Nebraska, to share updates regarding research projects, answer questions from NU alumni, Nebraska government delegates, University of Nebraska Foundation Trustees, donors and community members.

In an effort to grow outreach and support, DWFI's Board of Directors hosted an event in Washington, D.C., during the Water for Food International Forum in January. University of Nebraska President Hank Bounds, Senator Michael Johanns, Robert B. Daugherty Foundation Chair Mogens Bay and Earth Institute Advisory Board Member Howard W. Buffett addressed an engaged group of alumni, representatives from the World Bank, the Gates Foundation and the USDA, along with students and other global stakeholders in food and water security.

In February, DWFI Executive Director Peter G. McCornick joined the University of Nebraska

Foundation to speak to an overflowing room of alumni and donors in Palm Springs, California, on how the institute has become a recognized global leader and partner in achieving a food and water secure world, and shared ways DWFI is making an impact on local, national and global levels.

The Robert B. Daugherty Foundation and the University of Nebraska Foundation established a matching grant program to create an endowed fund to support students who are advancing the institute's mission. These funds double donors' contributions to students for scholarships, fellowships, research and presentations.

Grants from visionary stakeholders supported several students from Nebraska, as well as those from several international countries, pursuing research that will influence the future of improved water and food security. These grants open doors not only to the students, but also to the global communities that will benefit from their expertise and leadership.

One of the supported international students, Mavuto Banda, stated, "I remain thankful that I was given this chance as a beneficiary of this sponsorship program. This opportunity is a stepping stone to the great imaginations that I harbor in my mind for my country, Malawi. I have gained much knowledge about the underlying principles in solving some of the water issues in my country."

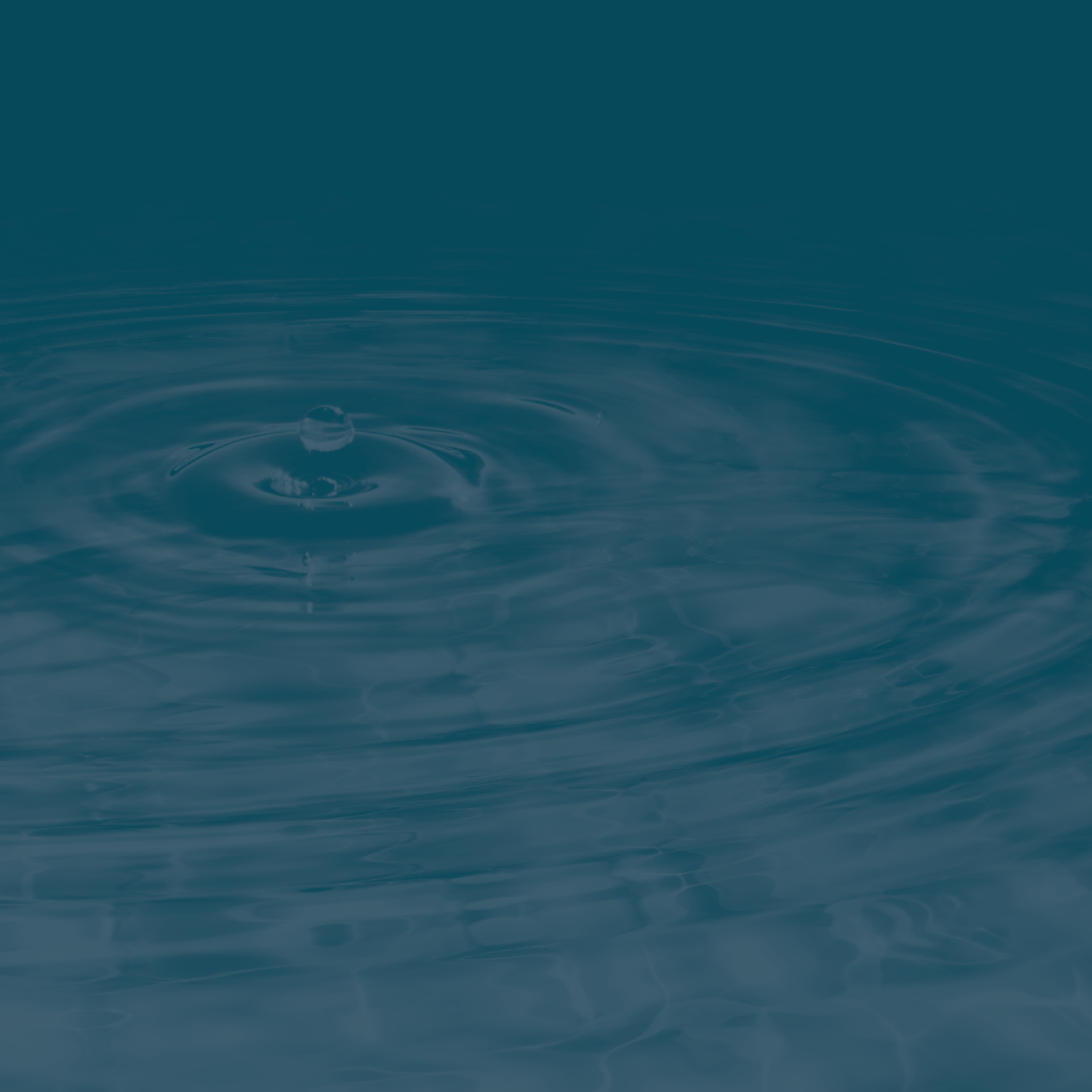
There are many opportunities for donors to share in the vision of a water and food secure world and invest in DWFI's work. For more information and to explore ways of investing, please contact C.K. Duryea, development director, at ck.duryea@nufoundation.org or 402-472-5706.

