



Photo: Shutterstock.com

## **EVIDENCE FOR DIGITAL AND BUNDLED SERVICES**

Framing a Research Agenda for the Digital Agricultural Innovations and Services Initiative

# I. Motivating a new initiative to study digital and bundled agricultural services in sub-Saharan Africa and South Asia

Agriculture remains central to improving living standards and reducing extreme hunger and poverty in low- and middle-income countries. Across Africa and South Asia, large shares of the population, approximately 50 percent of the labor force, are engaged in agricultural activities (ILOSTAT 2021). Agriculture in these countries is overwhelmingly characterized by small-scale producers; for example, about 80 percent of African farmers are smallholders with under 2 hectares of land. They account for 40 percent of the cultivated area, but landholdings among African farmers are declining rapidly (Lowder et al 2016; Jayne et al 2018).

A primary policy concern is, therefore, how to improve productivity and incomes for such small-scale producers. A large body of research, some of which was funded through the [Agricultural Technology Adoption Initiative](#), documents the importance of agricultural productivity to improve farmer welfare, such as a reduction in poverty (for a review, also see de Janvry and Sadoulet 2009, 2020). Improved agricultural yields can also lead to improved child nutrition (Suri and Glennerster 2021). Similarly, advances in agricultural productivity can be critical for longer-run development through structural transformation, which transitions a largely agriculture-based economy toward being more manufacturing- and services-led. For example, research shows that increasing agricultural productivity through improved technologies is key to this process of transformation (for example, see Bustos et al 2016, 2020; Dercon and Gollin 2014; Gollin et al 2021). Although these links between agricultural productivity, poverty reduction, and, ultimately, long-run development have been widely studied, productivity increases remain elusive in Africa and large parts of South Asia.

It is well documented that farmers face a myriad of constraints to adopting new technologies that are proven to increase agricultural productivity, like access to credit and savings, information, inputs, externalities, risk, labor, and land (Jack 2013; Suri and Udry 2022; see [Annex I](#) for more on constraints). Alleviating any one of these constraints can help improve the adoption of technologies, but the increases in adoption from relieving any single constraint seem to be quite small. No one constraint appears to be able to explain the persistently low rates of technology use in some parts of the world (Suri and Udry 2022). Interventions that address multiple constraints at one time must be tested to explore which combinations of constraints must be eased to unlock production outcomes and, ultimately, effectively increase consumption and income.

Evidence also suggests that heterogeneity in returns to adoption plays an important role in realizing the potential of agricultural technologies. Differences across geographic space (due to variations in soil quality, water access, etc., as well as transport costs and market access for both

inputs and outputs) and across time (due to different weather realizations) imply that any intervention to help improve farmers' technology adoption will need to be tailored carefully to the local context (Suri and Udry 2022). Taken together, the two critical research gaps of heterogeneity and bundled constraints present a compelling research agenda to generate much-needed information on how the adoption of new technologies can be increased to enable advances in productivity.

## **A. Role and rise of digitalization and bundling in agriculture**

The potential power of digital services to address binding constraints and heterogeneity in returns may be substantial, but we have yet to build an evidence base around their effectiveness. The sheer size of the digital sector suggests that actors within an agricultural value chain have begun to recognize the benefits of digitalization in agriculture; in 2019, there were over 390 distinct digital agricultural solutions active in Africa (Tsan et al 2019).<sup>1</sup> The recent and rapid expansion of services across Africa—60 percent of which were launched in the previous three years—emphasizes the urgency of a research agenda to unpack their effectiveness and impact on small-scale producers' outcomes. As digitalization spreads to more services and products, building an evidence base on how digital solutions can be designed, implemented, and scaled to align with the priorities of small-scale producers will be important.

There are multiple pathways by which the digitalization of services might enable gains in production, technical efficiency, information flows, inclusion for marginalized groups, and transparency across segments in an agricultural value chain—all of which contribute to improved outcomes for small-scale producers. Common applications of digital services include individually tailored advisory and extension services, financial services, and market linkages (Tsan et al 2019). On the farm, digital technologies lower access costs and increase the reach of information on new technologies, with the added benefit of leveraging digital tools, such as localized satellite weather data, to tailor information to local conditions. Off the farm, digital technologies have the power to drastically reduce barriers to small-scale producers' access to both input and output markets, including by connecting buyers and sellers, lowering transport costs, and strengthening information flows between actors (Schroeder et al 2021). Digital financial services also increase financial inclusion for small-scale producers. Lower barriers to accessing mobile money on digital platforms can unlock previously inaccessible credit, loans, savings, insurance, and more (Tsan et al 2019).

Importantly, digital services may also be key to increasing productivity, among other welfare and business outcomes, for small-scale producers because of the increased ability to bundle services together to alleviate multiple constraints at one time. The practice of bundling digital agricultural

---

<sup>1</sup> For an in-depth review of the digital agriculture landscape in 47 countries in sub-Saharan Africa, see the FAO and ITU's 2022 report.

services is even more nascent than digitalization but similarly quickly growing, where 50 percent of active solutions include more than one use case (Tsan et al 2019). Moreover, bundling services together may produce a multiplier effect (i.e., bundles may have complementarities) where the bundle is more effective at alleviating constraints as compared to the sum of its individual components delivered digitally. For example, one common solution to the multiple constraints problem for farmers in low- and middle-income countries has been to tie markets together. Contract farming, which ties output markets to credit markets, has been quite popular (see Arouna et al 2021; Little and Watts 1994). Similarly, cereal banks that acted as storage vehicles for crops also tie output and credit markets together (see Aggarwal et al 2018; Burke et al 2019; Casaburi et al 2014). For a deeper look at the evidence landscape around bundles, see the literature review from Vox Dev Lit (Suri et al forthcoming).

In addition to these gains, there may be broader supply chain gains from digitalization. Suppliers themselves may be able to experiment more efficiently and target technologies to their customers more easily. Platforms may also make broader agronomic trials easier and, perhaps, allow the development of better technologies.

With the advent of digital services, many more opportunities to bundle solutions to address various constraints have been created. Business models that combine advisory services with market linkages and financial services are most common (Tsan et al 2019). An evaluation of one such service that combines advisory information with relaxing liquidity constraints (RiceAdvice) found significant increases in both income and yield (Arouna et al 2020). However, studies such as these are rare; a recent scoping review, [Agriculture in the Digital Age](#), found that only 30 of 315 relevant studies on digital agricultural services examined bundled services, suggesting that more evidence is needed to establish how or why bundling services may be more effective than providing them individually.

Even as the proliferation of these bundled digital agricultural services has been accompanied by a growing body of literature, there remain critical evidence gaps. While there has been some research on the role of digital technologies on incomes and poverty more broadly, this has been narrowly concentrated on technologies that are singularly focused (not bundled). For example, there is a growing literature on the impacts of mobile money (Suri et al 2021), the Internet (Hjort and Tian 2022), and cell phones (Baumüller 2018). Most of this work has not addressed bundled services directly or even tried to better understand the bundled nature of the particular technology being studied and what components of the technology may be more (or less) important.

## **B. Introducing the Digital Agricultural Innovations and Services Initiative**

The Digital Agricultural Innovations and Services Initiative (DAISI) will generate a rigorous evidence base on the impact of digital services and bundled approaches on improving

small-scale farmer outcomes, bolstering farmers’ resilience to climate change, connecting farmers to markets, and expanding commercialization in sub-Saharan Africa and South Asia. Primarily, DAISI will fund grants for full-scale randomized evaluations, pilot studies, rapid product A/B tests, travel/proposal development grants, and scaling grants.

