



**Cracking
the Nut®**

Promoting Agricultural
Technology Adoption
and Resilience



Lessons from
the 2018
Conference

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Acknowledgements

Connexus Corporation would like to thank the many presenters, participants and organizations that supported Cracking the Nut 2018 (www.crackingthenutconference.com). This publication was made possible thanks to the generous contributions of our sponsors and partners who are committed to working on the tough nuts related to “Promoting Agricultural Technology and Resilience.” In particular, Connexus would like to thank the following sponsors of this important learning event:

- **DIAMOND SPONSORS:** Multilateral Investment Fund (MIF) at the Inter-American Development Bank (IDB) and IDB Invest
- **PLATINUM SPONSOR:** United States Agency for International Development (USAID), Feed the Future and Catholic Relief Services (CRS)
- **SILVER SPONSORS:** Chemonics International
- **BRONZE SPONSORS:** NCBA CLUSA

Connexus would also like to acknowledge the important role of the Advisory Committee, who helped to plan and develop the content for the conference, including the following members:

- Anita Campion
- Melissa Benn
- Geoffrey Chalmers
- Liuben Chipev
- Elizabeth Eckert
- Shaun Ferris
- Katie Garcia
- Troy Hoppenjan
- Melissa Matlock
- Romina Valeria Ordonez
- Ana Rios Galvez
- TJ Ryan
- Fred Smith
- Yuri Suarez Soares
- Anna Ulbrich
- Greg Watson
- Patricia Yañez Pagans

Connexus would like to also recognize our staff and consultants, whose significant contributions made the conference and publication possible:

- Laura Smith, Operations Manager
- Melissa Matlock, Project Manager
- Liuben Chipev, Associate
- Rashmi Ekka, Consultant

A special thanks to Alefia Merchant from USAID, Patricia Yañez Pagans from IDB Invest, Shaun Ferris from CRS and Judy Payne, Independent Consultant, who took the time to review this publication and suggest edits.

Acronyms

AI	Artificial Intelligence
CATIE	<i>Centro Agronómico Tropical de Investigación y Enseñanza</i>
CIMMYT	International Maize and Wheat Improvement Center (in Spanish)
CO ₂	Carbon Dioxide
CRS	Catholic Relief Services
CSAI	Catalytic Sustainable Agribusiness Initiative
EDC	Education Development Center
FGA	Forest Garden Approach
GCAN	Gender Climate Change and Nutrition Integration Initiative
GHG	Greenhouse Gases
GPS	Global Positioning System
IACA	Integrated Access to Climate Smart Agriculture
IB	Inclusive Business
ICT	Information Communication and Technology
ICT4D	Information, Communication and Technology for Development
IDB	Inter-American Development Bank
IFPRI	International Food Policy Research Institute
INGENAES	Integrating Gender and Nutrition within Agricultural Extension Services
IoT	Internet of Things
MIF	Multilateral Investment Fund
MRV	Monitoring, Reporting and Verification
NAMA	Nationally Appropriate Mitigation Action
NCBA CLUSA	National Cooperative Business Association Cooperative League of the USA
NDVI	Normalized Difference Vegetation Index
SACCO	Savings and Credit Cooperative
SNIA	National Agriculture Information System (in Spanish)
SMS	Short Message Service
USAID	United States Agency for International Development
USDA	United States Department of Agriculture
WSA	Water Smart Agriculture

Foreword

This was the first time we held a *Cracking the Nut*® event in Latin America. Despite Mother Nature's attempt to scare us away from Guatemala with the eruption of the Volcano of Fire just ten miles away from Antigua, I am happy to report that the majority of registered participants were able to attend *Cracking the Nut 2018*. We proved to be a resilient bunch, clearly dedicated to rural and agricultural development and facilitating access to finance. With 185 participants from 34 different countries around the world, the conference included representatives from technical assistance providers (54%), private sector professionals (21%), financial institutions and investors (12%), donors (5%), researchers (5%) and policy makers (3%). With this diverse representation and most participants (59%) having more than ten years of experience, the quality of content and caliber of discussions was superb! With 85% of evaluated participants stating that they would recommend this conference to others, some of the most valuable aspects noted were:

- The opportunity to network with key persons from across Latin America and the Caribbean;
- The plenaries and small group discussions, including “honest” sessions where presenters did not gloss over the challenges;
- Short presentations with practical work; applying a business perspective to development challenges;
- Realistic success stories and lessons learned, easier for other organizations to apply to their work not reinventing the wheel;
- A chance to learn about new technologies and exchange ideas with people.

Thank you to all who participated and contributed to this version of *Cracking the Nut*. While it is impossible to capture every nugget and lesson learned that came out of the conference, I hope you will find this publication useful and relevant to your work. With new technologies and digital applications, the world is changing quickly. I appreciate the *Cracking the Nut* community's willingness to share positive and negative experiences in promoting agricultural technology adoption and its commitment to making sure smallholders, including women, youth and minorities are benefiting from these lessons.

Sincerely,



Anita Campion
President and CEO



Executive Summary

Microsoft's Director of Digital Advisory Services, Enrique Andaluz, opened *Cracking the Nut 2018* by explaining that we are operating in a circular economy, in which we must consider economic, environmental and social impacts simultaneously. He argued that technology can help agriculture to be practiced as more of an exact science, thereby allowing us to increase production for food amid population growth, adapt to climate change, and improve food safety at a faster rate. Below is a summary of the key findings extracted from the conference by theme.

Theme 1. Introducing Technologies in Support of Climate Resilience

There are an increasing number of technologies that can help farmers and agribusinesses to operate more efficiently, while simultaneously improving resiliency. At the conference, we emphasized climate resiliency or the ability to adapt to changes in the weather and environment. Several technologies also contribute to the economic and operational resiliency of agribusinesses. Below are some of the lessons.

Lesson 1: To attract investment, it is important to build linkages with the private sector and financial institutions early on. There are an increasing number of investment funds that target “climate smart” or “green” investments. As technology businesses seek investment funds to scale up the use of new agricultural technologies, they often need to resolve their end clients’ need for finance and identify the right investor for their risk profile and expected returns.

Lesson 2: User-centered design is needed to ensure uptake and scale agricultural technologies. To create tools to support climate resilience, product design should be based on target users’ needs and preferences (i.e. user-centered), as well as what they can afford.

Lesson 3: To convince smallholders to adopt climate-smart practices, a tailored approach is needed based on farmers’ resources and capabilities. To promote climate resilience in its cocoa supply chain, ECOM Agroindustrial provides technical assistance and credit to promote “*precision agriculture*” techniques for small producers as a strategy to make better use of inputs, improve yields, and reduce vulnerability.

Lesson 4: By assessing farmers’ capabilities and resources, one can identify the minimum ‘threshold’ needed to support appropriate and affordable agricultural technology options. For example, the Danone Margarita project in Mexico identified the minimum threshold of 40-50 productive cows to justify introducing farmers to investment-heavy technologies, such as biodigesters and solar panels.

Lesson 5: A holistic approach, including access to technology, finance, and markets, helps to build long-term sustainability and uptake of technology. Training farmers on a new technology is not enough to guarantee adoption and sustainability; often facilitation of finance and market linkages is required for a technology to be a sustainable tool for production, income and resilience.

Theme 2. Promoting Sustainable Natural Resource Use and Poverty Reduction

Rural poverty, agricultural production and environmental protection are all intertwined concerns for international development. The lessons below offer some insight into how to manage the inter-relationships and interdependencies that contribute to this complexity.

Lesson 6: Climate-smart agriculture should rely on knowledge-intensive agriculture rather than input-intensive agriculture. Multiple examples from CRS, CIMMYT and NCBA CLUSA highlighted

how agricultural research and knowledge could be used to improve the efficient use of resources, including water, soil and inputs.

Lesson 7: When designing an intervention, one must consider household concerns (nutrition, weather, climate, etc.) in addition to market needs. To build economic, social and environmental resilience, Trees for the Future considers these factors in its Forest Garden Approach which aims to simultaneously reduce household poverty, improve food security and revitalize degraded lands for smallholder families.

Lesson 8: Enhanced knowledge and technology can help to better manage dairy and cattle farming, while controlling harmful greenhouse gases. For example, Costa Rica used quantifiable research to legitimize policies and improve capacity building to measure, monitor and reduce emissions related to livestock farming. The findings were then used to guide regional planning, encourage uptake of climate resilient technologies and support positive behavior changes for cattle and dairy farmers.

Lesson 9: Focus on the ‘right’ technology over the ‘latest’ technology when introducing and financing new agricultural technologies. As part of IDB’s EcoMicro project, YAPU Solutions is working with microfinance institutions to improve their abilities to offer financial products for “appropriate” climate smart technologies for smallholders in Latin America and the Caribbean.

Lesson 10: It is important to understand what motivates farmers and leverage local culture to encourage adoption of new technologies. Given the importance of corn in the Guatemalan culture, Semilla Nueva’s market research found that it needed to promote hybrid biofortified corn based on what mattered most to the farmers – increased yields, revenues and income; rather than its high nutritional value as compared to traditional corn.

Lesson 11: Sometimes economic and scientific benefits are insufficient to encourage smallholders to apply new climate-smart behaviors. After an initial pilot in Mexico, smallholders were not using the GreenSeeker Handheld Technology for measuring nitrogen content in soil despite demonstrating the technology’s ability to improve cost-effectiveness of inputs, increase farmer profits and reduce carbon dioxide (CO₂) emissions. RTI International is now applying human-design centered techniques to understand constraints and to develop a sustainable business model.

Theme 3: Using Digital Platforms to Facilitate Agricultural Knowledge and Finance

Global growth in digital tools is unleashing a new agricultural revolution: one in which data and technology allow for improved communications across value chains, enable on-demand services, providing more relevant information for precision farming and streamlining payment processes. Digital platforms are becoming increasingly important for reducing transaction costs and facilitating the flow of knowledge, resources and finance to agribusinesses. Below are some of the lessons shared related to this theme.

Lesson 12: Cloud-based, mobile accessible platforms can automate a variety of management functions across the value chain. For example, Akili Holdings, an agribusiness in Kenya, developed its Akili eT software, which includes modules for farm production and geo-referenced asset management, input procurement, produce purchasing, payment processing, farm production, inventory management, savings and credit and carbon credit monitoring.

Lesson 13: SMS-based digital warning systems can help farmers cope with climate change and mitigate losses by providing actionable information and building resilient systems. For example,

Grameen Foundation used digital Short Message Services (SMS) in working with coconut smallholders in the Philippines where 65% of the farmer respondents said that the SMS system helped them to know how to mitigate risks associated with pests and extremely dry weather conditions.

Lesson 14: Digital tools, such as for gross margin calculation, can enable farmers to better understand their own costs and improve decision-making. For example, CRS' Farmbook Digital Toolkit helps farmers to plan their business, including looking at the gross margin achievable for different mixed crops. This helps farmers and field agents get a better understanding of their costs and income so that they can make better decisions based on yield and profit potential.

Lesson 15: The rapid proliferation of digital tools is helping to facilitate the flow of agricultural knowledge across value chains and financial access to the rural poor. USAID offered several examples of how it has been supporting efforts globally through a number of mechanisms, including innovation prizes, competitions, research support, and private sector partnerships; as well as evidence on how digital tools have helped to improve production, increase incomes and reduce risks around the world.

Lesson 16. Market segmentation impacts access to digital tools. Because the incentives to increase transparency, quality and predictability of supply are stronger, commercially digitizing agricultural value chains is more likely in procurement models where farmers have formal relationships with large crop buyers.

Lesson 17: In creating new ICT4D platforms, implementers should consider sustainability upfront, ensuring an exit strategy off donor or project dependence. Before implementing a new platform for agricultural extension, for example, it is important to develop a strategy for data collection and ongoing maintenance beyond the initial design and pilot testing phases.

Moving Forward

Several cross-cutting lessons that emerged related to agricultural technology adoption and resilience. Factors such as gender, youth, nutrition and partnerships are extremely important considerations as we attempt to wield the power of new technologies to address long-standing development problems.

