FEED THE FUTURE
The U.S. Government's Global Hunger & Food Security Initiative

LOW-COST SENSORS FOR AGRICULTURE

Key Findings Report | June 2-3, 2016

The U.S. Agency for International Development (USAID) hosted a 1.5-day workshop June 2-3, 2016, at the Omidyar Network in Redwood City, Calif., for 27 technology providers (start-ups & companies), academics, funders, development organizations, representatives from the U.S. Global Development Lab, the Bureau for Food Security at USAID, and others working at the intersection of sensors and agriculture (see Annex A for list of attendees).

The objectives of the event were to:

- Gain greater clarity around the potential of sensors to improve agriculture and food security in developing contexts
- Convene leading individuals working on sensors and agriculture to learn from one another and identify potential areas for collaboration
- Identify obstacles to realizing the potential of sensors that can be addressed by USAID, other donors and participants

During the event, participants gained insight on current applications of sensors in agriculture through presentations from IDEO.org, Arable, GSMA mAgri, and Granular; learned about the U.S. Global Development Lab, the U.S. Government's global hunger and food security initiative, Feed the Future, and the Digital Development for Feed the Future collaboration at USAID; and engaged in a series of interactive activities to identify challenges and opportunities for applying sensors to support smallholder farming (see full agenda in Annex B).

Takeaways from the day can be summarized into three main areas – technology, adoption and ecosystem. High-level findings with detailed analysis follow.

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Key findings:

- **Technology.** Relevant sensor technologies exist and the market is already addressing issues inhibiting developing context applications including data transmission challenges and cost. However, there may be a role for donors in accelerating the reduction in cost for sensors and related technologies and for local development partners in testing and refining technologies for context-specific applications.

- **Adoption.** A major challenge facing sensor applications for agriculture is the need to catalyze context-led innovation that integrates sensor technology (and/or resulting data) into locally appropriate products and services that address specific problems affecting smallholders. Donors, entrepreneurs, development and private sector actors all have a role to play in promoting adoption by creating and disseminating actionable information to smallholders and others along the agricultural value chains.

- **Ecosystem.** There is a rapidly growing community of entrepreneurs, academics, development professionals, donors and others working on sensors and agriculture that are, for the most part, disconnected. Participants see tremendous value in growing an inclusive network that cuts across disciplines and can have access to varied expertise and centralized funding and collaboration opportunities to support smallholder farmers, thus enabling a more coordinated approach and more impactful actions.

TECHNOLOGY

As one participant put it, “Technology is the easy part!” There are already many existing sensor technologies ranging from all-in-one weather stations and dedicated moisture sensors to spectrometers and remote sensing tools, though these are at varying stages of testing and implementation. Participants believed the most significant technology barriers are 1) enabling efficient data transmission, 2) testing and refining analysis to accurately reflect local conditions, and 3) reaching a production scale that supports a price point that enables widespread use in developing markets (including not just cost of the hardware, but also of maintenance, training, and other related costs).

Efficient data transmission requires low-power solutions and streamlined protocols.

The mobile data network covers much of the world and provides a mechanism for transmitting sensor data. This means of transmission, however, requires significant power compared to emerging radio technologies being developed for the Internet of Things (IoT). Many companies are creating radio communication technologies that have significant implications for sustainability. Mobile network operators, governments or others may build

out transmission infrastructure that reduces power needs. The level of investment this would require, however, is highly risky as the industry has yet to standardize protocols. Until protocols are harmonized, there is a risk that significant investment could be made in a technology that becomes obsolete in a few years.

Data analysis must be groundtruthed and refined for specific geographies and applications. The value of data depends on the ease and quality of analysis. Data might be analyzed in different ways and for different purposes based on the local conditions, crop and other factors. In order to generate accurate insight, analytic models must be tested and trained through a process of comparing sensor data to quality data gathered and analyzed on the ground. This is difficult to do in developing contexts where the ground data does not exist and/or data quality is inconsistent.

