Digital Innovations for the Coffee Value Chain in Honduras and Guatemala

A scoping study

Jenny Melo
Jenny Wiegel
Alliance of CIAT and Bioversity

1

ABOUT THE AUTHORS

Jenny Melo is a Ph.D. Candidate in Rural Sociology at the University of Missouri and a Visiting Researcher at the Alliance of CIAT and Bioversity. Jenny Wiegel is a Senior Research Fellow at the Alliance of CIAT and Bioversity

Table of Contents

Executive Summary

- Several digital technologies across the value chain in agriculture vary in complexity and scope. The common thing in these technologies is their use of data, which is the core of this new economy.

- Not all data is equal; it can be generated and used on-farm and off-farm. According to the type of data are specific concerns on access and sharing.

- When considering these technologies' social impacts, inclusion/Exclusion, Data governance, and Power Distribution are three aspects to pay attention to.

- According to the Agricultural Digitalization Index (The World Bank), Honduras and Guatemala have a low availability and affordability development and a better situation in the enabling environment for a digital transformation.

- Twenty-three digital technologies were mapped, varying in their readiness to scale.

- **Digital advisory and extension:** Six technologies were identified (2 in Honduras, 1 in Guatemala, and 1 in Nicaragua). These technologies are focused on delivering data on weather and crop diseases, aiming to inform better decision-making by farmers.

- **Digitized Farm Tools:** Five technologies were identified. Only one with action in Central America. These technologies are oriented to facilitate farmers' information management in the crop. Only one, offers specific information for an aspect of the coffee process (level of ripening of coffee grains).

- **Digital financial services:** Three technologies were identified. One developed in Honduras, and one already with operations in the country. Both included a digital wallet.

- **Digitized Market Linkages:** Nine technologies were identified. Four have actions in Central America. These technologies, mainly developed on blockchain, aim to promote traceability along the food chain. Some emphasize on sustainability information and others in price.

Introduction

This work offers a synthesis of the current digital technologies available for coffee that are relevant to the context of Honduras and Guatemala. It results from desk research considering current literature (grey and academic) and interviews with actors selling digital technologies to the Centro-American coffee sector.

This summary is organized into four parts. First, there are introductory concepts on digital technologies applied in agriculture, useful to have a common ground; Three aspects are covered here: what are digital technologies, their potential, and what socio-ethical aspects should be considered when promoting these technologies.

Second, there is an overview of digital technologies in Honduras and Guatemala.

Third, there is an overview of the digital technologies currently available in the coffee sector. In this section, twenty-three technologies are presented and organized by service types, level of development, and seller information.

Four, there are comments on the potential impactful technologies, a review of aspects to consider when supporting these technologies, and conceptual and methodological recommendations useful for the future work of the team testing digital technologies in the field.

This work was developed in the context of the Initiative Rethinking Food Markets and Value Chains for Inclusion and Sustainability, developed by the Bioversity-CIAT Alliance and the CGIAR support.

Initial Concepts
What we should know about digital technologies in agriculture?

What are digital agricultural technologies?

Several technologies with different layers of technological complexity, focused on data.

Several names referring to digital ag technologies

Agriculture 4.0, e-agriculture, precision agriculture, smart farming, and Agtech are some names scholars and industry people use.

These names often overlap in their meaning, scope and innovations included. Despite their differences in naming, in general terms, all these refer to the "digitalization of agriculture," a process under which all sorts of activities conducted to produce, commercialize, and consume food use at some point digital technologies (Klerkx., et al. 2019).

Digital technologies are "tools that collect, store, analyze, and share information digitally, including mobile phones and the Internet" (World Bank Group, 2019)

Different kinds of digital technologies vary in complexity

This sector is not monolithic and comprises different layers of technological sophistication.
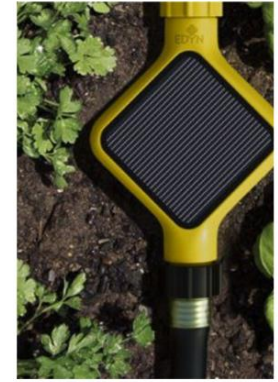
Farm management platforms

Robotics

Sensors

Apps for farmers, SMS

Blockchain

Apps for consumers

How to classify digital agricultural technologies?

Layers of complexity, Place in the commodity chain and types of service

Layers of complexity	Place in the commodity chain		Types of service	
FAO, Interamerican Development Bank and identifies five segments within digital technologies in agriculture (Trendov et al., 2019): 1. Mobile devices and social media 2. Precision agriculture and remote sensing technologies; 3. Big data, cloud, analytics, and cybersecurity 4. Integration and coordination systems such as blockchain, financing, and insurance systems; and 5. Intelligent systems such as deep learning, machine learning, and artificial intelligence.	Agricultural inputs	Fintech for credit evaluation and payment services Data-based insurances Genome-edited seeds	Digital Advisory & Extension	Information delivered digitally to farmers on different topics looking to improve decision-making and increase in productivity and quality.
	Farm operations	Precision agriculture equipment Digital machine-sharing platforms Data-based agronomy advice and information Farm management platforms	Digitized Farm Tools	Products and services that facilitate the collection, synthesis, and interpretation of farm data, aiming to optimize farming practices and production.
	Food Processing	Collaborative robotics 3D food printing	Digital Financial Services	Digital products and services offering access to different financial services intending to improve farmers' yields and income.
	Transport	Quality sensors and analytics Digital transport logistics for small-scale producers		
	Storage	Automated warehouses	Digital Market Linkages	Digital services that facilitate farmers' access to transactional interactions along the food chain.
	Retail and Consumption	Smart shopping E-commerce platforms	Supply chain management	Solutions along the food system helping different actors to facilitate flows of information.
	Entire commodity chain	Digital tools for commodity chain traceability and transparency		

Source: Prause, Hackfort and Lingren (2020)

Source: Based on Porciello et al., (2021) and Digital Agri Hub (2021)

What is digitalization?

Using technologies does not mean digitalization

Three different stages

There are different stages when we refer to the use of digital technologies.

- Digitalization is the use of digital technologies to improve and streamline various business and management tasks. It can involve linking data from different sources, using context and situational awareness to make decisions, and reacting to real-time events. (Rijswijka, et al., 2021)

- Digital transformation is using digital technologies to improve and transform various aspects of an organization or society. This process involves increasing the system's complexity, including the interactions between elements such as technologies, institutions, organizations, people, and the environment. The impact of digital transformation can be either positive or negative. (Rijswijka, et al., 2021)