Lesson 18: When designing agricultural technologies, gender and nutrition dimensions need to be considered to create more equal access, outcomes and impact. IFPRI's Gender Climate Change and Nutrition Integration Initiative (GCAN) Framework and the USAID's Integrating Gender and Nutrition within Agricultural Extension Services (INGENAES) toolkit are two tools that have been developed to explore these dimensions.

Lesson 19: Facilitating access to finance for agricultural technology can help launch young entrepreneurs' agribusinesses. Connexus explained how linking youth to agribusinesses through technical internships and financial institutions have helped vulnerable youth to start successful horticultural businesses through its work on USAID/Rwanda's Huguca Dukore project in partnership with EDC.

Lesson 20: Governments, donors and multilateral institutions should actively promote climate smart agricultural intensification. With World Bank support, for example, the Government of Uruguay strengthened its institutional framework to identify agricultural vulnerabilities and turn them into opportunities through a set of laws, regulations, and interventions, which collectively incentivized farmers to use land more intensively and significantly reduced greenhouse gases.

I. Introduction

Keynote Speaker, Enrique Andaluz, Microsoft’s Director of Digital Advisory Services explained, “We are now operating in a circular economy,” in which we need to consider the impacts that we all can have on economic, environmental and social aspects of our communities. With the need to deliver 70% more food by 2050, he asserts that we need a new framework for agricultural development. Technology is one of the best ways for us to move agriculture for food production and safety toward more of an exact science. Technology also helps improve the flow of information in real time and enhance the quality of interactions to adapt faster to changing conditions. Mr. Andaluz argued that digital platforms are needed to accelerate knowledge-sharing in agricultural value chains. While there are many massive data sets owned by agribusiness companies, he posits that Microsoft is a neutral party that the public and private sector can trust to centralize and manage data in ways that can support rapid learning and progress through new technologies, such as “artificial intelligence.” Mr. Andaluz highlighted several examples in which Microsoft has supported agricultural advancements through technology, including:

FarmBeats is a program that uses an iterative process to turn large-scale agricultural production and crop management into as much of a science as possible to achieve predictable outcomes at the lowest possible costs. FarmBeats uses sensors and provides farmers with access to the Microsoft Cloud and its Artificial Intelligence (AI) capabilities, enabling data-driven decisions to help improve agricultural yield, lower overall costs, and reduce the environmental impact of agricultural production. The platform integrates a variety of databases on weather and climate, as well as crops and inputs, combined with satellite or drone-based images of land to improve productive yields and monitor climate impacts. First advancements produced positive outcomes in terms of yield and environmental impacts, but much lower costs needed to be achieved. After a few iterations, sensors are becoming less expensive and less needed when combined with satellite image systems. Instead of using Wi-Fi – which is scarce in rural areas – one can now transfer data through unused TV channels, which are typically more available in rural areas. The FarmBeats now combine the benefits AI and IoT to provide a very low-cost approach to achieve precision agriculture.

Precision agriculture is based on the concept that the combination of technology and data can take the guess work out of agriculture and make it more of a predictable science. In India, Microsoft has used soil data sensor technology to monitor soil moisture for precision irrigation and fertilization, simultaneously addressing water scarcity and minimizing the use of chemicals, which can have a negative impact on the environment. Microsoft Azure helps with predictive modeling, which can lead to improved yields at reduced costs (see Box 1.1 on how Land O’Lakes is applying this technology as well).

Blockchain is a decentralized technology that allows users to record information within an “open digital ledger” that helps to reduce errors and false reporting. Microsoft is working with MARS Food to improve transparency and efficiency to manage sensitive data and address problems in real time with high levels of data security.

Box 1.1: Improving Agricultural Modeling

Land O’Lakes migrated its agricultural application to Microsoft Azure. This app takes a vast array of agronomic research, weather information and satellite data and puts it on a mobile device for farmers and the WinField specialists. With its new Azure-powered app, Land O’Lakes has enabled farmers to make better planning decisions and react to changes in the field in real time. Using new tools and technologies, such as Cortana Analytics, the time to take new products to market is shorter and employees and co-op members are more productive. Farmers can now analyze data and plan together with their representatives, while standing in the middle of their field.

MARS’s objective was to connect their customers with farmers in a credible way and enable greater visibility into their supply chain, with an end goal of sourcing rice more sustainably by 2020. To do this,

MARS worked with SGS, Blippar, and Transparency-One to create an end-to-end supply chain transparency solution. Built on Microsoft Azure's Blockchain Services, the Transparency-One tool maps the supply chain and manages risk, providing transparency and enabling MARS to ensure the security and integrity of supply chain data. With blockchain technology, all transactions, including any updates or modifications, are immediately recorded and stored in the blockchain. Data can immediately be accessed by designated supply chain partners, providing full transparency at each step of the supply chain. The Transparency-One platform manages a range of data, including: complete supply chain mapping, product integrity information, supplier compliance details, and regulatory compliance documentation. It makes the process of transactions more efficient across the multiple supply chain players. Blockchain can also support the creation of new business opportunities, such as asset-based financing, risk management services, data-driven predictive modelling, and trading between smaller companies.

With these and other technologies, food waste and CO₂ emissions from agriculture can both be reduced 20% by 2030, demonstrating the potential of technology to balance food security and climate resilience simultaneously. With food representing a \$4.8 trillion industry, one can argue that public private partnerships could go a long way to create agricultural data platforms that would serve the needs of planet and people, including smallholder farmers. Building on these concepts, the rest of this publication focuses on lessons shared on how we can promote agricultural technology adoption and resilience around the world, especially as they relate to the conference's core themes:

1. Introducing Technologies in Support of Climate Resilience
2. Promoting Sustainable Natural Resource Use and Poverty Reduction
3. Using Digital Platforms to Facilitate Agricultural Knowledge and Finance

II. Introducing Technologies in Support of Climate Resilience

There are an increasing number of technologies that can help farmers and agribusinesses to operate more efficiently, while simultaneously improving resiliency. According to the Meriam-Webster dictionary, resiliency means “the capacity to recover quickly from difficulties.” At the conference, we emphasized climate resiliency or the ability to adapt to changes in the weather and environment. Nonetheless, several technologies also contribute to the economic and operational resiliency of agribusinesses. This section highlights some of the key lessons extracted from technologies, such as biodigesters to reduce waste, cost effective approaches to harvest rain water or reduce water demands, as well as tools to improve agricultural precision and risk mitigation.

Lesson 1: To attract investment, it is important to build linkages with the private sector and financial institutions early on.

With a growing number of investors looking for promising ventures, demonstrating profitability and scalability is key. Eelco Baan of SNV explained that we want to avoid pilots that “never fail and never scale.” SNV is a leader in Inclusive Business (IB) Acceleration and promotes entrepreneurial initiatives that address social and environmental problems through innovation and climate-smart solutions. SNV has supported over 200 IB cases in 33 countries across Africa, Asia and Latin America. Daniel Granada, of Pomona Impact, assessed three agricultural technologies in terms of their readiness for investment and prioritized them based on his fund’s interest and investment profile. In particular, Pomona Impact Fund II is a Central America focused fund investing in agricultural technologies with a proven track record that are ready to scale up. The fund evaluators look at sales and product histories as signs of traction in the market and seeks financials that are close to break even and demonstrate the ability to scale profitably. Initial investments from the Fund range from US\$500K to US\$2 million. He argued that agribusinesses “need to find the right partners, including for finance,” as each investor has a different risk appetite and return expectation. Below we explain the three technologies that were selected for assessment.

Sistema Biobolsa is a company that manufactures, distributes, and installs high quality biogas systems for small farmers with the mission to create value from waste. The company was created to respond to the following challenges: inappropriate waste management, overuse of chemical fertilizers, rising cost of fossil fuels, and negative health effects caused by the overuse of wood fuel in households. The Sistema.bio product is a hybrid reactor-biodigester that transforms the manure of animals into biogas for energy and a potent natural fertilizer. The energy generated from the systems can be used to heat water, power heater lamps and kitchen stoves, or on a more productive scale, for mechanical and electrical generation for cereal grinders, milking machines, corn strippers, and electric generators. By inputting the farm manure in the system on a daily basis, households can increase productivity in agricultural crops, improve energy security, reduce respiratory diseases by replacing open-fire wood-fuel kitchens, and protect the environment, as the system protects the water sources and basins, reduces greenhouse gases (GHGs) and eliminates the waste that can invite flies and disease.

Sistema Biobolsa offers last mile sales, pre- and post-purchase maintenance, as well as customized loans (using Kiva crowd lending) based on cash flow and repayment capacity and using mobile technology. Agents use Salesforce and smart phones for cloud-based integrated data management. Product pricing is three tiered: \$402 for subsistence farmers, \$580 for small for-profit farmers, and \$1085 for larger productive farmers. Sistema Biobolsa started 10 years ago in Mexico, but has since expanded to include Kenya, India, Nicaragua and Colombia; and now works with local firms in each country. Sistema Biobolsa partnered with SNV in Nicaragua, through the National Biogas Program with funding from MIF at IDB. It has been

profitable since 2015 and anticipates sales of US\$4.5 million in 2018. To continue expansion, Sistema Biobolsa seeks to raise US\$10 million this round (50% equity; 50% debt) to support working capital and expansion in India and East Africa.

DryGro is a UK-based agriculture technology company that has developed new ways to grow animal feed ingredients on arid, unproductive land. DryGro’s technology grows feed ingredients for aquaculture, ruminants and poultry at a lower cost than soy, fishmeal and other traditional inputs. Based on the lemna or “duckweed” crop, the product grows on ponds and is high in protein. This technology uses a fraction of the water of traditional agriculture, making it a valuable climate change mitigation tool. This is important because the demand for feed ingredients is growing faster than supply and, as CEO Sean Peters stated, “communities have identified the animal feed problem as critical to climate change.” In Kenya, protein feeds are expensive, poor quality, and face incremental scarcity. DryGro solves these problems through cost-effective, locally grown feed ingredients.

Figure 1: DryGro Lemna in Kenya



In Kenya, DryGro partnered with SNV as part of the Feed the Future East Africa Catalytic Sustainable Agribusiness Initiative (CSAI) funded by USAID to support innovative climate-smart technologies through customized business training, technical assistance, strategic partnering and matchmaking. DryGro has already raised US\$2 million from climate change focused funds (i.e., green investors) and has been able to demonstrate profit potential in Kenya. DryGro now seeks to raise another \$2.7 million to expand operations and demonstrate at-scale unit economics in Kenya. As Eelco Baan explains, “This is an example where research translated into a business case” and SNV is working with DryGro on market validation. Given that animal feed protein represents a \$104 billion global market, DryGro offers a lot of potential for market growth.

CARE Honduras. In the Dry Corridor of Central America, access to water continues to be one of the main challenges, generating crop losses, increasing levels of malnutrition, and increasing the contamination of water sources. While precipitation levels can be high, the annual distribution is increasingly erratic, with long periods of drought and torrential rains. For this reason, in 2013, the PROSADE project from CARE International in conjunction with Mexichem Honduras began the process of developing an alternative solution for the water supply in rural areas. Together they came up with a simple and economical rainwater harvesting method using a geomembrane bag to collect, store and distribute rainwater at the household level, which can also be used for micro irrigation of home gardens.

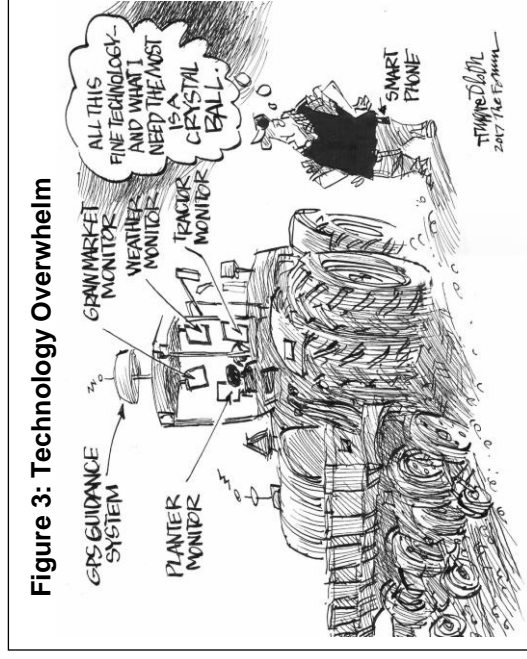
Figure 2: Rain Water Harvesting



With a mesh filter and air valve, the Geomembrane bag is good as it is cheap and protects water from contamination. The corresponding water pump is also accessible as it is made from local hardware materials. To irrigate family gardens requires an investment of US\$,1000, the cost of which is usually spread over five people. Since the loans are small and banks don't serve rural areas, CARE Honduras has partnered with local credit unions to offer financial products with repayment linked to the garden's three harvest cycles per year. CARE has found that the net profit from the investment is approximately US\$450 after repaying the loan and covering production costs, even assuming families will consume about US\$200 of the garden produce. These systems helped to harvest 31 million liters of water in 2017 and their use is being scaled up through universities and communities. To date, 3,500 units have been sold, but most have been funded by the government, with a few purchased by medium scale producers. As the benefits of water harvesting are demonstrated, CARE Honduras hopes to increase sales to private markets, and recognizes access to finance as being a remaining limitation.