A randomized evaluation can be a powerful tool for testing specific components of a program’s theory of change and identifying the mechanisms behind the success of specific interventions. However, when multiple services are bundled together in an intervention (for example, advisory services + credit + insurance to manage weather-based risk), it becomes more difficult to disentangle the effects of each component alone or to interpret the behavioral mechanisms associated with take-up and adoption of the bundle. As such, DAISI will emphasize the funding of evaluations which are budgeted and scaled to a size where the impacts of intervention arms can be measured in combination as well as in isolation. [Learn more](#) about our request for proposals, grant types, and researcher eligibility.

### 1.1. What are bundled and digital agricultural services?

To guide our understanding of the space as well as the relevance of existing and eligible future services and interventions, we have defined the following components of bundled, digital agricultural services as they pertain to DAISI’s research agenda.

**Digital agricultural services:** Platforms and solutions that leverage digital hardware and/or software to deploy agricultural services for farmers and/or other actors in an agricultural system to improve their access to information, financial services, markets, equipment, and more.

Definitions	
<b>Digital</b>	<p>Leveraging any digital hardware and/or software to connect farmers and/or other actors in an agricultural system to agricultural services (e.g., information, advisory services, insurance, loans, credit, savings accounts, e-marketplaces, etc.)</p> <p><b>Digital technologies may include but are not limited to:</b> Radio, television, mobile phones (including interactive voice response, SMS, and applications), computer and network hardware and software (and all associated services, applications, and devices, such as videoconferencing and distance learning), satellite systems, GPS, geodata, and geo-referencing systems, remote sensors, drones, and artificial intelligence (See Tsan et al 2019; Shakhovskoy et al 2021; and Huth et al 2017).</p>

Definitions, continued	
<b>Bundles or packages</b>	<p>Connecting farmers or other actors in agricultural systems to agricultural services, technologies, or products that simultaneously relax two or more constraints they face</p> <p><b>Note:</b> When characterizing services as a bundle, we consider the number of constraints targeted by the service rather than the mechanism or structure of the service itself.</p> <p>Constraints include information, credit, savings, risk, land, labor, institutions, and externalities, among others. See <a href="#">Annex I</a> for more details.</p> <p>See <a href="#">Annex II</a> for examples of existing bundles or packages.</p>
<b>Fully digital bundle</b>	Fully digitally-enabled or -delivered package of services that relax multiple constraints
<b>Hybrid bundle</b>	Partially digitally-enabled delivery of at least one service in a package of services that relax multiple constraints (e.g., agent-based models, delivery of video extension messages to women's self-help groups, followed by a facilitated group discussion, credit, or vouchers distributed via mobile lending/banking platform after attending in-person extension services)
<b>Analog/material bundle</b>	<p>Non-digitally-enabled package of services that relax multiple constraints</p> <p><b>Note:</b> Analog/material bundles alone do not fit the eligibility requirements of the Digital Agricultural Innovations and Services Initiative.</p>

## 1.2. Our focus on gender, youth, and climate as cross-cutting themes

In addition to the broader focus on digital and bundled agricultural solutions, DAISI will prioritize generating evidence across three overarching themes: gender, youth, and resource use and climate resilience.

### Gender

In many contexts, agriculture is the main livelihood for women, yet productivity for women farmers in sub-Saharan Africa significantly lags behind that of men (Katz 2021). Women can also be disproportionately excluded from the benefits of digital technologies and services. This disparity is often compounded by overlapping social barriers, such as autonomy, mobility, security, education level, and poverty (Porciello et al 2021). In addition to social and cultural barriers, women face unique constraints to adopting productivity-increasing technologies, such as differential digital access, information, participation in agricultural groups or services, and spheres of production and investment. Reducing barriers that limit women's agency, influence,

and decision-making power and identifying the best-fit delivery mechanism for women farmers will be critical in realizing economic and welfare outcomes for women farmers. While past research has primarily focused on the heterogeneity of an intervention's impact by the household head, DAISI-funded studies will be encouraged to thoughtfully incorporate gender-intentional issues into the evaluation design, successfully leveraging the unique opportunities and expanded reach of digital tools (see Mercy Corps' [AGRIFIN](#) for examples). Ultimately, DAISI will build a body of evidence on the individual-level impacts of services on gender-specific outcomes, and on how services can be intentionally designed and implemented to address gender-specific constraints.

## Youth

As youth under the age of 25 make up 60 percent of the population of sub-Saharan Africa, they have an outsized importance in the design and use of digital services (FAO and ITU 2022). Youth may be more familiar and more likely to engage with digital services than older groups. Additionally, youth who first engage with an agricultural service or platform as a user may transition into an agent for the service or move upwards along the value chain.

## Resource use and climate resilience

The advent of bundled digital services presents an opportunity to study the climate and environmental impacts of the bundles themselves, as well as their impact on the resilience of production systems, farmers, and their households to climate change, weather shocks, or other environmental hazards.

### **Direct climate and environmental impacts of the bundle:**

In the context of larger-scale (regional or global) sustainability, agricultural production and productivity improvements that are achieved without concomitant food-related emissions or further degradation of other resources, like groundwater, are especially important. DAISI will ask researchers to consider the environmental resource use changes induced by the bundle, with specific attention to documenting changes in land, water, or input use.

### **Climate and environmental resilience impacts of the bundle:**

As farmers face changing climate pressures, interventions that increase households' climate and economic resilience, whether by directly enhancing their ability to weather shocks or indirectly by managing risk, are key to ensuring stability and continued productivity increases. Such adaptation and resilience benefits could come from building natural capital stocks (for example, improved soil fertility and decreased erosion) or enhancing ecosystem services on agricultural land (for example, improved pollination or nitrogen fixation) through digital advisory and agronomic services. Direct resilience to climate shocks, weather extremes, and other environmental hazards might also be impacted through innovative hybrid bundles that include improved seeds or irrigation

and digital extension; access to markets and facilities to reduce postharvest losses, climate advisory services, or innovative risk management and financial tools.

DAISI will prioritize research that may elicit dual benefits in economic development as well as climate and environment, whether through a reduction in climate or environmental impacts, or an increase in resilience, including post-harvest risk.

## II. Framing a research agenda for the Digital Agricultural Innovations and Services Initiative

In this section, we outline the open questions and areas of focus under DAISI. While specific questions of interest relevant to each of the three cross-cutting themes are expanded upon in **section G**, the questions below (**sections A-F**) should also be considered through a gender, youth, and/or climate resilience lens. We highly encourage one or more of these themes to be considered as part of each question and section.

### A. Uptake and use of digital and bundled services in agriculture

The constraints to adoption by small-scale farmers are many and include limited access to credit, loans, savings, insurance, inputs, markets, and land, among others (Jack 2013). Over the years, there have been different projects and programs implemented as part of attempts to relax these constraints to improve farmers' productivity. However, in large part, efforts that sought to relax one constraint at a time had limited efficacy (Karlan et al 2014).

Digitalization of agricultural services elevates the opportunities for bundling and, by extension, offers increased potential to reduce constraints and achieve significant leaps in agricultural productivity of small-scale farmers. According to anecdotal evidence, the impact of bundled services on yield and income can be significantly higher than when they are implemented individually (Tsan et al 2019). While there is little disagreement on the value of bundling, the utility of digital and bundling services in agriculture lies in getting evidence on what bundles work and how; and which ones farmers and other actors in the agricultural value chain are willing to adopt, and why. Some relevant questions for this topic are:

- What models of integrated or bundled digital and non-digital services drive high rates of adoption and use of agricultural technologies by small-scale producers?
- Which bundles raise profits the most for farmers and why?

Is the digitalization of certain programs more desired by farmers over others and why?

