Abdul Latif Jameel Water and Food Systems Lab

Program Overview

The Abdul Latif Jameel Water and Food Systems Lab (J-WAFS) at MIT is catalyzing groundbreaking, solutions-oriented research focused on the world's most urgent water, food, and climate challenges. Both agriculture and the availability of fresh water for human use are expected to be severely impacted by accelerating transformation of our environment due to climate change. At the same time, food systems are responsible for 30% of global greenhouse gas (GHG) emissions, with agricultural activities accounting for up to 86% of total food system emissions. The intricately linked water systems, food systems, and climate crises are coupled with a dramatically rising world population, a situation that overwhelmingly demands more sustainable, resilient practices and methods to provide clean, safe water, and food for all.

J-WAFS is the leading funder of water and food-related research at MIT, with funding opportunities open to researchers in all MIT departments, labs, and centers (DLCs). J-WAFS research projects span all disciplines, encompassing engineering, science, technology, and business innovation, as well as social science and economics, architecture, and urban planning.

Funding for early-stage development and more advanced commercialization efforts is provided through a variety of grant initiatives. We also support and mentor student-run organizations on campus, coordinate local and global events that feature experts in the field, and collaborate with international research institutions and organizations.

The global water, food, and climate emergency makes J-WAFS' work both timely and urgent. J-WAFS funded research is achieving tangible, real-time solutions and results. Since its inception in 2014, through fiscal year 2021, J-WAFS has:

- Funded 86 MIT principal investigators (PIs), representing 29 MIT DLCs, spanning all five schools and the Schwarzman College of Computing
- Funded over 200 MIT students, postdoctoral researchers, and research staff
- Funded 4 PIs outside of MIT
- Distributed over of $14.75 million in research funding to the MIT community, and another $1 million in support for graduate student fellowships, expert workshops, prize competitions, and other student support.
- Seen the spinout of six companies and products from J-WAFS-funded research: Xibus Systems, Via Separations, SiTration, AgXen, Takachar, xylem-based water filtration device, and the EEC Vial (test kit for E. coli)
- Awarded 20 fellowships to advanced PhD students working on water sector research
- Formed important industry collaborations with two Research Affiliates, Xylem, Inc. and GoAigua, who are both working to advance technologies in the water sector
- Built on-the-ground relationships with researchers and stakeholders in 17 different countries and throughout the African continent

- Hosted four international visiting scholars, from Australia, Singapore, Canada, and the US
- Mentored and supported two MIT student-organized clubs—the MIT Water Club and the MIT Food and Agriculture Club

Details on all of these achievements, as they relate specifically to what was accomplished in FY2021, plus more key initiatives from the year are included below.

Pivoting During COVID-19

The COVID-19 pandemic continued to affect our daily professional and personal lives throughout FY2021. The J-WAFS staff maintained an entirely work-from-home schedule, and all events were held virtually. Travel was suspended, leading to the deferment of our travel grants for water conferences, as well as what would have been the next round of funding for the J-WAFS Grant for Water and Food Projects in India. However, the virtual nature of this past year's work allowed for an opportunity to implement two new student video competitions—one aligned with World Water Day and the other with World Food Day. Students submitted videos describing their research-based solutions to water and food-related issues; and the winning videos were celebrated online, in lieu of in-person events.

Many J-WAFS-funded researchers had to find innovative ways to carry out their projects under the unique challenges of working remotely. For example, J-WAFS-funded researcher Amos Winter was unable to pilot his drip irrigation technology in Kenya, so he instead set up a prototype closer to home on the Charles River. J-WAFS-supported graduate student Hilary Johnson moved her variable volute pump project from the MIT lab in mechanical engineering to her parents' bathtub in Oregon, where she continued her experiments.

Despite the year's unusual circumstances, J-WAFS' day-to-day operations were performed without major disruption, and our programs were able to remain functional. With events and competitions taking place online, engagement improved because people's locations were not a constraint, allowing many from all over the globe to participate. For instance, in place of a smaller in-person workshop, the J-WAFS-led Alliance for Food and Climate Systems Transformation hosted a series of virtual dialogues throughout the summer of 2020 that featured 48 researchers and 57 stakeholders from around the world. The virtual events provided the opportunity to hear from a diverse range of international participants, include multiple farmers' organizations.

Open-Access Publication of J-WAFS Funded Research

During FY2021, J-WAFS worked with the MIT Libraries, the Office of General Counsel, and the MIT Open-Access Task Force to develop an open-access (OA) policy for research awarded by J-WAFS and funded through MIT's endowment and other gifts to the Institute. J-WAFS OA policy has two elements: all J-WAFS funded papers must be available open-access as soon as possible and no later than 1 year after publication, and if authors choose to pay for open access, the use of J-WAFS funds for article processing charges is capped.

The rationale for the OA policy is that J-WAFS (as a part of MIT) is a nonprofit, charitable organization with a mission of contributing to human knowledge. The knowledge created should be freely accessible to everyone, not locked behind publishers' paywalls. Similar OA requirements have been instituted by the US Federal Government and by many major foundations that fund scientific research. J-WAFS policy was launched during summer 2021 and will be reviewed periodically.

J-WAFS Grant Funding and Research Support

J-WAFS implements a variety of MIT funding programs. A description of these follows, including current funded projects and ones that concluded during this fiscal year.