Sensors must be produced and deployed at large scale to reach a price point that will enable widespread use in developing country contexts. The price of sensors is coming down, but, especially when packaged with the components allowing for the transmission, analysis, and use of data, sensor technologies are still above a price point that will enable mass adoption of these technologies in developing countries. This results in a "chicken and egg" problem: To get to a price that is affordable, the level of production would need to jump significantly. Yet technology providers would have to take a huge financial risk to produce devices at levels far beyond current market demand to meaningfully drop prices.

Other technology barriers discussed include: capacity for data processing, shareability of data and interoperability of data platforms, frequency and resolution of imagery for remote sensing, need for additional information on soil testing sensors (no experts on soil sensing were present at the workshop)

How Can We Accelerate Sensor Technology Advances?	
Tech Providers	• Continue to design transmission technologies that minimize power needs and can sustain long periods in rural areas • Promote interoperability of sensor and transmission technologies by working to harmonize communication protocols
Agricultural Orgs	• Utilize networks of local agricultural experts to gather quality data that can be used to test and train algorithms for local application
Academics	• Work with local organizations to build capacity to collect high quality data to improve and localize data analysis capabilities

Funders	• Accelerate cost reduction by enabling production at scale (i.e. market guarantees, PPPs, large-scale implementations by grantees/implementing partners)

ADOPTION

There was broad agreement that context, not technology, should lead the development of sensor-enabled solutions for agriculture to maximize value and adoption. Sensors will achieve highest levels of adoption when the technologies and data address specific needs of smallholders and integrate into their workflows. One participant used the example of the Fitbit, stating that accelerometer technology has been around for decades. It wasn't until it was packaged in a durable product that created value and was easy to use without requiring users to change their day-to-day activities that people started to see the value in monitoring daily steps to improve health. Discussion about how best to drive adoption focused around: 1) creating actionable data, 2) integrating and simplifying sensors, 3) building from existing technologies and 4) the value of local partnerships to support context-led innovation and as a path to market.

Data must be actionable to create impact. The hard data collected from sensors is important, but for this data to create impact for smallholder farmers, farmers must have the capacity to effectively understand how to act on this data – whether by analyzing the data themselves or receiving actionable advice from others within their networks or working within their value chains. Data analysis must translate to actionable instructions that are relevant for specific crops, in specific geographies, and delivered at a level of sophistication upon which smallholders can act. While there are some global best practices, much of this "translation" and localization will have to be done locally and according to specific contexts.

Integrating multiple sensors can improve the breadth and comprehensiveness of data, but this must be balanced with simplicity to create insights that are "good enough" for to inform action. There are many measurements that can be taken to improve production and yield. Rather than introducing sensors as stand-alone products, and having to invest separately in R&D, marketing, business models, training/adoption, data transmission for each, participants saw value in bundling them into integrated tools that, together, could provide a more complete picture of farm

Emerging Ideas: Open Ag Data Analytics Platform
A subset of participants expressed a need for a centralized platform that could aggregate agricultural data and provide farm-level decision support. As visioned, the platform would aggregate global data from sources such as NASA, NOA, etc. as well as local data and allow Government, NGO and private sector actors to pull data and create localized decision-support services.

conditions and needs. The group cautioned, however, that integrated solutions should not be overly engineered, adding to cost and complexity. Sensor-enabled solutions should focus on providing the data that farmers can realistically act upon and the providing information that will meaningfully improve outcomes (e.g. focus on sensors that support proper use of fertilizer that can significantly increase crop yields rather than identifying rust that can't be treated).

Adoption will be greater if sensors leverage technologies that are currently utilized in the developing context. Introducing new technology is difficult, but one way to lower the barriers to adoption would be to build on tools that smallholders and others in the agricultural ecosystem are already using. There was significant interest in the role the mobile phone could play – either developing sensor "plug-ins" for smartphones that could be used by extension agents or lead farmers or harnessing the power of the smartphone camera to support image-based analysis. Similarly, the potential of utilizing infrastructure such as cellular towers for weather stations and/or low-power transmission base stations was discussed.