IVANHOE FOUNDATION GIFT WILL HELP PREPARE GLOBAL LEADERS IN WATER AND FOOD SECURITY

L.F. "Buz" Ivanhoe built a successful career as an international expert in petroleum exploration. But it was his experience growing up in Brazil and later as a poor student attending the South Dakota School of Mines and working in developing countries that inspired his mission to support foreign students studying in U.S. universities. He felt talented master's degree students could bridge the knowledge gap between policymakers and people working on the ground to solve the complex challenges of environmental, urban and agricultural landscapes.

Upon learning about the Daugherty Water for Food Global Institute online, Mr. Ivanhoe's daughter and chair of the Ivanhoe Foundation, Cheryl Ivanhoe Townsend, attended the 2017 Water for Food Global Conference to learn more about the institute's work around the world. This year, the Ivanhoe Foundation presented a $355,000 gift to the University of Nebraska Foundation to establish fellowships and research assistance for international graduate students pursuing careers in water management to improve water and food security in developing countries. These funds were matched by the Robert B. Daugherty Foundation's grant to the University of Nebraska Foundation for a combined endowment of $710,000. This funding will strengthen and enhance the institute's efforts to cultivate future leaders in water and food security.

"The Daugherty Water for Food Global Institute will be able to reach many more global students than they could before," Ms. Ivanhoe Townsend said. "We are excited to see the impact these students will make as they use the knowledge gained to tackle these enormous challenges that lie ahead of us. We want to be a part of DWFI's mission to ensure water and food security for our world."



COMMUNICATION

DWFI Program Associate Kate Gibson shares news about the institute's research using smart water meters with a TV news reporter at Husker Harvest Days in Grand Island, Nebraska, USA. Credit: Morgan Spiehs

DWFI's communication efforts expand and support the institute's global reach, building the institute's reputation by sharing accurate, timely information and producing impactful conferences and events.

The communications team shared many stories of DWFI's progress throughout the year in a variety of media, such as: blogs describing the use of water markets to help improve water management and advanced technology to measure plant stress through satellite imagery; video interviews of Rwandan students sharing their perspectives on Nebraska's water management policies; photos of faculty working on projects in far flung areas of the world; and daily tweets about water and security issues and advancements.

Social media platforms allow the institute Social media platforms allow the institute to quickly reach and engage with partners and stakeholders around the world. Through Facebook, Twitter, YouTube, LinkedIn and Instagram, we encourage our audiences to connect and actively participate with us to amplify brand awareness, increase engagement and enhance our global relationships and thought leadership throughout the industry. The institute's primary platforms showed increases in the number of followers, as well as interactions:

Twitter

From
4,277 FOLLOWERS
in July 2017 to
4,644 FOLLOWERS
in June 2018. (↑ 367 followers)

779 MENTIONS
during the year

More than
1,260,000 IMPRESSIONS
during the year

Facebook

From
8,499 PAGE LIKES
in July 2017 to
9,336 PAGE LIKES
in June 2018. (↑837 page likes)

More than
501,000 POST REACH
during the year

The institute refreshed its design standards to more closely align with the University of Nebraska and update the look of its materials. The refreshed branding is most evident in the institute's newly redesigned website, launched in July 2018. The new website offers improved navigation and is mobile-friendly, a vital improvement for the 65 percent of users who access the site through mobile devices.

