



Removing Roadblocks

LESSONS LEARNED IN LEVERAGING DIGITAL TECHNOLOGY TO INCREASE SMALLHOLDER FARM MECHANIZATION

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Executive Summary

In many places where the majority of smallholder farmers still operate with manual or animal labor, mechanization holds tremendous potential for increasing farm yields, opening new market opportunities for smallholders, attracting youth to the sector and boosting agricultural production. But a tractor is a major investment, and few individual, small-scale farmers have the financial resources or the justification to purchase such equipment. Meanwhile, equipment owners who could earn extra income by providing mechanization services confront the hurdles of finding and aggregating customers for profitable delivery of mechanization services.

Through the Financial Inclusion for Smallholder Farmers in Africa Project (FISFAP), implemented by Alliance for a Green Revolution in Africa (AGRA) with funding from the Mastercard Foundation, several innovators have been tackling these challenges. Three of them—TROTRO in collaboration with AGRO Africa in Ghana, Hello Tractor in Kenya and ETC Agro in Tanzania—have experimented with a range of partnerships, digital platforms and solutions that bring together banks, farm equipment owners and operators, smallholder farmers, maintenance providers and other value chain actors to align their interests, facilitate mechanization service provision, and ultimately increase smallholder production.

This technical paper draws on the experiences of three AGRA partners to present their lessons learned so far in using the potential of digital technology to unite value chain actors and expand farm mechanization in sub-Saharan Africa. Starting with a summary of the goals and constraints of key actors across the farm mechanization ecosystem, the paper goes on to examine how the three partners are attempting to achieve the network effects needed for smallholder mechanization to succeed.

On the supply side, the partners are engaging equipment owners by:

- Building the business case for farm equipment ownership and provision of rental services
- De-risking investment to increase tractor ownership
- Aggregating demand and maximizing tractor uptime

On the demand side, they are engaging farmers by:

- Reinforcing interest in and justification for farm mechanization
- Fostering access to, trust in and usage of mechanization rental services
- Making farm mechanization affordable and effective

The paper presents examples of each partner's efforts in these areas to inform and inspire ongoing innovation. Based on the experience of AGRA and the three partners to date, the paper offers preliminary answers to several overarching questions:

- Agricultural production: Are digital platforms successful in enhancing access to mechanized services for smallholder farmers?
- Finance: Do the models reduce risk for Financial Service Providers (FSPs), leading to increased farm equipment financing, and how could this be further improved?
- Gender: What is known about women's use of the service, the proportion of end clients who are female, the value proposition for them as compared to men and the potential that this innovation holds for female smallholders?

- Youth: What is the role of youth in this ecosystem and the potential for engaging youth in agricultural livelihoods?
- Environment and employment: what are the adverse effects of mechanization and how can they be mitigated?
- Role of subsidy: What did AGRA's investment enable and de-risk, and where are donor funds still critical to fostering mechanization?

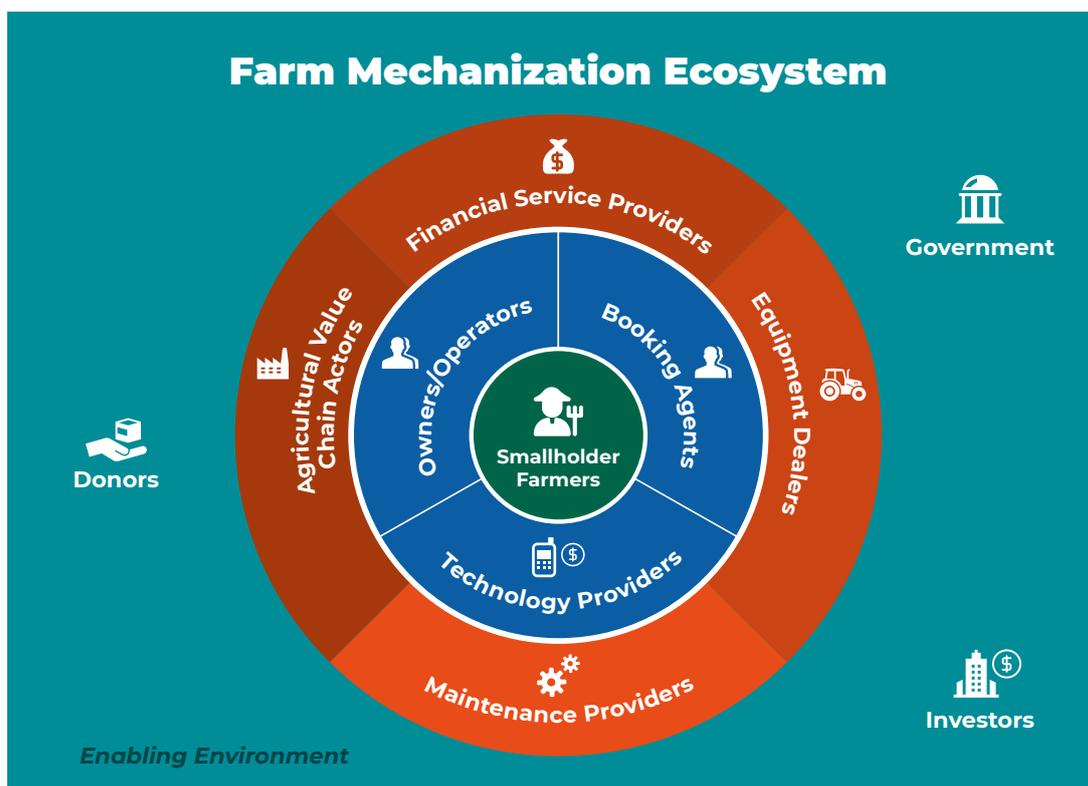
As digital platforms for agriculture and other agritech solutions continue to evolve, the experiences of these digitally enabled mechanization service pioneers can help advance innovation, practice and scalability to make farm mechanization rental a viable proposition for all stakeholders.