Lesson 2: User-centered design is needed to ensure uptake and scale agricultural technologies.

The success of any new technology largely depends on how well it interfaces with the end-user. To create tools to support climate resilience, the design of the product should be based on target users' needs and preferences (i.e. user-centered) rather than simply on the designers' perception of needs. User-centered design needs to make the technology easy and enjoyable enough to attract sufficient numbers of users to achieve commercial success. Figure 3 highlights the overwhelm that farmers can feel in trying to manage all the data and technology available to them. Below are a few examples of climate-resilient agriculture technologies that have benefited from user-centered design.



Clima Diario App – Norman Avila explained that Meteo.Tech wanted to test a new technology by Google to see how well it could provide weather forecast information to help farmers make better informed decisions. They developed a small portal, Clima Ya.com, which now has 7,000 active users, mostly in the countries of Guatemala, Mexico, Argentina and El Salvador. Based on user input, they found that users need information in simple, understandable language as opposed to technical terminology, as well as help and advice on how to apply the information. Meteo.Tech is now looking into how to translate weather forecasts into specific actions, based on a farmer's location, crop and stage of development.

Coffee Cloud is a mobile application created by a USAID-funded project to support climate change adaptation for the Central American region. The project collaborated with the Tropical Agriculture Research and Higher Education Center (CATIE in Spanish) and national associations (Anacafé, Icafe, IHcafe), and a regional coffee association to create an app, in response to the coffee rust disease and its impact on coffee producers in Central America.

The app has proven extremely useful for Anacafé in Guatemala, which has invested its own resources to improve the information provided in the app in order to increase the number of users in the country. Coffee Cloud is a free application for coffee farmers and currently serves 1,700 Guatemalan users. Farmers enter

information into the system and the application calculates the incidence of rust on the farm and provides instructions on how to treat the disease. The app provides answers to questions in 30 minutes, on average, compared to the 30 days prior to its existence. Coffee Cloud has also lowered costs for Anacafé by reducing the need for extension agents to visit farms to gather information, answer inquiries from producers, and produce general maps of the entire country.

FarmCAAT – a tool that helps individual farmers, and other actors in the agricultural value chain, understand the impacts of climate change and take specific actions to improve farm system stability using climate change data services (e.g. Climate Wizard). Originally the tool was paper-based, designed through a collaborative process between farmers and institutional stakeholders, to identify the various risks, vulnerabilities and opportunities associated with climate change in a given community. The tool was developed in collaboration with Caribsave in the Eastern Caribbean and pilot tested in Vermont and Kenya. DAI is now developing an electronic, web-based platform to scale its use and application to programs in Haiti and Mozambique.

DAI Maker Lab Hardware – In his presentation, Rob Ryan-Silva challenged participants to see how user-centered design can go beyond software and development programming to enable non-traditional players – including development practitioners – to design and implement hardware. In many projects, if hardware is used, it is purchased off the shelf and commercially pre-manufactured. However, off-the-shelf options are often not a good fit for developing country environments; they can be expensive, designed for different kinds of problems, and, in many cases, with no available support for maintenance or repair. The DAI Maker Lab is challenging this notion by using user-centered design to create hardware innovations like water pressure telemetry for small utilities under the USAID-funded IUWASH Plus project (see Figure 4). With local partners, DAI has used a three-phase approach (proof of concept; prototype and iterations; and deployment and replication) to co-create the telemetry units with end users and local innovators.

Figure 4: DAI Maker Lab Demo



Lesson 3: To convince smallholders to adopt climate-smart practices, a tailored approach is needed based on farmers' resources and capabilities.

Each farmer is unique, with different needs, depending on their knowledge of business, finance and specific agricultural crops and value chains. [ECOM Agroindustrial](#) is a leading global commodities merchant and sustainable supply chain company. Known as Agroarriba S.A. in Ecuador, ECOM offers customized solutions to cocoa farmers, including technical assistance, access to inputs, and access to finance, which they call Sustainable Management Services (SMS). SMS motivates farmers to change behaviors to improve adoption of climate-smart technologies to increase productivity, while protecting the natural environment. To promote climate resilience in its cocoa supply chain, SMS has begun to develop “*precision agriculture*” techniques for small producers as a strategy to make better use of inputs, improve yields, and reduce vulnerability. Often described as using the right inputs, in the right amounts, at the right time, precision agriculture aims to manage variability by tailoring the application of water, nutrients, and other inputs to match the specific needs on the farm rather than applying generic solutions. These solutions can lead to

improved yields, efficiency in the use of inputs, and provide cost savings over time. Depending on their level of knowledge and growth potential, farmers begin in one of the following three SMS tiers and advance as they demonstrate increased capacity:

SMS Tier 1: Building the Foundation includes training on Good Agricultural Practices, how to achieve Utz certification (including complying with strong labor laws in Ecuador as well as international quality and trade standards), managing commercial relationships, demo plots and direct agricultural technical assistance.

SMS Tier 2: Providing Access to Inputs includes developing fertilizer blends (after soil and leaf analysis), building and managing nurseries, providing inputs and tools for direct sale, offering short-term credit to be repaid in kind with cocoa.

SMS Tier 3: Medium to Long-term Credit includes detailed farm management plans identifying investments to improve productivity and reduce climate risks (e.g. CCN 51 variety of cocoa); financial training and tools (e.g. purchase irrigation system); offering medium to long-term loans to be repaid with cocoa.

Prior to lending, ECOM evaluates the risk of each producer in the program. The evaluation faces challenges considering the informal economy as well as the market and environmental risks that exist for cocoa. In order to lend, ECOM looks for solutions that will mitigate the risk both for the producer and for ECOM to continue the “win-win” relationship. For example, if a producer requests credit but does not have a history of deliveries or of improving farm management, it would represent a risk of default for ECOM. This can be mitigated by looking at the commercial history and technical recommendation from agronomists in the field. Some of the risks of climate change can be mitigated with investments in improved inputs and cocoa varieties, irrigation systems and insurance that ECOM has validated or is in the process of validating. In three years, ECOM has seen cocoa producers increase yields by 35%, on average, by using regional fertilizer blends created especially for ECOM as a result of soil and leaf analyses over various years. The remaining challenge is to expand the solutions offered to other producers and to replicate success with a larger number of farmers by increasing adoption rates and repayments despite market price variability. ECOM currently works directly with over 1500 producers in Ecuador and hopes to target 20% with short and medium-term credit options over the next 3 years.

Lesson 4: By assessing farmers’ capabilities and resources, one can identify the minimum ‘threshold’ needed to support appropriate and affordable agricultural technology options.

In a supply chain climate risk assessment of the Danone Margarita project in Mexico, funded by ProAdapt, one of the principal findings was identification of the minimum threshold or ‘threshold effect’ (maintaining 40-50 productive cows), which helped categorize and prioritize climate resilient technology investments for farmers. If a farmer was at or above the threshold, then agricultural technologies that require high initial investments, like solar panels and biodigesters, were introduced. For farmers below the threshold, a more gradual approach to technology and climate resilience was used, which included a greater range of interventions that required low capital investments, including financial, institutional, knowledge, behavioral and structural. These types of interventions included improving feed quality, installing feeders and drinking troughs in the farmyard to improve feed efficiency and introducing different cattle breeds and new crop varieties that are more resilient to drought. By identifying and organizing farmers based on the threshold

effect, the project was able to make sure that interventions were feasible and matched the resources and capabilities of the farmers; this ultimately contributed to a more sustainable, climate resilient supply chain.

Lesson 5: A holistic approach, including access to technology, finance and markets, helps to build long-term sustainability and uptake of a technology.

For an agricultural technology to take root, it needs to overcome several challenges and risks. Introducing a technology and providing capacity building on the technology is often not enough to guarantee adoption and sustainability. A holistic approach that combines technical training, access to finance, and the creation of market linkages, is required for a technology to be a sustainable tool of production and income for farmers. In Jamaica, where environmental factors, such as severe drought and land degradation caused by climate change, continue to pose growing challenges for farmers, INMED Partnerships for Children has introduced this type of holistic approach for climate-smart aquaponics agribusinesses (see Box 2.4). Through nationwide outreach and recruitment programs to educate people about new technologies, technical trainings in business planning and financial education, and the facilitation of meetings and networking with buyers and farmers, the project is addressing multiple systemic challenges to ensure that the adoption of aquaponics technology is successful in the short and long-term.

Box 2.1: Climate-Smart Aquaponics Agribusinesses

In Jamaica, INMED Partnerships for Children is working with the IDB, Caribbean Development Bank and other partners to introduce aquaponics technology through the Integrated Access to Climate-Smart Agriculture project (IACA). INMED has developed the aquaponics technology to be simple, less expensive, and adaptable to fit the needs of farmers (available space, fish and plant preferences, climate conditions, etc.). To increase economic opportunities for small-scale farmers, reduce climate change vulnerability, and minimize environmental impacts, IACA is scaling access to this technology through technical trainings, market development, and credit financing.

To identify committed farmers, all potential candidates must first complete an online prequalification training course on aquaponics operations and business management. The project then supplements the introduction of the technology with extensive technical trainings, services, and consultations to assist farmers with the installation and utilization of aquaponic technology. As the Jamaican government's extension services are available throughout the country through the Rural Agricultural Development Authority, the project trains them and students from the College of Agriculture, Science and Education to provide this type of assistance to farmers. The project then facilitates linkages between farmers and buyers through buyer networking events so that farmers know what types of crops to plant, making sure that supply is meeting demand. INMED is also working with financial institutions to develop custom financial products for the purchase of the systems and training farmers on how to navigate financial documents and apply for credit.

Through this holistic approach, Jamaican farmers are increasing their incomes and crop yields significantly, while also receiving greater access to credit and opportunities for financing. Furthermore, the aquaponics design has improved the sustainability of food security and farmers' ability to overcome climate change challenges while reducing their environmental impact.

III. Promoting Sustainable Natural Resource Use and Poverty Reduction

Rural poverty, agricultural production and environmental protection are all intertwined concerns for international development. This section explores some of the inter-relationships and interdependencies that make the development of rural and agricultural markets complex in developing countries. The lessons below offer some insight into how to manage through those complexities.

Lesson 6: Climate-smart agriculture should rely on knowledge-intensive agriculture rather than input-intensive agriculture.

When designing agricultural production systems, Shaun Ferris of Catholic Relief Services (CRS) suggests we build them to be “knowledge-intensive” rather than “input-intensive.” Building on some of the lessons shared at the *Cracking the Nut* conference in 2016, CRS highlighted various ways in which it had applied this lesson and was cracking some of the tough nuts associated with land degradation and soil quality.