Several research stories were published in news media and are available for review on the DWFI website waterforfood.nebraska.edu/news-and-events.

The communications team planned and executed the institute's major and minor events this year, ranging from the Water for Food International Forum in Washington, D.C., and the World Water Forum in Brasilia, Brazil, to local campus lunch and learn seminars and field study tours.

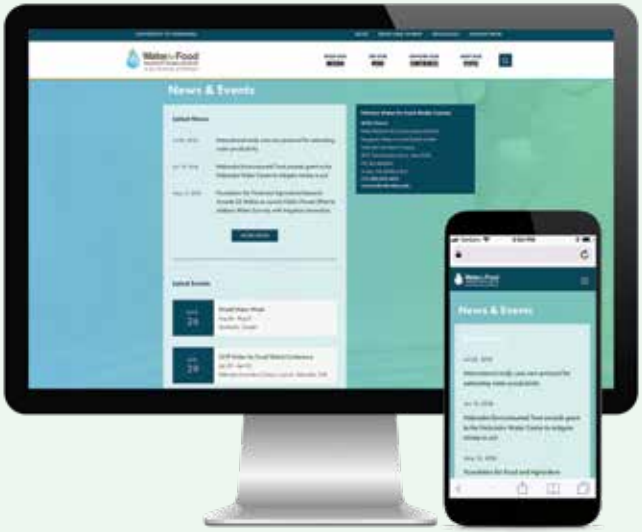
Each event, article, video and social media post shares DWFI's work with current or new stakeholders, building connections and fostering partnerships. The invitation to cohost the 2018 Water for Food International Forum grew out of enthusiasm for the smallholder farming seminar at the 2017 Water for Food Global Conference. A significant donation from the Ivanhoe Foundation also resulted from 2017 Global Conference. A blog post about the Nebraska Water Productivity Report led to an editorial in the Omaha World Herald. These are just a few examples of the ways in which the institute's strategic communications are helping to expand and strengthen our relationships with state, national and international stakeholders. These relationships validate DWFI's leadership and facilitate collaborations in water and food security efforts.

The Daugherty Water for Food Global Institute YouTube channel: youtube.com/WaterForFood.

DWFI WEBSITE REDESIGNED TO REACH TO SMARTPHONE USERS

With support from the University of Nebraska's web development team, DWFI finalized and launched its newly redesigned website in July 2018. More than two years in development, the new site was built using Sitecore, a website platform that provides maximum flexibility and functionality and is used by all University of Nebraska system institutes.

The new site features bold banner photos, intuitive navigation and mobile-friendly features. In the first few weeks since launch, site visits have increased, and stakeholders are spending more time on the pages they visit. The website will continue to evolve and improve as more content is added each day.



