Abdul Latif Jameel Water and Food Systems Lab

The Abdul Latif Jameel Water and Food Systems Lab (J-WAFS) fuels research, innovation, and collaboration at and beyond MIT to solve urgent global water and food systems challenges. Our aim is to ensure safe and resilient supplies of water and food to meet the local and global needs of a rapidly expanding and evolving population on a planet impacted by climate change and other human activities.

J-WAFS supports a portfolio of early-stage and sponsored research projects, commercialization efforts, student activities and mentorship, events that convene local and global experts, and international-scale research collaborations. J-WAFS is the major funder of water and food-related research on campus, and our funding and opportunities are available to researchers in all MIT departments, labs, and centers. This year, J-WAFS:

- Distributed $2,050,000 to the MIT community through its annual funding initiatives and other programs—including two new grant opportunities
- Launched a transdisciplinary, multi-institutional research collaboration focused on mitigating the effects of climate change on global food systems
- Awarded three fellowships to advanced PhD students working on water sector research
- Hosted a visiting scholar from the University of Southern Australia
- Convened a multidisciplinary, multi-institutional group to apply for a $20 million federal grant to fund a center focusing on applying artificial intelligence (AI) and machine learning to agriculture and food systems
- From March 2020 onward, rapidly transformed our initiatives and operations in response to the global COVID-19 pandemic

Impact of COVID-19 on J-WAFS Activities

In early January 2020, the World Health Organization reported a disease outbreak in Wuhan, China. Since then, the disease—a novel coronavirus known as COVID-19—has spread across the world, leading to an ongoing global pandemic. The pandemic has affected nearly every aspect of the Institute's research, educational, and administrative operations. Leaders across the Institute have created policies aimed at controlling the spread of COVID-19, accelerating COVID-19–specific research, and protecting members of the MIT community. These policies—including remote teaching and remote work, bans on in-person gatherings, restrictions on campus research and lab activities, travel bans, hiring restrictions, and others—have affected J-WAFS' activities in numerous ways. These include:

- J-WAFS staff and leadership have worked from their homes since March 2020.
- The progress of many J-WAFS-funded researchers has stalled or ceased for a period of time.

- Research taking place outside the United States has been suspended, along with essentially all travel.
- J-WAFS-sponsored events were migrated online, changed in form, or canceled.
- The search for a new director of external relations was suspended, in view of the economic disruption resulting from the pandemic.

Grant Making and Research Support

J-WAFS implements a variety of MIT funding programs. In FY2020 these opportunities included the following:

- J-WAFS Seed Grants: Two-year grants supporting new research initiatives that have the potential to have significant impact on challenges related to the world's water and food supply
- J-WAFS Solutions Grants: One-year commercialization grants supporting translational water and food systems research with the intent of moving technology from the laboratory to market
- J-WAFS Research Affiliate Program: Sponsored research led by MIT principal investigators (PIs) and conducted in collaboration with companies participating in the J-WAFS Research Affiliate Program
- J-WAFS Fellowships for Water Solutions: One-semester fellowships for advanced PhD students conducting innovative water sector research
- J-WAFS Grant for Water and Food Projects in India: Implementation grants for on-the-ground research projects addressing water and food systems challenges in India
- MIT-IIT Ropar Seed Fund (New in FY2020): A collaboratively managed grant supporting new research collaborations with the Indian Institute for Technology at Ropar (IIT Ropar)
- J-WAFS Grant for Transforming Animal Agriculture Systems (New in FY2020): Implementation grants for research addressing the challenges associated with industrial animal agriculture
- J-WAFS Water Leaders Travel Grants (Postponed in FY2020 due to COVID-19): Travel grants enabling graduate students to attend Stockholm World Water Week, an international conference convening academic, industry, and policy leaders in the water sector

By the Numbers

With the addition of FY2020 grants that were announced in the spring, the MIT research community funded since 2015 by J-WAFS via the grant programs above will include the following:

Funded MIT faculty

- 72 PIs representing 24 MIT departments, labs, and centers (DLCs) spanning all five schools and the MIT Schwarzman College of Computing
- Three PIs at the Indian Institute of Technology Ropar and one at the Harvard Medical School, each collaborating with MIT faculty

Funded MIT Students

Note that these numbers cover all funding mechanisms except for our Solutions Grants.

- 126 students (including PhD candidates, SM candidates, visiting students, and undergraduates)
- 57 postdocs
- 26 additional research staff

J-WAFS Seed Grants

Seed Grant Awards Funded in June 2020

The J-WAFS seed grant program supports innovative, early-stage MIT research that has the potential to have significant impact on water and food supply challenges. Grants typically provide up to $75,000 per year, overhead free, for up to two years, however a slight reduction in the awards was made in spring 2020 due to COVID-19's impact on MIT endowment payout.

The seed grant request for payment distributed in the 2019 fall semester attracted submissions from 34 principal investigators from 15 departments across all five schools. A peer review process involving approximately 50 faculty members and research associates from across the Institute resulted in the selection of eight new projects led by 10 PIs from eight MIT DLCs. The projects, which have received grants of up to $145,000 for two years, overhead free, will begin on September 1, 2020. They are as follows:

Enhancing Water Affordability for Vulnerable Urban Households in the United States

PIs are Gabriella Y. Carolini, associate professor of international development and urban planning, Department of Urban Studies and Planning (DUSP) and Lawrence Susskind, Ford Professor of Urban and Environmental Planning, DUSP.

