IN² Food, Energy, Water Landscape

January 2019

White Paper

Executive Summary

Acknowledgements

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About the Wells Fargo Innovation Incubator (IN²)

IN² is a $30 million clean technology incubator and platform funded by the Wells Fargo Foundation. Co-administered by and housed at the US Department of Energy's National Renewable Energy Laboratory (NREL) in Golden, Colorado. IN²'s mission is to speed the path to market for early-stage, clean technology entrepreneurs. Companies selected for participation in the program receive up to $250,000 in non-dilutive funding from Wells Fargo, technical support and validation from experts at NREL or the Danforth Plant Science Center, and the opportunity to beta-test at a Wells Fargo facility or with a strategic program partner.

Launched in 2014 with an initial focus on supporting scalable solutions to reduce the energy impact of commercial buildings, IN² is expanding its focus in 2018 to support innovation in new sectors, starting with the nexus of food, energy, and water (FEW) - an area that tackles important sustainability challenges.

Project Purpose

To aid in the expansion effort into the nexus of food, energy, and water, the program analyzed the areas that were best suited for the IN² model of technology incubation; that is, one that seeks areas that are typically underinvested because of technology barriers to entry, but have a strong potential for positive environmental impact.

Methodology

To narrow down the areas of focus, IN² began this analysis request by identifying three main themes – 1) water conservation, 2) food system inefficiencies, and 3) agriculture production digitization – where IN² can best serve the startup community and the AgTech sector. In our approach to these themes, we considered the IN² model in our analysis: U.S.-centric, focus on energy impact, provider of resources for technical validation, potential for companies to conduct an alpha or beta demonstration, funding levels around $250,000-$500,000 per company, and connection to our large ecosystem.

The overall approach of the project was to develop a framework based on related technology value chains, identify key environmental trends and challenges, map existing investments, and then identify high impact challenges that are not being met.

The scope of this study was limited to the three main themes stated above with a particular lens on technology innovation. We acknowledge that the FEW topic is very expansive and has many possible crossovers and, therefore, this study is not exhaustive and we have made several exclusions in order to keep the focus within a reasonable scope. Exclusions in this analysis include: food processing, livestock, genetic engineering/plant breeding, indoor agriculture, and regulatory policy.

Executive Summary

The following report provides a summary of recommendations for IN² to support the agtech sector startup community's activities that intersect with underlying themes of:

1. Water conservation
2. Food distribution
3. Ag production digitization

The goal of this effort is to identify technology areas with the greatest potential to address energy consumption, water use and/or greenhouse gas (GHG) emissions within each of the identified themes that, for a variety of reasons to be explored further, are not currently receiving investment support, so that IN² could help them toward commercialization.

The full report can be downloaded here.

Theme 1: Water Conservation

Theme definition: Water conservation refers to the preservation, control and development of water resources, both surface and groundwater, and prevention of pollution.

Thesis: The current water system in the United States incurs enough losses that the greatest impact to water would be to conserve, rather than increase supply, through increased efficiency of water use and reuse. Water use analytics and nutrient recovery technologies have the potential to reduce water and nutrient consumption.