FOOD DEMAND

40%
Population Increase

2017 ▸▸▸ 2050

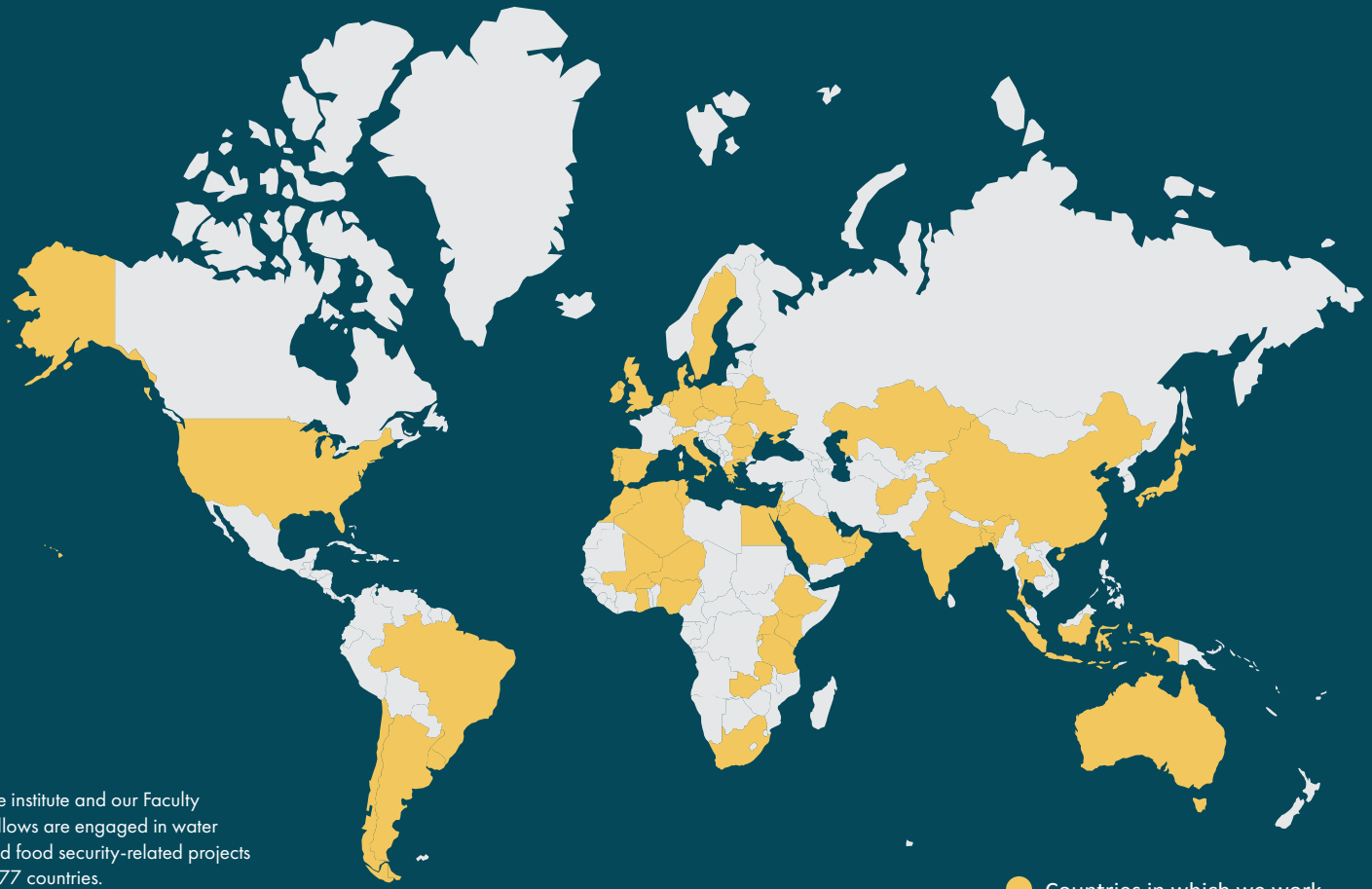
40% population increase by 2050, means 70% increase in the demand for food

70%
Demand for Food

WATER DEMAND

70%
of all freshwater withdrawals are for agriculture

GLOBAL PROJECTS



The institute and our Faculty Fellows are engaged in water and food security-related projects in 77 countries.