Partnerships with private sector, NGOs and government provide a pathway to market. Mobile network operators, agribusiness, NGOs and government agricultural support services all have connections to smallholder farmers and have a better understanding of local needs that those not in-market. While their infrastructure, capacity and incentives vary from market to market, they may offer unique ways to quickly connect with and empower smallholders to use sensor-enabled solutions and bring localized knowledge about social, cultural, economic and other factors affecting utility and adoption of new tools.

Other adoption barriers discussed include: maintenance and durability, challenges of rapid iteration in agricultural cycles, UAV policies and regulations

How Can We Accelerate Sensor Adoption?	
Tech Providers	• Partner with local individuals and organizations to develop holistic solutions that address context-specific problems and take solutions to market
Agricultural Orgs	• Work with technology providers to ground design of sensor-enabled solutions in localized contexts (i.e. problem identification, actionable data, business models) • Partner with funders and tech providers to leverage existing (human) networks to promote awareness and adoption of sensor-enabled solutions
Academics	• Test context-specific innovations that may not have a clear business model or market at this time • Identify trends in how sensor-enabled solutions are and are not creating value across contexts and share learning that supports development of globally relevant solutions
Funders	• Fund context specific innovation (i.e. design, testing, productization) and scale-up (i.e. in-market growth, adaptation for new markets)

ECOSYSTEM

Each individual and organization working on sensor technology and agriculture offers a different piece of the puzzle. Collaboration is essential to accelerate the impact sensors can have on smallholder farmers globally. Many of the participants, mostly based on in the Western U.S. states, had never met and did not know about each other's work. There was even less awareness of sensor work happening in developing countries. Additionally, all knew of USAID, but many did not know the most efficient and effective way to plug-in to the U.S. Government's Feed the Future initiative or U.S. Global Development Lab.

The opportunity to meet and network was highly valued by participants who believed progress could be accelerated by 1) building an inclusive network of individuals and organizations working in this space and 2) creating a centralized way to find partnership and funding opportunities specific to the sensor and agriculture innovation sectors.

Providing information on who is doing what could enable greater collaboration and impact. Participants saw value in coming together and wanted more opportunities to connect. Recognizing time, geographic limitations and financial cost of in-person convening, some said that an updated map of actors working in the space could be a useful tool to help them connect with potential partners and better access learning. The specifics of how a resource like this would be set up and managed were not discussed.

Centralizing and targeting funding opportunities would improve the ability of non-traditional development actors to engage with donors. Many organizations working on sensors and agriculture are in start-up phase and focused on getting their technologies and products off the ground. They do not have the resources to sort through different funding and collaboration opportunities, engage implementing partners, and generally figure out how to navigate USAID landscape. However, if there were a way to filter what opportunities they receive (tailored to sensors, agriculture, and innovation) they would be more likely to see relevant opportunities and successfully engage with USAID and/or implementing partners. The Global Innovation Exchange (www.globalinnovationexchange.org) is one resource that may be useful to build upon to better meet the needs of innovators.

Other ecosystem barriers discussed include: silos of technical, business and geographic expertise (potentially addressed through accelerators, professional exchanges, etc.)

How Can We Improve the Ag Sensor Ecosystem?	
Tech Providers, Ag Orgs, Academics	• Actively seek opportunities to collaborate and share learning with a diverse group of individuals and organizations working to improve agriculture through sensors
Funders	• Invest in developing and strengthening a network of actors through in-person and virtual means • Assess the benefit of promoting collaboration through various methods including partnership-focused procurements, convening events, exchanges, etc.

NEXT STEPS

Each participant in attendance expressed different ways they were going to utilize the knowledge, ideas and relationships gained through the 1.5-day workshop. Participants expressed a desire to stay in touch with one another, some noting specific relationships and potential collaboration opportunities they would pursue.