Diminished federal support for water infrastructure investments and stagnant, state-level subsidies have resulted in municipal water departments raising water rates, which has stressed clean water access for urban households across the United States. This pattern, which has grown over the last decade, has caused an increasing water poverty cycle in cities across the US, where poor urban households experience water shutoffs that often end with home foreclosures. This project will involve research into local-level policy responses to urban water poverty through 10 case studies. These studies will inform the development of online dashboards for both municipal water utilities and for residents and their advocates, providing a way to help decision makers envision productive policy solutions to water poverty.

Smart Porous Hydrogels for Atmospheric Water Harvesting

PIs are Xuanhe Zhao, associate professor, Department of Mechanical Engineering and Department of Civil and Environmental Engineering (CEE), and Gang Chen, Carl Richard Soderberg Professor of Power Engineering, Department of Mechanical Engineering.

Developing technologies that harvest water from air has emerged as a promising strategy to address water scarcity in arid regions and decentralized communities. Existing versions typically rely on water adsorption using materials such as hydrogels and salts. Unfortunately, these strategies tend to be slow-producing and low-yielding, which limits their sustainable scale-up potential. This research team aims to design a smart, porous hydrogel to serve as a cost-effective and energy-efficient water harvesting device that is faster and more effective at water recycling than existing technologies.

Solving the Phosphite Bottleneck for Next Generation Agriculture and Clean Water

PI is Christopher C. Cummins, Henry Dreyfus Professor of Chemistry, Department of Chemistry.

Recent advances in plant bioengineering have produced crops—including corn, soybeans, and cotton—that can metabolize phosphite, a reduced phosphorus compound that is not able to be metabolized by non-engineered plants, including weeds. This development presents the possibility of using phosphite as both a fertilizer and an approach to weed control. The challenge, however, is that current industrial processes used to develop phosphite are energy intensive, involve mining practices that disrupt land ecosystems and result in high carbon emissions. For this project, researchers will invent a new low-energy process for phosphite manufacturing that pulls it from existing waste streams, resulting in a sustainable closed-loop system that supports crop yields as well as riparian ecosystems.

Data-driven Development of Probiotics for Shrimp Aquaculture in Ecuador

PI is Otto X. Cordero, Doherty Professor in Ocean Utilization, CEE.

Aquaculture is the fastest growing mode of food production in the world, at a rate of approximately 10% per year. While the rapid expansion of aquaculture can serve to alleviate the pressure on natural fisheries, it comes at a high environmental cost, including the destruction of environmentally beneficial mangroves and the eutrophication of rivers and costal environments. For this project, researchers will collaborate with scientists and shrimp producers in Ecuador to develop improved biologically engineered probiotics that can help shrimp populations more effectively resist pathogens, reducing waste and decreasing the need for the overuse of antibiotics that negatively affect local ecosystems.

Developing Flexible Estimates of Agricultural Supply Functions for Answering Demand-side Agricultural Questions

PI is David J. Donaldson, professor of economics, Department of Economics.

How will agricultural systems meet growing demand for crops from expanding world populations with increasing financial resources, and what will the affect be on markets and supply chains? Using satellite data, statistics, and advanced models, researchers will analyze the impact of agricultural price support policies, tariff policies, and the ongoing US-China trade discussions.

Securing the Food Supply with Sustainable Packaging

PI is Bradley Olsen, associate professor of chemical engineering, Department of Chemical Engineering.

Our current global system of industrial agriculture and food distribution uses farms and other processing and production locations that are typically far from where the food is consumed, leading to the near ubiquitous use of plastic packaging, creating a major sustainability crisis. Researchers will develop a novel material that is both fully compostable and carries all of the food safety and preservation properties of plastics. They will use new, sustainable polymers produced from biomass and that degrade at the end of use, thus creating a closed carbon cycle.

Reduction of Risk from Water- and Food-borne N-nitrosamines by Induction of the Nrf2 Chemo-protective Pathway in Mammals

PIs are John M. Essigmann, William R. (1956) and Betsy P. Leitch Professor in Residence, professor of chemistry, toxicology, and biological engineering, Department of Biological Engineering; and Robert Croy, research scientist, Center for Environmental Health Science and Department of Biological Engineering.

Research studies are showing how food and beverages—including drinking water—carry higher levels of carcinogens than previously thought, with longstanding negative health effects. The presence of carcinogens in water and food is often caused by environmental contamination caused by manufacturing or other industrial processes. While there are many efforts to reduce the production of these chemicals or remove them from the environment, this project will leverage molecular biology strategies, such as gene editing, to help improve people's natural resistance to these toxins.

Using Siderphore-Conjugated Microcins to Combat Foodborne Pathogens

PI is Elizabeth M. Nolan, professor of chemistry, Department of Chemistry.