J-WAFS Seed Grants

The J-WAFS seed grant program supports new, innovative, early-stage MIT research that has the potential to significantly impact water-and-food-related challenges. Seed grant funding is available up to $75,000 per year for two years. Proposals in all areas related to water and food security, safety, and sustainability are considered for funding, and all MIT professors and research staff holding PI privileges are eligible to apply.

The FY2021 seed grant request for proposals closed on January 14, 2021. Thirty-three proposals were submitted from 14 different MIT DLCs. A peer review process involving over five dozen faculty and senior researchers from across the Institute resulted in the selection of eight new projects led by ten PIs representing seven DLCs. The selected projects will begin on September 1, 2021.

FY2021 Seed Grant Projects and their PIs

A project led by Elfatih A. B. Eltahir, Breene M. Kerr Professor in the Department of Civil and Environmental Engineering, aims to better understand the projected near-term effects of the climate crisis on agricultural production at the southern edge of the Sahara Desert. Eltahir's research will focus on integrating regional climate modeling with an analysis of archived observations on rainfall, temperature, and yield. His team will work closely with other scientists and the policy makers in Africa who are in charge of planning climate change adaptation in the water and agriculture sectors to support a transition to resilient agriculture planning.

Mary Gehring, an associate professor in the Department of Biology, is re-imagining the future of plant breeding beyond current practices that rely on natural variation. She will develop methods that rapidly produce genetic variations in order to increase the genetic diversity of food crop species. Using pigeon pea, a legume that is widely grown as a food, Gehring and her team will test these variations against environmental stresses such as heat and drought in order to identify strains that could be more adapted to climate change.

Jeffrey C. Grossman, Morton and Claire Goulder and Family Professor in Environmental Systems in the Department of Materials Science and Engineering (DMSE), has teamed up with Evelyn N. Wang, Ford Professor of Engineering in the Department of Mechanical Engineering (MechE), to develop a low-cost device to prevent food

waste that uses an innovative combination of two methods of cooling: evaporative and radiative technologies. Their structure will use solar-reflecting materials and highly porous insulation to double the shelf life of perishable foods in remote and rural settings, without the need for electricity.

Rohit Karnik, a professor in MechE, and Pratik Shah, a principal research scientist at the MIT Media Lab, will develop a food safety test that is rapid, sensitive, and easy-to-use. The device that they are developing will use a novel technology called density-shift immunomagnetic separation (DIMS) to detect a wide variety of pathogens within a matter of hours to enable on-site testing at food processing plants.

A technology being developed by Ariel L. Furst, an assistant professor in the Department of Chemical Engineering (ChemE), will quickly and effectively detect and remove organophosphates (OPs), which are toxic to humans though commonly used for pesticides. Currently, OPs are only monitored in people's blood or urine to determine exposures, rather than in the environment at the source of exposure. Furst is engineering specific strains of bacteria to work together to both detect and degrade OPs in the environment.

Benedetto Marelli, associate professor in the Department of Civil and Environmental Engineering (CEE), is creating a microneedle for fish vaccination that is made of silk. This novel technology will enable controlled drug release in fish and will also naturally degrade in water, supporting the health of fish populations and reducing losses for aquaculture farms. Stopping the spread of preventable infectious diseases that cripple farmed fish populations can improve the productivity of aquaculture and prevent substantial economic losses.

Amos G. Winter, an associate professor in MechE, is working on a new design for desalination devices that can be used in regions around the world that lack access to safe or abundant supplies of freshwater. His device will have the potential to make reverse osmosis water treatment more affordable and better suited to be powered by renewable energy. This will ensure that the resulting technology is accessible to poor and rural communities around the world.

Millions of smallholder farmers worldwide often sell their goods through a complex network of traders and intermediaries. Due to the highly fragmented nature of this system, these farmers persistently struggle with low productivity and high poverty. Yanchong Zheng, associate professor of operations management at the Sloan School of Management (Sloan), aims to improve farmers' access to markets and information by developing AI-driven tools that can sift through data to develop unbiased weather, crop planning, and pricing information.

Seed Grant Projects that Concluded in FY2021

Significant outcomes for projects that concluded this year are below.

Concluded projects that were funded in spring 2017:

- **Affordable potassium fertilizer from K feldspar for Africa**
  PI: Antoine Allanore, DMSE
  The researchers created a novel potassium fertilizer material from the common mineral potassium feldspar. Distributed local production of the fertilizer was determined to be possible in Africa, and greenhouse studies of the fertilizer properties were performed with tomatoes, showing good results compared to commercial potassium fertilizers. Laboratory studies of the long-term nutrient release behavior of the material were completed and published, as well as a study outlining the potential of local fertilizer production to increase fertilizer application and address the yield gap in Africa. Another study has been submitted for review that quantifies the economic distinctions and benefits of local fertilizers over imported fertilizers in Africa. These works serve as a guidepost for researchers and policy makers for the future development of new fertilizers for Africa.