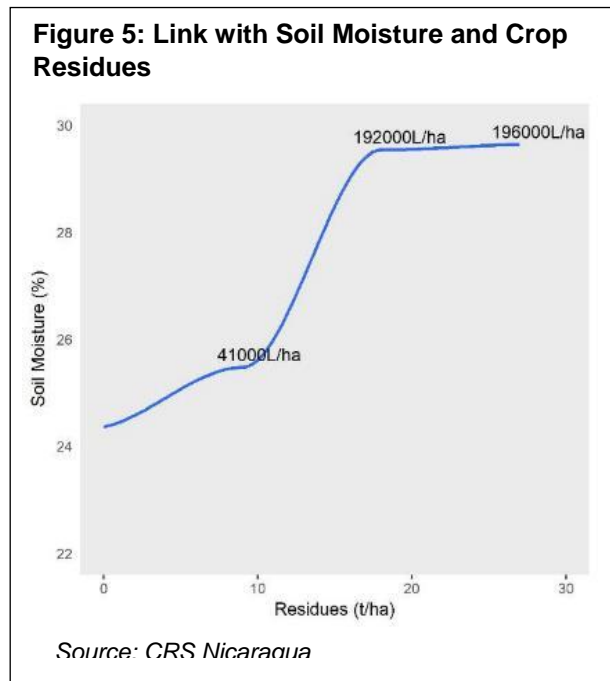
In Southern Africa, maize yields are declining despite massive government subsidies for seeds and fertilizer. This is due to land degradation caused by continued monocropping. According to Geoff Heinrich of CRS, this trend is making rural communities particularly vulnerable to climate impacts (droughts, floods) because their soils lack the structure and organic matter needed for productive maize cropping.

To improve soil fertility, Christian Thierfelder from CIMMYT is working with CRS to encourage multi-level intercropping systems, which includes combinations of maize, grain legumes and leguminous trees in the farming system. The combination of crops, crop cover, limited tillage and no burn policies supports annual gains in soil organic matter, leading to better overall production levels, improved maize yields, plus food, fodder and income from the legume crops and the trees. Using their new knowledge, farmers can use less inorganic fertilizer but produce more food, using a sustainable farming system.

We know that farmers have choices, and some differ by gender. Cara Raboanarielina of CRS, for example, highlighted studies that show women tend to intercrop with cowpea, as this crop mix required less weeding; whereas men preferred to intercrop with pigeon pea because it provided more income. It was however important for the team to note that a recent evaluation found that scaling up of these systems was currently constrained by lack of legume seed. Men also noted there was increased labor required to plant more crops in a given area.

Using knowledge intensive methods is important because in Central America, 74% of soil is degraded, which is expected to decrease maize yields by 20% by 2050 if not addressed. CRS’ Water Smart Agriculture (WSA) program has demonstrated that healthy soils lose less water from runoff and evaporation, so more water is stored in the soil to fortify plants and crops. While CRS is working hard to make the scientific case for water smart agriculture with 3,000 farm demo plots (see Figure 5, which demonstrates the link between soil moisture and crop residues in Nicaragua), but adoption rates remain low. The project team is therefore focused on building soil management capacity for 250,000 farmers by 2021. Halfway through the five-year project, CRS is already seeing increased yields and net income (especially in maize and beans, coffee less due to rust and ongoing renovation).

CRS is mainstreaming WSA through partnerships with academia, public and private sector partners and leveraging additional investments to support WSA. Marie-Soleil Turmel of CRS explained that a particular challenge to scaling WSA in Central America is the trade off in crop and livestock systems; between feeding soil vs. feeding animals (especially cattle) and this requires additional work through local forums for making decisions on how to support crops and livestock.



At the landscape level, CRS is also working with Keurig Green Mountain Coffee on a WSA project, entitled Blue Harvest. The goal of the project is to upgrade watershed management systems that support upland cropping and also improves downstream water sources. This approach promotes a more resilient water-smart farming systems, as the upland crops such as coffee have a lot of downstream impact on water and the natural environment. Paul Hicks of CRS described how the project uses a tool, www.waterbenefitscalculator.com, to extrapolate on-farm practices and project landscape-level impacts, to help farmers and decision makers prioritize and invest in the most effective soil and water management practices. CRS has also developed a tool for digital mapping of functional soil properties, called DigiSoil, in partnership with Purdue University. It is applying this tool on its Agricultural Landscape Restoration Initiative

(ALRI) project to identify problems and solutions for whole watersheds in El Salvador, in partnership with the International Center for Tropical Agriculture and other scientific partners.

Douglas Bárcenas of NCBA CLUSA has also found that agricultural knowledge can be more important than inputs, as he described how NCBA CLUSA used knowledge to reduce coffee producers' costs by up to 60% on its El Salvador Coffee Rehabilitation and Agriculture Diversification project, financed by the United States Department of Agriculture (USDA). According to Bárcenas, "El Salvador's fertilizer is the most expensive production cost in Central America". So NCBA CLUSA advocated for the use of organic fertilizers and created 120 organic input manufacturing sites, as part of the "Low Cost Coffee Production System," which also includes low cost coffee seedling production, and mechanization system to transplant coffee plants to the field.

As a result, the project lowered the cost of fertilizers from \$17-\$40/liter to just \$0.17 per liter and, in some cases, laboratory analysis demonstrated that the organic fertilizers created by the project were more effective than the retail fertilizers. NCBA CLUSA also used knowledge to lower the production time to produce the cost of coffee plants; previously, coffee plants took up to one year in the nursery, but with the new system they reduced the time to six months therefore reducing the cost from \$0.46 to \$0.18 per plant; and by using mechanization the cost of transplant has also been reduced significantly. This cost savings will be particularly important in saving coffee farmers on renovation in response to coffee rust disease crisis, which previously cost \$4,500 per hectare to renovate and now costs just \$1,200 per hectare offering a positive environmental impact by using organic agricultural practices. The project has also identified new

genetic varieties that are resistant to coffee leaf rust, providing additional long-term benefits. Currently, NCBA CLUSA has worked with over 7,500 coffee farmers in El Salvador and will continue to provide assistance thru September 2019.

Lesson 7: When designing an intervention, one must consider household concerns (nutrition, weather, climate, etc.) in addition to market needs.

To build economic, social and environmental resilience, Trees for the Future (an international non-profit organization) applies its Forest Garden Approach (FGA) to reduce household poverty, improve food security and revitalize degraded lands. FGA factors in household needs, including nutrition, weather and climate impacts, to design a customized agroforestry approach that meets the broad needs of the smallholder's family.

FGA empowers farmers with technical training and in-kind grants to build their capacity to become better farmers. In particular, FGA teaches farmers to consider and adapt to outside forces that affect their livelihoods, including markets, variable climates and input costs, while promoting household food security and dietary diversity, higher incomes, and environmental resilience. FGA helps farmers to improve their resilience to weather extremes, pests, and economic shocks, and it promotes on-farm cost-savings by building their skills in using compost, integrated pest management, and by planting trees that will provide animal fodder and fertilizer for soil health. Beginning with an analysis of the layout of the land, FGA suggests agroforestry mapping designs that accommodate constant household needs, such as for food and timber. For example, by placing small woodlots near the house, women can access fire wood more safely and easily. A live fence made from a variety of trees is generally suggested to keep out pests and to produce fodder for animals and fruit for the family. FGA teaches farmers how to apply climate-smart agricultural practices while producing more diverse and intensely intercropped crops. Trees for the Future has found that profits and food security improve with diversity. In West Africa, FGA aims to have farmers plant at least 10 crops and have produce available for sale or consumption every day of the year. Since water is scarce, they are promoting more drought resistant crops, such as okra and cashews. FGA simultaneously supports the production of food for humans, food for animals, and food for soil. Trees for the Future has a variety of training materials available for download at training.trees.org.

Lesson 8: Enhanced knowledge and technology can help to better manage dairy and cattle farming, while controlling harmful greenhouse gases.

Although Latin America and the Caribbean (LAC) account for only 14% of the world's population, they produce a little over 23% of beef and buffalo meat at the global level. This sector, which continues to grow (annual rate of 3.7% in LAC compared to 2.1% global rate) is one of the main contributors to greenhouse gas (GHG) emissions, mostly related to enteric methane fermentation. Sustainable livestock management practices offer an opportunity to address the growing environmental challenges from this sector while supporting the income and livelihoods of the small-scale producers and communities who depend on this sector. For example, using a diverse group of edible plants, such as that in a biodiverse silvopastoral landscape, promotes healthy soil with better water retention, discourages pest, minimizes GHG emissions, improves job satisfaction for farm workers, reduces injury and stress in animals, improves welfare and encourages biodiversity using native shrubs and trees.

Costa Rica has formalized its plans for low emissions development in agriculture through the National Strategy for Low Carbon Livestock and their Livestock Nationally Appropriate Mitigation Action

(NAMA), linking with national goals of carbon neutrality and national contributions determined under the Paris Agreement. Working with local and international partners, including USDA and the U.S. Agency for International Development (USAID), the research being conducted in Costa Rica provides important lessons to the entire region for achieving sustainable natural resource management and improved livelihoods through low emission cattle farming. See Box 3.1 for a description of the project and nature of collaboration.

Box 3.1: Costa Rica's Strategy to Reduce Livestock Emissions

CATIE, an international research and education center in Costa Rica, has been working with FONTAGRO, a unique cooperation mechanism for agricultural innovation among 15 countries in Latin America, the Caribbean and Spain, to coordinate efforts between public and research sectors with the private sector to reduce GHG emissions related to the cattle and dairy industries. The concept was to legitimize policies based on quantifiable research, improve capacity building within the industries to measure, monitor and reduce emissions and to facilitate investment in improved practices. The findings were then used to guide regional planning and support positive behavior changes for cattle and dairy farmers.

The Dos Pinos' Milk Producers Cooperative was started in 1947 to support agricultural development and cattle raising, by selling milk at a fair price and buying inputs in bulk. Two cooperatives, Finca El Duraznal and Finca Ukrania, associated with the Dos Pinos Cooperative, have taken various actions to implement low-emission cattle farming and have participated in the CATIE research. These actions include water harvesting during the rainy season and the extraction of purines from cattle excretion for application in pastures. This makes soil less porous and, combined with organic matter, the soil needs less chemical fertilizer and is better able to retain water, meaning less water usage. They have found some farmers to be resistant to these technologies due to some extra work and because it uses non-traditional methods, but through capacity building provided by the cooperative, more farmers have come to see the importance and implemented the suggested practices.

As part of the research, CATIE was able to demonstrate that milk cows crossed *Bos Taurus x Bos Indicus* showed the lower emissions intensity of enteric methane in comparison to the Jersey breed. In addition, the research found that using fodder banks and concentrates can reduce GHG emissions related to cattle farming. CATIE, in the framework of the FONTAGRO platform, found that adjusting the mixed feed supplement (forage shrubs and concentrate) for milk cows could help to significantly to reduce N₂O gases, which negatively impact the environment. These lessons are now being shared to replicate results and strengthen regional collaboration.

Low emission cattle farming in Costa Rica has contributed to building a competitive, productive, and low carbon livestock sector through: (1) the promotion of technically sound policies; (2) capacity building on greenhouse gas emission quantification; and (3) facilitating investment and implementation opportunities for good farming practices. One significant outcome of this work was the development of complementary Monitoring, Reporting, and Verification (MRV) and Financial Mechanism systems. The MRV system, in particular, was viewed as innovative due to the quantification of greenhouse gas emissions sequestration attributed to cattle activity at the national level, assessment of levels of productivity and profitability of the application of the suggested good practices, documentation of fund availability assessments for implementation of low emissions practices, and evaluation, of biophysical, economic and social components of improved practices. There were also extension materials prepared (manuals and videos) for technicians and farmers to support the process of participatory learning with farmers. The extension materials include the themes prioritized by the NAMA such as improved pasture, silvopastoral systems, efficiency in the use of fertilizer, and manure management.

Lesson 9: Focus on the ‘right’ technology over the ‘latest’ technology when introducing & financing new agricultural technologies.

While international development practitioners have long talked about using “appropriate technologies” depending on the level of development of a country, its people, and infrastructure, cutting-edge technologies can be enticing to propose to rapidly scale impacts to farmers but can fall short of expectations in implementation. Although smallholders represent a large market opportunity, this is not an easy market to serve. It is important to consider the risk profile of these customers, their adaptive capacity and the ecosystems in which they live, work and grow crops.

Climate-smart finance (or “green” finance) can be helpful to encourage farmer uptake of new technologies and climate-smart solutions can help to reduce GHGs while increasing farmer resilience. Using climate-related data, from geo-tagged farms, soil testing, and mapping of weather and temperature patterns can help to facilitate green finance, especially when integrated with crop requirement databases, or used with credit scoring and early warning systems. There are an increasing number of private sector and global investors interested in scaling green investments, including the Green Climate Fund.