- Do digital bundles reduce barriers to adoption/access/entry to agricultural services?  
How do the delivery mechanisms and format for distributing services or content affect the use and take-up of platforms and services?
- Do incentives impact the take-up and use of bundled and digital services?  
How do agent-based models affect intensive margin use of digital and hybrid bundled services?  
Do incentives targeted to agents affect farmers' take-up? What are the incentives for service providers to offer bundled services?  
How do bundles targeted to users or providers at different levels or positions in a value chain affect use or transaction costs (e.g., meso-level insurance products at the bank or farmer group level)?  
How does digitalizing the flow of information in a value chain affect the flow of other resources from actors in the value chain to farmers (e.g., credit systems, digital footprints, and credit scores)?
- Do privacy concerns or challenges resulting from digital use and access to user data affect take-up of digital products?

## **B. Impacts of digital and bundled services on agricultural outcomes**

The hypotheses underlying DAISI as a whole bring together several strands of research: First, that bundling and digitalization of certain services will ease constraints related to uptake and use, as described above; and second, that bundling and digitalizing services will positively impact key agricultural outcomes. DAISI will prioritize evaluations that address whether and how bundled and digital services contribute to improved agricultural outcomes by helping farmers overcome simultaneous constraints that may be necessary for success, and/or by unlocking complementarities that the bundled services make accessible. It is also possible that digital services are purely low-cost substitutes for existing programs, but they may still be more cost-effective. DAISI would also welcome evaluations that address these questions.

When discussing the effectiveness of bundled digitally-enabled agricultural services, we consider and encourage researchers to address a range of outcomes: agricultural productivity (yields), agricultural production and profitability, farmer welfare (both quantitative and other self-reported well-being measures), expansion of opportunity for women and women's empowerment, and resilience to both extreme weather shocks and longer-run climate and environmental changes.

To better understand whether and how bundled and digital services can be effective, DAISI will also prioritize efforts to understand the quality of services provided, delivery mechanisms and costs, and the time costs of using the platform. We encourage research teams to explicitly address whether the bundle under study introduces any new constraints.

- How do digital and bundled services affect agronomic and agricultural outcomes, like crop yields and losses, crop quality, on-farm investments, profits, sales, etc.?
- How effective are bundled digital services at improving farmer outcomes, like income and assets, and other household welfare metrics, such as food/health/nutrition security, investments in other economic enterprises, child education, etc.?
- When does it make sense to digitally-enable a service versus maintain an analog service or hybridize a bundle?
- How do digital components facilitate access to and take-up of services that can never be digital (e.g., in-person extension followed by high-frequency follow-ups)?
- Does a digital product allow providers to effectively tailor services, products, and information to farmers?

Relatedly, does digital provision of services allow providers to more quickly tailor services, products, and information to farmers and facilitate faster iteration (potentially via increased frequency of communication) to improve quality or the tailoring of these services?

- What are the advantages of digitally-enabling services within a bundle?  
Do the digital components of a bundle lower costs or otherwise enable greater investment in other components of the bundle?
- Which bundles are most effective at relieving constraints and for which farmers, providers, or agents in a value chain?  
How does the bundle vary depending on socio-economic status or income group?
- Are digital technologies effective in providing services to farmers?  
Which delivery models are most effective? Which are most effective for women farmers?  
Are digital technologies effective in delivering a bundle of services?
  - What do we learn about the delivery mechanism and/or partner, including about their implementation strategy?
  - Do the bundles crowd out or substitute for existing services? How does that affect farmer outcomes (e.g., identifying the tradeoffs associated with changing the source

of agricultural information from extension agents to an online service or text messages from a private company)?

- How cost-effective is the bundle relative to the individual components?
- Are agents, like input dealers, willing to pay for digital services (e.g., providing a clear path to profitable business opportunities, like solving market uncertainty by providing information digitally on rural demand where there are missing markets)?

### C. Factors that affect how bundles perform relative to their individual components

Much as there is a small literature on the impacts of bundles, as described above, there is little to no work showing how bundles perform relative to individual components in the bundles.<sup>2</sup> This will be a core set of questions for DAISI, and not just along the dimensions of the knowledge of and take-up of agricultural technology, but also in terms of agricultural yields, profits, and the ability of farmers to deal with economic and environmental stresses.

Theoretically, there are various reasons to expect that bundles may be more effective than the individual components themselves. As described above, bundles (as defined) will alleviate multiple constraints that farmers face which already highlight their potential benefits. If farmers face multiple constraints at once, bundles could help address these more effectively. For instance, there could be strong complementarities (in terms of the benefits to the farmer) among the components of the bundles. If the services are digital, a common platform could lower the costs of accessing and learning about the components of the bundles.

We are therefore interested in better understanding the role bundles can play relative to the underlying individual components (conditional on the mechanism of delivering these services, see **Section B** above on open questions around the mechanism of delivery). In particular, we are interested in the following questions:

- How do the access and use of bundled services impact farmers relative to the individual components underlying the bundles? We would like to trace out the full spectrum of impacts:
  - First, how do bundles affect farmers' knowledge of agricultural practices and technologies, and their perceptions of these practices and technologies?
  - Second, how do bundles impact farmers' adoption of these practices and technologies?

---

<sup>2</sup> There is some work showing some of these effects outside of the context of agriculture, for example, Giné and Yang 2009 and Mbiti et al 2019.

Finally, do these changes in knowledge and behavior also affect broader farming outcomes, such as farmer investments, diversification into new crops, yields, incomes, and the ability of farmers to cope with shocks or stresses?

- How big are the complementarities in the components of a bundle? What is the comparative cost-effectiveness of a bundle versus its components?
- When might digital bundles not be enough to achieve impacts on productivity, welfare, women's empowerment, etc.? When might digital tools need to be complemented by other non-digital interventions?
- Does the use of one service on a platform incentivize the use of other services available on the same platform for an individual user? For example, if a bundled service or platform provides information on the location of retailers selling a new seed as well as credit to purchase this seed, does the information on the retailer mean not just more purchase of the new seed, but also an increased use of credit on the system?
- What factors facilitate the take-up (extensive margin) and use (intensive margin) of bundled services relative to the individual components, both overall as well as for women farmers (also see **Section G.1.** below on the gender cross-cutting theme)?

What factors create barriers to extensive and intensive margin use at different levels (e.g., household, institutional, community, national, etc.)?

How does digitalization increase the take-up, adoption, or longer-term use of specific agricultural services?

Does bundling interact with the delivery mechanism? Are bundled services more likely to have better intensive and extensive use among the components than services that are not bundled?

How does the delivery mechanism affect the take-up or services (e.g., digital, hybrid, or analog)?

## **D. Bundled platform externalities, general equilibrium effects, and spillovers**

The broader development economics literature has recently focused on understanding externalities, general equilibrium effects, and spillovers. Much of this has been focused on topic areas outside agriculture, though there have been a few studies conducted to understand information and learning externalities around the adoption of new agricultural technologies. These studies in large part do not find strong evidence of spillovers (see, for example, Suri and Glennerster 2021; Duflo et al 2020; Beaman et al 2021; Tjernström 2017). However, spillovers may be difficult to measure within randomized evaluations given the difficulty of maintaining

comparison groups at scale; DAISI encourages partnerships across research teams and theorists to investigate the impact of spillovers and general equilibrium effects in such cases.