- **The potential for private irrigation in Senegal**
  PIs: Stephen Graves, Sloan; Bishwapriya Sanyal, Department of Urban Studies and Planning (DUSP)
  Datasets were collected from hundreds of short and long-form interviews with farmers, public and civic organizations, irrigation-sector firms, and extension agencies. These datasets showed that quality and contractual risks permeate the Senegalese irrigation supply chain, and some risks are particularly concentrated in smaller cities or in lower echelons, e.g., among retailers. Across the supply chain, strategies to manage risks proactively are less common than strategies to manage risks retroactively. Currently, a manuscript is under review in *Production and Operations Management* on supply chain risk for the irrigation equipment supply chain in Senegal. A second manuscript is in preparation for *International Journal of Production Economics* on the local availability of sales and repairs of mechanization equipment in Senegal. The researchers have also briefed the United States Agency for International Development (USAID) Bureau of Food Security on their efforts and may collaborate on opportunities to shape program designs, one in Mali and one in Senegal.

- **High-efficiency chemical-free backwash strategy for reverse osmosis membrane antifouling**
  PIs: Xuanhe Zhao and John H. Lienhard V, MechE
  This project developed a chemical-free method of keeping membranes clean: membrane vibration. A vibration cell was built and experimental procedure was laid out to study the effect of vibration on the adhesion between the model foulant and the membrane. The adhesion energy between the model foulant layer and the reverse osmosis membrane reduced at the natural frequencies. From simulations, it was also shown that the stress at the interface increased drastically at the natural frequencies. The membrane was observed to deflect significantly with the varying pressure, which caused the foulant layer to delaminate from the membrane. Flux was found to recover significantly to approximately 85% of the original flux. Experimental results show applicability of cleaning mechanism to spiral-wound modules. Two technology disclosures have been submitted to MIT's Technology Licensing Office. The published work was selected as an Editor's Choice article in the *Journal of Membrane Science* for February 2021.

Concluded projects that were funded in spring 2018:

- **Purifying water from boron contamination with highly selective metal-organic framework (MOF) membranes**
  PI: Zachary Smith, ChemE
  J-WAFS funding enabled water-stable metal-organic frameworks (MOFs) UiO-66-NH2 and MIL-101(Cr)-NH2 with sub-50 nm particle size, different pore size, and surface chemistry to be rationally designed and synthesized. Thin-film nanocomposite (TFN) membranes were successfully fabricated by chemically incorporating the MOF nanoparticles into the polyamide rejection layer through the optimized interfacial polymerization method. Compared to state-of-the-art desalination membranes, the newly developed TFN MOF membranes show both higher water permeance and rejections to inorganic salts and boric acid at a neutral pH, which shows great potential for applications in the water industry.

- **Assessing climate vulnerability of West African food security using remote sensing observations**
  PI: Dara Entekhabi, CEE, Department of Earth, Atmospheric and Planetary Sciences (EAPS)
  The team developed an approach to characterize uncertainty distributions of smallholder yields on a high-resolution grid. The approach combines a process-based crop model, new applications of satellite data, and a novel cross-validation method. This can be used by regional planners to understand the range of farm-scale yields and their spatial distribution. It improves on previous point-estimate methods, which are either inaccurate or do not capture field-level variability due to spatial aggregation.

Continuing Seed Grants with No-cost Extensions, Awarded in 2018

Final outcomes will be reported in a future report, once the projects conclude.

- **What controls Arsenic contamination in South Asia? Making sense of two-decades of disjointed data**
  PI: Charles Harvey, CEE

- **Anthropogenic soils of the Amazon: Origins, extent, and implications for sustainable tropical agriculture**
  PIs: Dorothy Hosler, DMSE; Heather Lechtman, DMSE; J. Taylor Perron, EAPS

- **Supermolecular nanostructure gels for chelation of arsenic from drinking water**
  PI: Julia Ortony, DMSE

- **Printed silk-based colorimetric sensors for food spoilage prevention and supply chain authentication**
  PIs: A. John Hart, MechE; Benedetto Marelli, CEE

Continuing Seed Grant Projects, Funded in Spring 2019

- **Designing supply chain platforms for smallholders in Indonesia**
  PI: Joann de Zegher, Sloan
- **Learning food and water contaminants using wireless signals**
  PI: Fadel Adib, Program in Media Arts and Sciences, MIT Media Lab
- **Microparticle systems for the removal of organic micro pollutants**
  PI: Patrick Doyle, ChemE
- **Electrocatalytic ammonia synthesis for distributed agriculture**
  PI: Yogesh Surendranath, 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, Department of Economics
- **Understanding effects of intermittent flow on drinking water quality**
  PI: Andrew J. Whittle, CEE
- **Evaporative cooling technologies for fruit and vegetable preservation in Kenya**
  PIs: Daniel Frey, MechE and MIT D-Lab; Leon Glicksman, Department of Architecture and MechE; Eric Verploegen, MIT D-Lab

Continuing Seed Grant Projects, Funded in Spring 2020

- **Securing the food supply with sustainable packaging**
  PI: Bradley Olsen, ChemE
- **Reduction of risk from water-and food-borne N-nitrosamines by induction of the Nrf2 chemo-protective pathway in mammals**
  PI: John Essigmann and Robert Croy, Center for Environmental Health Science, Department of Biological Engineering (BE)
- **Solving the phosphite bottleneck for next generation agriculture and clean water**
  PI: Christopher C. Cummins, Department of Chemistry
- **Using siderophore-conjugated microcins to combat foodborne pathogens**
  PI: Elizabeth M. Nolan, Department of Chemistry
- **Data-driven development of probiotics for shrimp aquaculture in Ecuador**
  PI: Otto X. Cordero, CEE
- **Developing flexible estimates of agricultural supply functions for answering demand-side agricultural questions**
  PI: Dave Donaldson, Department of Economics
- **Smart porous hydrogels for atmospheric water harvesting**
  PIs: Xuanhe Zhao, MechE; Gang Chen, MechE
- **Enhancing water affordability for vulnerable urban households in the United States**
  PIs: Gabriella Carolini, DUSP; Lawrence Susskind, DUSP