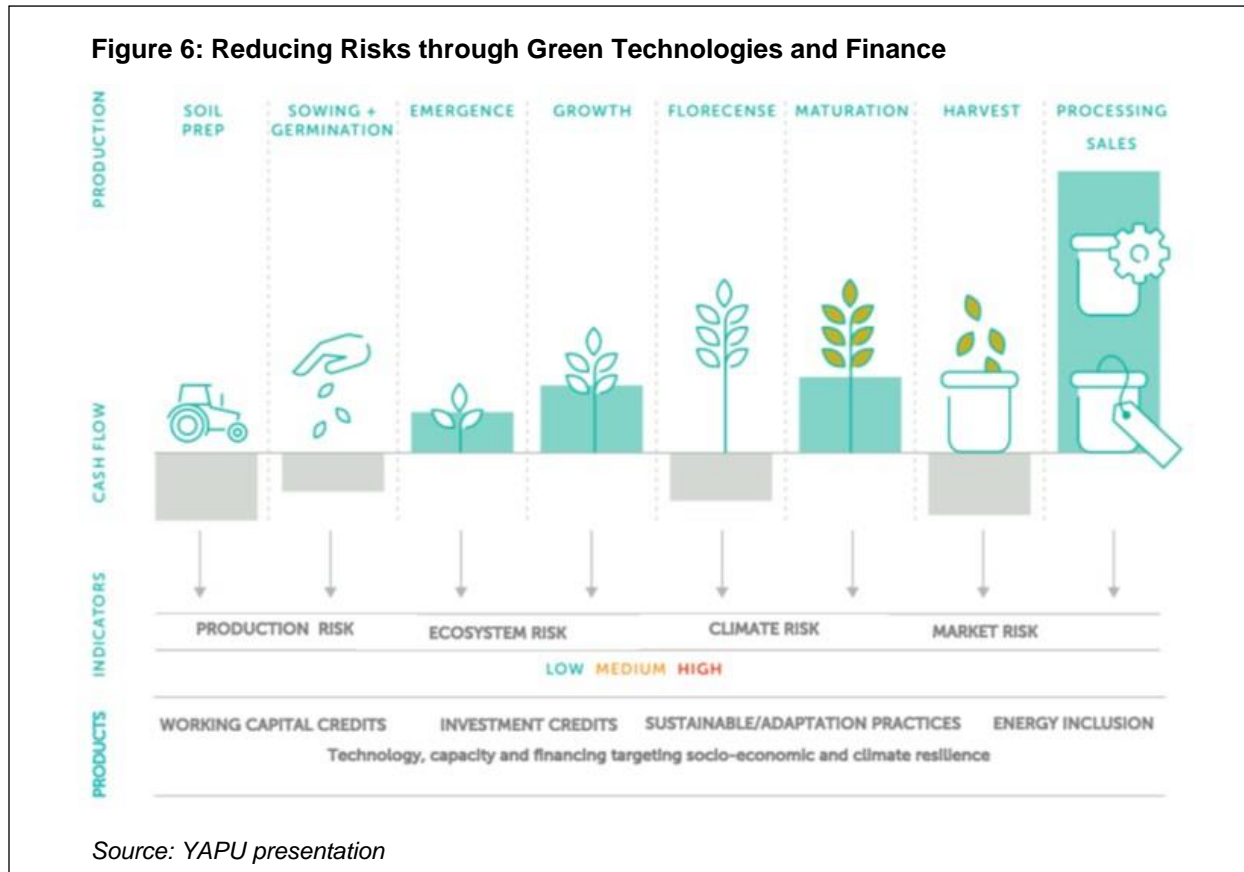
Simultaneously, financial institutions are increasingly prioritizing agriculture and rural finance, and considering climate and ecosystem dimensions. Though, they often do not possess the capacity to assess and manage associated risks or develop suitable financial products. At the same time, investors, donors and policy makers require sustainability not only in operational processes but also and primarily in financial investments. But promoting sustainable finance requires increased levels of awareness raising, training, field monitoring and evaluation, and is therefore often seen as an additional cost. As a consequence, numerous initiatives have failed to scale beyond initial promising pilots.

As part of IDB’s EcoMicro project, YAPU Solutions has found that climate change is a challenge for microfinance institutions and identified 183 MFIs that had developed climate-smart financial products. These, however, represent less than 1% of their portfolios, since climate change is complex, requires investment and is not MFIs’ core business focus.

In developing and applying a software solution for MFIs working in climate-smart finance (see Figure 6 for products that can mitigate risks), YAPU has the following lessons learned:

- Smallholder farmers need awareness and capacity building before finance.
- Access to available climate-smart inputs and practices needs to be ensured if not created.
- Storage solutions and market integration for final production should be integrated in an overall solution package.
- While MFIs are not primary providers of the above solutions, they can act as facilitators in rural areas.
- To that end, internal processes within MFIs need to be enhanced, such as:
 - Adjustment of corporate governance.
 - Introduction of digital lending processes.
 - Enhanced understanding and early identification of climate risks.
 - Integration into existing or emerging connective data ecosystems.
- A promising outlook is provided by the emergence of digital rural advisory services and agro-data platforms.

- Support mechanisms can be provided by donors and policy makers in the form of guarantee funds for first loss or performance guarantees, economic incentives and payments for ecosystem services, initial technical assistance, training programs, as well as coordination mechanisms and entities at regional or national level.



To engage sustainably in climate-smart finance, enabling and promoting climate-smart agriculture, a new framework and methodological approach in (agricultural) microfinance is needed. “MFIs can be catalysts and facilitators, serving the last mile of climate-smart finance,” but they need to be integrated with agri-data and technical assistance platforms. The “right” technology is not about big data collection and assessment, but more about managing the data more effectively and using information that is already available and layering additional analysis related to climate and ecosystems for improved lending and portfolio monitoring. In other words, MFIs should weigh the advantages and disadvantages of usage vs. complexity of information needed for enhanced decision making. YAPU presenters also argued that performance guarantees, tracking environmental impacts, can also be used to encourage scaling of climate-smart technologies.

Lesson 10: It is important to understand what motivates farmers and leverage local culture to encourage adoption of new technologies.

One non-profit learned this lesson the hard way. Karen Lopez and Angela Bastidas explained that their organization, Semilla Nueva, aims to address high levels of poverty and malnutrition in Guatemala by producing, marketing, and selling bio-fortified corn seeds to farmers. In most malnourished areas of

Guatemala, corn represents 70% of caloric intake. While it is easy to grow and store, making corn low cost to the consumer, it has limited nutritious value. So Semilla Nueva decided to introduce the QPM maize variety of corn, as well as Chaya (Mayan spinach) and pigeon pea, using a farmer to farmer model to address food security and improve nutrition. By 2015, Semilla Nueva realized that the model was not working. While nutritious, Chaya required too drastic a change in diet and Guatemalans simply did not like the taste of pigeon pea. The QPM maize variety was lower yielding than traditional corn and did not yet command a higher market price. It took Semilla Nueva four years to reach 25 communities while the Guatemalan population grew by 1.5 million. Semilla Nueva recognized that they needed a more efficient model to combat malnutrition.

Given the importance of corn in the culture, Semilla Nueva piloted hybrid biofortified corn that had 2.5 times more protein and 50% more zinc than traditional corn. As a result of market research, instead of marketing the corn based on its nutritional value, in 2016 Semilla Nueva focused on what mattered most to the farmers – increased yields, revenues, and income. Taste tests found that 98% of families said the tortillas made with this corn taste the same or better than their usual ones. By the end of 2017, 4,160 farmers had used seeds, 28% of which was sold through agrodealers. In 2018, Semilla Nueva’s approach is fully commercial, with 100% of the seed sold to 2,600 farmers who planted the corn as of May. Table 1 highlights Semilla Nueva’s escalating impact on Guatemalan diets based on this new market-oriented approach.

Table 1: Semilla Nueva’s Impact with Biofortified Corn on Guatemalan Diets

No. Diet Improved	2016 actual	2017 actual	2018 estimate
Total Diets	25,697	52,409	105,698
Children’s Diets (ages 0-14)	9,302	19,670	38,263

By the end of 2023, Semilla Nueva expects to sell 15,000 bags of biofortified maize seed, representing 1 million diets changed. Nonetheless, this will still represent only 10% of the maize market in Guatemala so Semilla Nueva is looking forward to partner with more farmer’s associations and local seed companies to increase the biofortification footprint.

Lesson 11: Sometimes economic and scientific benefits are insufficient to encourage smallholders to apply new climate-smart behaviors.

There are several reasons why small and medium producers may not apply climate-smart practices, including historical and cultural norms, risk avoidance, market structures, lack of access to finance, and the time delay to realize cost savings. It is critical to understand the context and farmer perceptions (the user) in order to better target climate-smart technologies in the field.

In Mexico, for example, RTI International and CIMMYT found that farmers stopped applying climate smart practices even after the initial pilot phase demonstrated improved cost-effectiveness of inputs, increased farmer profits, and reduced CO₂ emissions with the use of the GreenSeeker Handheld Technology (see Figure 7). CIMMYT piloted the technology in Sonora, Mexicali, and Guanajuato, Mexico, to address the economic and environmental problems associated with inefficient nitrogen



fertilization practices. GreenSeeker uses Normalized Difference Vegetation Index (NDVI) sensors to scan wheat, maize, barley, and sorghum plants to determine the appropriate amount of nitrogen to apply during the second application of the fertilization cycle, when the crops need the most and farmers tend to over apply fertilizer. Researchers have collected 11 years of data with more than 1,000 wheat observations in the Yaqui Valley of Sonora. As a result of using the GreenSeeker technology, farmers avoided a total of more than 14,000 tons of CO₂ emissions in the three regions, which is equivalent to more than 3,000 cars off the streets for a year. By applying the technology (even if they deviated from the recommendations), farmers saw an average profit increase of \$36-\$61 per hectare per crop cycle over the course of implementation. As mechanization increases in emerging economies, over-application of nitrogen fertilizer will increase; GreenSeeker attempts to improve the process by anticipating the need and preparing farmers to think about their inputs as demands in production change.

IV. Using Digital Platforms to Facilitate Agricultural Knowledge and Finance

Global growth in digital tools is unleashing a new agricultural revolution: one in which data and technology allow for improved communications across value chains, enable on-demand services (such as transport), providing more relevant information for precision farming and streamlining payment processes. Digital platforms are becoming increasingly important for reducing transaction costs and facilitating the flow of knowledge, resources, and finance to agribusinesses. Such platforms can automate management functions, including inputs procurement, product purchasing, inventory management, farm production, asset management, and access to savings and credit vehicles. Below are some of the lessons shared at the conference related to this theme.

Lesson 12: Cloud-based, mobile accessible platforms can automate a variety of management functions across the value chain.

Several applications supporting the management of value chains have emerged globally, including Farmforce, SourceTrace, Farmerline, iProcure and others. These software products provide an extensive suite of functionalities, which integrated agribusinesses can use to better manage their value chains. Such platforms can automate management functions, including inputs procurement, product purchasing, inventory management, farm production, asset management, and access to credit.

TechnoServe recently undertook a case study of Akili Holdings, a Kenyan agribusiness, to document its innovative model, called Akili eT, and developed a detailed business case for its use, including quantifying its success in creating profit for the smallholders in its value chain. Through its cloud-based, mobile platform, Akili is able to manage all aspects of its business. The software also enables them to have data on compliance, farmer profits, yields and Akili's profits, thereby helping to prove the business case for the usage of Akili eT. Technoserve's evaluation of Akili's model shows that farmers who move from growing maize to becoming an Akili spinach farmer can expect their average profits, on a quarter acre, to increase from US\$119 to US\$554. See Box 4.1 for a description of the Akili eT application.

It is important to note that while Akili's use of a cloud-based, mobile application has certainly contributed to its success, their approach is built on a strong foundation honoring the basic tenets of building relationship equity between a farmer and a buyer. In particular, Akili offers participating farmers entry into a new and high value crop with guaranteed prices, risk mitigation through crop insurance and health insurance, provision of quality inputs in a timely manner, access to finance, agricultural extension including standard cropping protocol, and a high-touch relationship management and farmer organization structure.