Foodborne pathogens, such as salmonella and E. coli, are a prevalent cause of human disease worldwide, imposing a severe economic burden and constituting a considerable health risk to young, elderly, or immunocompromised individuals. Livestock—particularly cattle—can contribute to the spread of these pathogens, which live in their guts. This research team will target cattle gut bacteria in order to limit the spread of foodborne illness. To do this they will use a novel antibacterial agent engineered using natural products—microcin M and micocin H47—that can target specific pathogens to control their growth.

Seed Grant Projects that Concluded FY2020

Distributed Water Harvesting from Air in Water-stressed and Remote Areas using Metal-Organic Frameworks

PIs are Mircea Dincă, associate professor of chemistry, Department of Chemistry; and Evelyn Wang, Gail E. Kendall (1978) Professor of Mechanical Engineering, Department of Mechanical Engineering.

J-WAFS funding enabled the development of a functional water harvesting prototype that demonstrated an 80% increase in water harvesting capacity compared to prior work. A start-up company, Transaera, aims to commercialize aspects of this research. The research team is also communicating with members of the Department of Defense and nonprofit organizations focused on water, sanitation, and health to guide funding initiatives in order to create opportunities to adapt the current design for military needs and developing country scenarios.

Evaluation of Fully Synthetic Nitrogen Fixation Pathway, Designed for Plant Mitochondria and Plastids

PI is Christopher Voigt, Daniel I. C. Wang Professor of Advanced Biotechnology, Department of Biological Engineering.

J-WAFS funding enabled the construction of the first-ever transgenic plant containing a complete and stable *nif* pathway, which is critical to the future development of nitrogen-fixing cereal grains, a goal that the research team continues to pursue. The team also developed a chloroplast cell-free system for rapid prototyping of engineered plants, which is a revolution in plant bioengineering research practice that has the potential to transform the field of plant genetics.

Electrochemical Nitrogen Fixation for Distributed Fertilizer Production

PI is Karthish Manthiram, Warren K. Lewis Career Development Professor, Department of Chemical Engineering.

J-WAFS funding enabled the exploration of how nitrogen can be converted to ammonia, including the development of a single pot, lithium-mediated approach. Additionally, prior to the 2017 seed grant call for proposals, Professor Manthiram was unaware of the importance of problems in the food sector and how his lab, whose mission is using air, water, and renewable electricity to make chemicals and everyday materials, could help. J-WAFS funding prompted what is now a prominent part of the lab's research portfolio: decarbonized routes to ammonia production. In FY2020 Manthiram received a National Science Foundation CAREER grant to support continued work in this area.

Multifunctional Light-diffusing Fibers for Simultaneous Light Management and Fluid Transport in Microalgae Bioreactors

PI is Mathias Kolle, associate professor of mechanical engineering, Department of Mechanical Engineering.

J-WAFS funding enabled the development of transparent, light-guiding acrylic rods that can be used for controlled, variable emission of light (so-called leaky light guides). These guides are designed for more efficient growth of microalgae within a bioreactor. The researchers have collaborated with Professor LaShanda Korley and her students at the University of Delaware to develop a tailored light emission profile using a process called electrospinning. This strategy has proven promising for scaling the light guide manufacture to industrial levels. The research team is also collaborating with researchers at Arizona State University to develop a grant proposal to the US Department of Energy or the US Department of Agriculture to support further research.

Real-time, On-site Detection of Foodborne Pathogens by Engineered Bacteriophage Integrated with Microfluidic Sample Preparation Platforms

PIs are Jongyoon Han, professor, Department of Electrical Engineering and Computer Science (EECS) and Department of Biological Engineering; and Timothy Lu, associate professor, EECS and Department of Biological Engineering.

J-WAFS funding fueled the development of a prototype that can concentrate small amounts of bacteria in large volumes. This enables the detection of food and other pathogens by culture (a conventional technique) faster than is currently possible. This technology is adaptable to many other applications, especially for contaminant monitoring and biomanufacturing, as well as waterborne virus detection. Jongyoon Han's research group has entered a non-disclosure agreement with AOSmith, a company that is interested in using this technology for water-based heavy metal and bacterial detection.

Gravity Fingering During Water Infiltration in Soil: Impact on the Resilience of Crops and Vegetation in Water-Stressed Ecosystems

PI is Ruben Juanes, ARCO Associate Professor in Energy Studies, CEE.

J-WAFS funding enabled the development of a 3D cell that enables the visualization of the patterns of "gravity fingering," which is the process by which water filters through soils of various compositions. The team has established a collaboration with a research group at Princeton University focused on the flow dynamics and how these affect vegetation and biota (termites) in semi-arid regions in Africa.

Waste to food: Yarrowia lipolytica as Protein and Lipid Production Platform

PI is Gregory Stephanopoulos, Willard Henry Dow Professor of Biotechnology and Chemical Engineering, Department of Chemical Engineering.

J-WAFS funding enabled the successful engineering of the genetic pathways leading to the production of linoleic acid into *Yarrowia lipolytica*, which has laid the foundation for a promising platform technology that can convert acid whey—an abundant byproduct in industrial cheese and yogurt making—into value-added products that are high in omega-3 fatty acids—products that are suitable for animal or human consumption. The team is currently exploring the application of this technology to fish feed development for aquaculture with the company KnipBio.