Similarly, there is new, nascent literature on the general equilibrium effects of digital technologies more broadly (digital technologies that are not directly focused on the agricultural sector). For example, Muralidharan et al (2021) look at the effects of biometric identification (Aadhaar) in India on labor markets, and Egger et al (forthcoming) look at the general equilibrium effects of cash transfers (delivered digitally via mobile money). Given what we know in these two areas, it may well be that digital agricultural services have broader impacts like those outlined above. But aside from these examples, there has been little research on the externalities of digital platforms in low- and middle-income economies. In particular, we are interested in the following questions:

- Does the use of one (or multiple) service on a platform incentivize other users in the household or community to take up the service?
  - Are there scaling requirements that need to be met before any spillover effects are observed, and if so, do these vary for different types of spillovers?
- Similarly, does one service serve as an onramp for access and use of other non-agricultural services (e.g., the expansion of mobile money creating opportunities for other digital services)?
- Does the use of digital services lead to broader digital literacy?
  - Does the inclusion of digital literacy training as a service delivered as part of a bundle increase take-up or use of the platform overall?
- Does access to services impact the way users interact with the agricultural system?
  - Do individuals, particularly women and youth, (see the cross-cutting theme on youth in **Section G.2.** for more) engage more deeply in value chains, expand market access, or commercialize as a result of using a digital, bundled service?
- How does combining a digital agricultural service with a non-agricultural service affect farmers' outcomes and welfare as well as the adoption and use of digital agricultural services?
  - For example, this could be a service that combines crop information, credit for on-farm investment, and a subsidy for girls' school fees for farming households. See [Annex II](#) for more information on bundles.
- Does going digital allow space and ability for providers to finetune their service or platform?

## E. How bundles or agricultural services can be most effective in addressing gender-specific constraints

A large body of research has shown that gender intersects with agricultural development in myriad ways (see Udry 1996; Meinzen-Dick et al 2012; Burney et al 2017). Ranging from geographically heterogeneous division of production systems, to differential access to inputs and information, to barriers to utilization of production and profits, female farmers may face entirely different production landscapes and constraints than male farmers in their same communities. Much of the existing literature has incorporated gender into impact analysis ex-post, primarily by estimating heterogeneity of impacts based on gender of the household head. However, DAISI will prioritize research on agricultural interventions that take a more structural approach to gender in both design and evaluation.

- Does the bundle relax constraints uniquely faced by women farmers to allow them access to higher productivity technologies and ultimately improve their empowerment and livelihoods?

In particular, we encourage research teams to explicitly articulate the gender-specific constraints faced by farmers in the project context and the specific dimensions of empowerment that might be affected. (IFPRI's [Women's Empowerment](#) in Agriculture project may be a helpful resource for research teams.)

- How do different types of bundled services affect women's ability to participate in agriculture and livestock value chains?

How can hybrid bundled services extend digital tools and services to women, helping them overcome the digital divide?

By helping them to overcome barriers, how can or does access to digital services introduce women to new agricultural industries, activities, and value chains?

- How well do gender-intentional services address constraints experienced by women farmers, relative to services which do not include a gender-intentional design?

Which factors are responsible for any observed increase in performance?

Are there specific combinations of services that, when offered together, have a greater likelihood of unlocking barriers and constraints for women, particularly women who seek to be more integrated into commercial agricultural markets?

- How do gender-related factors (e.g., cultural norms, time constraints, supply- and demand-based factors, such as risk, liquidity, privacy concerns, trust in and ease of use of financial systems, access to technology, and gender-neutral institutional practices) affect the use and take-up of bundled services among women small-scale producers?

- How does the architecture of social networks and learning function among women farmers, and how does this affect the ways digital services evolve and add value for users of the service?

## **F. Enabling a conducive environment for innovation, scaling, and sustainability of bundled and digital agricultural services**

To scale appropriately and effectively, policymakers and researchers must account for local conditions and implementation capacity, and then adapt programs to that new context accordingly. Scaling can include increasing the reach of an existing program in the same context; innovating, replicating, and expanding a successful evaluated program to similar contexts; or innovating, testing, and reassessing a program that was evaluated and found to be ineffective or not cost-effective.

- How can service providers effectively partner to bundle services?  
What are the incentives, and what partnership models are most successful?
- What are the feasible business models for service provision to replicate and cost-effectively scale these services?  
What business environment factors are required for scaling?
- How can service providers bundle across different scales (e.g., individual or group services provided on the same platform)?
- What environmental factors influence or facilitate scaling (e.g., data sharing, mechanisms, regulations, institutions, etc.)?  
Which are necessary for scaling the services?  
What social and cultural factors enable a product or service to scale; and how can those be influenced to achieve scaling?
- At baseline, which services are easier to integrate? Which are not easy to integrate into a digital platform?  
Can digital bundled interventions with other non-digital services ease the scaling of the whole package?
- Can the digital reach of the bundled interventions lower the costs enough to effectively reach farmers at scale?

- Does the shift to digital inspire or make it easier for providers to offer additional services beyond the anchor service (e.g., does digitizing a service allow a provider to expand or scale their offerings/business)?
- Can digitalization of a service or platform affect providers' knowledge of demand and help them predict and follow trends in demand from small-scale producers (through the use of administrative data)?
- How does scale interact with take-up of digital services, and in what cases are interventions more (or only) effective at scale (for example, digital marketplaces for selling crops may only work when a certain level of market thickness is achieved)?

## G. Cross-cutting themes: Gender, youth, and climate resilience

In addition to the set of research question categories above, we propose three cross-cutting themes: gender, youth in agriculture, and resource use and climate resilience.

### 1. Gender

Digital services allow us to look at interventions that are targeted to the individual, not only to the household, thereby opening up new opportunities for studying interventions that specifically target women. It also allows better measurement of gender-specific outcomes. Such digital services may also target alternative interventions along agricultural value chains that are needed in order to specifically engage and benefit women in the process of agricultural growth and development (more than simply conducting heterogeneity analysis by gender). As such, the gender cross-cutting theme seeks to answer these broader questions:

- What role do bundled digital services play in improving women's welfare and empowerment?  
Through what channels are these impacts realized?
- Does the digital nature/mode of delivery of any agricultural service affect how easily a service can be accessed (on both the extensive and intensive margins) for women?  
Digital, by its very nature, is individual. Is it crucial for women to have their own digital mode (for example, mobile phones) to be able to access these digital services more effectively?
- Do bundled digital services need to be targeted differentially to women?  
Are different bundles important for women?

- Do they face different combinations of constraints relative to men such that the ideal bundle of digital agricultural services is different for them? If so, what should these bundles look like?
- Are there gender differences in shock-coping behavior and risk protective interventions? If so, do digital services allow women to better invest in risk coping activities? These risk coping strategies may relate to gender differences in crops grown, social networks, credit and savings needs, labor investments, expenditure choices, etc.

How does this affect their investments and, ultimately, the levels of empowerment?

## 2. Youth in agriculture

With the aging of farmers coupled with the high rates of youth unemployment, there is little dispute that agriculture in developing countries will need to attract youth. However, there is still limited evidence on how to best attract them to the sector. One of the factors that has come up is the use of digital technologies as a mechanism of inclusion and incentive. Youth may be more willing and able to adopt and benefit from the digitalization of agriculture (Afero et al 2019). DAISI, therefore, seeks to build evidence on adoption and impact of digital and bundled agricultural services for youth relative to other groups. Some relevant issues and questions include:

- How engaged are youth with bundled, digital agricultural services and platforms as entrepreneurs?
  - Which part of the value chain is most attractive to them?
- Is the adoption of digital agricultural services different for youth?
  - If so, are there spillovers to other groups/actors in the agriculture sector?
- Do youth who first engage with an agricultural service or platform as a user transition into an agent for the service or otherwise move upwards along the value chain?

## 3. Resource use and climate resilience

DAISI will seek to fund evaluations of interventions that either (i) make food production less environmentally detrimental and/or (ii) enhance the climate resilience of farmers and production systems.