I. Background

Despite the promise of mechanization, persistent obstacles have prevented smallholder farmers in sub-Saharan Africa from leveraging modern tools to increase farm production and profits. While a growing population is raising the demand for food and employment in many countries, agricultural production still relies heavily on manual labor or animal traction (as much as 80% of cultivated land by some estimates), and crop yields in Africa are only about half of those in the rest of the world (FAO and AUC, 2018). There is widespread recognition that the “mechanization of crop production using tractors... can have a large effect on food production and agricultural labor productivity, thus affecting food security and farmers’ livelihoods” (Global Food Security, 2020). Yet decades of government efforts to mechanize have fallen short, and a majority of farmers in Ghana, Kenya and Tanzania—as well as other countries throughout the region—continue to cultivate without the benefit of tractors and other mechanical implements. As the FAO and African Union Commission assert, “doubling agricultural productivity and eliminating hunger and malnutrition in Africa by 2025 will be no more than a mirage unless mechanization is accorded utmost importance” (FAO and AUC, 2018).

However, getting tractors, threshers and other modern equipment onto more African farms remains a major challenge. Smallholder farms (defined as farms under 2.2 hectares) predominate in sub-Saharan Africa (FAO, 2015) and account for a significant proportion of agricultural production. Investing in a tractor is expensive, risky and simply does not make sound economic sense for individual smallholders. Pooling resources to share equipment is not a simple fix, either, because successful mechanization requires a well-functioning ecosystem of equipment dealers, asset and input financing, maintenance, spare parts, training and market access—such as off-takers ready to buy the farmers’ produce on time at a fair price. In the absence of such ecosystem coordination, there are few available, good quality, affordable mechanization options. Meanwhile, the equipment sellers and owners who could potentially address this demand, and earn income by deploying their often idle tractors, confront the hurdles of finding and aggregating customers for mechanization services. Figure 1 offers a generic map of the mechanization ecosystem and its key actors.

Figure 1: Farm Mechanization Ecosystem and Actors



Although these actors share overlapping goals, their incentives must be aligned and their contributions well coordinated, in order for the business case to work for all stakeholders. The role of each actor is vital to sustain a functioning farm mechanization ecosystem. Figure 2 summarizes the overlapping goals and constraints of the different stakeholder groups, illustrating the motivations that compel them to collaborate.