J-WAFS Solutions Grants

The J-WAFS Solutions program provides one-year, renewable, commercialization grants aimed to move MIT technology from the laboratory to market. The program is currently funded by Community Jameel and provides grants of up to $150,000 to MIT research teams that meet the program's requirements for commercialization readiness. Three Solutions grants were awarded funding in FY2021, although these projects do not commence until September 2021.

The 2021 Solutions Grantees

A team led by Daniel Frey, faculty director for research at MIT D-Lab and professor of MechE, has pioneered a new approach to enable farmers to better preserve their produce and improve access to nutritious food in local communities. The team includes Leon Glicksman, professor of building technology and MechE, and Eric Verploegen, a research engineer in MIT D-Lab. Instead of relying on traditional refrigeration with high energy and cost requirements, the team is utilizing forced-air evaporative cooling chambers. Their design, based on retrofitting shipping containers, will provide a lower cost, better performing solution, enabling farmers to chill their produce without access to power. The Solutions grant follows a J-WAFS seed grant and J-WAFS India Grant that supported the early development of their technology.

A team led by Jongyoon Han, professor of BE and EECS, has developed a portable desalination unit that utilizes an ion concentration polarization process. The compact and lightweight unit has the ability to remove dissolved and suspended solids from brackish water at a rate of one liter per hour, both in installed and remote field settings. The team plans to develop the next-generation prototype of the desalination unit alongside a mass-production strategy and business model.

Acid whey, a liquid by-product of Greek yogurt production, poses environmental risks if disposed untreated, due to its high-organic content and acidic odor. The Willard Henry Dow Professor in Chemical Engineering, Gregory Stephanopoulos, and Anthony J. Sinskey, professor of microbiology, are utilizing metabolic engineering to process acid whey into carotenoids, the yellow and orange organic pigments found naturally in carrots, autumn leaves, and salmon. The team is hoping that these carotenoids can be utilized as food supplements or feed additives.

The J-WAFS Solutions project below, started in September 2019 with PI Karen Gleason, the Alexander and I. Michael Kasser (1960) Professor, ChemE. A renewal grant was awarded for funding starting March 1, 2021, with Olivier de Weck, professor in the Department of Aeronautics and Astroanutics (AeroAstro), taking over the PI role. The results of this project will be detailed in the FY2022 report.

- **Supporting the resilience of the citrus industry**
  PI: Olivier de Weck, AeroAstro and Institute for Data, Systems, and Society

These Solutions projects remained ongoing in FY2021:

- **QuantiSoil: Commercialization of an on-site soil analysis system for smallholding farmers**
  PIs: John Hart, MechE, and Chintan Vaishnav, Sloan

- **Reducing runoff and environmental impact of agricultural sprays**
  PI: Kripa Varanasi, MechE

The following J-WAFS Solutions project concluded in FY2021. Final results are below.

- **Manufacturing and marketing E. coli test kits to promote safely managed drinking water and improved public health in Nepal**
  PIs: Jeffrey S. Ravel, Department of History, and MIT-Nepal Initiative; Susan Murcott, MIT D-Lab
  After two years of working in Nepal with the Environment and Public Health Organization and EcoConcern, J-WAFS funded researchers successfully manufactured and launched the ECC Vial—a water test kit that identifies fecal contamination in water samples through detection of the presence of E. coli and coliform. The product has two basic components: the glass vial containing a media-infused paper, and an incubator. Water samples of 10 ml are collected in the glass vial and incubate for 24 hours, after which a vivid color change in the water sample indicates if the water is microbiologically contaminated with E. coli or coliform, or both. The team has manufactured approximately 3,200 units and distributed 2,350 units, which is enough to help approximately 12,000 people in Nepal. They also developed a financial model, sold 600 units, identified target markets in Nepal and began outreach to them, and submitted the ECC Vial to UNICEF's Supply Division. As of this report they are awaiting bidding results.

MIT-IIT Ropar Seed Fund

The MIT-IIT Ropar Seed Fund supports new water-and-food-systems-related research collaborations between faculty and research scientists from MIT and the Indian Institute of Technology at Ropar (IIT Ropar). The program is administrated in partnership with MIT-India, which is a part of MIT International Science and Technology Initiatives (MISTI) and manages the MISTI Global Seed Fund grant program. The grant awards funding to MIT-IIT Ropar teams for travel and workshops in order to support new research collaborations.