Continuing Seed Grant Projects Funded in Spring 2019

- Designing supply chain platforms for smallholders in Indonesia
  PI: Joann de Zegher, Maurice F. Strong Career Development Professor and assistant professor of operations management, Sloan School of Management
- Learning food and water contaminants using wireless signals
  PI: Fadel Adib, Sony Career Development Professor of Media Arts and Sciences, Program in Media Arts and Sciences
- Microparticle systems for the removal of organic micro pollutants
  PI: Patrick Doyle, Robert T. Haslam (1911) Professor of Chemical Engineering, Department of Chemical Engineering

- Electrocatalytic ammonia synthesis for distributed agriculture
  PI: Yogesh Surendranath, Paul M. Cook Career Development Assistant Professor, Department of Chemistry

- Designing purely weather-contingent crop insurance with personalized coverage to improve farmers' investments in their crops for higher yields
  PI: Robert M. Townsend, Elizabeth and James Killian Professor of Economics, Department of Economics

- Understanding effects of intermittent flow on drinking water quality
  PI: Andrew J. Whittle, Edmund K. Turner Professor in Civil Engineering, Department of Civil Engineering

- Evaporative cooling technologies for fruit and vegetable preservation in Kenya
  PIs: Daniel Frey, professor of mechanical engineering, Department of Mechanical Engineering; Leon Glicksman, professor of building technology and mechanical engineering, Departments of Architecture and Mechanical Engineering; and Eric Verploegen, research engineer, MIT D-Lab

Continuing Seed Grant Projects Funded in Spring 2018

- Novel systems biology tools for improving crop tolerance to abiotic stressors
  PIs: David Des Marais, Gale Assistant Professor of Civil and Environmental Engineering, CEE; and Caroline Uhler, Henry L. and Grace Doherty Assistant Professor, EECS

- Assessing climate vulnerability of West African food security using remote sensing
  PI: Dara Entekhabi, Bacardi and Stockholm Water Foundations Professor, CEE

- Printed silk-based colorimetric sensors for food spoilage prevention and supply chain authentication
  PIs: John Hart, professor of Mechanical Engineering, Department of Mechanical Engineering; and Benedetto Marelli, Paul M. Cook Career Development Professor, CEE

- What controls arsenic contamination in South Asia? Making sense of two-decades of disjointed data
  PI: Charles Harvey, professor of civil and environmental engineering, CEE

- Supermolecular nanostructure gels for chelation of arsenic from drinking water
  PI: Julia Ortony, Finmeccanica Career Development Professor, Department of Materials Science and Engineering

- Anthropogenic soils of the Amazon: Origins, extent, and implications for sustainable tropical agriculture
  PIs: Dorothy Hosler, professor of archaeology and ancient technology, Department of Materials Science and Engineering (DMSE); Heather Lechtman, professor of archaeology and ancient technology, (DMSE); and J. Taylor Perron, associate professor of geology, Department of Earth, Planetary and Atmospheric Sciences

- Purifying water from Boron contamination with highly selective Metal-Organic Framework membranes
  PI: Zachary Smith, Joseph R. Mares (1924) Career Development Professor, Department of Chemical Engineering

Additional Ongoing Seed Grants with No-cost Extensions

- Affordable potassium fertilizer from K feldspar for Africa
  PI: Antoine Allanore, Thomas B. King Assistant Professor of Metallurgy, DMSE

- The potential for private irrigation in Senegal
  PIs: Stephen Graves, Abraham J. Siegel Professor of Management Science and professor of operations management, Sloan School of Management; Bishwapriya Sanyal, Ford International Professor of Urban Development and Planning, DUSP

J-WAFS Solutions Grants

The J-WAFS Solutions program provides one-year, renewable, commercialization grants designed to support the commercialization of early-stage MIT technologies. The program is currently funded by Community Jameel and administered in partnership with the MIT Deshpande Center for Technological Innovation. Through the program, annual grants of up to $150,000 are available to MIT research teams that meet the program's requirements for commercialization readiness.

One new J-WAFS Solutions project was initiated in September 2019.

- Supporting the Resilience of the Citrus Industry
  PI is Karen Gleason, Alexander and I. Michael Kasser (1960) Professor, Department of Chemical Engineering.

  Citrus fruits have become staples across seasons, cultures, and geographies, yet the large-scale citrus farms in the United States that support much of our domestic citrus consumption are challenged by Huanglongbing (HLB), known as citrus greening disease. The disease is an incurable bacterial infection that causes trees to wither and fruit to develop an unpleasantly bitter taste. If left undetected, HLB can very quickly destroy large citrus groves. This project uses low-cost, high-sensitivity sensors that can enable early detection in order to support tree removal before widespread infection begins. It detects volatile organic compounds emitted by citrus trees that change in concentration during early-stage HLB infection. An associated algorithm provides a high-accuracy prediction system for the presence of the disease so that farmers and farm managers can make informed decisions about tree removal.

The following J-WAFS Solutions-funded project started in September 2018, and received a renewal grant for a second year of funding starting September 2019. The results of this project will be detailed in the FY2021 report.