Box 4.1: Cloud-based, mobile application, Akili eT, use to manage value chain

Akili works in Kirinyaga country, on the slopes of Mt. Kenya and is an agribusiness that processes spinach, mangos, honey, and other high value food crops for domestic and export markets. This region is particularly well suited for spinach as farmers can grow four crops per year. Akili has a contract with a US buyer for dried spinach and has built an innovative contract farming model where farmers in the region produce the spinach and bring it to the collection points where it is picked up by an Akili truck and transported to Akili's processing facility for drying.

Akili uses a cloud-based software called Akili eT that they developed in-house. The software is reflective of Akili's holistic contract farming model. The model has three core components:

1. **Integrated contract package** (research and best practices information, production and marketing support, inputs, aggregation and value addition);
2. **Risk mitigation support** (input quality assurance, imbedded crop and health insurance and guaranteed pricing and buying); and
3. **Financial services** (credit on inputs to be repaid at harvest, transaction records and digital payments).

This business model allows smallholders to become competitive, as it covers their risks and assures them rewards. The Akili eT software has modules for farm production and geo-referenced asset management, input procurement, produce purchasing, payment processing, farm production, inventory management, savings and credit (via SACCOs) and carbon credit monitoring.

These modules allow Akili to create and store farmer profiles on the cloud that include i) GPS coordinates for farm location; ii) measurements of soil composition conducted every season; iii) cashless purchases of seedlings, inputs and irrigation supplies; iv) exact record of planting, fertilizer and pesticide use, and yield; v) payments after crop delivery; and vi) protocol adherence including for US regulatory standards for production. Farmers have access to their digital profiles and have the flexibility to auto-report. Updates are also made to the platform during regular farm visits by Akili's extension agents.

Lesson 13: SMS-based digital warning systems can help farmers cope with climate change and mitigate losses by providing actionable information and building resilient systems.

Some of the top challenges that farmers face is low productivity, lack of access to financial services and to markets, and negative impacts of pests/diseases as well as climate change. Several digital tools have been developed to overcome the above challenges – some are targeted more at managing the operations of the agribusiness (such as Akili eT from Lesson 12), whereas others are focused on directly engaging the farmer and providing personalized services to her.

SMS-based digital warning systems combined with actionable information can be a key tool in a farmers' arsenal to reduce on-field losses. However, to provide personalized information, as well as tackle the variety of issues farmers face, a more holistic approach requiring human and digital touch is required. Box 4.2 on Grameen Foundation's work with coconut smallholders in the Philippines illustrates their approach, where 65% of the farmer respondents said that they learned what to do to mitigate risks for pests and extreme (dry) weather through SMS.

Box 4.2: FarmerLink's Approach to Building Smallholder Resilience

Grameen Foundation is working with coconut smallholders in the Philippines in a project called FarmerLink. Despite being part of a multi-billion export industry, 60% of coconut smallholders live at or below the national poverty line. Grameen Foundation orchestrated a consortium of key partners to help smallholder farmers to achieve food security and integrate them as reliable and capable players in the coconut value chain. The partners included:

- Philippine Coconut Authority to improve productivity;
- People's Bank of Caraga to increase access to financial services;
- Nutiva, Franklin Baker and Chokolade de San Isidro for direct access to markets; and
- Palantir, aWhere and engageSpark for an Early Warning System pilot to detect pests and diseases.

Grameen uses the power of mobile technology to enable the last-mile human network of field agents. The field agents are trained on a mobile customer relationship management software that helps development sector-managed field operations. Using the mobile application, the agents create farmer profiles of participating farmers, which includes the farmer's socio-economic data, farm location, productivity information, and current agricultural practices. The farmer profiles are very robust, and the field agents collect 300 data points per farmer.

Based on their profile, the farmers start receiving personalized SMS messages on good agricultural practices, financial literacy, pests and diseases. During the one-year pilot, 27,554 farmers were registered to receive Early Warning System alerts via SMS with instructions on what to do to mitigate losses. The Early Warning System triggers alerts on weather conditions as well as potential pest and disease outbreaks using weather and farm-level data. Farmers also receive coaching on how to adopt best practices, which includes formulating a farm management plan and monitoring harvest levels.

FarmerLink's results show that the holistic approach combining human and digital touch increases farmers' resilience. The power of early warning system alerts is undeniable – through SMS alone, farmers are driven to action. Of the participating coconut farmers, 65% said that they applied the pests and disease mitigation practices. The step-by-step, granular advice and instructions sent through the text messages allowed farmers of varying backgrounds to implement the technical advice and improve their production systems. In addition, Grameen Foundation found that consistently returning to the farmers and the extension agents for trainings and feedback when deploying the digital tools was critical to their success.

Lesson 14: Digital tools, such as for gross margin calculation, can enable farmers to better understand their own costs and improve their decision-making.

One of the key challenges that farmers face in developing markets is that they tend to be limited to what is traditionally grown in their region due to limited knowledge of other crops and markets. A market-oriented approach can help farmers to grow what the market demands and increase their income. However, several barriers exist for such a farmer, including low access to information on market demand, market prices, as well as the challenges associated with a new crop. Farmers also need to decide their cropping calendar and the ideal mix of crops to optimize their land use as well as incomes. Subsistence farmers require a full suite of additional interventions related to good agricultural practices, financial services, and marketing. One of the solutions to these challenges is to integrate business planning and profitability assessment into the suite of farmer-level support activities. Going through the exercise of business planning, including using the business model canvas and looking at the gross margin achievable for different crops, can help farmers make better decisions on what to plant and put them on the pathway to growth and prosperity. Catholic

Relief Services (CRS) applied this approach with support from its Farmbook Digital Toolkit, as explained in detail in Box 4.3.

Box 4.3: Farmbook Digital Toolkit

Catholic Relief Services has been developing the Farmbook Digital Toolkit in collaboration with DiMagi, through its CommCare tool. The toolkit enables field agents to prepare farmers to better engage with the market “smartly” and sustainably. Currently the toolkit is reaching 200,000 beneficiaries in sub-Saharan Africa and Asia.

The toolkit has four primary features that meet the needs of farmers, field agents, and project managers:

1. Map & Track for farm-level data collection for monitoring and evaluation;
2. SMART Skills e-learning through online/offline courses on agro-enterprise trainings to help farmers increase production, grow their incomes, and engage with markets;
3. Farmbook Business Planner, a tool that guides field agents and farmers through the process of creating business plans that are based on participatory value chain studies; and
4. Farmer Feedback, ensuring data is analyzed and findings are shared with stakeholders.

The SMART Skills and Business Planner features are important in CRS’s methodology, called “Pathway to Prosperity,” to take farmers from pre-commercial to commercial stage. The SMART Skills curriculum has modules on savings and loans, group management, natural resource management basics, marketing basics, financial education, innovation, and the seven steps of marketing. The trainings are delivered in this order as households move from the recovery to growth stage in CRS’s Pathway to Prosperity.

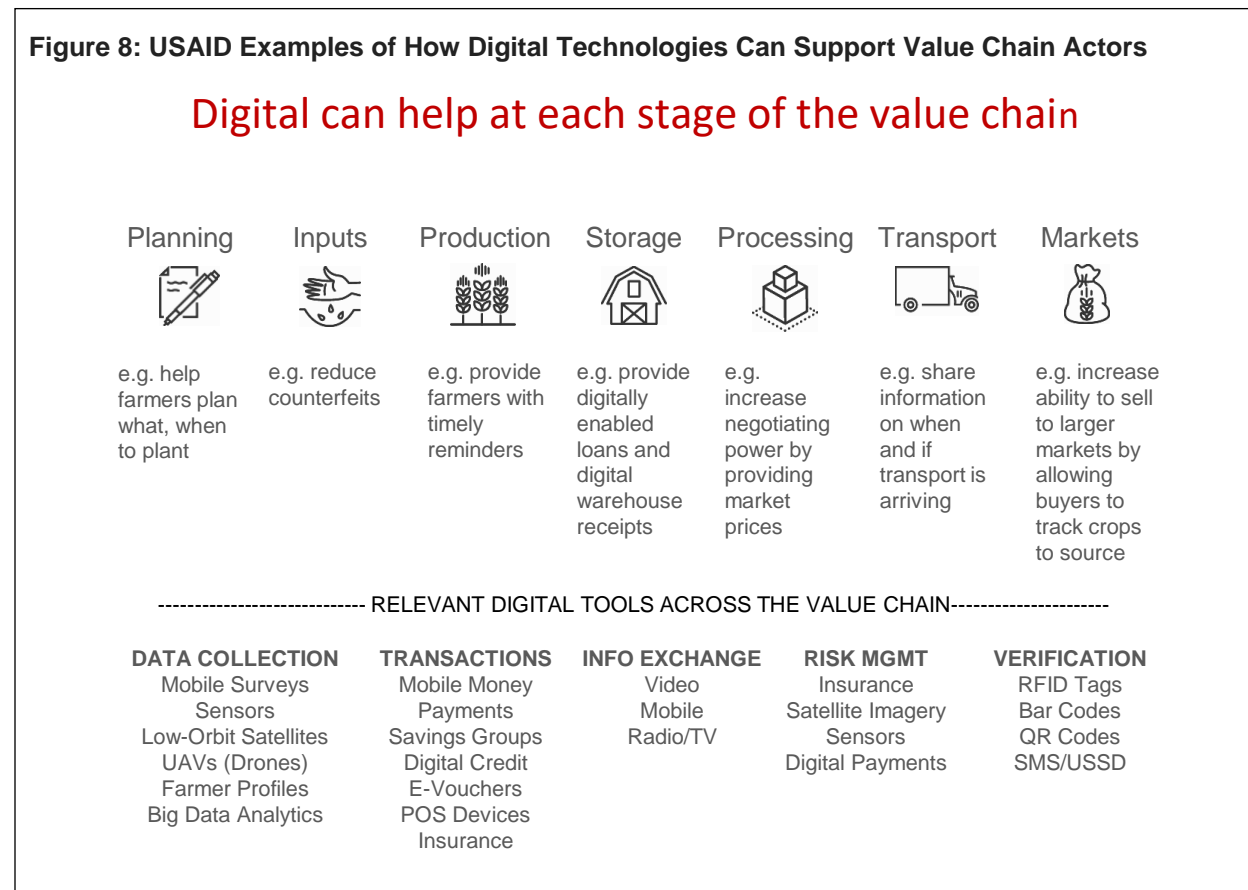
The Business Planner module includes Farmbook’s new Profitability Assessment Tool, which disaggregates data for improved decision making. The previous version of Farmbook’s business planning module focused on assessing profitability of products and developing business plans for farmers and farmer groups. The new tool incorporates multi-crop assessments to evaluate actual farm household finances. For example, the tool shows farmers the gross margin per hectare for a selection of crops, so the farmer can select the best combination of crops to cultivate. The tool also shows the number of crops a person should cultivate (based on agro-ecological zone and gender) to maximize their incomes while balancing workloads. In this way, the tool is able to aggregate information of the farmers in the region and then show this data to the farmers to support their decision making.

As a result of the implementation of the Farmbook toolkit across Sub-Saharan Africa, CRS has identified important lessons to consider in future iterations. For example, CRS is committed to reducing survey fatigue for field agents and farmers via a minimum number of standard surveys per country and customizing them to specific country needs. In addition, CRS now aims to report only important aspects depending on the targeted client, as not all survey data needs to be shared. Additional concerns include digital literacy and connectivity and the need to create champions of data appreciation and use through inclusive participation. Looking ahead, CRS also plans to work on integrating financial services into the toolkit and on incorporating advanced analytical models for site specific advisory services. Lastly, it continues to work on how to create incentives for better data collection.

Lesson 15: The rapid proliferation of digital tools is helping to facilitate the flow of agricultural knowledge across value chains and financial access to the rural poor.

There is a broad range of technologies that are considered digital, from radio, SMS texts and low-cost videos to Internet-based applications, GPS-enabled mapping, remote sensors, and big data. Leveraging

digital tools can improve the cost effectiveness, reach, and impact of agricultural development efforts. In selecting the best technology for development purposes, Judy Payne argues that what is important is to know your target users, including their access to power, communication devices, languages, literacy, and gender. On average, women are 14% less likely than men to own a mobile phone and the global Internet user gender gap has been widening in the last three years, compounding gender inequities.