For resource use, we seek evidence that elucidates the impacts of bundled, digital agricultural services on climate and environmental outcomes, particularly tied to metrics that assess both local and global sustainability issues, and any spillovers, trade-offs, or externalities (e.g., labor or productivity trade-offs, such as by shifting farmers out of environmentally disruptive agricultural practices like crop burning and fertilizer or pesticide overuse, or incentivizing farmers to adopt

environmentally sustainable practices as part of a bundled service package). Relevant questions of environmental impact and resource use could include:

- Does (or might) the bundle alter stocks of key natural resources (e.g., does water use change? Is there a bycatch associated with a bundle?)?
- Does the bundle result in land use or land cover change? Is native habitat or forest converted to cropland? Is degraded land or soil rehabilitated?
- Does the bundle change local production emissions or sequestration of carbon or nitrogen?

In addition to lessening the climate and environmental damages associated with agricultural production, digital or hybrid bundled services might offer especially compelling pathways toward improved climate resilience for farmers. This could be achieved through direct adaptation of production systems to changing climate conditions, improved ability to weather climate shocks or other environmental hazards, or new methods and tools for managing risk, including post-harvest storage:

- Does the bundle alter the relationship between climate or weather and productivity?
- Does the bundle change the impact of a climate shock on the production system or farmer welfare (e.g., the depth of a shock)?
- Does the bundle change recovery time from a climate shock or recovery level?
- Does the bundle change how farmers manage climate or environmental risk, including changing their likelihood of being exposed to a shock?

While not all evaluations will be expected to address environmental outcomes, evaluations that identify whether an intervention indeed has purported win-wins in economic development and climate and environment are desired. Furthermore, because resilience, adaptation, and environmental impacts may best be measured over decadal time scales, evaluations that include a long-range follow-up plan for climate or environmental assessment, including experimental design over appropriate spatial scales, are highly desired.

## Bibliography

Afere, Lawrence, Oluwaseun Adedeji, Varun Baker, Constance Barbou des Courieres, Lilian Mabonga, Michael Ocansey, and Paul Neate. “Making Agriculture Attractive to Young People.” CTA technical brief, February 2019. <https://www.cta.int/en/youth/all/issue/making-agriculture-attractive-to-young-people-sid0c0f4e16d-f818-4b7c-a882-60692564dbbb>.

Aggarwal, Shilpa, Eilin Francis, and Jonathan Robinson. 2018. “Grain Today, Gain Tomorrow: Evidence from a Storage Experiment with Savings Clubs in Kenya.” *Journal of Development Economics* 134 (September): 1–15. <https://doi.org/10.1016/j.jdeveco.2018.04.001>.

Arouna, Aminou, Jeffrey D. Michler, Wilfried G. Yergo, and Kazuki Saito. 2021. “One Size Fits All? Experimental Evidence on the Digital Delivery of Personalized Extension Advice in Nigeria.” *American Journal of Agricultural Economics* 103, no.2 (March): 596–619. <https://doi.org/10.1111/ajae.12151>.

Arouna, Aminou, Michler, Jeffrey D., Lokossou, Jourdain C. 2021. “Contract Farming and Rural Transformation: Evidence from a Field Experiment in Benin.” *Journal of Development Economics* 151 (June): 1–17. <https://doi.org/10.1016/j.jdeveco.2021.102626>.

Ashraf, Nava, Xavier Giné, and Dean Karlan. 2009. “Finding Missing Markets (and a Disturbing Epilogue): Evidence from an Export Crop Adoption and Marketing Intervention in Kenya.” *American Journal of Agricultural Economics* 91, no.4 (November): 973–990. <https://www.jstor.org/stable/20616255>.

Baumüller, Heike. 2018. “The Little We Know: An Exploratory Literature Review on the Utility of Mobile Phone-Enabled Services for Smallholder Farmers.” *Journal of International Development* 30, no.1 (January): 134–154. <https://doi.org/10.1002/jid.3314>.

Beaman, Lori, Ariel BenYishay, Jeremy Magruder, and Ahmed Mushfiq Mobarak. 2021. “Can Network Theory-Based Targeting Increase Technology Adoption?” *American Economic Review* 111, no.6 (June): 1918–1943. <https://doi.org/10.1257/aer.20200295>.

Bossuroy, Thomas, Markus Goldstein, Dean Karlan, Harounan Kazianga, William Pariente, Patrick Premand, Catherine Thomas, Christopher Udry, Julia Vaillant, and Kelsey Wright. “Pathways Out of Extreme Poverty: Tackling Psychosocial and Capital Constraints with a Multi-faceted Social Protection Program in Niger.” World Bank Policy Research Working Paper No. 9562, March 2021. Available at: <https://openknowledge.worldbank.org/handle/10986/35211>.

Burke, Marshall, Lauren Falcao Bergquist, and Edward Miguel. 2019. “Sell Low and Buy High: Arbitrage and Local Price Effects in Kenyan Markets.” *The Quarterly Journal of Economics* 134, no.2 (May): 785–842. <https://doi.org/10.1093/qje/qjy034>.

Burney, Jennifer, Halimatou Alaofè, Rosamond Naylor, and Douglas Taren. 2017. “Impact of a Rural Solar Electrification Project on the Level and Structure of Women’s Empowerment.” *Environmental Research Letters* 12, no.9 (September): 1–11. <https://doi.org/10.1088/1748-9326/aa7f38>.

Bustos, Paula, Bruno Caprettini, and Jacopo Ponticelli. 2016. “Agricultural Productivity and Structural Transformation: Evidence from Brazil.” *American Economic Review* 106, no.6 (June): 1320–1365. <https://doi.org/10.1257/aer.20131061>.

Bustos, Paula, Juan Manuel Castro Vincenzi, Joan Monras, and Jacopo Ponticelli. “Industrialization without Innovation.” Working paper, August 2020. Available at: [https://www.cemfi.es/~bustos/Ind\\_innov\\_Sept\\_2020.pdf](https://www.cemfi.es/~bustos/Ind_innov_Sept_2020.pdf).

Casaburi, Lorenzo, Rachel Glennerster, Tavneet Suri, and Sullay Kamara. “Providing Collateral and Improving Product Market Access for Smallholder Farmers: A Randomised Evaluation of Inventory Credit in Sierra Leone.” 3ie Impact Evaluation Report 14, July 2014. <https://www.3ieimpact.org/evidence-hub/publications/impact-evaluations/providing-collateral-and-improving-product-market>.

de Janvry, Alain and Elisabeth Sadoulet. 2009. “Agricultural Growth and Poverty Reduction.” *The World Bank Research Observer* 25, no.1 (November): 1–20. <https://doi.org/10.1093/wbro/lkp015>.

de Janvry, Alain and Elisabeth Sadoulet. 2020. “Using Agriculture for Development: Supply- and Demand-Side Approaches.” *World Development* 133 (September): 1–14. <https://doi.org/10.1016/j.worlddev.2020.105003>.

Dercon, Stefan and Douglas Gollin. 2014. “Agriculture in African Development: Theories and Strategies.” *Annual Review of Resource Economics* 6 (November): 471–492. <https://doi.org/10.1146/annurev-resource-100913-012706>.

Deutschmann, Joshua, Tanguy Bernard, and Ouambi Yameogo. “Contracting and quality upgrading: Evidence from an experiment in Senegal.” Working Paper, March 2021. Available at: <https://www.atai-research.org/contracting-and-quality-upgradingevidence-from-an-experiment-in-senegal/>.

Duflo, Esther, Daniel Keniston, Tavneet Suri, and Céline Zipfel. “Chat Over Coffee? Technology Diffusion Through Social and Geographic Networks in Rwanda.” Working paper, November 2020. [https://www.dropbox.com/s/vh2fzo7qzpympkn/Chat\\_over\\_coffee\\_Rwanda.pdf?dl=0](https://www.dropbox.com/s/vh2fzo7qzpympkn/Chat_over_coffee_Rwanda.pdf?dl=0).