Figure 2: Overlapping Goals and Constraints of Key Stakeholders

Stakeholder	Main Goal	Main Constraints
Smallholder farmers	Increase yield and income	Cost of mechanization, access to mechanization, recommended agronomic practices
Tractor owners	Maximize equipment investment (for own farm and/or via service provision)	Inefficiencies in finding and reaching customers, operating expense and lack of visibility on services rendered
Tractor operators	Maximize income by providing ploughing and other services	Inefficiencies in traveling to and serving customers, equipment maintenance and downtime, fair payment for services rendered
Booking agents	Maximize income by earning commissions on mechanization services	Reaching and convincing sufficient numbers of customers to hire services, in order to make the activity worthwhile
Financial service providers	Increase profits by expanding loan portfolio and outreach into new markets	Risk of lending especially in agricultural sector and without traditional collateral, insufficient information on tractor rental revenue model
Farm equipment dealers	Maximize sales and ensure adequate after-sales support to meet warranties	Increase the number of qualified and interested buyers, market to them, and facilitate or provide financing that meets their needs
Maintenance providers	Earn profit on reliable mechanical repair and related services for paying customers	Know-how to repair various equipment brands and models, accessibility of spare parts, critical mass of customers (in rural areas), efficient service provision
Agribusinesses	Purchase large quantities of high-quality produce	Limited number of high-production farms, growing competition, smallholders are under-mechanized and hard to reach/organize
(Social) Investors	Place capital in and maximize return on promising (agritech) business models (while achieving positive social and environmental outcomes)	Identifying and evaluating high-potential models, protecting against risk, and fueling scale within an acceptable time horizon
Governments	Boost food production, improve rural economy, create new employment opportunities, reduce poverty, reinforce environmental resilience	Adequate funds, sufficient technical capacity, successful and cost-effective outreach strategies, engagement of the private sector
Donors		Identifying, fueling and replicating promising partnerships and strategies; de-risking investments, providing patient capital and building local capacity without distorting the market; stimulating and achieving sustainability

Digital technology presents new opportunities to alleviate actors' constraints, reduce market frictions, enable cost-effective coordination of agricultural actors and also attract young people to a sector in need of new energy and ingenuity. The popularity and reach of mobile money have paved the way to other digital services, even in rural areas, where network connectivity and mobile phone ownership are rapidly reaching critical mass. The 'digital sharing economy' and the 'Internet of things' hold tremendous promise for creating the efficient linkages and transparency necessary to reinforce the ecosystem for sustainable agricultural mechanization. Whether it is aggregating farmer demand for mechanization and linking to rental tractor services via a digital platform or embedding a live data tracking device in a tractor to monitor acreage covered, digital tools are poised to open the door to asset finance, enable viable business models, improve farm production and revolutionize the agricultural sector.

Beginning in 2017, AGRA invested in several organizations pursuing innovation in agricultural mechanization. With the support of Mastercard Foundation, AGRA extended grants and technical assistance to private sector innovators seeking to test digital approaches to mechanization for enhancing smallholder farmer production and financial inclusion. This technical note focuses on the experiences and lessons learned of AGRA's mechanization partners, with a focus on three examples in Ghana, Kenya and Tanzania. Based on project documentation and interviews with AGRA and partner staff, the purpose of this technical note is to share learning, contribute to ongoing innovation and inform future investment and research related to smallholder mechanization.

II. Introduction to Three Mechanization Models

Over the past five years, AGRA and its mechanization partners have experimented with a range of approaches—learning and pivoting as their business models evolved. Among these partners, three companies in particular present compelling cases for analysis: TROTRO in Ghana, Hello Tractor in Kenya and ETC Agro in Tanzania. While each of them approached mechanization from a different angle at the outset, their findings and models have in many ways converged. As of early 2021, in these three countries alone, the three companies were leveraging digital technology to reach a combined total of nearly 90,000 farmers with over 1,000 tractors and other mechanized farm implements.

Applying the definitions and taxonomy presented in **Agricultural Platforms in a Digital Era: Defining the landscape** (ISF Advisors and RAF Learning Lab, 2021), these three examples are digital platforms offering agricultural product and service marketplaces, specifically asset rental marketplaces. The following brief introductions to the partners provide background for further discussion in the following chapter on lessons learned. Figure 3 offers an overview of the three partners' approaches to increasing smallholder mechanization.

TROTRO Tractor Limited (Ghana)