Countries in which we work

GLOBAL REACH

111 Faculty Fellows

9 International Advisory Panels

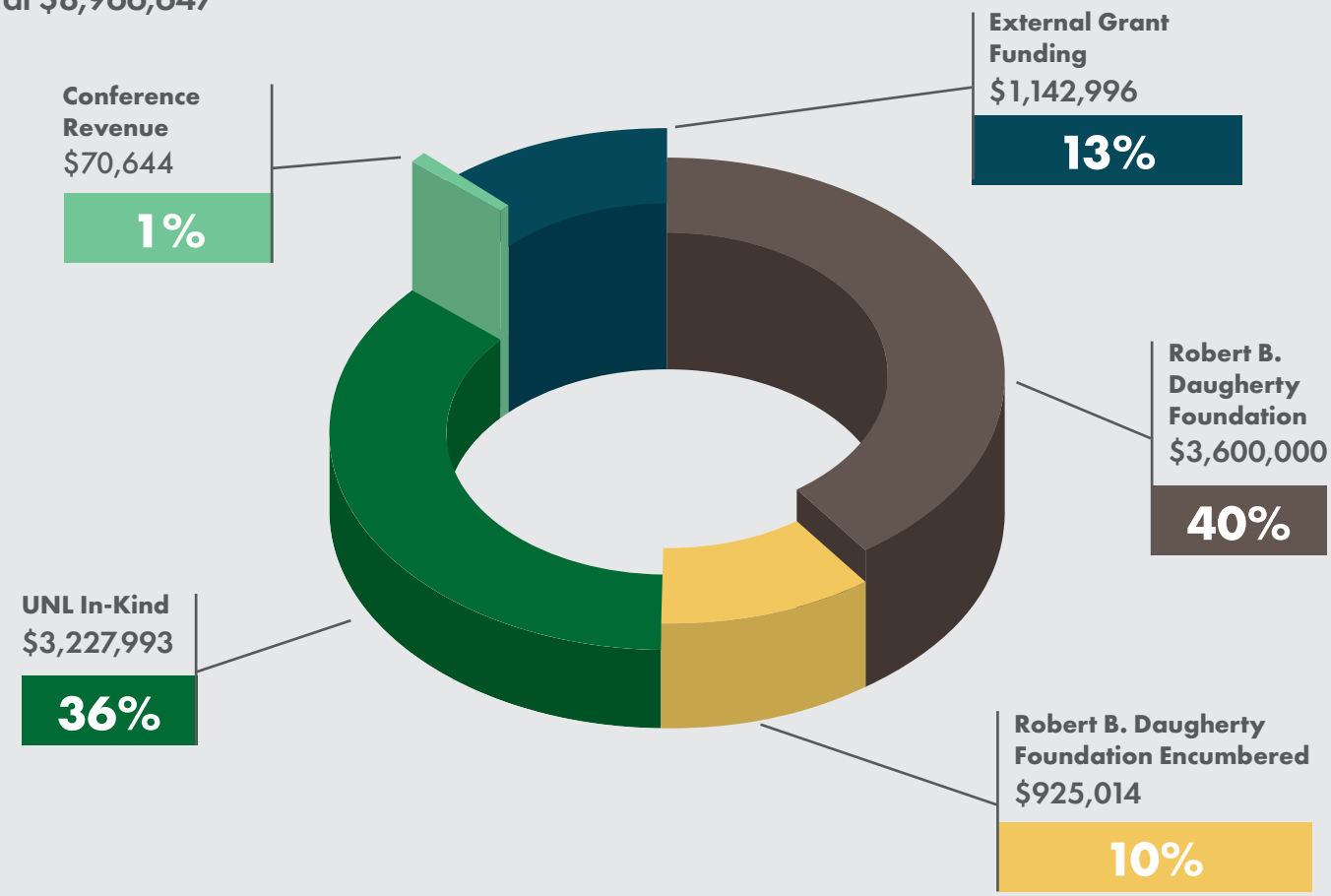
18 Global Fellows

8 Water for Food Global Conferences since 2010

FINANCIALS

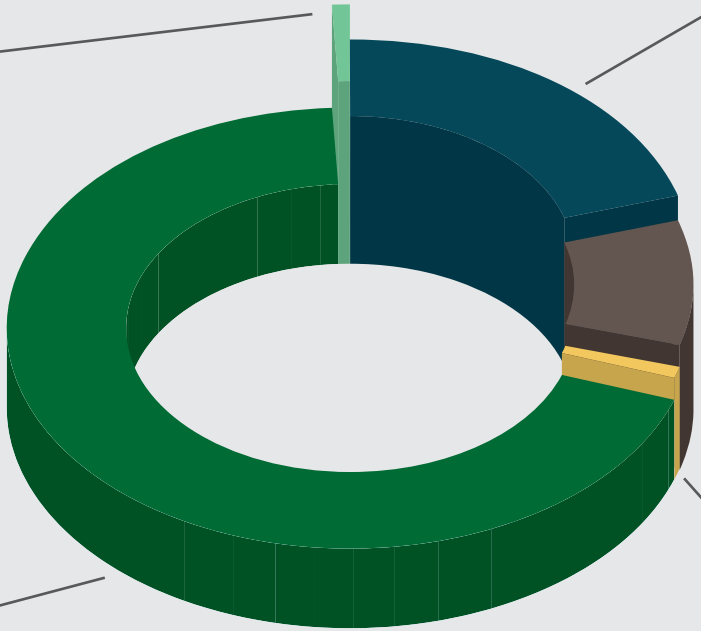
FY2018 Funding Sources

Total $8,966,647



FY2018 Expenditures

Total $8,966,647



Core Leadership
$1,826,293
20%

Faculty & Research Fellow Development
$817,363
9%

Marketing & Communication
$83,547
1%

Research, Policy and Education Programs
$6,168,974
69%

Change in Carryforward
$70,470
1%

Corporate Sponsors

World Bank

Monsanto (now Bayer)