Egger, Dennis, Johannes Haushofer, Edward Miguel, Paul Niehaus, and Michael Walker. “General Equilibrium Effects of Cash Transfers: Experimental Evidence from Kenya.” *Econometrica* (forthcoming). <http://emiguel.econ.berkeley.edu/research/general-equilibrium-effects-of-cash-transfers-experimental-evidence-from-kenya/>.

FAO and ITU. 2022. “Status of Digital Agriculture in 47 sub-Saharan African Countries.” Rome. <https://doi.org/10.4060/cb7943en>.

Giné, Xavier, and Dean Yang. 2009. “Insurance, Credit, and Technology Adoption: Field Experimental Evidence from Malawi.” *Journal of Development Economics* 89, no.1 (May): 1–11. <https://doi.org/10.1016/j.jdeveco.2008.09.007>.

Gollin, Douglas, Casper Worm Hansen, and Asger Mose Wingender. 2021. “Two Blades of Grass: The Impact of the Green Revolution.” *Journal of Political Economy* 129, no.8 (August): 2344–2384. <https://doi.org/10.1086/714444>.

Hjort, Jonas, and Lin Tian. “The Economic Impact of Internet Connectivity in Developing Countries.” Working paper, April 2022. [https://jhjort.github.io/MyWebsite/Internet\\_Connectivity\\_042022.pdf](https://jhjort.github.io/MyWebsite/Internet_Connectivity_042022.pdf).

Huth, M., C.Vishik, and R. Masucci. “From Risk Management to Risk Engineering: Challenges in Future ICT Systems.” In the *Handbook of System Safety and Security*, 131–174. Syngress, 2017. <https://doi.org/10.1016/B978-0-12-803773-7.00008-5>.

ILOSTAT database of the International Labour Organization. “Employment in agriculture (% of total employment) (modeled ILO estimate) - Sub-Saharan Africa.” Data as of January 2021. Accessed July 11, 2022. <https://data.worldbank.org/indicator/SL.AGR.EMPL.ZS?locations=ZG>.

International Food Policy Research Institute. “Women’s Empowerment in Agriculture Index (WEAI).” Accessed May 5, 2022. <https://www.ifpri.org/project/weai>.

Jack, B. Kelsey. “Market Inefficiencies and The Adoption of Agricultural Technologies in Developing Countries.” White paper prepared for the Agricultural Technology Adoption Initiative, J-PAL (MIT) / CEGA (Berkeley), May 2013. Available at: [www.atai-research.org/atai-review-paper-market-inefficiencies-and-the-adoption-of-agricultural-technologies-in-developing-countries/](http://www.atai-research.org/atai-review-paper-market-inefficiencies-and-the-adoption-of-agricultural-technologies-in-developing-countries/).

Jayne, Thomas S., Jordan Chamberlin, and Rui Benfica. 2018. “Africa’s Unfolding Economic Transformation.” *Journal of Development Studies* 54, no.5 (March): 777–787. <https://doi.org/10.1080/00220388.2018.1430774>.

Karlan, Dean, Robert Osei, Isaac Osei-Akoto, and Christopher Udry. 2014. “Agricultural Decisions after Relaxing Credit and Risk Constraints.” *The Quarterly Journal of Economics* 129, no.2 (May): 597–652. <https://doi.org/10.1093/qje/qju002>.

Katz, Elizabeth. 2021. “Gender and Agricultural Advisory Services: Issue Brief.” Prepared for the Agricultural Development Program Strategy Team and the Gender Equality Team of the Bill & Melinda Gates Foundation. [https://www.gatesgenderequalitytoolbox.org/wp-content/uploads/BMGF\\_AG-Advisory-Services-Brief\\_web.pdf](https://www.gatesgenderequalitytoolbox.org/wp-content/uploads/BMGF_AG-Advisory-Services-Brief_web.pdf).

Little, Peter D., and Michael Watts. 1994. *Living Under Contract: Contract Farming and Agrarian Transformation in Sub-Saharan Africa*. Madison: University of Wisconsin Press.

Lowder, Sarah K., Jakob Skoet, and Terri Raney. 2016. “The Number, Size, and Distribution of Farms, Smallholder Farms, and Family Farms Worldwide.” *World Development* 87 (November): 16–29. <https://doi.org/10.1016/j.worlddev.2015.10.041>.

Mbiti, Isaac, Karthik Muralidharan, Mauricio Romero, Youdi Schipper, Constantine Manda, and Rakesh Rajani. 2019. “Inputs, Incentives, and Complementarities in Education: Experimental Evidence from Tanzania.” *The Quarterly Journal of Economics* 134, no.3 (April): 1627–1673. <https://doi.org/10.1093/qje/qjz010>.

Meinzen-Dick, Ruth, Barbara van Koppen, Julia Behrman, Zhenya Karelina, Vincent Akamandisa, Lesley Hope, and Ben Wielgosz. “Putting Gender on the Map: Methods for Mapping Gendered Farm Management Systems in sub-Saharan Africa.” IFPRI Discussion Paper No. 01153, January 2012. <https://www.ifpri.org/publication/putting-gender-map-methods-mapping-gendered-farm-management-systems-sub-saharan-africa>.

Mercy Corps AGRIFIN. 2021. “The Impact of Digital Services on Women Smallholder Farmers.” Kenya and Zambia. <https://www.mercycorpsagrifin.org/2021/05/25/digital-services-women-smallholder-farmers/>.

Muralidharan, Karthik, Paul Niehaus, and Sandip Sukhtankar. “General Equilibrium Effects of (Improving) Public Employment Programs: Experimental Evidence from India.” Working paper, September 2021. <https://econweb.ucsd.edu/~pniehaus/papers/SmartcardsGE.pdf>.

Mukherjee, Sanghamitra, Lauren Falcao Bergquist, Marshall Burke, and Edward Miguel. “Unlocking the Benefit of Credit through Savings.” Working Paper, April 2022. Available at: <https://www.dropbox.com/s/hqb7eu4smr1nlet/Lockbox.pdf?dl=0>.

Porciello, Jaron, Sam Coggins, Gabriella Otunba-Payne, and Edward Mbaya. “A Systematic Scoping Review: How Are Farmers Using Digital Services in Low- and Middle-Income Countries?” Technical report, April 2021. [https://agricultureinthedigitalage.org/wp-content/uploads/2021/04/Full-Report\\_Agriculture-in-the-Digital-Age\\_compressed.pdf](https://agricultureinthedigitalage.org/wp-content/uploads/2021/04/Full-Report_Agriculture-in-the-Digital-Age_compressed.pdf).

Schroeder, Kateryna, Julian Lampietti, and Ghada Elabed. 2021. What's Cooking: Digital Transformation of the Agrifood System. Washington, DC: World Bank. <https://openknowledge.worldbank.org/handle/10986/35216>.

Shakhovskoy, Matt, William Saab, and Clara Colina. "Agricultural "Platforms" in a Digital Era: Defining the Landscape." Technical report, March 2021. [https://isfadvisors.org/wp-content/uploads/2021/03/ISF\\_RAFLA\\_Agricultural\\_Platforms\\_Report.pdf](https://isfadvisors.org/wp-content/uploads/2021/03/ISF_RAFLA_Agricultural_Platforms_Report.pdf).

Suri, Tavneet, Jenny Aker, Catia Batista, Michael Callen, Tarek Ghani, William Jack, Leora Klapper, Emma Riley, Simone Schaner, and Sandip Sukhtankar. 2021. "Mobile Money." *VoxDevLit* 2, no.1 (February): 1–28. <https://voxdev.org/voxdevlit/mobile-money>.

Suri, Tavneet and Rachel Glennerster. "Agricultural Technology and Nutrition in Sierra Leone." Working Paper, 2021.

Suri, Tavneet and Christopher Udry. 2022. "Agricultural Technology in Africa." *Journal of Economic Perspectives* 36, no.1 (Winter): 33–56. <https://doi.org/10.1257/jep.36.1.33>.