- Manufacturing and marketing E. coli test kits to promote safely managed drinking water and improved public health in Nepal
  PIs: Jeffrey S. Ravel, professor of history, Department of History; and Susan Murcott, lecturer, MIT D-Lab

The following J-WAFS Solutions projects received no-cost extensions and are continuing into AY2021:

- QuantiSoil: Commercialization of an on-site soil analysis system for smallholding farmers
  PIs: John Hart and Chintan Vaishnav, senior lecturer in management, Sloan School of Management
- Reducing runoff and environmental impact of agricultural sprays
  PI: Kripa Varanasi, associate professor of mechanical engineering, Department of Mechanical Engineering

J-WAFS Research Affiliates Program

In FY2020, Xylem, J-WAFS' first research affiliate, renewed its membership for a second three-year term and launched one new research project. In addition to funding research, Xylem provides student support through a variety of mechanisms: financial sponsorship of the MIT Water Club and the J-WAFS Water Leader Travel Grant, contributions to the J-WAFS Fellowships for Water Solutions, and mentoring MIT teams competing in the annual Water Innovation Prize.

This year J-WAFS initiated conversations with several other potential industry sponsors. Some discussions were stalled during the initial COVID-19 shutdown, but J-WAFS expects one or more new research affiliate companies to come on board in FY2021.

J-WAFS Fellowships for Water Solutions

In FY2020, two graduate students were funded with one-semester fellowships in our third year of offering the Rasikbhai L. Meswani Fellowship for Water Solutions and the J-WAFS Graduate Student Fellowship (funded by Xylem, through our Research Affiliates program). In June we announced the award of our FY2021 fellowships.

FY2020 J-WAFS Fellows

The two selected students in FY2020, both of whom are PhD candidates in the Department of Mechanical Engineering, were Peter Godart and Sahil Shah.

FY2021 Fellowship Selection and Awards

During FY2020, three new students were selected for FY2021 fellowship awards; four honorable mention recipients were also selected, who received cash prizes. The additional cash awards recognized this year's outstanding applicant pool, with its strong showing of academic excellence combined with commitment to the security, safety, and efficiency of the world's water supplies.

FY2021 Rasikbhai L. Meswani Fellow for Water Solutions

- Nadia Christidi, PhD candidate, Doctoral Program in History, Anthropology, and Science, Technology, and Society

FY2021 J-WAFS Graduate Student Fellows

- Chun Man Chow, PhD candidate, Department of Mechanical Engineering
- Huanhuan Tian, PhD candidate, Department of Chemical Engineering

Students Receiving Honorable Mentions

- Elena Sobrino, PhD candidate, Doctoral Program in History, Anthropology, and Science, Technology, and Society
- Jonars Spielberg, PhD candidate, Department of Urban Studies and Planning
- Georgia Van de Zande, PhD candidate, Department of Mechanical Engineering
- Lenan Zhang, PhD candidate, Department of Mechanical Engineering

MIT-IIT Ropar Seed Fund

In FY2020, J-WAFS launched the MIT-IIT Ropar Seed Fund to support new water- and food systems–related research collaborations between faculty and researchers from MIT and the Indian Institute of Technology at Ropar. This grant program was developed between J-WAFS and IIT Ropar and is administrated in partnership with MIT-India, which is a part of MIT International Science and Technology Initiatives. Awards of up to $15,000 support research and student engagement between MIT and IIT Ropar in order to develop water and food systems solutions to challenges in India. The FY2020 grant award winners are listed below.

A checklist-based Advisory to Minimize the Cost and Duration of Worse-Before-Better in Transitioning from Chemical to Organic Smallholder Farming

MIT PI is Chintan Vaishnav, MIT Sloan School of Management. IIT Ropar collaborator is Parwinder Singh, assistant professor, Department of Humanities and Social Sciences.

In India, 98% of farmers currently follow conventional practices using chemical fertilizers. They remain hesitant to adopt organic farming practices despite its promise of greater sustainability and profitability. In this project, the cross-institutional research team will develop an ethnography-based system dynamics model to determine the conditions that would be most supportive to the transition from conventional to organic farming, as well as those that would be most favorable to the farmer and develop a decision-support tool to assist farmers in effectively making this transition.

Mapping Agriculture and Yields Forecasting Over India Using High-Resolution Microwave Remote Sensing

MIT PI is Dara Entekhabi, Bacardi and Stockholm Water Foundations Professor, CEE. IIT Ropar collaborator is Reet Kamal Tiwari, professor, Department of Civil Engineering.

Knowing how much land is under cultivation and what the likely food crop yields are in areas that are cultivated is fundamental for agricultural planners, yet at present there is a lack of near-real-time information on both, especially in India, where small-scale subsistence agriculture is the dominant source of food. For this project, the research team will use remote sensing to regularly map the vegetation health, growth stage, soil moisture, and growing degree days of land under agricultural production in India. They will use these data to monitor food crop yields and perform crop forecasting in advance of harvests to help improve the productivity and efficiency of smallholder farms.