USAID has been supporting efforts globally through a number of mechanisms, including innovation prizes, competitions, research support, and private sector partnerships. The United States’ Global Food Security Strategy (FY2017-2021) recognizes digital platforms as a key tool to improve development impacts. Figure 8 highlights ways in which digital technologies can be used at each level of the value chain and Box 4.4 highlights some of the global evidence USAID has compiled on the use and value of digital tools for agriculture. While USAID-funded agricultural projects often use digital tools, far too few are scalable and sustainable. The trick is to keep users at the center of digital tool design, while maintaining low costs per user and following the Principles for Digital Development (<https://digitalprinciples.org>). Development projects should look to build on pre-existing technologies and plan for scaling and exit from the start.

As Alefia Merchant and Gerson Morales explained, USAID/Guatemala recently studied the digital ecosystem in Guatemala and is looking for ways to apply some of the global lessons to the Guatemalan context, where there is decent use of smart phones (59% of mobile phone users), but no national financial inclusion strategy or regulations for mobile banking yet. USAID/Guatemala’s AgriJoven activity, for example, is a public private partnership with Rana Labs to empower 55 youth groups to tell compelling stories using videos that reinforce good agricultural practices. The AgriJoven Project and its youth groups

also work with horticulture exporter, Fair Fruit, to pilot a savings and loan methodology and to demonstrate what agricultural technology is most appropriate for small-farmer adoption.

Box 4.4: Evidence from USAID’s Investments in Digital Tools for Agricultural Development

- In Ethiopia, livestock deaths were cut in half by using satellite imagery to find good grazing lands;
- In Haiti, a mango exporter saved more than \$1,600 per year by shifting from cash to mobile purchases;
- In Kenya, soil testing has helped thousands of farmers improve their use of inputs;
- In Senegal, Web-based spreadsheets helped a rice miller to improve transport scheduling resulting in better prices for tens of thousands of smallholders.
- In sub-Saharan Africa, farmers who pay for market prices via a private digital service realize 200% return on investment – i.e., the price they paid for this service -- on average.
- SMS messages to farmers to remind them to do specific tasks at the right time increased yields by 11% on average in Africa.
- In West Africa, a simple lay-away savings service that helped farmers to buy inputs resulted in 50%-100% increases in yields.

In addition to a variety of case studies and toolkits, USAID offers the following digital resources that could benefit rural and agricultural development:

- [Identity in a Digital Age: Infrastructure for Inclusive Development](#)
- [Making the Journey from Cash to Electronic Payments](#)
- [Gender and Information Communication Technology \(ICT\) Survey Toolkit](#)
- [Integrating Low-Cost Video into Agricultural Development Projects](#)
- [Integrating Mobiles into Development Projects](#)

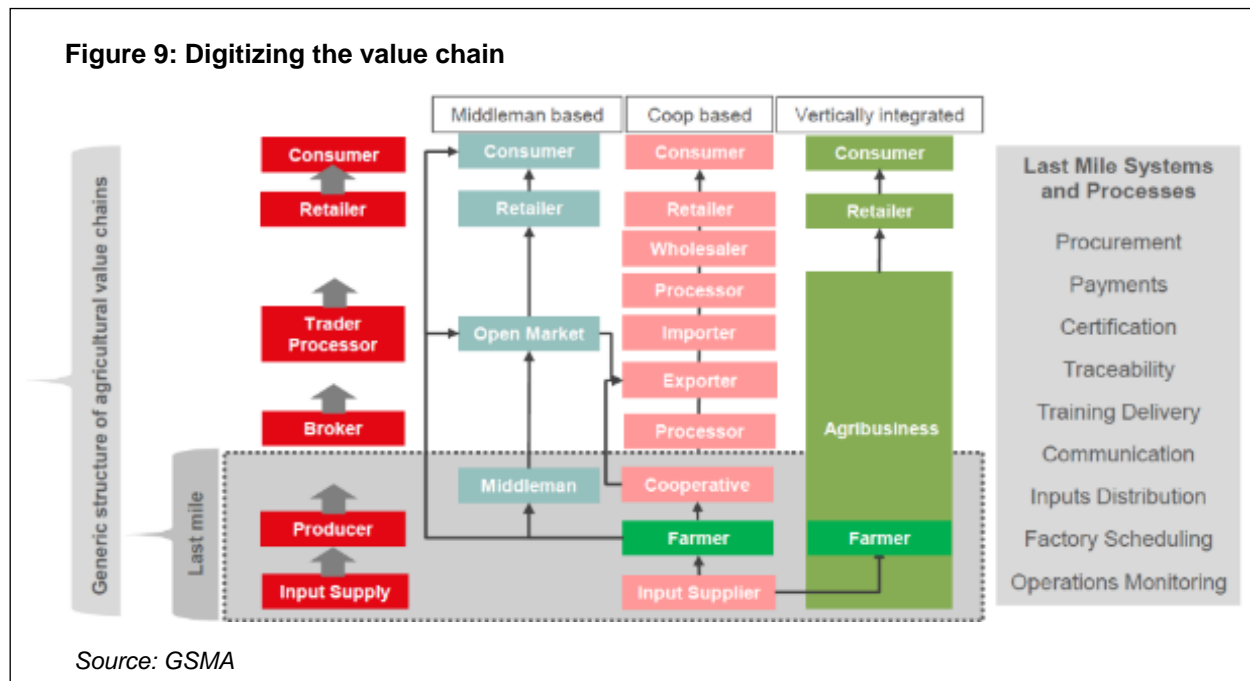
Lesson 16. Market segmentation impacts access to digital tools.

Some early digitization initiatives have found that entry points for digitizing agricultural value chains are more likely to be in procurement models where farmers have formal relationships with the buyers of crops because the incentives to increase transparency, quality and predictability of supply are stronger. Under such models of procurement, cooperatives and agribusinesses – either local commercial businesses or larger multinational companies operating via contract farming – are the most likely customers of digital tools for the last mile here defined as “the web of relationships and transactions between buyers of crops such as agribusinesses, cooperatives and middlemen, and the farmers who produce and sell their crops.” In this context, digitizing the last mile refers to supporting the buyers of crops to use mobile-enabled tools that support systems and processes in remote rural areas. Figure 9 below identifies the three main procurement models in agricultural value chains (middleman based, cooperative based, vertically integrated) and offers examples of last mile systems and processes.

Digitizing value chains via mobile-enabled tools brings a wide array of benefits to farmers in emerging markets by enabling financial inclusion; supporting the uptake of better agricultural practices and skills development; and allowing for more transparency and visibility for farmers into last mile operations.

To assess the attractiveness of value chains for digitization, GSMA follows a framework, the aim of which is to generate insights on different aspects of a value chain’s operations. The framework assesses the

suitability of the value chain (formal procurement, frequency and size of transactions), competition in the value chain (farmer's access to market and drive toward farmer loyalty), traceability and certification requirements (pressure from international markets), agribusiness technology readiness (availability of technology and digital literacy) and profile of key stakeholders.



GSMA has identified six main types of digital tools where mobile technology can address challenges farmers and agribusinesses face in the last mile:

1. Mobile information services to overcome farmers' lack of knowledge and access to agri-related information;
2. Mobile money to overcome the heightened risk and cost of dealing in cash. Mobile money also helps farmers build a credit history that allows them to eventually access formal finance;
3. Digital profiles to address the challenge of lacking a formal economic identity;
4. Track and trace systems that respond to the need of agribusinesses to ensure full and real-time visibility in the supply chain for traceability and certification of goods;
5. Internet of Things (IoT) applications for agriculture that allow agribusinesses to monitor and control operations and assets;
6. Agribusiness analytics tools which, by leveraging multiple existing data sets and integrating them with analytics capabilities, enable agribusinesses and farmers to make informed decisions in real time.

Lesson 17: In creating new ICT4D platforms, implementers should consider sustainability upfront, ensuring an exit strategy off of donor or project dependence.

In creating ICT4D platforms to support agricultural extension services, for example, it is important to develop a strategy upfront for data collection, ongoing maintenance and sustainability beyond the initial design and pilot testing phases. Smallholder farmers generally need agricultural extension services, but they rarely can afford to cover the full cost. While “we haven’t yet cracked this nut,” admits Garrett Schiche of Lutheran World Relief, technology can help to reduce costs to make agricultural extension services more

sustainable. Nonetheless, an exit strategy should be designed early on to ensure that the ongoing content updates and maintenance costs are covered. Schiche warns project implementers to “Be careful not to focus on technologies that are for project reporting rather than locally sustainable; technology needs to make business sense.” Schiche advises that the “size of cooperative and profitability must be understood to select appropriate technology.” Often technology that is developed to serve a single agricultural cooperative is not sustainable. Whereas an ICT4D platform developed to serve a federation of cooperatives with thousands of farmers in Niger was financially viable.

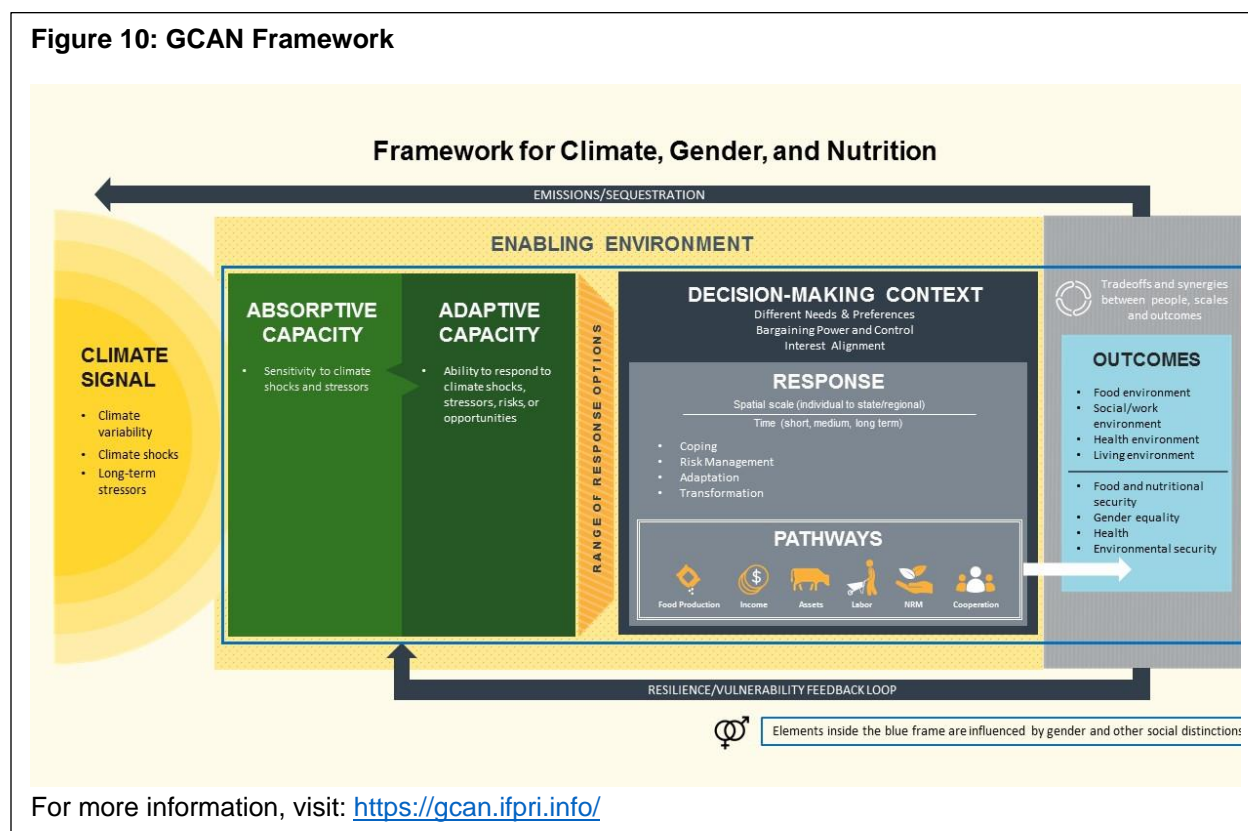
Open source software, such as TaroWorks and We Farm, tends to be more cost-effective than customized, proprietary software and therefore more sustainable over time. Before implementing a new ICT4D platform for agricultural extension, it is important to start with basic data and make a clear case for data collection; the value of the data and analysis should exceed the cost of accessing it. In Ecuador, ECOM’s agronomists collect information and use it to help farmers improve their agricultural practices, which builds trust and loyalty. Reliance on salaried agronomists is expensive, however, so ECOM is now looking at ways to use technology to improve efficiency without losing loyalty. ECOM’s Pamela Schreier explains that “this means relying more on self-reported data,” but acknowledges that farmers are afraid to provide real data for fear it might be used in negative ways, such as to increase taxes. So, there is still need of field workers to verify data, but perhaps with less frequent visits. Alternatively, one could determine who else could use the data and for what purpose. This could open the opportunity to share the cost of data collection with other service providers, such as credit agencies or input providers, or reduce the insecurity of producers by identifying ways in which the data serves them directly, so they see the usefulness of providing real information.