Value Chain and Technology Landscape

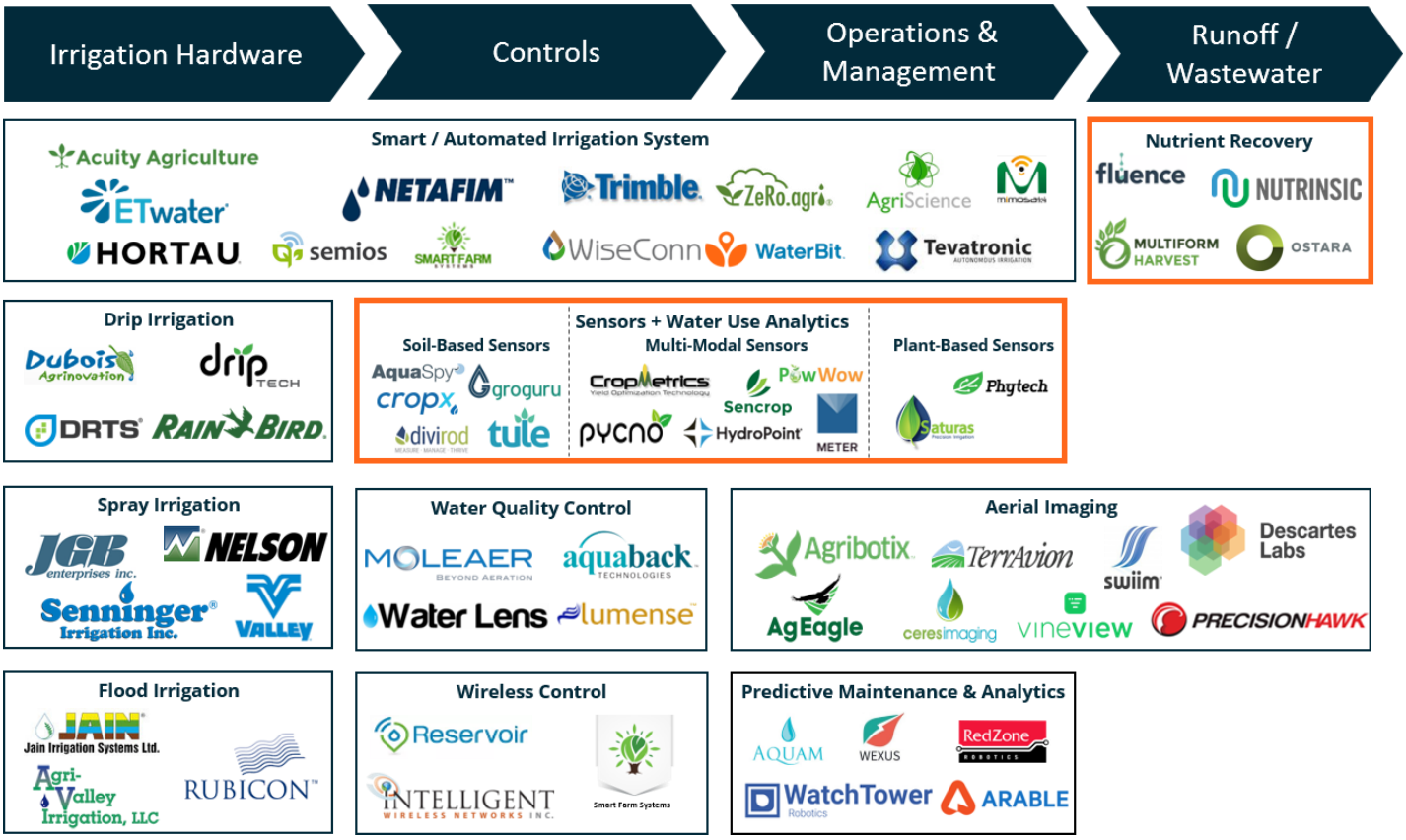
The value chain for the water conservation theme includes four major components: irrigation hardware, controls, operations and management, and runoff / wastewater.

- **Irrigation hardware** refers to hardware that measure soil moisture, plant health, and weather, as well as irrigation equipment and infrastructure.
- **Controls** refers to software and hardware that provide insight, recommendations, and operational control of irrigation, including advanced features such as automation and remote control.
- **Operations and management** refers to water management software, irrigation and pumping infrastructure maintenance, and IoT solutions for water.
- **Runoff wastewater** refers to water runoff, reuse, extraction of fertilizer and organic materials from wastewater, and water disposal.

Investment and Impact Potential

Sensors and water use analytics and nutrient recovery are two focus segments that are relatively underfunded and have high environmental impact potential.

- **Sensors and Water Use Analytics**
    - The increasing availability of sensors allows for more data, and greater granularity of data, on how water is being used in a plant.
    - In-plant sensors are the most recent innovation – measurement of water intake rate provides insights on the most efficient irrigation schedule.
- **Nutrient Recovery**
    - Nutrient recovery closes the loop in agriculture. As runoff and wastewater streams contain fertilizer that is difficult to filter, technologies that extract and reuse these chemicals have high impact scores.