J-WAFS Grant for Water and Food Projects in India

This grant program, made possible by a donation from MIT alumnus Kishore Mariwala SM ’59 supports solutions-oriented research by members of the MIT community focused on water and food challenges in India. Grants of up to $15,000 are intended to further work being pursued by individuals as part of their MIT research, innovation and entrepreneurship, or coursework, and are open to members of the MIT community in all departments and programs.

New projects awarded in FY2020 are as follows:

Sustainable Agricultural Planning for Small Farm Holders in the Bist Doab Region of Punjab

Project team members are Saurabh Amin, associate professor, CEE, MIT; and Deepak Kashyap, visiting professor and department head, Department of Civil Engineering, Indian Institute of Technology, Ropar, India.

Punjab, a northwestern state of India, occupies only 1.53% of the total geographical area of the country, but produces about two-thirds of the total food grains. In the last three decades, groundwater has been the most important source for irrigation there. However, this intensive use of groundwater is leading to resource depletion, salinization of existing supplies, and high energy use. This project addresses how smallholder farmers can productively participate in agricultural activity and support the sustainable management of groundwater resources. The research team, working across MIT and IIT Ropar, will use on-the-ground surveys along with groundwater simulation and planning tools in an attempt to better understand and address the problem and inform policy solutions.

Low-cost Water Testing and Disinfection

Project team members are Susan Murcott, lecturer, MIT D-Lab; and Ankita Singh and Deborah Go, both MBA and SM degree candidates in the Sloan School of Management and the Department of Mechanical Engineering.

In India, waterborne diseases affect approximately 38 million people every year and over 1.5 million children die due to symptoms of waterborne diseases such as diarrhea. These illnesses disproportionately affect people living in rural areas below the poverty index and who are without water and sanitation resources from the central Indian government. This project focuses on West Singhbhum in the state of Jharkhand, where researchers will work with state agencies to design and pilot a water treatment solution

for 20 government-run residential schools for girls. The treatment systems will filter water, test for microbiological contamination, and communicate test results and alerts to local leaders. They will apply the E. coli test developed by Susan Murcott, adding a novel UV-based water disinfection technology to create systems that supply clean water to each school building.

Two projects announced in 2019 received no-cost extensions:

- Piloting evaporative cooling technologies to improve vegetable shelf life and farmer income in western India
  Project team: Eric Verploegen, research engineer, MIT D-Lab; and Anish Paul Antony, postdoctoral researcher, MIT D-Lab
- Development of communication materials for the dissemination and commercialization of an open-sourced xylem water filter
  Project team: Rohit Karnik, associate professor of mechanical engineering, Department of Mechanical Engineering; Krithika Ramchander, PhD candidate, Department of Mechanical Engineering; Amy Smith, founding director, MIT D-Lab; Kendra Leith, associate director for research, MIT D-Lab; Megha Hegde, research associate, MIT D-Lab; and Anish Paul Antony, postdoctoral researcher, MIT D-Lab

J-WAFS Grant for Transforming Animal Agriculture Systems

This grant program was launched in October 2019, enabled by a gift from donor Carmen Lee. The grant, which provides up to $25,000 in funding to current members of the MIT community, supports MIT research projects that address problems associated with industrial animal food production. As a new funding initiative, two sequential calls for proposals were distributed, one in fall 2019 and one in spring 2020.

One project was selected for funding in December 2019.

Evaluating Alternative Proteins in Africa: A Practical Guide Based on a Rwanda Case Study

Project lead is Thomas Llewellin Smith, SM candidate, Program in Systems Design and Management.

This project aims to explore whether technologies supporting the development of alternative proteins could be effective in improving the nutritional availability of protein in Rwanda while lowering costs and the environmental impacts of protein production. However, COVID-19 disrupted Thomas Smith's planned travel to Rwanda for research purposes—expenses that the J-WAFS grant was intended to offset. Then, in June, 2020, as a result of travel restrictions and other personal reasons, Smith decided to return the grant.

One project was selected for funding in July 2020.

Multi-Criteria Formulation for Sustainable Swine Production

Project lead is Jasmina Burek, postdoctoral associate, Materials Systems Laboratory.

In the production of animal agriculture, the formulation of livestock feed is largely based on the cost of ingredients for producers. However, the composition of animal feed also plays an important role in the quality of the animal products—the meat, dairy, and eggs—that are produced, as well as the environmental impact of their production. This project aims to create a feed formulation for swine that lowers both production costs and emissions while preserving or enhancing nutritional quality. It aims to provide research-informed tools, specifically a model that provides recommendations for sustainable feed ingredients that swine producers can use to prioritize ecological impacts alongside economic needs in order to improve the environmental footprint of pork production.

J-WAFS Water Leader Travel Grant

Since FY2018, J-WAFS has awarded grants through this program to graduate students to allow their attendance at Stockholm World Water Week. This grant program is funded through our research affiliate arrangement with Xylem. Because of international disruptions due to COVID-19 and MIT's related travel restrictions, we did not offer this grant in FY2020.