Suri, Tavneet, Christopher Udry, Jenny C. Aker, Lauren Falcao Bergquist, Markus Goldstein, Thomas Jayne, Jeremy Magruder, Hope Michelson, Meredith Startz, and Emilia Tjernstrom. "Agricultural Technology in Africa." *VoxDevLit*, forthcoming.

Tjernström, Emilia. "Learning from Others in Heterogeneous Environments." Working paper, April 2017. <https://www.atai-research.org/signals-similarity-and-seeds-social-learning-in-the-presence-of-imperfect-information-and-heterogeneity/>.

Tsan, Michael, Swetha Totapally, Michael Hailu, and Benjamin Addom. "The Digitalisation of African Agriculture Report, 2018-2019." Technical report, June 2019. <https://www.cta.int/en/digitalisation/issue/the-digitalisation-of-african-agriculture-report-2018-2019-sid0d88610e2-d24e-4d6a-8257-455b43cf5ed6>.

Udry, Christopher. 1996. "Gender, Agricultural Production, and the Theory of the Household." *Journal of Political Economy* 104, no.5 (October): 1010–1046. <https://doi.org/10.1086/262050>.

## Annex I: Examples of common constraints to agricultural technology or service adoption

Below is a compilation of common constraints faced by farmers which impact productivity levels (see Suri and Udry 2022 and Jack 2013). Findings from the first iteration of J-PAL and CEGA's [Agricultural Technology Adoption Initiative](#) generally found that no single constraint explains low productivity; rather, different combinations of constraints seem to bind for different farmers. Thus, interventions which target multiple constraints at the same time may be most effective in boosting productivity.

Constraints	
<b>Credit, liquidity, and savings</b>	Barriers to savings or credit access may prohibit farmers from investing in new agricultural technologies.
<b>Insurance</b>	Access to insurance impacts the risk tolerance of farmers, which in turn may bias their decisions conservatively toward low-risk, low-return technologies; particularly for poorer farmers for whom downside risk is more intolerable.
<b>Information</b>	Farmers may not know about new technologies and/or how to use them effectively.
<b>High transaction costs and infrastructure</b>	These constraints exist in dimensions. Input and output markets may be hard to access, search costs, and many layers of intermediaries between producers and final buyers may make accurate information inaccessible; markets may not be well integrated.
<b>Imperfect labor markets</b>	Particularly in sub-Saharan Africa (due to low population density), farmers in rural labor markets may find it difficult to hire labor effectively.
<b>Imperfect land markets</b>	Poorly defined property rights may lower confidence in access to any future or long-term returns on investments in new technologies.
<b>Institutional</b>	Including legal frameworks, such as those around property rights, safety, etc., certification systems, including international certification as a way to access export markets, and contractual risk broadly (not just from contract farming type situations, but also insurance contracts, etc.)

## Constraints

### Gender-based barriers

- Legal and social parameters for access to land, labor and markets that are uniquely faced by women may constrain or change their behavior in relation to male norms/patterns.
- Mobility and time constraints: Gender norms may prevent women from traveling away from home for long distances, reducing access to services, and a higher burden of typically unpaid labor (child raising, household tasks) place higher constraints on women's time.
- Unequal access to education may cause higher information costs on adoption of new technologies.
- Low financial independence and household bargaining power.

## Annex II: Bundles matrix

### Examples of bundled agricultural services and platforms by constraint type and level of digitalization

The following examples are a selection of products and services which tackle multiple constraints through one delivery platform, at least one of which is digitally enabled. This list is non-exhaustive and intended to clarify DAISI's definition of bundled services; the specific goals and sets of constraints targeted by these bundles are not necessarily indicative of DAISI's funding priorities.

Bundle number	Bundle provider	Credit, liquidity, and savings	Information costs	Labor	Land	Risk	Input markets	Output markets	Institutional constraints	Gender-based barriers
<a href="#">1</a>	Senegalese groundnut cooperatives	Yellow	Green						Yellow	
<a href="#">2</a>	<a href="#">One Acre Fund</a>	Yellow	Green			Yellow				
<a href="#">3</a>	<a href="#">RiceAfrica</a>	Yellow	Dark Blue				Yellow	Yellow		
<a href="#">4</a>	<a href="#">Mahindi Master</a>		Dark Blue			Dark Blue				
<a href="#">5</a>	Government of Niger	Yellow	Green							Green
<a href="#">6</a>	<a href="#">Pula</a>		Dark Blue			Dark Blue			Dark Blue	
<a href="#">7</a>	<a href="#">PxD</a>		Dark Blue			Dark Blue	Green			
<a href="#">8</a>	<a href="#">ACRE Africa</a>					Dark Blue	Yellow			

■ Analog   
 ■ Hybrid   
 ■ Digital

Bundle number	Bundled provider	Credit, liquidity, & savings	Information costs	Labor	Land	Risk	Input markets	Output markets	Institutional constraints	Gender-based constraints
<a href="#">9</a>	<a href="#">DigiFarm</a>	Digital	Digital				Hybrid			
<a href="#">10</a>	<a href="#">Ninayo</a>	Digital	Digital							
<a href="#">11</a>	<a href="#">M-Farm Kenya</a>		Digital				Hybrid			
<a href="#">12</a>	<a href="#">DigitalGreen</a>		Digital			Digital				
<a href="#">13</a>	<a href="#">iProcure</a>		Digital				Digital	Digital		
<a href="#">14</a>	<a href="#">iCow</a>		Digital			Digital	Digital	Digital		
<a href="#">15</a>	<a href="#">WeFarm</a>		Digital				Digital			
<a href="#">16</a>	<a href="#">AgroStar</a>		Hybrid		Digital	Hybrid				
<a href="#">17</a>	<a href="#">AGRIBUDDY</a>	Digital	Digital			Digital			Digital	
<a href="#">18</a>	<a href="#">Dvara E-Registry's KhetScore</a>	Digital			Digital				Digital	Digital
<a href="#">19</a>	<a href="#">myAgro</a>	Digital	Digital				Hybrid			
<a href="#">20</a>	<a href="#">Apollo Agriculture</a>	Digital	Digital				Digital			
<a href="#">21</a>	<a href="#">AGRA (agent-based delivery model)</a>		Hybrid				Hybrid			

■ Analog   
 ■ Hybrid   
 ■ Digital

## Bundle descriptions and related papers

### Bundle 1

**Related paper:** Deutschmann, Joshua, Tanguy Bernard, and Ouambi Yameogo. “Contracting and Quality Upgrading: Evidence From an Experiment in Senegal.” Working Paper, March 2021. <https://www.atai-research.org/contracting-and-quality-upgradingevidence-from-an-experiment-in-senegal/>.

**Description:** Researchers implemented a new contracting arrangement that bundled price premium certainty with training and credit for the purchase of a new quality-improving technology. They conducted a randomized evaluation to test whether this contract induced adoption of the technology and improvements in production quality. Producers randomly offered the contract were significantly more likely to purchase and use the technology. They also found that producers in the treatment group increased output sales to the cooperative on average. Importantly, the new contract is significantly more effective at increasing sales to the cooperative for producers who are more reciprocal and for whom signaling reliability is more valuable.

### Bundle 2

**Related paper:** Deutschmann, Joshua, Maya Duru, Kim Siegal, and Emilia Tjernström. “Can Smallholder Extension Transform African Agriculture?” NBER Working Paper No. 26054, February 2021. [https://www.nber.org/system/files/working\\_papers/w26054/w26054.pdf](https://www.nber.org/system/files/working_papers/w26054/w26054.pdf).