			INVESTMENT	IMPACT POTENTIAL	
Segment	**Total $ Amount**	**Deal Volume**	**Energy Reduction**	**GHG Reduction**	**Water Conservation**
Wireless Control	**$3.3M**	**3**	High	Medium	Medium
Irrigation Equipment	**$10.3M**	**6**	Medium	Low	Medium
Water Quality Control	**$12.9M**	**3**	Low	Low	High
Sensors & Water Use Analytics	**$23.2M**	**6**	Medium	Medium	High
Predictive Maintenance	**$46.3M**	**7**	High	Medium	Medium
Nutrient Recovery	**$64.7M**	**4**	Medium	High	High
Smart/Automated Irrigation System	**$65.4M**	**16**	Medium	Medium	High
Aerial Imaging	**$204.4M**	**21**	High	Medium	High

Environmental Impact

Sensors and Water Use Analytics

- **Energy**: Increasing the efficiency of water use through greater understanding of plant water use and need reduces the use of pumps and irrigation equipment system-wide.
- **GHG**: Agricultural irrigation has a large footprint, sensors remove the need for human inspection, and efficient water use reduces load on pumps and irrigation infrastructure.
- **Water**: Efficient use reduces system load and agricultural runoff, as well as reducing the quantity withdrawn in the first place.

Nutrient Recovery

- **Energy:** Nutrient recovery reduces fertilizer usage as fertilizer production is energy intensive.
- **GHG**: GHG emissions from fertilizer production is high, and using a waste-to-value product from wastewater treatment would displace these emissions.
- **Water**: Nutrient capture allows for re-use of water and minimizes runoff.

Theme 2: Food Distribution

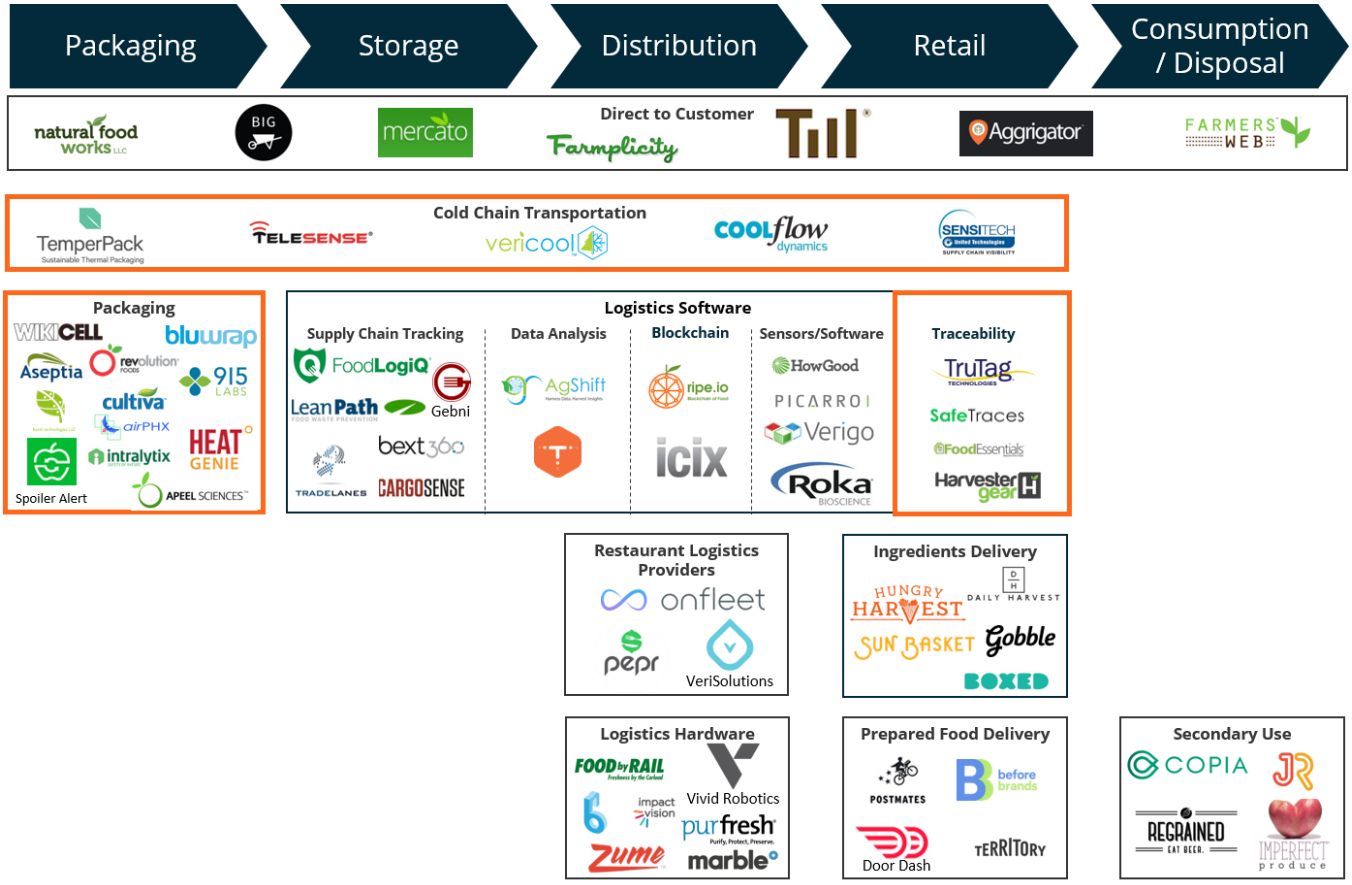
Theme definition: Food distribution consists of various processes that are required to move food from the producer to the consumer. The food distribution system considered here analyzes the value chain between food leaving the processing plant to its end-of-life as waste or recycled goods, including packaging.