J-WAFS-Initiated Research Efforts

The Alliance for Climate Change and Food Systems Research

In early FY2020, J-WAFS launched a research initiative addressing climate change and global food systems, focusing on how research can be targeted to support adaptation and mitigation strategies. The project will identify the most important knowledge gaps and technology needs at the nexus of climate change and food systems. It is convening a diverse group of researchers, decision makers, and other key stakeholders to develop a prioritized, actionable research agenda and collaboratively identify a path to achieving it.

The effort involves a cross-institutional collaboration focused on developing convergence research, building on the outcomes of J-WAFS' 2018 expert workshop, Climate Change, Agriculture, Water, and Food Security: What We Know and Don't Know. As a result of significant follow-on efforts, J-WAFS has established the Alliance for Climate Change and Food Systems Research, a 12-member, multi-institutional and transdisciplinary group of universities and institutional partners. The alliance brings together researchers and global stakeholders to produce convergence research aimed at mitigating the impact of food systems on climate, and significantly improving their resilience through the development and implementation of adaptation strategies.

Through the alliance J-WAFS has assembled a group of researchers from leading institutions in agriculture, nutrition, and food systems that complement MIT's expertise in engineering, science, technology, and management. By identifying stakeholders' and decision makers' research needs and bringing the perspectives and methodologies from diverse disciplines together, the alliance will facilitate innovative new research partnerships that are capable of addressing the more challenging aspects of the complex global food and agriculture system and its relationship to climate change. The alliance

includes researchers from 12 global institutions at the vanguard of research and policy on climate change and food systems. They are as follows:

- MIT (US)
- University of Washington (US)
- University of California-Davis (US)
- Tufts University's Friedman School of Nutrition Science and Policy (US)
- Cornell University (US)
- Columbia University (US)
- Colorado State University (US)
- Wageningen University and Research (Netherlands)
- University of Talca (Chile)
- University of Pretoria (South Africa)
- University of Aberdeen (Scotland)
- Ethiopian Institute of Agricultural Research (Ethiopia)

Before COVID-19, J-WAFS planned on convening alliance members and select stakeholders for a two-day meeting at MIT in June 2020. The Covid shutdown forced the cancelation of that event. J-WAFS instead held a series of virtual stakeholder "mini-dialogues" that took place from June through August 2020, engaging over 100 stakeholders and researchers. The virtual format enabled a much wider set of stakeholders to provide input. Through these discussions, we have compiled a body of knowledge that will help define and initiate alliance research proposals that will be developed in FY2021.

This effort is being led by Greg Sixt, J-WAFS research manager for climate and food systems. In FY2020, on behalf of the project, Sixt represented J-WAFS and the alliance in several significant meetings and events, among them:

- 20 Breakthroughs Convening, July 11–12, 2019, Washington, DC (hosted by the Institute for Transformative Technologies, the Lemelson Foundation, and the Rockefeller Foundation)
- Stockholm World Water Week, August 25–31, 2019, Stockholm, Sweden (hosted by SIWI, the Stockholm International Water Institute)
- Climate Crisis and the Future of Food, September 25, 2019, New York, NY (hosted by the Global Alliance for the Future of Food)
- Leveraging Partnerships to Impact Climate Change at Scale, February 4, 2020, Washington, DC (hosted by the Foundation for Food and Agriculture Research, the US Farmers and Ranchers Alliance; and the World Farmers Organization)
- Foster our Future, February 5, 2020, Washington, DC (hosted by the Foundation for Food and Agriculture Research)

Proposal for Artificial Intelligence and Machine Learning for Agriculture and Food Systems

Throughout fall and winter 2019, J-WAFS convened and led a team that submitted a proposal in January 2020 to the National Science Foundation (NSF) National Artificial Intelligence Research Institute program solicitation. AI-Driven Innovation in Agriculture and the Food System was one of six themes set out in the solicitation. While numerous other MIT teams submitted to the 2019 solicitation, the J-WAFS-led team was the only one submitting within NSF's AI-Agriculture category. Our proposal to develop FAST-AID (Food and Agriculture Security Through Artificial Intelligence and Data) received positive reviews, but was ultimately not selected for funding.

The highly interdisciplinary team included participants spanning multiple schools at MIT as well as three external collaborators: Stanford University, the International Food Policy Research Institute, and Radiant Earth. MIT has world-class strengths in artificial intelligence, machine learning, and data analytics, as well as in modeling and prediction. Coupled with equally strong capabilities in genomics and bioengineering, chemical and biological sensors, supply chain analysis, remote imaging, climate modeling, and domain expertise in agriculture and food systems, the team we convened is both broad and deep in its ability to further foundational AI research and to make meaningful advances for food and agriculture security.

Outreach and Engagement

In addition to providing research funding across all schools at MIT, J-WAFS supports and initiates a range of events and activities aimed at cultivating a broader water and food systems research community, promoting water and food-focused student groups at the Institute, and engaging around water and food issues with other MIT stakeholders.

MIT Community Engagement

Working Group on Campus Water Sustainability

At the start of FY2020, the MIT Office of Sustainability convened a university-wide working group focused on water sustainability and aimed at analyzing MIT's water practices and crafting recommendations for increased sustainability. J-WAFS was represented by Andi Sutton, our communications and program manager. The working group suspended meeting in March 2020 after COVID-19-related campus policies were initiated and most of the campus started remote work.