TROTRO Tractor Limited started in 2017 with an "Uber for tractors" model aiming to connect tractor owners with farmers seeking pay-as-you-go rental tractor services for pre-planting and harvesting. TROTRO's USSD platform allows farmers to request, schedule and pre-pay for tractor services, while tractor owners can remotely monitor the use and efficiency of their machines (typically driven by an operator hired by the owner). The company's goal was to make tractor services affordable and accessible by pooling demand and minimizing the transaction costs between owners, operators and farmers. TROTRO built in several measures to reinforce the farm mechanization ecosystem. In order to increase transparency and reduce the risks of cash transactions, TROTRO developed in-app payments via mobile money. TROTRO is partnering with farm equipment dealers such as AGRO Africa and Tata to help expand the supply of tractors. They have connected with two banks so far to facilitate asset financing for equipment owners. In an effort to ensure quality service delivery to smallholders, as well as prudent operation of tractors to maximize their lifespan, training is provided to tractor owners and operators on

equipment maintenance and operation, as well as best practices in land preparation. Finally, recognizing early on the need for “human touch points” to promote and support the digital platform, TROTRO trained lead farmers to help groups of outgrowers and others access the digital services. In order to unite the maintenance, training and financing elements and bring them closer to farmers, TROTRO is now testing a Decentralized Mechanization Center (DMC) model. As of early 2020, TROTRO’s platform counted 591 tractors servicing 27,500 farmers, and two DMCs had become operational by early 2021.

Hello Tractor (Kenya)

Hello Tractor is an agricultural technology (agritech) company that equips tractors with digital tools to facilitate the delivery of hired tractor services. Hello Tractor’s core product is a monitoring device with GPRS and specialized software, which offers real-time visibility of a tractor’s location and movement, including transmitting data and SMS messages to both owner and operator. Hello Tractor is focused on supplying the technology and data analytics necessary to improve tractor efficiency, including job batching and strategic routing, in order to reinforce the provision of tractor services as a profitable business model. Hello Tractor partners with equipment dealers to arrange asset finance on the basis of farmers’ data-backed business plans. The agritech sells their device to tractor owners engaged in organized, commercial value chains. The tractor owners in turn provide tractor services to smallholders in their value chain networks. Hence Hello Tractor’s entry point is different than TROTRO’s more direct focus on farmers and ETC Agro’s linkage to the end users of mechanization services. AGRA provided support to Hello Tractor to train tractor owners, operators and booking agents on using the technology and providing quality tractor service to farmers. Payments for service are made in cash since Hello Tractor and its customers found in-app mobile money payments to be prohibitively expensive. As of early 2021, the Hello Tractor platform in Kenya had 300 tractors serving 41,000 farmers, in addition to the company’s outreach in several other countries.

ETC Agro (Tanzania)

ETC Agro Tractors and Implements Ltd is a farm equipment dealer that sells and services tractors and other farm implements in Tanzania. ETC Agro is a subsidiary of the Export Trading Group (ETG), a global offtaking company with 25 agricultural commodity centers nationwide. As part of ETG, ETC Agro has a vested interest in increasing farm yields among outgrowers. When ETC Agro began collaborating with AGRA in early 2017, they were seeking to develop an equipment finance model that would enable more farmers, including smallholders, to buy tractors—thereby increasing tractor sales, mechanization and farm production in Tanzania. ETC Agro partnered with several banks (Akiba, CRBD, NMB and others) to link lead farmers and qualified SMEs to affordable financing to acquire tractors that could be used for their own farms, as well as for rental services to other farmers. The company soon realized that more support was needed to reduce downtime due to maintenance and repair needs, and to connect smallholder farmers with equipment owners. In response, ETC Agro trained about two dozen local garages to increase the availability of quality maintenance and spare parts. They established a call center to match farmers with tractors, but the logistical complexity led to long time lags and unsatisfactory service. So ETC Agro developed a GPS-enabled digital application to allow owners to monitor service provision and farmers to place service orders.

As of early 2021, ETC Agro had facilitated equipment financing for 174 lead farmers who had provided hiring services to a total of about 21,453 farmers. Twenty-two ETC-trained partner garages were actively providing quality maintenance. In addition, ETC Agro had just started an off-season soft-launch of its new digital platform to facilitate mechanization service delivery in place of the call centers; 26 tractor owners had already signed on, and with the help of 14 booking agents equipped with smartphones, around 170 smallholder farmers had recently joined the platform to schedule mechanization services.