**Description:** Researchers evaluated the impact of One Acre Fund’s “market bundle,” which provides farmer groups with group-liability loans for improved seeds and fertilizer, training on modern agricultural techniques, crop insurance, and market facilitation support to help farmers obtain higher prices for their output.

### Bundle 3

**Related paper:** Arouna, Aminou, Jeffrey D. Michler, Wilfried G. Yergo, and Kazuki Saito. 2021. “One Size Fits All? Experimental Evidence on the Digital Delivery of Personalized Extension Advice in Nigeria.” *American Journal of Agricultural Economics* 103, no.2 (March): 596–619. <https://doi.org/10.1111/ajae.1215>.

**Description:** Researchers evaluated the effectiveness of a mobile application, RiceAdvice, that provides personalized advice on rice nutrient management, with the added provision of a subsidy

for 100 percent of the quantity of fertilizer recommended by the RiceAdvice app. They found that personalized advice increased yields without increasing the overall quantity of fertilizer used.

#### Bundle 4

**Related paper:** Tjernström, Emilia, Travis J. Lybbert, Rachel Frattarola Hernández, Juan Sebastian Correa. 2021. “Learning by (Virtually) Doing: Experimentation and Belief Updating in Smallholder Agriculture.” *Journal of Economic Behavior & Organization*, 189: 28–50. <https://doi.org/10.1016/j.jebo.2021.03.001>.

**Description:** Mahindi Master is an app combining crop modeling, rainfall data, and soil information that enables farmers to experiment as they would on their own farm without risking real investments in purchased inputs. The app enables farmers' learning about returns to different fertilizer and input combinations and soil characteristics on a virtual field that is calibrated to their own production conditions and context.

#### Bundle 5

**Related paper:** Bossuoy, Thomas, Markus Goldstein, Dean Karlan, Harounan Kazianga, William Pariente, Patrick Premand, Catherine Thomas, Christopher Udry, Julia Vaillant, and Kelsey Wright. “Pathways Out of Extreme Poverty: Tackling Psychosocial and Capital Constraints with a Multi-Faceted Social Protection Program in Niger.” World Bank Policy Research Working Paper No. 9562, March 2021. <https://openknowledge.worldbank.org/handle/10986/35211>.

**Description:** Researchers evaluated a multi-faceted “graduation” program targeted at women in Niger. The three treatment arms included group savings promotion, coaching, and entrepreneurship training, and then added either a lump-sum cash grant, psychosocial interventions, or both the cash grant and psychosocial interventions. All three arms generated positive effects on economic outcomes and psychosocial well-being, but there were notable differences in the pathways and the timing of effects.

#### Bundle 6

**Description:** Pula offers various bundled insurance and advisory products, including weather index insurance, area yield index insurance, hybrid crop insurance, index-based livestock insurance, and digitally-enabled “Field Sense” products. These are bundled with data-driven monitoring and predictions services, tailored agronomy tips, and insurance and product information.

### Bundle 7

**Description:** Precision Development (PxD) is a non-profit organization that provides customized digital information and services that increase productivity, profitability, and environmental sustainability. PxD's model provides personalized extension advice through users' mobile phones that is customized to their geography, market, and characteristics.

### Bundle 8

**Description:** ACRE's Hakika index insurance product is a mobile-based weather index-based product that also provides educational information on insurance and agronomic practices. ACRE Africa is not an insurance company, but a service provider working with insurers and players exploring effective market options for farmers.

### Bundle 9

**Description:** DigiFarm is an integrated mobile platform that offers farmers one-stop access to a variety of services: discounted quality inputs for smallholders available from depots run by iProcure; an adaptive learning system delivered through a digital learning platform from Arifu; and Safaricom services such as M-PESA, Lipa na M-PESA, and M-Shwari.

### Bundle 10

**Description:** NINAYO is a free marketplace used by Tanzanian farmers to sell their crops. The team is currently evaluating two synergistic products. The first is a series of WhatsApp groups that enable farmers to order discounted agro-inputs and receive real-time agronomic advice. The second is a "Quick Codes" interface that enables farmers to own their harvests as digital assets further up the value chain.

### Bundle 11

**Description:** M-Farm is an SMS-based transparency tool for farmers to get information pertaining to the retail price of their products, buy inputs directly from manufacturers at favorable prices, and find buyers for their produce. They are currently collecting wholesale market price information on 42 crops in five markets in Kenya. Pricing information is collected daily through independent data collectors using geocoding.

### **Bundle 12**

**Description:** DigitalGreen is a digital extension and training service that provides access to information about soil health, availability of inputs, weather forecasting, and pests to subscribed farmers.

### **Bundle 13**

**Description:** iProcure is a Nairobi-based start-up working to optimize the agriculture input supply chain in rural Kenya. iProcure's web and mobile technology solution lets agricultural retailers manage ordering based on inventory, point of sale activities, and client profiles. They also leverage geospatial data to provide geo-located purchasing patterns, track real-time agent performance and transaction analysis, and offer built-in mobile payments.

### **Bundle 14**

**Description:** iCow is a Kenyan digital platform with a suite of services for dairy farmers, including SMS broadcasting ("Masomo" livestock rearing advisory services), personalized calendar-based management tools ("Kalenda"), farmer library (learning resources), Soko countrywide virtual marketplace, and expert location services (e.g., assistance in accessing veterinarians, artificial inseminators, forestry experts, soil experts, etc.).

### **Bundle 15**

**Description:** WeFarm is a mobile app based in Kenya that offers a platform to interact with fellow farmers to solve problems and collaborate. WeFarm also offers a channel through which farmers can order their inputs online, as well as check prices and availability on Wefarm Shop.

### **Bundle 16**

**Description:** AgroStar's app serves as a digital farmer network. It includes a virtual video guide with over 3,000 training videos for over 26 crops and uses technology to access land information on demand to the farmer by taking into account their specific data inputs, such as soil quality, water availability, and stage of the crop. The app also hosts webinars and Q&A sessions conducted by agricultural experts through Zoom calls and YouTube Live, including information on multiple crops, farming "do's & don'ts," and farm nurturing tips.

### Bundle 17

**Description:** AGRIBUDDY offers credit scoring algorithms to develop risk profiles of individual farmers, using a mix of information about crops, weather, land, market, and the individual. They gather and analyze data on weather, soil conditions, hydrology, market conditions, infrastructure, etc. to manage risk. The platform also offers aggregate outputs for domestic and export bulk consumers of crops, tracking availability in real time. Additionally, the service hosts a rural network for aggregation and direct sales of consumer goods to the rural population.

### Bundle 18

**Description:** KhetScore is a digital innovation platform/app to improve access to credit (and promote productive investments in agriculture) for farmers, particularly women, who lack access to land records or credit scores.

### Bundle 19

**Description:** myAgro is a mobile layaway platform that allows farmers to use their mobile phones to purchase seeds and fertilizer in small increments. After six to eight months of paying on mobile layaway, myAgro delivers input packages directly to the farmers' villages. myAgro provides agricultural training to all farmers who have purchased these input packages.

### Bundle 20

**Description:** Apollo Agriculture is a company launched in 2016 that uses mobile technology, machine learning, and remote sensing to deliver customized packages of seed, fertilizer, advice, insurance, and credit to small-scale farmers.

### Bundle 21

**Description:** AGRA's Village-Based Advisors (VBA) is an agent-based service delivery model that leverages a lead farmer selected by Ministry of Agriculture extension agents to work in his or her village. Extension services and relevant information is delivered digitally to VBAs and to farmers within VBA communities. VBAs can send SMS or voice messages through the digital platform to farmers, but the VBAs are the main users of the digital platform for their own information and training needs. Specifically, VBAs can conduct a needs assessment of a farm, share the information through the platform, and then receive recommendations on the practices or technologies that could improve the farmer's productivity and profits all through the digital platform.