The 2021 recipient of the MIT-IIT Ropar Seed Fund:

- **Accurate Optical Sensing for Efficient Fertilizer Use and Increased Yield in Small Farms**
  MIT PI: Rajeev Ram, EECS
  IIT Ropar Collaborator: P Rajesh Kumar, Biomedical Engineering
  Small sharefarmers make daily decisions about how to manage their crops—from fertilizer application, to irrigation, to timing the harvest, and controlling pests. These decisions affect fertilizer run-off, use of water resources, and other impacts that directly influence their costs, profits, and the sustainability of their enterprise. Rajeev Ram, a professor in EECS, and Rajesh Kumar, an assistant professor of biomedical engineering at IIT-Ropar, seek to establish the potential

for portable optical sensors to provide rapid, actionable data that can allow smallholder farmers to better manage their crops. In particular, their research explores the potential for spectroscopic 'fingerprinting' of the nitrogen uptake to better guide management of fertilizer use in field crops that are economically important and highly relevant to the region of Punjab, India. The team will work together to demonstrate rapid, specific crop diagnostics as decision support tools that are accessible to marginal farmers.

Due to COVID-19 pandemic travel restrictions, these projects, originally funded in FY2020, have remained open but with little activity:

- **A checklist-based advisory to minimize the cost and duration of worse-before-better in transitioning from chemical to organic smallholder farming**
  MIT PI: Chintan Vaishnav, Sloan
  IIT Ropar Collaborator: Parwinder Singh, Department of Humanities and Social Sciences

- **Mapping agriculture and yields forecasting over India using high-resolution microwave remote sensing**
  MIT PI: Dara Entekhabi, CEE
  IIT Ropar Collaborator: Reet Kamal Tiwari, Department of Civil Engineering

J-WAFS Grant for Water and Food Projects in India

This grant program also supports water and food challenges in India and was made possible by a donation from Kishore Mariwala '59. Faculty members, full-time research staff, currently matriculated MIT graduate and undergraduate students, or small teams with at least 50% MIT participation and an eligible individual in the leadership role are eligible for funding. Grants of up to $15,000 are intended to help further solutions-oriented research. While new projects were not awarded in FY2021 since the COVID-19 pandemic inhibited travel, the projects below, originally announced in 2020, remained ongoing.

- **Sustainable agricultural planning for small farm holders in the Bist Doab region of Punjab**
  Project team: Saurabh Amin, CEE; Deepak Kashyap, Department of Civil Engineering, ITT-Ropar

- **Low-cost water testing and disinfection**
  Project team: Susan Murcott, MIT D-Lab, Ankita Singh, Sloan and MechE, and Deborah Go, Sloan and MechE

Final Results of FY2021 Concluded Projects

- **Piloting evaporative cooling technologies to improve vegetable shelf-life and farmer income in western India**
  Project team: Eric Verploegen, MIT D-Lab and Anish Paul Antony, MIT D-Lab
  The researchers constructed three brick evaporative cooling chambers in three villages in Gujarat, India. They used sensors to show the average interior temperature was 2–3º C lower than the ambient temperature and the maximum daily temperature was reduced by as much as 15 ºC. Farmers reported an increase in shelf life for tomatoes from three to five days, and eggplants from

three to seven days when using the brick evaporative cooling chamber, compared to the user's previous storage method. In a next stage, the researchers will pilot the evaporative cooling technology in a standard 40-foot-long shipping container with the support of a 2021 J-WAFS Solutions grant.

- **Development of communication materials for the dissemination and commercialization of an open-sourced xylem water filter**
  Project team: Rohit Karnik, MechE; Krithika Ramchander, PhD candidate, MechE; Amy Smith, MIT D-Lab; Kendra Leith, associate director for research, MIT D-Lab; Megha Hegde, research associate, MIT D-Lab; Anish Paul Antony, postdoctoral researcher, MIT D-Lab
  The researchers facilitated the dissemination of open-access xylem filtration technology to improve access to safe drinking water by creating educational videos and an open access web portal for school students, educators, entrepreneurs, and NGOs. They also proved that the filters showed greater than 4-log removal of rotavirus, and greater than 3-log removal of E. coli and MS-2 phage. The prototype filtration device uses daily-to-weekly-replaceable xylem filters and advances the understanding of xylem as a filtration material, opening opportunities for engineering a diverse range of low-cost, biodegradable xylem-based filtration products on a global scale. The scientific findings associated with the technology were compiled in a manuscript that has been accepted for publication in *Nature Communications*.

J-WAFS Grant for Transforming Animal Agriculture Systems

This grant program, enabled by a gift from Carmen Lee, enables research addressing the challenges associated with industrial animal food production. The program has funded two $25,000-grants to members of the MIT community who are pursuing research that aims to transform animal agriculture systems and reduce negative impacts on the environment.

The FY2021 grant recipient of the J-WAFS Grant for Transforming Animal Agriculture Systems:

- **Systems analytics for small farms animal waste resource recovery**
  PIs: Olivier de Weck, AeroAstro; Afreen Siddiqi, AeroAstro
  Smallholder farmers account for the majority of farms worldwide but have few to no systems for environmentally safe disposal of animal wastes. Large industrial animal farms are often able to convert animal wastes into energy; however, the costs of waste management systems remain prohibitive for small farms. This project, using a system analytics approach, will examine how combinations of interventions (consisting of technical systems, social incentives, and policy measures) can create economically viable and robust solutions for handling small-farm animal wastes. Data from a pilot program in Paraná, Brazil will be analyzed to create new cost-benefit models that explicitly account for avoided pollution and emissions reductions, and monetize those benefits through payments for environmental services programs.