Thesis: Efficiency gains in the physical transportation of food, improvements in food packaging, and food traceability technologies that identify waste present opportunities for GHG reductions and energy efficiency gains.

Value Chain and Technology Landscape

The value chain for the food distribution theme includes five major components: packaging, storage, distribution, retail, and consumption/disposal.

- **Packaging** refers to post-production (growing/harvesting) bundling of products.
- **Storage** refers to keeping goods before they enter the distribution chain.
- **Distribution** refers to logistics and transportation of getting goods to market.
- **Retail** refers to selling goods to the consumer.
- **Consumption/disposal** refers to eating/cooking/using of the goods and their end-of-life process.



Investment and Impact Potential

Logistics software (traceability), cold chain transportation, and packaging are three focus segments that are relatively underfunded and have high environmental impact potential.

- **Logistics Software (Traceability)**
    - Supply chain traceability is an underfunded technology. Consumers are willing to pay a price premium for certified environmentally friendly agricultural products.
    - The introduction of tracking and analytics solutions is the fastest way to reduce the knowledge gaps present in the food system and help prevent waste. Knowledge gaps occur around how food is being wasted, in what quantity, and in what part of the supply chain.
- **Packaging**
    - Food packaging solutions require relatively fewer capital expenditures compared to many infrastructure-heavy recycling solutions.
    - Packaging solutions can include both innovative new materials, processes, and chemical treatment, but more effective packaging size and design can also make a difference.

- **Cold Chain Transportation**
    - Refrigeration systems in transportation and storage, and cold chain management at the initial stage of cooling, were highlighted as two underfunded technology areas.
    - Cold chain service providers can benefit from many of logistics software solutions already deployed in other sectors to reduce GHG emissions and increase energy efficiency.

	INVESTMENT		IMPACT POTENTIAL		
Segment	**Total $ Amount**	**Deal Volume**	**Energy Reduction**	**GHG Reduction**	**Water Conservation**
Restaurant Logistics	**$4.6M**	**2**	Medium	Medium	Low
Direct to Customer	**$6.6M**	**6**	Medium	High	Medium
Secondary Use	**$8.7M**	**2**	Medium	Medium	Medium
Logistics Software (Traceability)	**$12.5M**	**8**	High	High	Medium
Cold Chain Transportation	**$15.5M**	**5**	High	High	Low
Logistics Hardware	**$134.9M**	**13**	High	High	Low
Packaging	**$200.4M**	**21**	High	High	Medium
Food/Ingredient Delivery	**$576.4M**	**20**	Low	Low	Low

Environmental Impact

Logistics Software (Traceability)

- **Energy**: Reduces food waste, which thereby reduces energy input into food production.
- **GHG**: Displaces GHG emissions in food production and transportation by reduction of food waste.