Figure 3: Overview of Three AGRA Partners Addressing Smallholder Mechanization

	TROTRO	ETC Agro	Hello Tractor
Geography¹	Ghana (also Togo, Zimbabwe, Nigeria)	Tanzania (also Rwanda)	Kenya (also Nigeria, Tanzania, Mozambique, South Africa, Ghana, Senegal, Pakistan, Bangladesh)
Business description	Digital platform for tractor rental that increases smallholder production while creating business and equipment financing opportunities for owners and operators	Tractor dealer and end-to-end value chain actor that purchases farmer produce and provides post-sale tractor support, including equipment sales and local maintenance providers	Digital supply chain management solution that enables the business case for tractor ownership, operation and rental by providing a digital application for equipment owners, booking agents and farmers
Equipment financing model	Enabling an “owner-to-operator” model with tractor operators leasing from TROTRO, which is backed by banks until they assume full ownership	Partnering with financial service providers (FSPs) who share credit risk with ETC and tractor owners	Partnering with equipment dealers who finance on basis of Hello Tractor credit rating tool and business case based on tractor’s use
Current direction	Decentralized mechanization centers as a hub for digital tractor leasing, training mechanics and operators, and batching jobs; testing new public and private sector partnerships	Mobile application and GPS for tracking, service matching and payments; replicating in a new country (Rwanda)	Linking with corporations and cooperatives in commercial VCs who want to provide mechanization to their networks and members
Approach²	Build a new user base in both supply and demand side (Decentralized Mechanization Centers)	Leverage an existing user base (agricultural offtaking business network)	Build new user base on supply side (tractor fleet owners) who use the technology solution to better serve and reach their (farmer) customers
Scale (as of early 2021)	Number of farmers accessing tractor hiring services: 16,539 (27,534 registered) Number of owners offering services on platform: 591 Number of tractors sold through TROTRO partnerships: 35 Tractor owners trained: 997 Farmers trained: 22,213 Hectares ploughed: 14,784	Number of farmers accessing tractor hiring services: 21,453 Number of lead farmers/agri-SMEs offering hiring: 174 Number of tractors financed: 140 Number of local garages upgraded, trained and offering maintenance: 22 Hectares ploughed: 52,156	Number of farmers accessing tractor hiring services: 41,000 Number of owners offering hiring services using Hello Tractor technology (Kenya only): 300 Owners availing equipment finance with Hello Tractor support: 26 expected in 2021 Hectares ploughed: 130,000

¹ This paper focuses on the services and experience in one specific country per partner, although all of the companies are offering some form of service in other countries, as well (mentioned as “also”).

² Referencing Agricultural Platforms in a Digital Era: Defining the landscape (ISF Advisors and RAF Learning Lab, March 2021).

III. Lessons Learned

Leveraging technology to foster ecosystem interconnectivity is at the root of all three business models. These innovators are increasing mechanization for smallholder farmers by reducing information asymmetries, increasing transparency, improving efficiencies and minimizing risk so that each stakeholder category is able to overcome constraints and achieve their objectives (as described in Figure 2, above). Although the stakeholders have demonstrably complementary interests, until recently the ecosystem has lacked an efficient mechanism to bring the actors together, effectively align their incentives and facilitate their coordination and collaboration.

The digital solutions introduced by the three AGRA partners show strong potential to enable a viable business case for each ecosystem actor, thereby setting in motion a virtuous cycle for mechanization. While their entry points and business models differ, TROTRO, ETC Agro and Hello Tractor are each aiming to bring together various actors in the farm mechanization ecosystem to achieve their respective goals. TROTRO, for example, unites smallholder farmers, owners/operators, booking agents and technology providers (the green and blue circles in Figure 1) through a digital platform, to create a virtual marketplace for farm rental services; through its partnership with AGRO Africa, TROTRO added a value chain actor to the platform, and with its recent DMCs, TROTRO is also bringing maintenance providers into the loop. ETC Agro approaches the challenge from its main objective as an equipment dealer selling tractors by bolstering the ecosystem through a range of complementary services—such as capacity building of maintenance providers—to help increase the off-taking business of its parent company, ETG (an agricultural value chain actor). Hello Tractor offers a digital solution for supply chain management to owners of tractor fleets, which indirectly increases the supply of mechanization services for outgrowers and other smallholder farmers. As they tackle the market frictions and connect key actors in the ecosystem, all three partners are applying digital technology to address similar supply side and demand side goals.

Bringing the ecosystem actors together is only useful, of course, if their respective needs can be met on a scale that enables and motivates ongoing exchange—the concept known as “network effects”. Appropriate mechanization equipment and services must be available on the market, and there have to be enough consumers aware of, willing and able to access and pay for those services. By the same token, the value of offering mechanization services increases for suppliers as the number of farmers in the network grows (more customers and higher density for efficient deployment); and the value that farmers derive from mechanization is enhanced by the quality, diversity and ready availability of the farm equipment and operators. Digital technology can play a pivotal role in bringing together supply-side and demand-side actors to achieve network effects in the farm mechanization ecosystem.