DIGITIZATION
Converting analog information to a binary code

DIGITALIZATION
Using digital technologies to adapt how processes are carried out

DIGITAL TRANSFORMATION
Renewed model based on the integration of digital technologies
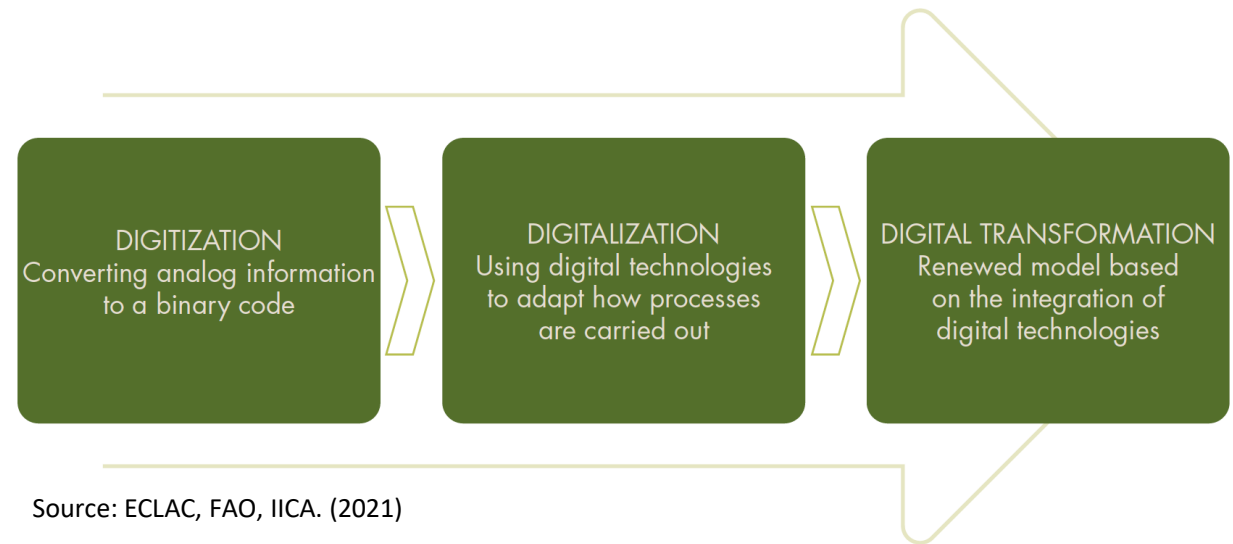
Source: ECLAC, FAO, IICA. (2021)

What is the data of digital agricultural technologies?

Data imported and exported, for use on-farm and off-farm

Data is the core of the concept

In this context, data is all information related to food systems that can be digitally collected, stored, analyzed, and shared.

Not all data used in the farm is the same

Localized data: data created and compiled on the farm to be used solely on the farm

Imported data: market prices and climatic information analyzed and tailored for use on-farm by a third entity that owns, manages and controls this data.

Exported data: data generated and compiled on the farm for off-farm use comprises the third stream; it is called "exported data" and can be gathered by farmers or using advanced tools.

Ancillary data: on-farm and off-farm data for use off-farm make up the fourth stream. It is called "ancillary data" and includes, for example, government statistical and research data on agriculture.

Streams of farming data
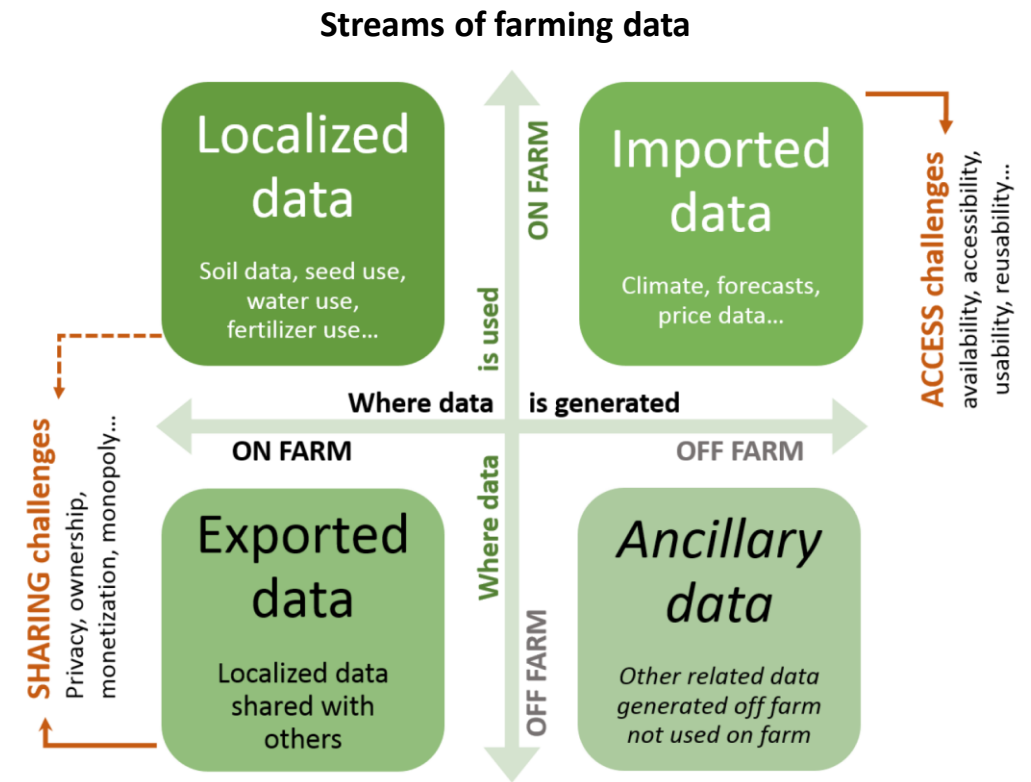
Source: GFAR, GODAN, and CTA (2018)

What is the data of digital agricultural technologies?

Data as a commodity and means to governance

Data has multiple uses relevant to business and development

Data can be a simple piece of information with no value, a commodity, and can be used to make decisions or change a system's governance.

Using data requires understanding the data economy and the whole new system that could be possible with game-changing technologies.

For Wolfert et al., (2021).,

"Data economy is a physical economy in which traditional processes are influenced and transformed by better use of data, with focus on topics such as 'big data analytics, 'digital transformation' and 'digital transitions' p.17

"A data ecosystem is a network of databases and stakeholders working together on or being connected by the data they produce or use" p.22

The value ladder of data in different functions and roles
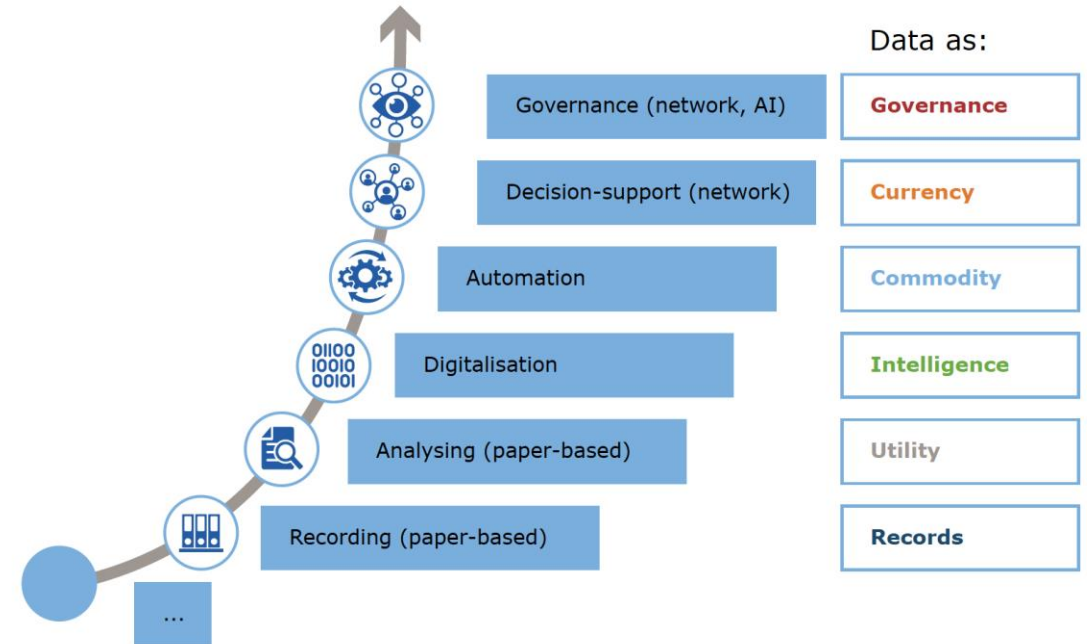
Source: Wolfert et al., (2021).