USAID praised the value of engaging non-traditional development actors working outside of Washington and committed to sharing knowledge with their DC-counterparts and discussing how to make it easier for small innovative companies to know how and when to plug into USAID resources. They also expressed that the deeper understanding of the current state and potential for sensors in agriculture would help the Digital Development for Feed the Future group develop effective strategies to support the acceleration and adoption of these technologies.

Annex A: Low-cost sensors for agriculture attendee list

First	Last	Affiliation
Daniel	Wilson	UC Berkeley/Sweetsense
Deepak	Puri	Skilled Analysts
Temina	Madon	Executive Director, CEGA
Robert	On	One Acre Fund
Katherine	Clements	Unorthodox Philanthropy
Shahrzad	Yavari	Nexleaf Analytics
Ruchit	Garg	Harvesting
Erin	Connor	Cisco
Daniele	Tricarico	GSMA
Ben	Hubbard	Movement Partners
Kathi	Kitner	Intel Labs, Intel Corporation
Nathalie	Collins	IDEO.org
Adam	Wolf	Arable
Ramesh	Raskar	Facebook, Emerging Worlds
Jason	Neff	LandPKS
Daniel	Conrad	Beep Networks
Robert	Ryan-Silva	DAI
Josette	Lewis	World Food Center, UC Davis
Christian	Merz	Gates Foundation
Roy	Steiner	Omidyar
Christopher	Seifert	Granular
Nikki	Brand	USAID
Sabeen	Dhanani	USAID
Brian	King	USAID
Esther	Obonyo	USAID
Judy	Payne	USAID
Moffatt	Ngugi	USAID
Jessica	Henizelman	Reach (Facilitator)

Annex B: Low-cost sensors for agriculture agenda

Day One: June 2, 2016	
9:00 - 9:30	**Arrival and Light Breakfast**
Morning	**Welcome & Introductions**
	Setting the Stage: Examples of Sensors for Agriculture • *Nathalie Collins, Senior Design Lead, IDEO.org* • *Adam Wolf, Co-Founder/CEO, Arable* • *Christopher Seifert, Director of Agronomic Data Science, Granular* • Daniele Tricarico, Insights Manager mNutrition, GSMA
	Coffee break
	Profile of a Smallholder & the Agricultural Cycle *USAID provides a brief overview of the typical smallholder, discussing the various decisions from planning to sales.*
	Interactive Session #1: Information Needs for Smallholder Farmers *Participants identify challenges faced by smallholders that can be addressed through the collection and dissemination of information.*
12:00 - 1:00	**Lunch**
Afternoon	**Interactive Session #2: Mapping Sensors to Smallholder Needs** *Small groups map current and potential sensor technologies to smallholder information needs identified at each stage of the agricultural cycle and identify the most promising technologies to support farm-level decision-making and productivity.*
	Interactive Session #3: The State of Sensors *Small groups discuss priority sensor technologies identified through Session #2 and detail the technology's current applications (if any), lessons learned as well as the opportunities and barriers to the technology, adoption and scale.*
	Coffee break
	Interactive Session #3: The State of Sensors (Continued)
	Day 1 Wrap-up
4:30-6:00	**No-host Happy Hour (Optional):** *Martin's West Gastropub (831 Main Street)*

Day Two: June 3, 2016	
9:00 - 9:30	**Arrival and Light Breakfast**
Morning	**USAID 101: Feed the Future, U.S. Global Development Lab, and Digital Development for Feed the Future Collaboration**
	Interactive Session #4: Opportunities for Action *Building from previous exercises and a smallholder scenario, small groups work together to pitch a concept for a high impact product, service or suite of technologies that could be brought to developing markets through investment and partnerships.*
	Coffee break
	Interactive Session #4: Opportunities for Action (Continued)
	Wrap-up and Next Steps
12:30 - 1:30	**Networking Lunch**