Ongoing Projects

- **Multi-criteria formulation for sustainable swine production**
  Project lead: Jasmina Burek, Materials Systems Laboratory

J-WAFS Research Affiliate Program

The J-WAFS Research Affiliate Program supports sponsored research led by MIT PIs and conducted in collaboration with Research Affiliate companies. The program is an opportunity for corporate, government, or nonprofit partners to directly support and engage with the MIT research community to pursue research addressing specific water and food sector challenges that are identified by the sponsoring partner. Sponsored research projects funded through this program vary in funding level and duration. J-WAFS coordinates engagement between Research Affiliate partners and MIT researchers, starting with the company's idea formulation, and subsequently making introductions to potential research partners, facilitating research workshops and other exploratory processes, and supporting projects from proposal development through to project completion.

In FY2021, Xylem, Inc., a J-WAFS Research Affiliate, continued its second year of a three-year renewal agreement. Xylem was J-WAFS' first Research Affiliate, having started its initial three-year agreement in 2017. This year, two Xylem-funded sponsored research projects were ongoing: (1) a project led by Amos Winter of MechE is creating a smart, integrated, low-cost pumping solution for solar-powered drip irrigation in Sub-Saharan Africa, and (2) a project led by Alex Slocum of MechE is developing a novel pump that uses adaptive hydraulics for improved pump efficiency.

In addition to funding research, Xylem provides student support by financially sponsoring the MIT Water Club, contributing to the J-WAFS Fellowships for Water Solutions, and mentoring MIT teams competing in the annual Water Innovation Prize.

J-WAFS secured another Research Affiliate this year. GoAigua—a Spanish company that is digitally transforming water utilities and other water organizations so that they are more efficient—initiated a three-year Research Affiliate agreement with J-WAFS. Following extensive discussions that J-WAFS organized with researchers in numerous MIT departments, the company selected a project to support that is led by Eric Alm of BE and Fabio Duarte, of the Senseable Cities Lab in DUSP. This project will commence in the next reporting period.

J-WAFS-Led Research and Activities

The Alliance for Food and Climate Systems Transformation

J-WAFS continued building the initiative that it started in FY2020 to address climate change and global food systems called, the Food and Climate Systems Transformation (FACT) Alliance. The alliance is a first-of-its-kind initiative, connecting researchers, the private sector, nongovernment organizations, farming communities, and government agencies in the hopes of driving innovation and informing better decision making for resilient and sustainable food systems. This effort is being led by Greg Sixt, J-WAFS research manager for food and climate systems.

What sets the FACT Alliance apart is its collaborative, transdisciplinary, cross-institutional approach. With a group of researchers from leading institutions in agriculture, nutrition, and food systems, the alliance is strategically positioned to facilitate new solutions-oriented capabilities for addressing the more challenging aspects of food systems as they relate to climate change.

This year the alliance gained four new collaborating institutions, bringing the total to sixteen global organizations at the vanguard of research and policy on climate change and food systems. They are:

- MIT (US)
- Agricultural Model Intercomparison and Improvement Project (international network)
- American University of Beirut (Lebanon)
- Colorado State University (US)
- Columbia University Mailman School of Public Health (US)
- Ethiopian Institute of Agricultural Research (Ethiopia)
- International Crops Research Institute for the Semi-Arid Tropics (international network)
- International Food Policy Research Institute (international network)
- McGill University (Canada)
- Tufts University's Friedman School of Nutrition Science and Policy (US)
- University of Aberdeen (Scotland)
- University of California Davis (US)
- University of Pretoria (South Africa)
- University of South Australia (Australia)
- University of Talca (Chile)
- Wageningen University and Research (Netherlands)

The alliance also works with a growing network of collaborative stakeholder organizations that include:

- Organisation for Economic Co-operation and Development
- World Wildlife Fund
- The World Business Council for Sustainable Development
- Just Rural Transition

In April, the alliance embarked on a project supported by USAID, co-led by J-WAFS and MIT D-Lab. Other collaborators include the University of Notre Dame and International Initiative for Impact Evaluation, Inc. The project, RFS Evidence Aggregation for Programmatic Approaches (REAPER), uses a combination of machine learning and traditional systematic review to identify evidence gaps in USAID's evaluation metrics in the areas of agriculture, nutrition, water, and resilience.

J-WAFS held a series of virtual stakeholder mini-dialogues that took place from June through August 2020, engaging more than 100 stakeholders and researchers. The virtual format enabled a much wider set of stakeholders to provide input to the participating researchers. Through these discussions, J-WAFS compiled a body of knowledge that helped to refine the scope and mission of the alliance in FY2021.

In the summer of 2021, the alliance planned and conducted two other dialogues in advance of the United Nation's 2021 Food Systems Summit. The online dialogues were intended to engage people across the globe, especially those working on the front lines of food systems. The events included keynote addresses from experts in food systems transformation, as well as thought-provoking panel discussions and breakout sessions. The first dialogue, "Using Data for Food Systems Transformation," took place on June 30, 2021. It sought to highlight the importance of monitoring and evaluating food systems data in government, private sector, and other applied contexts. The second dialogue, "Monitoring and Evaluation for Food Systems Transformation," will be reported on in FY2022.