Why the enthusiasm with digital agricultural technologies?

Technologies promising to improve efficiency, profitability, and sustainability

The promise of efficiency, profitability, and sustainability through increasing efficiency and decreasing transaction costs

The central promise of these technologies is to improve efficiency, profitability, and sustainability along the food value chain.

This promise is delivered through two cumulative pathways related to technical and allocative efficiency and transaction costs (Schroeder, Lampietti, and Elabed, 2021).

Data provided by digital agricultural technologies allow for a better allocation of physical, natural, and human resources while reducing transaction costs for searching, contracting, monitoring, and enforcement. The results of this efficiency should be profitability and environmental sustainability.

Pathways for Digital Agriculture to Improve Efficiency, Equity, and Environmental Sustainability
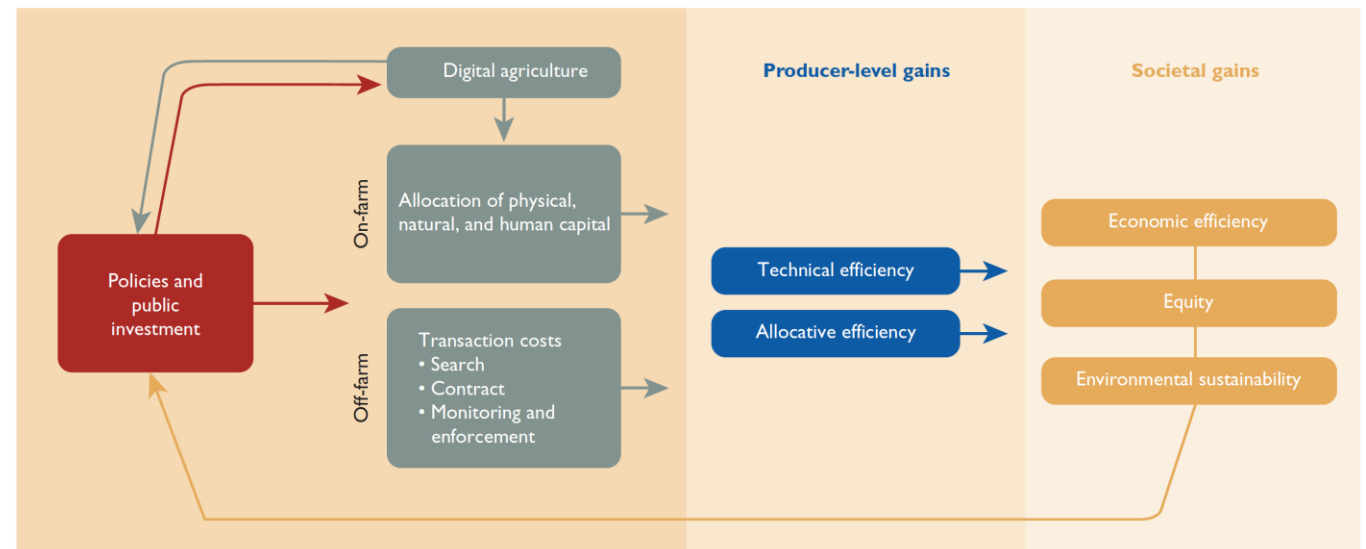
Source: World Bank, cited in Schroeder, Lampietti, and Elabed (2021).

What are the potential impacts of these technologies?

Potential outcomes could be traced in growth, resilience, sustainability, inclusivity and empowerment

Porciello et al., (2021) , propose four categories and specific outcomes related to each one.

Agricultural-led growth	Resilience and Risk	Healthy People and Planet	Inclusivity, empowerment and agency
Specific Outcomes	Specific Outcomes	Specific Outcomes	Specific Outcomes
• Income: Change in income • Productivity: Change in on-farm crop, labor livestock productivity • Yield: A change in harvested crops • Practice Change: Changes in a user's practice related to other agricultural outcomes, such as yield, productivity, and/or income • Market efficiency: Change in decision-making based on available, relevant market information	• Resilience: Mitigate, adapt and recover from shocks and stressors • Cost effectiveness: Cost benefit analysis for the Digitally Enabled Agricultural Services (DEAS) supplier (including quantified development outcomes, not just monetary outcomes) • Climate resilience: Prevention or minimizing the impacts of climate change • Community cohesion: Reduced conflict, stronger social networks and/or increased collaboration within a community	• Environmental sustainability: Improved sustainability of natural resource management, such as water, forest or soil management • Nutrition: Improved household nutrition, including increased food supply and security	• Increased knowledge about agriculture-related content • Gender and women's empowerment: Increase in influence, decision-making or agency • Social inclusion: Reduce or remove the obstacles that limit the agency, decision-making capacity • Social learning: non-users indirectly increasing their knowledge and/or changing their practices through digital technologies by observing and/or interacting with technology users.

What are the problematic aspects of these technologies?

Inclusion/Exclusion, Data governance and Power Distribution

Multilateral organizations, social movements, and rural scholars have expressed concerns about technology implications. The voices from diverse arenas show that worries about technology's potential implications are not only about diffusing the technology to farmers but are also present in their design and governance.

Three interlinked practical factors can inform practitioners' and farmers' conversations on these technologies (Melo and Hendrickson, 2022):

Inclusion /Exclusion

The biggest concern is the digital divide, which refers to the unequal access populations worldwide have to the Internet and digital technologies. A comprehensive view of the digital divide must consider inequalities in access, competencies, and capacities to obtain benefits.

Considering inclusion and exclusion acknowledges that social, spatial, and economic inequalities exist and play a role in benefiting from access to digital technologies.

Data governance

Thinking about data governance requires understanding the specific type of data in question, ownership rights in place through contractual agreements, and interests being protected through these arrangements.

Power Distribution

Power "is an unequal relation, or inequality, based on personal attributes, institutional positioning, and statuses that are defined, codified and acted upon within historical and cultural contexts."

Power in action:

- How is the narrative about these technologies shaped?

- Who intervenes in designing, testing, and placing technologies in the market? Who can make choices, who designs, who sells, who buys, who can pay, which price, who can repair, who owns data, who can profit from data?

- Who benefits in the end? Do these technologies deepen control and value extraction?

What aspects to consider when promoting digital technologies?

We are in a twilight zone when thinking in digital technologies.

Digitalization is happening so fast, and many aspects are unclear and under debate

Scholars from Wageningen University highlighted that we are in a twilight zone because definitions are under debate, pros and cons are unclear, there are only a few preliminary examples of data platforms for food systems known, and data ecosystems are only just emerging (p8).

They suggest that navigating this zone will require the following:

- Responsible Innovation Lens

- Sustainability through a life cycle analysis

- Deepen on trust and data-sharing features

- Explore the implications of technological limitations and connectivity

- Relationship with Agricultural Knowledge and Innovation System (AKIS)

The evolution of the digital transformation in food systems towards a twilight zone where a paradigm shift is needed.
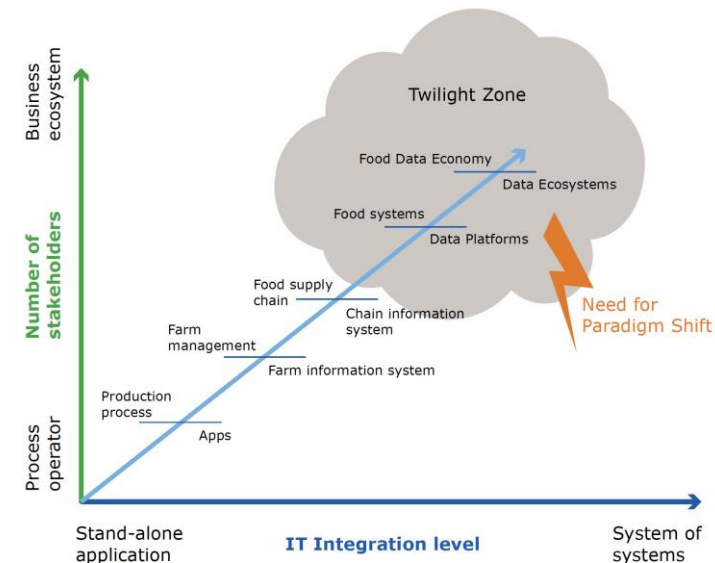
Source: Wolfert et al., (2021).