V. Moving Forward

There are several cross-cutting lessons that emerged at the conference related to agricultural technology adoption and resilience. Factors such as gender, youth, nutrition and partnerships are extremely important considerations as we attempt to wield the power of new technologies to address long-standing development problems.

Lesson 18: When designing agricultural technologies, gender and nutrition dimensions need to be considered to create more equal access and outcomes and greater impact.

Women and men have different needs, preferences, capabilities, resources, and bargaining power which, in turn, affects their adoption and utilization of agricultural technologies and the outcomes associated with these technologies. To promote better understanding among researchers, policy-makers, development practitioners, and other stakeholders of the linkages between climate change, gender and nutrition, the International Food Policy Research Institute (IFPRI) has created a Gender Climate Change and Nutrition Integration Initiative (GCAN) Framework (see Figure 10), which identifies several elements in which gender and nutrition issues should be considered. An accompanying checklist provides guidance to development practitioners on how to integrate gender and nutrition as they design and implement resilience-building programs.



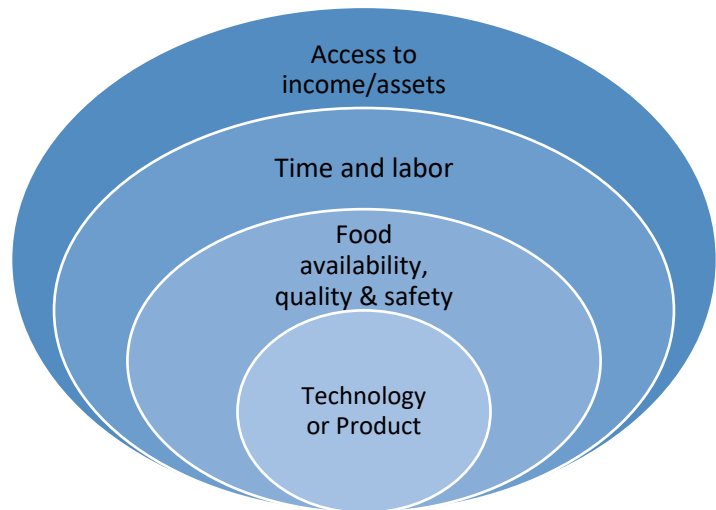
Another tool that incorporates a gender technology assessment and nutrition considerations is the USAID-funded Integrating Gender and Nutrition within Agricultural Extension Services (INGENAES) toolkit, “Assessing How Agricultural Technologies can Change Gender Dynamics and Food Security Outcomes,” (see Box 5.2) developed by Cultural Practice, LLC.

Box 5.2: INGENAES Toolkit

The toolkit comprises three sections: Learn, Apply, and Share. The Learn section of the toolkit describes how an agricultural technology affects food security dimensions, time and labor, and access to income or assets for women and men. The Apply section provides different tool options that can be used to enhance the design and dissemination of agricultural technologies, and the Share section includes a facilitator’s guide on how to design and conduct a workshop to share the methodology.

For more information, visit:

<http://ingenaes.illinois.edu/technology-assessment-toolkit/>



What both tools emphasize is that the end-user and the context in which agricultural technologies are introduced matter. When designing a technology, there are potential trade-offs and opportunities for different groups of users; analyzing and being cognizant of this allows practitioners to make more informed decisions. Ultimately, this can help to not only increase agricultural technology adoption, but also ensure social inclusion and gender equality, mitigate potential harm, enhance effectiveness and impact, and achieve other development outcomes.

Lesson 19: Facilitating access to finance for agricultural technology can help launch young entrepreneurs’ agribusinesses.

At past *Cracking the Nut* conferences, the concern has been raised that youth are not very attracted to working in agriculture, especially in direct production. However, youth are particularly attracted to new technologies and how they can be used to create business opportunities. In Rwanda, Connexus has been working with Education Development Center (EDC) on its USAID/Huguka Dukore project, which aims to provide 40,000 vulnerable youth with gainful employment. Given that many of these youth live in rural and agricultural areas, Connexus is working with youth groups to set up horticultural businesses, accessing drip irrigation equipment and inputs through group discounts, savings, and loans. In the first six months, Connexus identified technical training and job opportunities for 1,040 youth through partnerships with six private businesses. One agro-dealer, Holland Greentech, has created 14 demonstration plots through which it trains youth on horticultural best practices. The youth do the majority of the work and, at harvest, they are allowed to sell the produce in local markets. With this initial savings, they are then connected to local financial institutions for access to a small loan to purchase drip irrigation and climate resilient seeds to start their own agribusiness. Connexus has trained a number of local finance institutions on “Designing Youth-Appropriate Financial Services,” which include savings and loan products at reasonable interest rates.

Several of the partner financial institutions have already adapted their financial products to the needs of young agripreneurs, based on cash flow analysis and with loan repayment linked to the harvest. In less than two years, Huguka Dukore has already linked 1,361 youth to formal financial service providers. Connexus is now expanding this model in connection with CRS’ Savings and Internal Lending Committees that operate in rural areas across Rwanda.

Lesson 20: Governments, donors and multilateral institutions should actively promote climate smart agricultural intensification.

A strong policy framework can be used to guide farmers to implement climate smart agricultural practices. Governments can incentivize the adoption of climate smart agricultural practices and technologies to reduce vulnerability to climate change and build resilience, including diversification and intercropping, efficient irrigation and water management systems, solar energy and pumping systems, enhanced genetics and seed varieties that increase yield and resilience, to name a few. With World Bank support, for example, the Government of Uruguay built on its existing institutional framework to identify agricultural vulnerabilities and turn them into opportunities through a set of laws, regulations and interventions that incentivized farmers to use land more intensively. As Julia Navarro of The World Bank explained, “The shock of the drought in 2007 forced Uruguay to take a different approach.” The Sustainable Management of Natural Resources and Climate Change project (known as DACC in Uruguay) supported the set up and design of the National Agriculture Information System (SNIA), which publicly launched in 2016. Created as a “public good,” this online, state of the art platform integrates data from 32 national agencies and provides tailored information to support a broad range of users, including policy makers, researchers and the private sector. With a strong focus on soil management, SNIA uses satellite monitoring and soil sampling, which has to date resulted in quadrupling food production 2010), increasing adaptive capacity by 20% and reducing CO2 emissions by 8.8 metric tons per annum. (See Figures 11 and 12 below exemplifying the applicability of SNIA for soil water content from the Government of Uruguay)

Figure 11

Estimated Water Available (%)
in Uruguayan Soil by Political Section
February 1 – 10, 2015

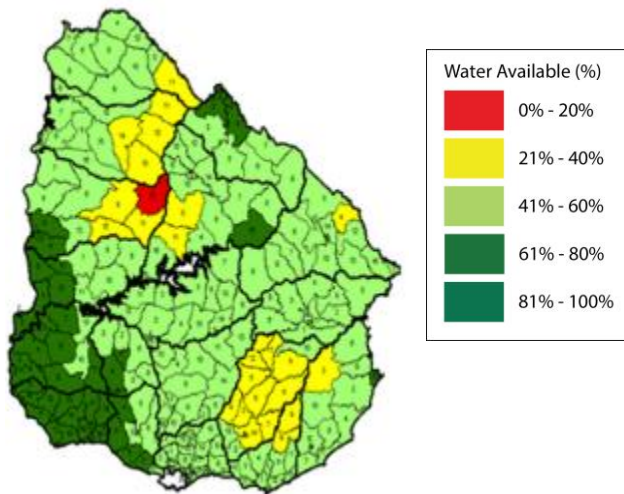
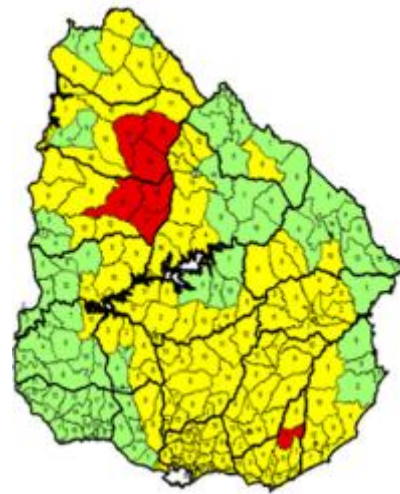


Figure 12

Estimated Water Available (%)
in Uruguayan Soil by Political Section
February 11 – 20, 2015



In addition to the SNIA knowledge platform, the Government of Uruguay has created an institutional framework including early warning and early response systems, indexed based insurance, and policies that reduce risks, including water and grasslands monitoring, risk mapping for drought and production, agro-

chemical controls, livestock registration and promotion of climate smart nutrient models for feeding livestock. The Government has also offered paid incentives (or reduced taxes) to encourage the adoption of climate smart practices and made traceability mandatory, which has paid off in terms of better export prices and higher incomes.

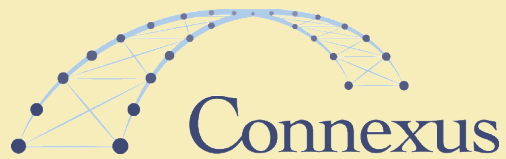
Ireland offers another example of a strong policy framework, which led to improved productivity and competitiveness within the beef and lamb value chains, while simultaneously reducing greenhouse gas emissions. The Irish Agriculture and Food Development Authority supported the creation of the Beef and Lamb Quality Assurance Scheme and Sustainable Dairy Assurance Scheme, which relies on a carbon audit tool, called the Carbon Navigator (see Table 2, which highlights the Carbon Navigator’s core elements to deliver economic and environmental benefits). To date, Ireland has audited 45,000 beef farmers (90% of production) and 13,000 dairy farms (75% of production).

Table 2. Carbon Navigator’s Core Elements

Dairy Carbon Navigator	Beef Carbon Navigator
Grazing season length	Grazing season length: Suckler cows and followers
Improved genetics and breeding	Age at first calving
Improved nitrogen efficiency	Calving rate
Improved manure management	Live weight performance
Energy efficiency	Improved nitrogen efficiency
	Improved manure management

Conclusion. Luis Alejandro Mejía, Lead Investment Officer of IDB Invest, closed the conference with some important comments. He emphasized the importance of building collaborative networks based on champions and incentives. While small players can come up with innovative technologies, short-term results are often needed to motivate farmers to implement climate smart behaviors and facilitate access to finance. However, national and regional policies and institutions are needed to support broadscale uptake of climate smart solutions and to create eco-system level impacts needed to address the risks of climate change. Nonetheless, he highlighted the role of market-based approaches and private sector partnerships to reinforce this policy framework. To be truly effective, digital platforms will need to combine elements of big data and analysis as a public good, combined with market-based applications and user-friendly data sharing and access. He concluded by encouraging the community to further explore how technology can be a market inclusion enabler for women, youth, and minorities in developing countries.

As implementers of *Cracking the Nut*®, Connexus Corporation hopes that these lessons and cases will be helpful to others working to promote agricultural technology adoption and resilience around the world. For the next *Cracking the Nut*® learning event, participants suggested that the community look beyond technology at the other drivers of rural and agricultural policies and markets, to consider the role that large buyers can play in causing price shocks and how public and private actors can respond to mitigate risks throughout value chains, including but not limited to smallholder farmers. Stay tuned!



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