Greg Sixt and J-WAFS researcher, Kenneth Strzepek, produced a report for Community Jameel detailing the impacts of climate change on food security in high food-importing countries in West Asia. This work will support Community Jameel's efforts at the G-20 and the UN Climate Change Conference in 2021 (COP26). Sixt and Strzepek plan to develop a paper from this report. This work has led to a request from Community Jameel for a J-WAFS proposal for expanding the scope of this analysis through collaboration with other alliance members.

Other important progress for the J-WAFS-led alliance in FY2021 includes:

- Sixt submitted a proposal as the MIT submission for a COP26 Side Event titled, "Bridging the Science-Policy Gap for Impactful, Demand-Driven Food Systems Innovation"
- Sixt represented J-WAFS and the alliance as a panelist at the event, "EAT@Home: Policy Asks for Changing & Re-Arranging our Consumption Patterns"
- Sixt served as a panelist at the event, "Crisis Control: What Philanthropy Can do to Prepare for and Prevent Future Disasters"
- Strzepek presented findings of a report he co-authored with Sixt at the 2021 International Water Resources Association Online Conference

Student Engagement

Student Club Activities and Competitions

Throughout FY2021, J-WAFS staff continued to work closely with the leadership of two MIT student groups: the Water Club and the Food and Agriculture Club.

With a renewed gift from Rabobank Wholesale North America, FY2021 marked the sixth year of the Rabobank-MIT Food and Agribusiness Innovation Prize. This student business plan competition is sponsored by Rabobank, supported by J-WAFS, and managed by the MIT Food and Agriculture Club. The competition invites college and graduate students from North America to present new products or technologies to improve sustainability in our food system. A virtual, final pitch event took place in April where finalists presented their business plans and competed to win $30,000 in total prize money and invaluable mentorship and networking opportunities. The first-place winner was Human Dynamics—a company seeking to improve sanitation in food production plants with a robotic drone, or a "drobot" that flies through facilities spraying soap and disinfectant.

J-WAFS also provides funding to the Water Club, which includes sponsorship of the Water Innovation Prize, a student pitch competition. The Water Prize helps student teams translate water-related research and ideas into businesses and impact. On May 6, 2021, a virtual event took place where six student-led finalist teams from around the world pitched their innovations to students, faculty, investors, and people working in various water-related industries. The $18,000 first place winner of this year's Water Innovation Prize was Bloom Alert, which is a data monitoring platform to improve desalination plant operations.

J-WAFS Fellowships for Water Solutions

J-WAFS offers two graduate student fellowships: the Rasikbhai L. Meswani Fellowship for Water Solutions and the J-WAFS Graduate Student Fellowship Program. The one-semester-long fellowships are both for advanced MIT PhD students conducting innovative water sector research. These fellowships are funded in part by J-WAFS Research Affiliates Xylem, Inc. and GoAigua. The Rasikbhai L. Meswani Fellowship for Water Solutions was made possible by a generous gift from Elina and Nikhil Meswani and family. In FY2021, three PhD candidates in MechE were named J-WAFS fellows. Danyal Rehman and Ippolyti Dellatolas received J-WAFS Fellowships for Water Solutions, and Hilary Johnson was awarded a Rasikbhai L. Meswani Fellowship for Water Solutions. Eric Ponce, a PhD candidate in EECS, received honorable mention for the J-WAFS Fellowships for Water Solutions.

Video Competitions

This year J-WAFS launched two new student video competitions. The first was for World Food Day on October 16, 2020, and the second was for World Water Day on March 22, 2021. Both days are international "holidays" started by the United Nations that are aimed at building awareness of food systems challenges, and sustainable water use and equitable water access, respectively.

The video competitions showcased water and food sector research projects by MIT students, postdoctoral researchers, and recent alumni. Students submitted short videos describing a significant water or food challenge and their MIT research that addresses that challenge. The videos were reviewed by a panel of judges both internal and external to MIT, including researchers, industry representatives, journalists, and others in communications fields that focus on water or food sector topics. Videos were judged on two criteria: importance and potential for impact, and creative and effective communication. Online festivals were then held on both World Food Day and World Water Day to showcase the winning videos. Winners received cash prizes up to $1,500. The World Food Day competition was funded through the generous support of MIT alumnus Sanjay Manandhar ’89, SM ’91.

Winners of the World Food Day Video Competition: MIT Research for a Food Secure Future

- First place: Georgia Van de Zande, PhD candidate, MechE; Carolyn Sheline, PhD candidate, MechE; Julia Sokol, postdoctoral researcher, MechE
- Second place: Björn Lüjens, PhD candidate, AeroAstro
- Judges’ choice awards:
    - Alejandro Diaz, BS candidate, EECS
    - Angela Loescher-Montal, MArch candidate, Department of Architecture; Ous Abou Ras, MArch candidate, Department of Architecture; Arthur Boscolo, MArch candidate, Department of Architecture
    - Celi Khanyile-Lynch, MBA ’20, Sloan
    - Olivier Faber, MArch candidate, Department of Architecture; Eytan Levi, MArch and MS in real estate development dual degree candidate, Department of Architecture; Tim Cousin, MArch candidate, Department of Architecture

Winners of the World Water Day Video Competition: MIT Research for a Water Secure Future