Digital Agriculture Overview for Honduras and Guatemala
What is the current situation?

How is the digital agriculture context?

Honduras and Guatemala have a low development in availability and affordability, and a better situation in the enabling environment for a digital transformation

According to the **Agricultural digitalization index* ,** Guatemala and Honduras are in a similar situation regarding the enabling environment for a digital transformation.

Country	Agriculture Digitalization Index	Availability				Affordability					Enabling environment				
		2G coverage (%)	3G coverage (%)	4G coverage (%)	Digital Agriculture Availability Subindex	Mobile tariffs	Handset price	Mobile-specific tax	Inequality	Digital Affordability Subindex	Market Access Index	Access To electricity	Basic skills	Online Services Index	Nondigital Enabling Environment Subindex
Costa Rica	64.7	93.1	73.7	26.0	**58.5**	69.1	58.8	39.5	32.0	**52.7**	93.7	100.0	70.1	68.2	**83.0**
El Salvador	63.2	99.7	74.2	38.6	**65.1**	40.4	45.3	52.5	54.5	**47.1**	99.5	100.0	52.3	57.7	**77.4**
Guatemala	52.0	84.0	43.5	21.8	**42.9**	29.7	50.6	85.0	24.0	**45.9**	78.1	94.7	45.3	51.2	**67.3**
Honduras	48.2	87.2	53.7	10.0	**42.9**	12.5	27.1	79.4	25.3	**32.8**	89.6	91.9	47.4	46.5	**68.9**
Nicaragua	40.3	59.1	21.7	2.2	**21.4**	19.1	34.0	63.6	39.5	**36.6**	55.9	88.1	52.9	54.7	**62.9**

Source: Schroeder, Lampietti, and Elabed (2021).

* The World Bank (Schroeder, Lampietti, and Elabed , 2021) introduced the agricultural digitalization index, a 0-100 measure covering:

Availability: it estimates the share of farmland in a country with mobile coverage.

Affordability: it measures the availability of mobile services and devices at price points that reflect the level of income across a national population.

Nondigital enabling environment: it considers enablers of non-digital enablers and market capacity to support digital innovation: market access, access to electricity, basic skills level, and the Online Services Index.

How is the digital agriculture context?

The ICT regulatory environment is transitioning and more advanced in Honduras than in Guatemala.

Guatemala's score on ICT Regulatory tracker* is 62,70, which is in the second generation of regulation: opening markets and partial liberalization and privatization.

Honduras's score is 79,00, is in the third generation of regulation: enabling investment, innovation, and access, and has a dual focus on stimulating competition in service and content delivery and consumer protection.

ICT Regulatory Tracker Guatemala 2007-2022
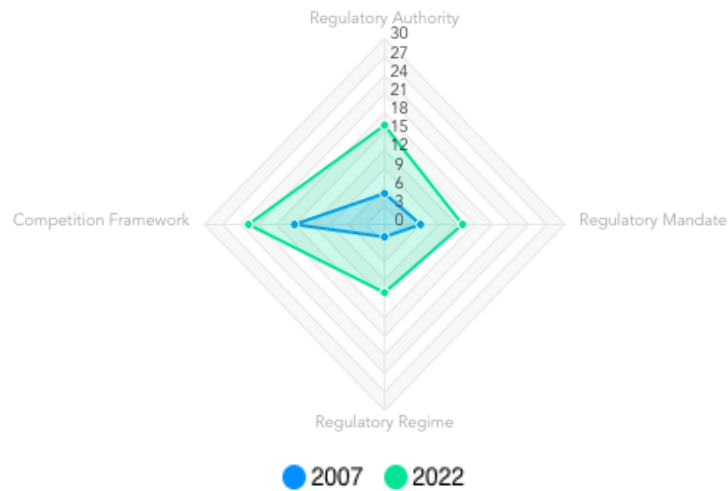
ICT Regulatory Tracker Honduras 2007-2022
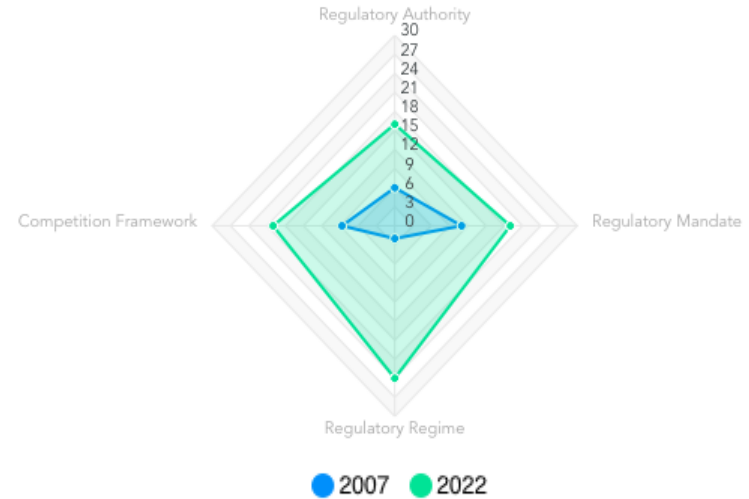
*The tracker, developed by International Telecommunication Union (ITU), "pinpoints the changes taking place in the ICT regulatory environment. It has four sub-indicators: regulatory authority, regulatory mandates, regulatory regime and competition framework.

Source: ITU (2022)

How is the digital agriculture situation in Honduras?
An extremely nascent sector facing infrastructure challenges

A recent report developed for USAID (Strategic Impact Advisors. 2022) summarizes the main of the main characteristics of the Digital Agriculture landscape in Honduras:

Supply-side actors

The vast majority of digital agriculture services are delivered either via international development projects or through larger value chain partners.

Three types of suppliers of digital agriculture services in Honduras:

1. Agribusinesses that have built their platforms using either internal programmers or outsourced software engineers,
2. Technology companies or
3. International development projects that have built their services using either internal programmers or outsourced software engineers.

Advisory services

Advisory services are the most abundant digital agriculture service available in Honduras. Donor-funded projects or government-led initiatives provide the vast majority of these services.

- WhatsApp as a primary digital channel use case
- Fewer options for non-smartphone and illiterate populations
- Multiple efforts with the same functions
- Platform sustainability is a big question mark
- In an interview, COHONDUCAFE stated their coffee farmers saw a 20% yield increase among farmers interacting with their digital advisory services.

Market Linkages

- Most do not use e-commerce or online marketplaces but connect buyers to farmers' groups through WhatsApp.
- Olagro, a marketplace funded by the EU, faces challenges in aggregation, post-harvest storage, and transportation logistics

How is the digital agriculture situation in Honduras?