Packaging

- **Energy**: Reduced food waste requires less food to be produced, saving energy at all points of the supply chain.
- **GHG**: Non-plastic packaging materials reduce GHG emissions embedded in packaging, as well as reducing emissions related to needless food waste in the supply chain.

Cold Chain Transportation

- **Energy**: Reduction in refrigeration and transportation energy use, which are energy-intensive processes.

Theme 3: Agriculture Production Digitization

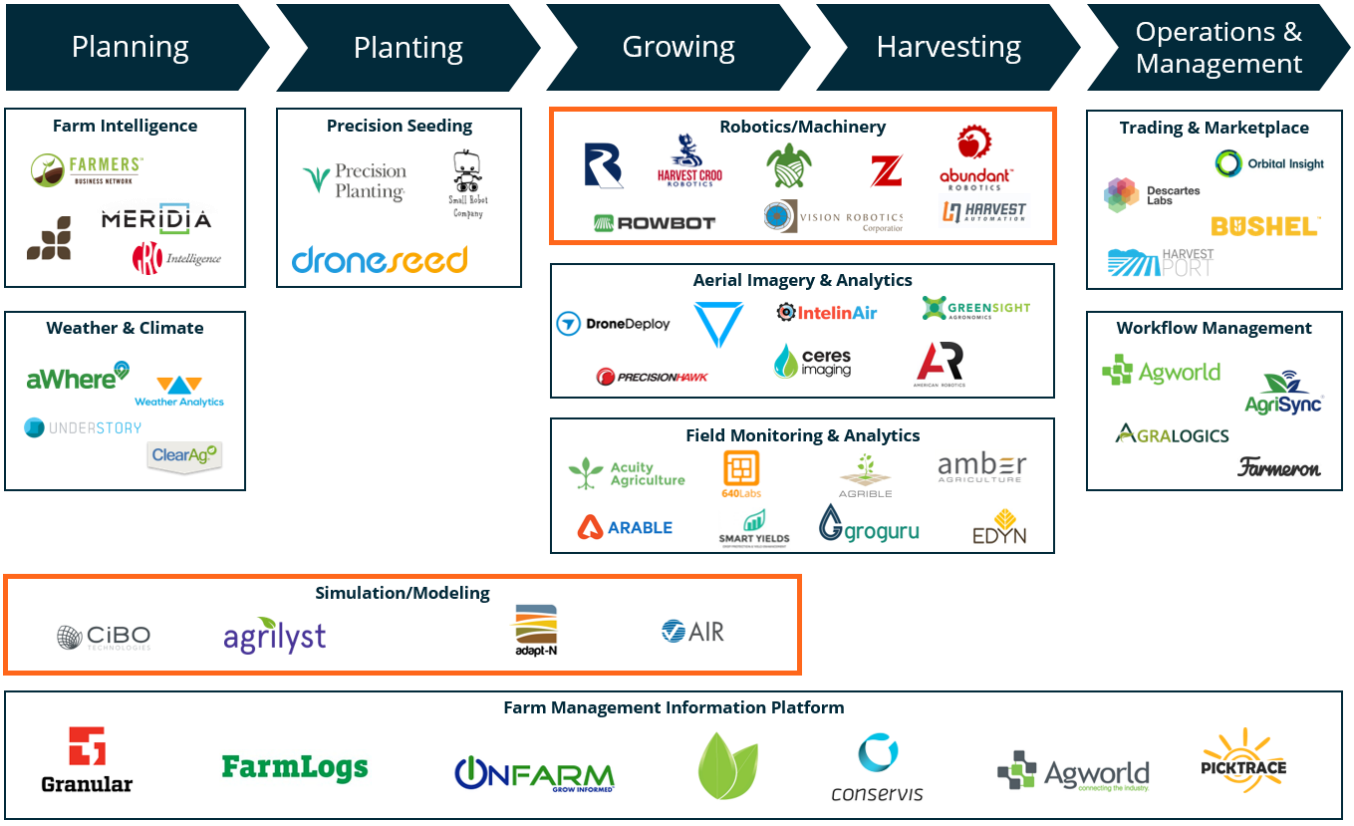
Theme Definition: Agriculture production digitization refers to technologies that leverage large data sets, advanced analytic models, and automation to enable more sustainable and profitable agriculture production.