- First place: Hilary Johnson, PhD candidate, MechE
- Second place: Tzu-Chieh Tang, PhD ’21, postdoctoral researcher, Research Laboratory of Electronics (RLE)
- Third place: Ty Christoff-Tempesta, PhD candidate, DMSE
- Judges’ choice awards:
    - Junghyo Yoon, postdoctoral researcher, RLE
    - Peter Godart, PhD candidate, MechE
    - Grace Connors, MS candidate, MechE

- Filippos Tourlomousis, postdoctoral researcher, Center for Bits and Atoms; Patritsia Stathatou, visiting scholar, Center for Bits and Atoms
- Sayed Saad Afzal, PhD candidate, EECS; Waleed Akbar, MS candidate, MIT Media Lab; Osvy Rodriguez, undergraduate student, MIT Media Lab
- Devashish Gokhale, PhD candidate, ChemE
- Andrew Bouma, PhD candidate, MechE

Outreach, Engagement, and Events

Despite the virtual nature of FY2021, J-WAFS continued to play an important role and have a meaningful presence in the MIT community, with sponsored and co-sponsored events held online.

Communications Initiatives

The monthly e-newsletter to our subscriber list went out August, 2020 through May of 2021, pausing for the rest of the summer. We also sent special edition newsletters for World Food Day in October and World Water Day in March. Our email open rates this year averaged 29.28%, with a click-through rate of 4.45%, both of which are much higher than the education industry averages of 23.42% for opens and 2.9% for clicks.

J-WAFS was featured or mentioned in 16 pieces published in MIT News this year, and J-WAFS funded researchers were responsible for nine journal publications.

Communications staff stayed active in several MIT working group meetings including: sustainability communicators, social media managers, engineering communicators, and event planners.

Over the course of FY2021 the J-WAFS Twitter account gained 393 followers, more than doubling the audience count with a total of 632 followers at the end of FY2021. This increase may have been due to a more robust social media strategy for posting engaging content and promoting online events like the new J-WAFS video competitions, as well as collaborating with key players in similar spaces on shared outreach opportunities. For example, J-WAFS worked with J-PAL and Community Jameel on an Earth Day campaign, highlighting research on sustainability that began in February and ran until Earth Day on April 22, 2021.

Conferences and Events

This chart lists J-WAFS produced, sponsored, or co-sponsored online events, as well as virtual conferences we attended or presented at in FY2021, that have not been aforementioned.

Abdul Latif Jameel Water and Food Systems Lab Conferences and Events

Title	Dates	J-WAFS role	Collaborators	Target audience
J-WAFS Seed Grant Program 2020 Cohort Kick-Off	8/12/2020	Producer	--	2020 seed grantees and their labs
J-WAFS Fellows Event	9/24/2020	Producer	--	J-WAFS Fellows
J-WAFS Research Workshops (five sessions)	10/7/2020, 10/21/2020 10/23/2020, 11/16/2020, 11/23/2020	Producer	--	J-WAFS seed grantees and related J-WAFS research community
2020 MIT Water Summit	11/11/2020–11/13/2020	Co-sponsor	MIT Water Club	College students, professors, researchers, and water industry professionals
Campaign for a Better World (Sustainability)	3/16/2021	Co-presenter	Resource Development	MIT alumni and community
Working Water: Research-to-Policy Workshops (four sessions)	3/25/2021, 3/30/2021, 4/6/2021, 4/14/2021	Co-sponsor	MIT Water Club	Students and researchers
2021 MIT Sustainability Summit, "For Good Measure"	4/16/2021	Co-sponsor	MIT Food and Agriculture Club	Entrepreneurs, students, MIT research community
MIT Water Night	4/22/2021	Co-sponsor	MIT Water Club	MIT community
ILP Presentation	5/28/2021	Presenter	--	MIT's Industrial Liaison Program

Awards and Honors

John H. Lienhard V, J-WAFS director and Abdul Latif Jameel Professor of Water and Mechanical Engineering, was recognized by the International Association for the Properties of Water and Steam who designated his work on seawater surface tension, with Kishor Nayar SM '14, PhD '19, to be an international guideline. Lienhard was also elected as a Fellow of the American Society of Thermal and Fluid Engineers.

Renee J. Robins '83, J-WAFS executive director, was honored with a 2021 MIT Infinite Mile Award presented by the Office of the Vice President for Research.

Personnel

- Director: John H. Lienhard V
- Executive Director: Renee J. Robins '83
- Research Manager for Climate and Food Systems: Greg Sixt
- Communications and Program Manager: Andi Sutton
- Financial and Project Coordinator: Jasmine Edo (through January 2021); B. Nicholas Pasinella (starting March 2021)
- Communications and Project Assistant: Lauren Pohlmann (July through December 2020); Susanna Maize (starting January 2021)

J-WAFS Office Space

In November of 2020, J-WAFS moved office locations from Building E70 to Building E38, a newly renovated LEED-certified building in Kendall Square. Staff were granted Covid Pass access to move their belongings from the old office to the new office, but mostly continued to work from home. J-WAFS staff members have attended virtual meetings throughout FY2021 with other DLCs who have also moved to Building E38, in order to provide insights into ways the building can serve as a model for environmental sustainability on campus.

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

Renee J. Robins
Executive Director