An extremely nascent sector facing infrastructure challenges

Finance

- Honduras has a national financial inclusion rate of 45%, while only 39% of the rural population has financial accounts. There is also a significant gender gap between men and women account ownership; 50% of men have accounts and only 41% of women own accounts.
- E-money wallets grew 34% between 2019 and 2020, with COVID-19 pushing for digital payments.
- Financial institutions serving small farmers and other members of agricultural value chains deploy only a few digital solutions that serve the farmer.
- There are no data sharing agreements or pilots that use alternative data sets to assess creditworthiness between banks and fintech.
- Proagro and Banco Atlántida both offer crop insurance products, with a total of 11,500 hectares under coverage. The uptake of insurance has been complex primarily due to the high premium costs.

Ecosystem support

Two organizations provide necessary digital agriculture ecosystem support services that enable other digital agriculture products to function:

- CENAOS is a government agency that runs 180 weather stations throughout the country. They offer weather information directly to farmers and other digital agriculture services. Weather information includes rain, temperature, and soil moisture where sensors exist.
- Instituto de la Propiedad is a government agency that runs land and movable asset registries. They provide ways to register property ownership online and manage the registry enabling over 1,500 different public and private sector stakeholders, such as banks, to access land ownership information.

Digital Agriculture technologies for coffee
What is available today?

Introduction

A methodological note

Below are the main findings of desk research on the digital technologies available today for the coffee sector and related to the context of Centro-America.

This mapping was conducted between October-December 2022 and targeted different layers of complexity and service types. Four interviews were conducted with social companies (1), private companies (1), and development organizations (2) developing specific technologies for coffee in Central America to obtain more information on the features of these technologies.

With this mapping, 23 technologies were identified. These are presented considering the following:

- Types of service

- Readiness to scale

- Types of sellers

When analyzing this mapping, it is essential to consider the following:

- There is a scarcity of information available. The information available on the official websites shows the main features but it does not provide information on the number of implementations, prices, and the business model behind them.

- This mapping focuses on Central America and is not exhaustive. A few cases from other countries were included to illustrate the possibilities for the sector.

- Within the list of digital technologies, only a few focused on coffee. Finding a technology that can be used in several crops is expected.

The information obtained is organized in a Readiness to scale. It categorizes technologies into four groups according to their development level. This matrix was classified based on the available information only.

Overview of the digital technologies in the mapping
## Each type of technology make different promises

The twenty-three technologies make different promises:

Digital advisory and extension: access to helpful information for better decision-making, reducing vulnerabilities, and promoting optimization.

Digitized Farm Tools: access to organized on-farm valuable information for better decision-making, optimization, and increase in production; organization of information, helpful to access differentiated markets compliance of value chain standards.

Digital financial services: access to financial services.

Digitized Market Linkages: traceability as a means to have a better position in the market.

Digital Financial Services	Digitized Farm Tools	Digital Advisory & Extension	Digital Market Linkages
3	5	6	9

23 technologies identified
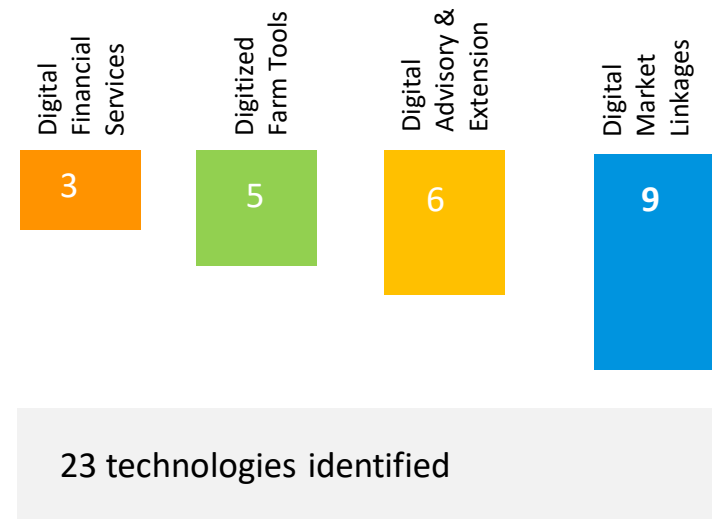
Digital technologies offering digital advisory and extension

Information delivered digitally to farmers on different topics looking to improve decision-making and increase in productivity and quality

Country	Name	Description	Seller
Honduras	Agricultor Conectado	Platform offering several data on weather, natural resources and other variables linked to productivity. It suggest best agronomic practices.	Dimitra
Guatemala	Coffee Cloud	Coffee Cloud enables coffee growers to run offline crop tests in the field, based on methods approved by the regional agriculture ministries, and receive immediate recommendations on how to combat the rust based on the level of contagion and current weather conditions. The app tracks the levels of the disease in the crop and shows behavioral graphs.	Anacafé
Nicaragua	Clima y Café	It is an early warning system designed to improve coffee growers' resilience. It is based on a network of youth promoters of Coops associated with Cafenica. It is also a communication network. Farmers receive the information through the app and WhatsApp groups It shares information on crop management, resilience, weather, diseases, and pests.	Asociación de Cooperativas de Pequeños Productores de Café de Nicaragua
India	Coffee Krishi Taranga	The service provides regular advisory to growers via their mobile phones and an inbound hotline that farmers can call to access free information services. Farmers registered on the service receive a two-minute voice call in their local language with targeted agricultural advice to optimize coffee-growing practices throughout the coffee crop cycle. This information is customized across a variety of parameters including irrigation facilities, the location of the farmer, and the variety of coffee grown.	Precision Development (PxD) has partnered with the Coffee Board of India (CBI)
Honduras	INFOAGRO-SIMPAH	This platform is a long-standing information center for the agricultural sector to access market prices and early warnings concerning pests and diseases. The platform takes prices from different regions and makes them available via their website. Farmers can also register to receive messages via WhatsApp or SMS concerning specific regions and crops.	Fundación Hondureña de Investigación Agrícola and the Ministry of Agriculture in Honduras
Colombia	Plataforma Agroclimatica Cafetera	Website platform offering historical data on weather, studies on zonification, and land use for coffee regions in Colombia.	Centro Nacional de Investigaciones de Café - Cenicafé

Digital technologies offering digitized farm tools

Products and services that facilitate the collection, synthesis, and interpretation of farm data, aiming to optimize farming practices and production.

Country	Name	Description	Seller
Central America	Farm Diary	It is an application supporting farmers to register information about on-farm activities.	Solidaridad
Mexico	Sirio App	A digital tool supporting coffee coops for data management. Data: yield, crop, quality, prices, sales. Do not require an internet connection to work.	Nuup
United States	Taroworks	A farm management platform used to support farm certification. Use mobile forms to track harvest yields, and certifications, visualize disease conditions and monitor the progress of agriculture projects. Includes: Real-time data Offline CRM – build farmer profiles Record orders, sales, quality Photo capture Geotag"	Taroworks
Colombia and El Salvador	Smart Agro	Installation of sensors to identify soil moisture, irrigation and water consumption in the field, and use of an app to make decisions base on that data. Farmers receive recommendations of irrigation and use of ag inputs.	Telefonica Movistar in partnership with FAO
Brasil	Cromai	Vision computational – An algorithm that identify the level of ripening of coffee grains and indicates where to start their harvest.	Cromai

Digital technologies offering financial services

Digital products and services offering access to different financial services intending to improve farmers' yields and income.