Private Funding

Robert B. Daugherty Foundation

Anonymous

The Ivanhoe Foundation

Melissa A. Malkovich

E. Robert and Angenette Meaney

Nebraska Legal Professionals Organization

Mr. and Mrs. William L. North

Dr. and Mrs. Raymond C. Ward

Grant Funding

al-Farabi Kazakh National University

Colorado State University

Heidelberg University

JEO Consulting

Michigan State University

Nebraska Department of Environmental Quality

Nebraska Environmental Trust

Nebraska Natural Resources Commission

Papio-Missouri River Natural Resources District

Pennsylvania State University

United States Department of Agriculture – Agricultural Research Service

United States Department of Agriculture – Office of the Chief Economist

United States Department of the Interior

University of South Dakota

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Lameck Odhiambo, Irrigation Specialist

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Jesse Starita, Education and Outreach Coordinator

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Matteo D'Alessio, Research Assistant Professor

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Jahangeer, Postdoctoral Fellow

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Crystal Powers, Research & Extension Communication Specialist

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Sathaporn (Tong) Onanong, LC/MS Specialist

Aaron Shultis, Isotope Chemist

Victoria Wickham, Research Technician

Credits

The 2018 Annual Report is published by the Robert B. Daugherty Water for Food Global Institute at the University of Nebraska. For more information, please visit the website at waterforfood.nebraska.edu.

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The DWFI Annual Report was made possible through content contributions of DWFI, NWC and WSL staff, Faculty Fellows, advisors and other partners.

Acronyms

ACRONYM	ORGANIZATION/TERM
ALEXI-DisALEXI	Atmosphere-Land Exchange Inverse / Disaggregated Atmosphere-Land Exchange Inverse
ARD	Agricultural Research Division- University of Nebraska-Lincoln
ARS	Agricultural Research Service- U.S. Department of Agriculture
CDI	Composite Drought Index
DWFI	Daugherty Water for Food Global Institute at the University of Nebraska
EDF	Environmental Defense Fund
ENREC	Eastern Nebraska Research and Extension Center
EPA	Environmental Protection Agency
ESALQ	College of Agriculture, University of Sao Paulo, Brazil
ET	Evapotranspiration

ACRONYM	ORGANIZATION/TERM
FAO	Food and Agriculture Organization of the United Nations
FAP	Faculty Advisory Panel
FFAR	Foundation for Food and Agriculture Research
GIS	Geographical Information System
GRIPP	Groundwater Solutions Initiative for Policy and Practice- International Water Management Institute
GYGA	Global Yield Gap and Water Productivity Atlas
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

ACRONYM	ORGANIZATION/TERM
ICID	International Commission on Irrigation and Drainage
IFPRI	International Food Policy Research Institute
IHE Delft	Institute for Water Education, Delft, The Netherlands
IUSSTF	Indo-U.S. Science and Technology Forum
IWMI	International Water Management Institute
MDG	Millennium Development Goals
MENA	Middle East and North Africa
MOU	Memorandum of Understanding
NARD	Nebraska Association of Resources Districts
NASA	National Aeronautics and Space Administration
NDEQ	Nebraska Department of Environmental Quality
NDMC	National Drought Mitigation Center at the University of Nebraska-Lincoln
NET	Nebraska Environmental Trust
NET	Nebraska Educational Telecommunications
NGO	Non-governmental Organization
NIC	Nebraska Innovation Campus
NOAA	National Oceanic and Atmospheric Administration
NRDs	Natural Resources Districts
NU	University of Nebraska
NWC	Nebraska Water Center, part of the Daugherty Water for Food Global Institute

ACRONYM	ORGANIZATION/TERM
SEEDS	Service, Engagement, Entrepreneurship, Development, Sustainability
SIWI	Swedish International Water Institute
SWM	Smart Water Meters Inc.
UAV	Unmanned aerial vehicle
UN	United Nations
UNEP	United Nations Environment Program
UNICEF	United Nations Children's Fund
UNK	University of Nebraska at Kearney
UNL	University of Nebraska-Lincoln
UNMC	University of Nebraska Medical Center
UNO	University of Nebraska at Omaha
USAID	U.S. Agency for International Development
USDA	U.S. Department of Agriculture
USDA-NIFA	U.S. Department of Agriculture- National Institute of Food and Agriculture
VRI	Variable rate irrigation
WARI	Water Advanced Research and Innovation
WASAG	Water Scarcity in Agriculture
WB	World Bank
WLE	Water, Land and Ecosystem- CGIAR Research Program
WSL	Water Sciences Lab
WWF	World Water Forum
WWW	World Water Week (Stockholm)

Water *for* Food
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