Thesis: Agriculture data has significant potential to transform the agriculture industry by reducing energy consumption and GHG emissions. Agriculture digitization can provide better crop yields using less energy, or get more yield using the same or less amount of energy. Digitization can also reduce GHG emissions by optimizing the production process, reducing intensive GHG emission activities such as fertilizer application.

Value Chain and Technology Landscape

The value chain for the agriculture production digitization theme includes five major components: planning, planting, growing, harvesting, and operations and management.

- **Planning** refers to software tools that provide insights on farm mapping, climate patterns, financial projections.
- **Planting** refers to software and hardware tools to improve planting efficiency.
- **Growing** refers to software and hardware tools to optimize and maximize crop growth.
- **Harvesting** refers to software and hardware tools that increase speed, accuracy, timing, automation of harvesting.



Investment and Impact Potential

Simulation/modeling and robotics and machinery are two focus segments that are relatively underfunded and have high environmental impact potential.

- **Simulation/Modeling**
  - Data collection is abundant, but real value is in actionable information to farmers.
  - Growth in data collected, but very little results in deriving meaningful insights. Huge problem with data integration and converting sensor data to farm management.

For example, with predictive weather data (a subset of simulation/modeling, one could take the weather data from today and use the info to predict weather in the following days – seems feasible to do at an impactful scaled and have high environmental impact potential.

- **Robotics and Machinery**
  - Harvesting technologies are underfunded relative to aerial imaging partly due to variations in tree architecture, thereby requiring unique harvesting solutions for different crop types.
  - Besides automation, mechanization also provides more details on the fruit (location, harvest date, more accurate shelf-life estimates).
  - Robotic machines can also be deployed to optimize planting and growing practices. No longer need to plant in rows or monocultures, which leads to reduced weeds, pests, and diseases.

	INVESTMENT		IMPACT POTENTIAL		
Segment	**Total $ Amount**	**Deal Volume**	**Energy Reduction**	**GHG Reduction**	**Water Conservation**
Simulation / Modeling	**$3.65M**	**5**	High	High	High
Workflow Management	**$9.47M**	**8**	Low	Low	Low
Trading & Marketplace	**$18.7M**	**7**	Low	Low	Low
Weather & Climate	**$51.9M**	**8**	Medium	Medium	Medium
Robotics / Machinery	**$72.8M**	**20**	High	High	High
Field Monitoring & Analytics	**$112.4M**	**39**	Medium	High	High
Farm Management Platform	**$144.9M**	**18**	Medium	Medium	Medium
Farm Intelligence	**$195.4M**	**13**	Low	Medium	Medium
Aerial Imaging & Analytics	**$736.1M**	**70**	Medium	Medium	Medium

Environmental Impact

Simulation/Modeling

- **Energy**: Simulation software's capability in virtual field trial, reducing energy-intensive production activities throughout the crop's entire lifespan.
- **GHG**: Improved soil management and precision fertilizer applications represent significant GHG reduction potential in agriculture production.
- **Water**: Insights on weather patterns to reduce excessive/unnecessary irrigation.

Robotics and Machinery

- **Energy**: Robotics reduce/eliminate diesel fuel consumption from traditional farm equipment, which is one of highest energy expenditures in agriculture production.
- **GHG**: Indirectly reduces emissions from fuel/diesel production.
- **Water**: Potential savings in precision irrigation and reducing in-field water pipe.

Contributing Partners

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