Country	Name	Description	Seller
Honduras	Mi Caja	Mi Caja is a digital savings wallet. As part of a broader bundled service, Mi Caja also offers agronomic advice to farmers via the app, accessed through Android and iOS devices. The content and planning for this advice is done by FUNDER, which uses the Agrodigital platform to push agronomic advice messaging. Agrodigital provides the software and technical support but does not do any direct farmer outreach. Instead, it works with clients such as FUNDER who then work directly with farmers.	Agrodigital and Fundación para el Desarrollo Empresarial Rural (FUNDER)
Colombia	Coffee Growers' Smart ID	The Smart ID is an ID for coffee growers associated with the National Federation of Coffeegrowers with the capability to store data about the cardholders' farms; • Allows for payments to coffee growers for crops sold to the Federation, and store data on these purchases (like the type of coffee sold); • Allow for the payment of other transfers, such as subsidies, from the Federation to the coffee growers; • Guarantee the coffee growers' access to withdraw cash, especially in municipalities without a financial presence, both online and offline; • Provide at least three transactional points in at least 380 municipalities16 (one of which should allow cash withdrawal), and keep track of "points" accumulated by coffee growers at designated commercial establishments — to be used for discounts or prizes.	National Federation of Coffeegrowers
United States With operations in Honduras	GrainChain	• Banks will use GrainChain to manage loans to small- and medium-size farmers, including using the digital wallet for unbanked farms to enable loan disbursements. • Insurance companies will use GrainChain tools to simplify and automate underwriting of farmer loans backed by banks and the federal government. • Co-ops and growers will benefit from GrainChain's advanced traceability tools, farmer management, logistics management and farmer loan programs. • National exporters and marketplace buyers benefit from using GrainChain's smart contracts for settlement, traceability, purchasing commodities and instant transfer of title"	Grain Chain

Digital technologies offering digital market linkages

Digital services that facilitate farmers' access to transactional interactions along the food chain

	Country	Name	Description	Seller
	International	Sustainable Coffee Verification	It is a data-driven sustainability verification program for coffee. Enveritas assesses sustainability practices across three pillars at coffee origins: social, environmental and economic. Roasters use it for risk assurance in sustainability compliance. Farmers use it for data-driven, yield-increasing technical assistance.	Enveritas
	International	Sello #GetFair	A platform of information management showing the impact of a product in people and planet through a blockchain register on quality, sustainability and productive processes.	GetFair
	United States	TraceCoffee	It captures content and data on origin, processes and supply chain all the way to the destination. Creates a transparency link from farm to cup.	Trace.Global, Inc.
	Colombia and United States	ifinca	A digitalization system, protected digital ledger, allowing transparency, and traceability from source to consumer.	Ifinca
	United States, with operations in Honduras	IBM Food Trust	Food Trust helps enable farmers and buyers trace coffee and cocoa beans from the farm to the point of sale. The blockchain technology also provides a record of provenance for smallholder farms.	Alliance between IBM Food Trust and IBM Watson Decision Platform for Agriculture, Heifer International and IBM
	International	Cropster Origin	Cropster Origin is a complete information management system for coffee producers. Record raw cherry delivered to you with the Origin mobile app, monitor drying and storage conditions with Cropster AmbientSensors, and use built-in cupping and green grading tools to ensure consistent quality.	Cropster
	Germany with operations in Honduras	INAtrace	INATrace is a blockchain solution that maps every process step and transaction from the farmer to the final product. It creates WR Codes that can be put in products and read through smart phones. INATrace is a transferable, open source blockchain-based traceability solution that makes agricultural commodities traceable from production up to the final product.	GIZ
	Central America	TRACE	It is a digital tool allowing traceability from farm to consumer.	Solidaridad in alliance with FairFood
	Central America	Calidad de Taza	It is an app based on coffee international standards that delivers a report with the coffee quality score.	Solidaridad

A focus on digitized market linkages

Technologies are flourishing across service types, with a higher concentration on market linkages

Digital advisory and extension

- Six technologies were identified. Two developed in Honduras, 1 in Guatemala, and 1 in Nicaragua. The other two are from Colombia and India.

- Four of the six are coffee focused. The other are being developed to work with other crops.

- These technologies are focused on delivering data on weather and crop diseases, aiming to inform better decision-making by farmers.

- Promotors of these technologies are mainly national organizations supporting coffee farmers at the country level.

Digitized Farm Tools

- Five technologies were identified—only one with action in Central America.

- These technologies are oriented to facilitate farmers' information management in the crop. SmartAgro —Movistar, and FAO— offer installment of sensors to gather information. Cromai, developed in Brazil and already in the market, provides specific information about an aspect of the coffee process (level of ripening of coffee grains).

Digital financial services

- Three technologies were identified. One developed in Honduras, and one already with operations in the country. Both included a digital wallet, but Grainchain is also looking to explore loans for farmers.

Digitized Market Linkages

- Nine technologies were identified. Four have actions in Central America.

- These technologies, mainly developed on blockchain, aim to promote traceability along the food chain. Some emphasize sustainability information, and others in price.

- The readiness to scale varies across this group. Some of them are still working on the platform —INATrace developed by GIZ —while others are doing pilots —TRACE, Tracecoffe — and others seem to be growing their client base.

- INATrace is the only one in this group offering an open-source blockchain-based traceability solution. Options such as Ifinca — developed by a US startup based in Colombia, chose the patent approach.

Readiness to scale of the digital technologies in the mapping
General view

Service Types
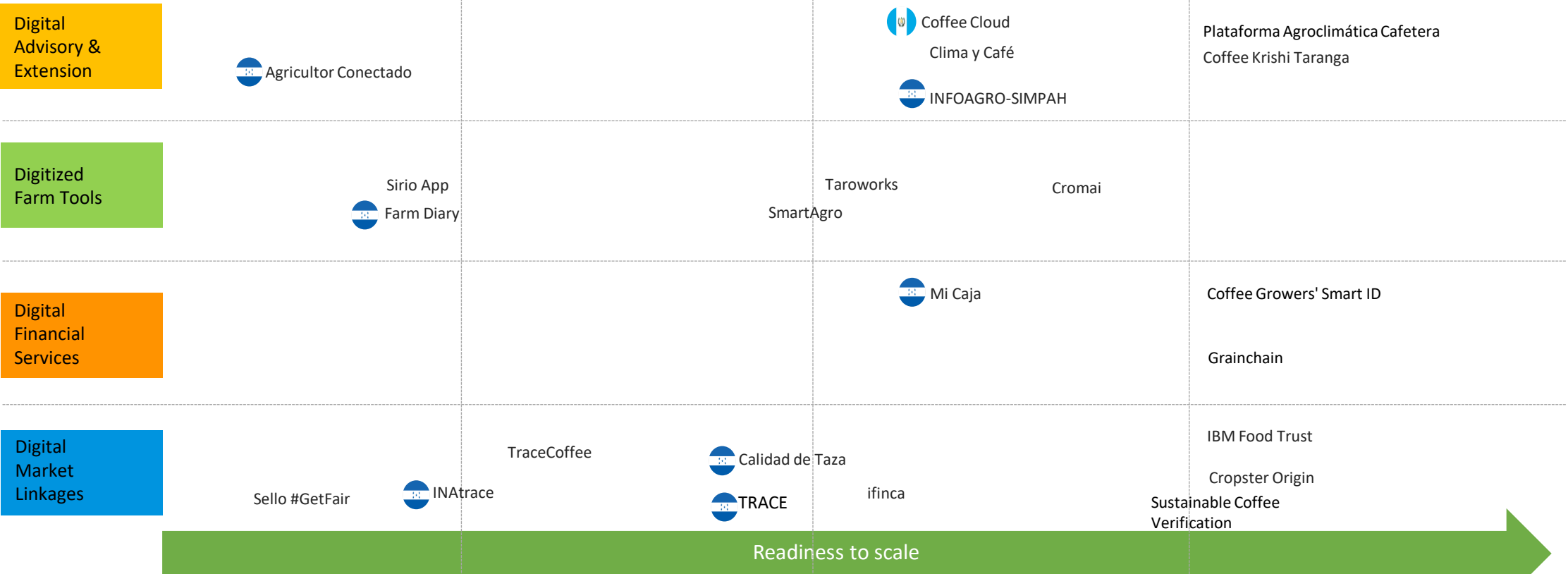
Digital Advisory & Extension