Site 4/E38 Sustainability Committee

In FY2021, J-WAFS, along with several other MIT offices and DLCs, will be moving to Building E38, a newly constructed, LEED-certified building in Kendall Square. Representatives of these offices, including Renee Robins and Andi Sutton of J-WAFS, convened throughout FY2020 to help make recommendations and craft policies for Building E38. These policies are aimed at making the practices employed within the building an exemplar of environmental sustainability, for example through prioritizing water and food sustainability practices.

Community Events

- J-WAFS Research Workshop, September 13 and 18, 2019
- J-WAFS Fellows Lunch, September 28, 2019
- Visiting Scholar seminars featuring the 2020 J-WAFS visiting scholar Joanne Tingey-Holyoak, February 18 and 25, 2020, and March 3, 2020

Events J-WAFS co-sponsored include the following:

- Sustainable Water Consumption Event for MIT first-year students, August 26–30, 2019—collaboration with the MIT Office of Sustainability, MIT Dining, Environmental Solutions Initiative, and MIT Water Club
- Rabobank-MIT Food and Agribusiness Innovation Prize Generator Dinner, November 7, 2019—collaboration with MIT Food and Agriculture Club
- MIT Water Summit: Drowning in Plastic (conference), November 21–22, 2019—collaboration with MIT Water Club
- MIT Water Innovation Prize Kick-Off Dinner, November 21, 2019—collaboration with MIT Water Club
- MIT Water Innovation Prize, April 22, 2020—collaboration with MIT Water Club
- Rabobank-MIT Food and Agriculture Innovation Prize, April 29, 2020—collaboration with MIT Food and Agriculture Club

J-WAFS Outreach Events

Events J-WAFS produced:

- Vyla Alliance Workshop, November 26, 2019
- J-WAFS Alliance for Climate Change and Food Systems Research (virtual) Mini-Dialogues (these events were affected by the dramatic shifts in university policies, international travel, and general practices pertaining to in-person gatherings as a result of COVID-19)

Events J-WAFS presented:

- Jameel-Toyota Scholars Anniversary Celebration, October 30, 2019—collaboration with Community Jameel
- Department of Biological Engineering Capstone: Food and Water Security, February 11, 2020—collaboration with the MIT Department of Biological Engineering

Events J-WAFS co-sponsored:

- Bayer Ag-Connect: Networking series focused on topics in agriculture innovation, September 25, 2019, October 22, 2019, November 12, 2019, and December 10, 2019—collaboration with Bayer Lifehub

Planned co-sponsored events that were canceled due to Covid:

- Water Night (MIT Water Club event)
- Water Hackathon (MIT Water Club event)
- Student Research Roundtable: Agriculture and Africa

Communications Initiatives

J-WAFS emphasizes communications and outreach activities in support of our visibility within and outside of MIT. In FY2020 we expanded our outreach efforts by:

- Releasing a fully redesigned website in October 2019
- Launching LinkedIn, Twitter, and Facebook accounts and developing a social media strategy

In June 2020, an incident of race-based police violence in Minneapolis catalyzed a series of nationwide protests and community dialogues, including throughout MIT. In response to this, and in combination with the ongoing COVID-19 disruptions, J-WAFS distributed a letter from the director to our community affirming our institutional commitment to diversity and equity, which included the following statement:

> J-WAFS itself was founded with the goal of improving access to water and food for all of humanity. We conduct our mission through research, building on the strengths and human diversity of the Institute. Our programs will not cure COVID-19, but we can help sustain the food systems stressed by the pandemic and help ensure the clean water needed to combat it. Our programs cannot eradicate racism, but the people in our programs can raise their voices to demand justice, to demand fairness, and to remind us all to respect and help one another, without regard to race, religion, sex, or social standing. The challenges facing humankind—the climate crisis, the pandemic, food and water insecurity—can only be met if all of us work together.

Distinctions

- John H. Lienhard, J-WAFS director and Abdul Latif Jameel Professor of Water and Mechanical Engineering, was appointed to the board of directors of the International Desalination Association.
- Karthish Manthiram, Theodore T. Miller Career Development Chair, Department of Chemical Engineering, received a National Science Foundation CAREER Award provided to further research that was launched with a 2017 J-WAFS Seed Grant.

Personnel

- Director: John H. Lienhard, Department of Mechanical Engineering
- Executive director: Renee J. Robins ’83

- Director of External Relations: Maren Cattonar (August 2018–August 2019); Robert Ellison (October 2019–December 2019)
- Research manager for Climate and Food Systems: Greg Sixt
- Communications and program manager: Andi Sutton
- Financial and project coordinator: Jasmine Edo
- Communications and project assistant: Lisa Miller (July 2019–January 2020), Oona Gaffney (January 2020–July 2020)
- Visiting scholar: Joanne Tingey-Holyoak, senior lecturer and researcher, Sustainable Engineering, Accounting and Law Group, Centre for Sustainability Governance, School of Commerce, University of Southern Australia Business School (February 2020–March 2020)

John H. Lienhard
Director
Abdul Latif Jameel Professor of Water and Mechanical Engineering

Renee J. Robins
Executive Director