Coffee Cloud
Clima y Café
INFOAGRO-SIMPAH

Plataforma Agroclimática Cafetera
Coffee Krishi Taranga

Agricultor Conectado

Digitized Farm Tools

Sirio App
Farm Diary

Taroworks
SmartAgro

Cromai

Digital Financial Services

Mi Caja

Coffee Growers' Smart ID

Grainchain

Digital Market Linkages

TraceCoffee

Calidad de Taza

IBM Food Trust

Sello #GetFair   INAtrace

TRACE

ifinca

Cropster Origin

Sustainable Coffee Verification

Readiness to scale

Prototype – concept has been tested and demonstrated in limited trials;

Close to market – solution functions under real production settings, and the service provider is investigating one or more business models to reach clients

Scaling – the solution has been adopted by several end users/clients, and one or more business models are profitable

Mature– the solution has a dedicated client base, one or more business models are profitable, and demand is growing.

Readiness to scale of the digital technologies in the mapping

Technologies developed in Central America or with current operations in Honduras and Guatemala

Service Types

Digital Advisory & Extension	Agricultor Conectado		Coffee Cloud / INFOAGRO-SIMPAH
Digitized Farm Tools	Farm Diary		
Digital Financial Services			Mi Caja / Grainchain
Digital Market Linkages	INAtrace	Calidad de Taza / TRACE	IBM Food Trust

Readiness to scale →

Prototype – concept has been tested and demonstrated in limited trials;

Close to market – solution functions under real production settings, and the service provider is investigating one or more business models to reach clients

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30

Types of actors promoting digital technologies in the mapping

Development organizations working in partnership and private companies as relevant promoters

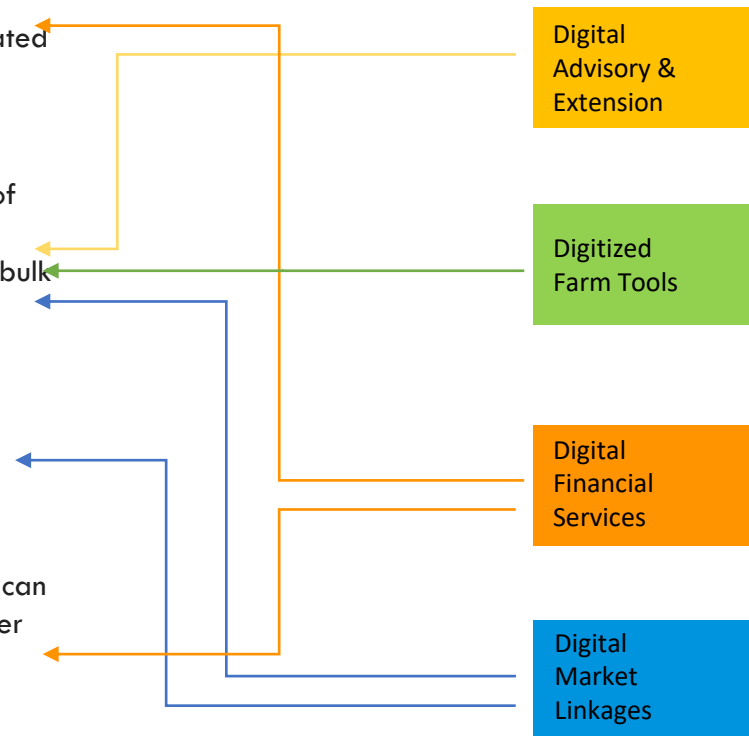|	Partnerships	Development organizations	Coffee Associations	Startups and medium companies
Digital Advisory & Extension	DAI with USAID, ANACAFE	Solidaridad	Nicaraguan Association of Small coffee growers cooperatives	
	PxD, partnership with Coffee Board of India and Walmart		National Center for Coffe Research -CENICAFE	Dimitra
Digitized Farm Tools	Movistar in partnership with FAO	Solidaridad		Nuup (social Enterprise)
				Taroworks (social Enterprise)
				Cromai
Digital Financial Services	Agrodigital and Fundación para el Desarrollo Empresarial Rural (FUNDER)		Colombia National Federation of Coffee Growers	Grainchain
Digital Market Linkages	Alliance between IBM Food Trust and IBM Watson Decision Platform for Agriculture, Heifer International and IBM	GIZ		TraceInc
				Cropster
	Solidaridad in Alliance with FairFood	Solidaridad		Ifinca
		Enveritas		GetFair

A potential relationship between current bottlenecks of the coffee chain and technologies service types

(i)   Disorganized labor market threatened by scarcity and informality, aggravated by increasing internal and external migration, and ageing of farmers.

(ii)   Faulty bean quality control across all links in the value chain: (i) the culture of picking only ripe coffee is not widespread among farmers and pickers, (ii) intermediaries consolidate coffees of varying qualities, and (iii) mills process it in bulk with an eye on efficiency rather than quality.

(iii)   Imperfect vertical price transmission enabling domestic and international intermediaries to capture rents and reduce social welfare

(iv)   Negative cash flow between harvests which, when savings are unavailable, can lead to: (i) underinvestment and/or (ii) presale of harvest to intermediaries at lower prices.

Digital Advisory & Extension

Digitized Farm Tools

Digital Financial Services

Digital Market Linkages

Recommendations for future work

Distributed ledger as a potential impactful technology

Technologies services using distributed ledger (for example, blockchain) can potentially change the governance and the relationships within a value chain.

Many applications identified in the mapping use this technology—however, more empirical evidence on whether its promise is fulfilled or how it is needed. Today is a significant promise with a giant question mark.

When analyzing this technology, it is essential to consider that Blockchain is a governance technology for which rules and agreements must be set and enforced regarding the distributed ledger and the utilities derived from it.

Overview of topics and applications in different blockchain use cases in agriculture

Problems addressed	Relevant topics	Aspects	Applications
Lack of trust	Transparency	- Identity management - Events management - Auditability	- Risk management - Anti-corruption - Authenticity of agri-food products
	Traceability	- Provenance - Tracking & tracing - Accountability	- Marketing premium products (organic, PDO) - Reducing food waste - Digital product passports (origin and provenance)
	Information integrity	- Reliable information - Data validation - Data provenance	- Quality certification - Quality assurance - Fraud prevention - Data passports
	Consensus	- Business rules and agreements	- Supply community - Supply chain traceability - Supply chain finance
New value creation /distribution	Fairness	- Inclusive business model	- Living wage for smallholders - Monitoring and enforcing labour conditions (slavery, child labour, gender equality)
	Efficiency	- Value chain structure	- Short supply chains
	Nature-based Solutions (NbS)	- Conservation of bio-diversity - Transparency and accountability of pesticide use (WEF, 2018)	- Monitoring use of pesticides - Natural capital - Biodiversity index

Source: Van Wassenaer, L., van Hilten, M., van Ingen, E., van Asseldonk, M., 2021

Distributed ledger as a potential impactful technology

Literature shows several challenges and barriers that can be considered when analyzing its viability.

Opportunities and potential benefits	Challenges and barriers
Traceability in value chains	SME have difficulties in adopting the technology
Support for small farmers	Information infrastructure might prevent access to markets for new users
Finance and insurance of rural farmers	Lack of expertise by small SME
Facilitation of financial transactions in developing countries	High uncertainties and market volatility
Fairer pricing through the whole value chain	Limited education and training platforms
A useful platform in emission reduction efforts	No regulations in place
Consumer awareness and empowerment	Lack of understanding among policy makers and technical experts
More informed consumer purchasing decisions	Open technical questions and scalability issues (e.g. latency of transactions)
Increased sustainability and reduction of waste	Digital divide among developed and developing world
Reduced transaction fees and less dependence on intermediaries	Decline of cryptocurrencies in market share and high volatility (reputation issues)
More transparent transactions and less frauds	Cost of computing/IoT equipment required
Better quality of products, lower probability for foodborne diseases	Design decisions might reduce overall flexibility
	Privacy issues
	Some quality parameters of food products cannot be monitored by objective analytical methods, especially environmental indicators

Source: Kamilaris, A., Fonts, A., & Prenafeta-Boldú, F. X., 2019

Recommendations for future work with specific technologies

Traceability as a market imperative

European countries and coffee buyers are pushing for more information about the origin of the products. There is a need for assurances that the coffee they buy is ethically and sustainably sourced.

On December 6, 2022, the European Commission announced a new EU Regulation on deforestation-free supply chains. This new law will set mandatory solid due diligence rules for companies that want to place relevant products on the EU market or export them. This new law applies to commodities, including palm oil, cattle, soy, **coffee,** cocoa, timber, rubber, and derived products (such as beef, furniture, or chocolate).

This new regulation will affect the buyer requirements in high-value markets. Those farmers, currently better-positioned, can maintain their position; farmers with challenges accessing markets will face more barriers.

Traceability is the result of better management across the chain and within coops.

Working on traceability requires a process across the value chain. It requires digitized farm tools and a combination of capabilities, opportunities, and motivation (see User Readiness Framework).

Not all markets are interested in the same set of aspects. They could be more interested in environmental, social, or quality aspects. Choosing a traceability approach requires understanding the specific markets relevant to small farmers.

Recommendations for future work with specific technologies
The four dimensions of the Responsible Innovation framework can inform the work with developers

Social science scholars have suggested that Responsible Innovation (RI)offers a way to foresee potential impacts and shape the trajectories of digital agricultural technologies. Responsible innovation, as defined by Stilgoe et al. (2013), "means taking care of the future through collective stewardship of science and innovation in the present." RI has four dimensions —anticipation, inclusion, reflexivity, and responsiveness— that allow a framework to elicit a conversation on the several implications of these technologies.

**Responsible Innovation dimensions and potential activities**

Inclusion	Anticipation	Reflexivity	Responsiveness
Definition: Inclusive innovation processes allow stakeholders with diverging concerns and perspectives to deliberate and dialogue.	Definition: Defining the possible scenarios for and consequences of innovations and considering concerns regarding these consequences.	Definition: Reflecting on activities, commitments, and assumptions that shape science, innovation and governance. This includes the individual capacity to call into question processes and results of innovations.	Definition: Changing the shape or direction of digital design or intervention in response to demands or values of stakeholders society, or the enabling environment change, new insights etc.
• Involvement of relevant actors • Private sector engagement • Encouraging transformative mutual learning through User-centred design, open innovation, and co-innovation	• Foresight exercises • Scenario building of digital technologies futures	• Reflexive guidance, as processes to guide reflection within research teams on underlying assumptions and values around development and use of technology • Structures guide second-order reflexivity)e.g codes of conduct, best practice guidelines	• Potential to adapt Projects based on stakeholder feedback (e.g (Stage-gating, mid-project reviews, structures for adapting milestones and deliverables • Open research processes • and access to research • Data (e.g Open data exchange, open access to research results, declaring conflicts of interest)

Source: Based on McCampbell, (2021) and Eastwood et al., (2019)

# Recommendations for future work with specific technologies
Use an User Readiness Framework to explore the side of farmers

McCampbell, (2021) created a User Readiness Framework applicable to digital agricultural technologies. According to this framework, "the optimal user readiness for a digital technology lies at the intersection of the component's capability, opportunity, and motivation."

- Capability is "the individual's psychological and physical capacity to use a digital technology'".

- Opportunity is defined as "all the factors that lie outside the individual that make the use of a digital technology or extension service possible or prompt it'" Including factors that shape accessibility (e.g., infrastructure), affordability (e.g., economic resources), and social acceptance (e.g., gender norms and mindset about digital technologies).

- Motivation is defined as 'all those brain processes that energize and direct the use of a digital technology, not limited to goals and conscious decision-making.' It includes (unconscious) habitual processes, emotional responses, goals, and analytically made decisions.
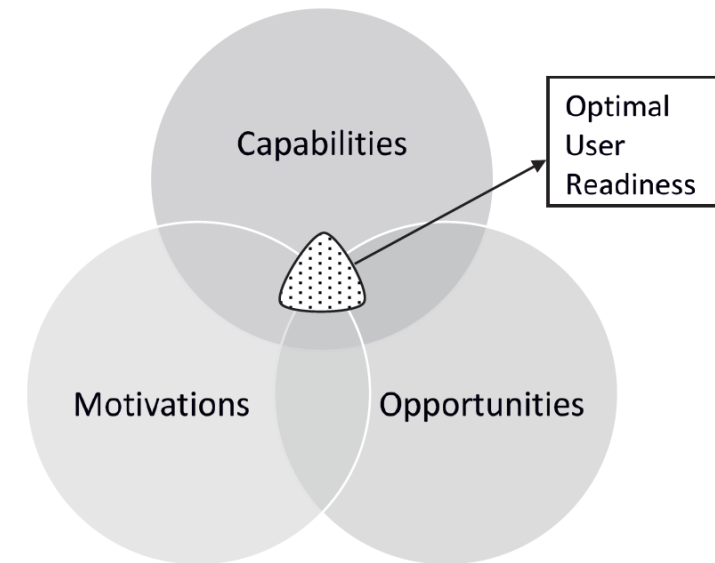
Source: McCampbell, (2021)
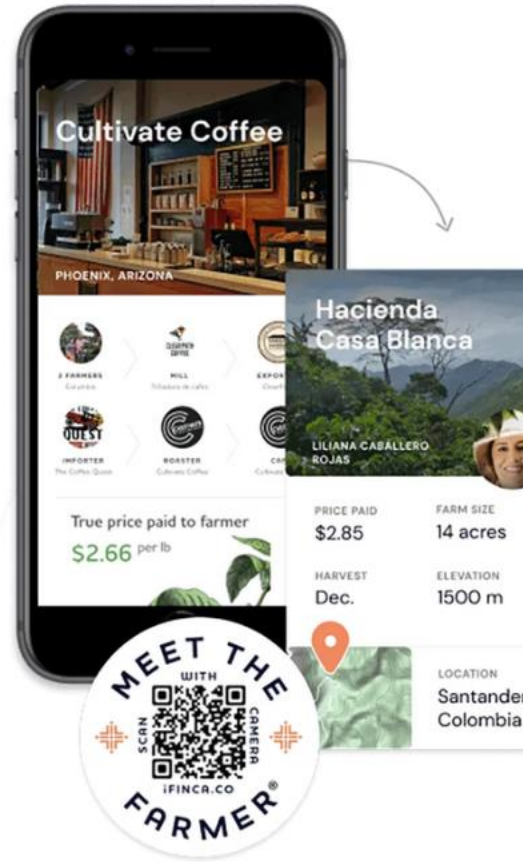
Digital Innovations for the Coffee Value Chain in Honduras & Guatemala

Jenny Melo-Velasco

December 2022