The conditions that give rise to a functioning mechanization service market coalesce around three main dimensions for both equipment owners (supply side) and farmers (demand side):

- **Rationale:** Why mechanization? There needs to be a business case for supplying and utilizing mechanization services; equipment owners and farmers alike need to perceive the value and have the impetus to sell/buy farm mechanization.
- **Acquisition:** How to obtain it? Even when both supply side and demand side actors see a strong rationale, they face friction in acquiring the means to mechanization. Suppliers need capital and risk protection to acquire farm equipment, while farmers need to know about and be able to find and access trustworthy services.
- **Efficiency:** How to make it cost-effective? Finally, understanding the value and accessing the means to farm mechanization are only useful if there is a financial upside for both supply side and demand side actors. For owners, this means that mechanization services are delivered efficiently, thereby making the equipment and service investment worthwhile. For farmers, this means that their investment in mechanization leads to increased yields, a lower expense to sales ratio, and ultimately a net gain in income or other valued benefit.

Figure 4 encapsulates these dimensions and the key levers to increasing mechanization supply and demand. The following section delves into each of these levers, explores how the three partners are activating them to attain positive network effects, and documents what they have learned so far along the way.

Figure 4: Supply and Demand Levers for Increasing Smallholder Mechanization

Dimension	Supply side levers (equipment owners)	Demand side levers (farmers)
Rationale	Building the business case for ownership and provision of rental services	Reinforcing interest in and justification for farm mechanization
Acquisition	De-risking investment to increase tractor ownership	Fostering access to, trust in and usage of mechanization rental services
Efficiency	Aggregating demand and maximizing tractor uptime	Making farm mechanization affordable and effective

SUPPLY SIDE LEVERS

In order to increase supply, there need to be more tractors and other farm equipment available in the local area, more provision of rental services to expand the reach of the equipment to more numerous and smaller farms, and tractors need to maximize the number of farms served, including operating as much as possible during the season and over the course of the year. The AGRA partners have experimented with various approaches to addressing the ecosystem gaps that prevent potential owners from investing in equipment and providing farm mechanization services, as described below.

Building the business case for ownership and provision of rental services

The business case for investing in and leveraging idle farm equipment to offer rental services needs to be reinforced for owners. The concept of pooling resources to spread mechanization services among many small farms is not new in and of itself. But the transparency and visibility offered by digital technology open the door to a compelling business model that was not feasible before and that can stimulate an increase not only in ownership but also in the provision of rental services to multiple farmers.

Equipment tracking: A critical ingredient of all three models is a tracking device with GPRS capability that allows tractor owners to monitor the location and activity of their equipment. As TROTRO's equipment dealer partner AGRO Africa puts it, "the biggest challenge we face is operator mischief." This device coupled with digital software permits owners to see where the tractor is in real time, and to record acreage, receive a dashboard report and even remotely stop the machine when necessary. Although equipment manufacturers typically embed some form of tracking mechanism in their tractors, the greater functionality of these new devices has led AGRO Africa, for example, to incorporate TROTRO's technology in their tractors instead. ETC Agro has overcome network connection hurdles to get their own GPRS-based tracking up and running (for instance, incorporating two SIM cards to accommodate spotty network coverage in the areas they serve), as a way of incentivizing owners to use tractors for service provision. All three partners are finding that such technology makes service provision more transparent, less risky and more viable as a business activity, for owners as well as operators.

Hello Tractor has gone a step further by building on its GPRS device to offer several features that support and guide the business of providing mechanization services. Hello Tractor's smart phone-based application enables not only real-time monitoring of tractor location and hectares serviced, but also tracking of active time, fuel utilization, maintenance scheduling, driver management and customer bookings. By enabling owners to measure and monitor such cost and revenue drivers, Hello Tractor is

also facilitating better business planning to enhance profitability and return on investment.

Targeting owners to fuel scale and outreach: With this technology and resulting business case justification in hand, the partners are also learning which markets are most receptive to new equipment acquisition and can therefore fuel scale-up as well as grassroots outreach. The three partners have adopted different strategies for achieving the network effects necessary to make their digital platforms viable and to create value for equipment owners in order to increase supply. Their strategies illustrate the three main approaches outlined by ISF Advisors and RAF Learning Lab for digital platforms in the agricultural sector (2021).

Figure 5: Strategies for Achieving Digital Platform Network Effects

Approach	AGRA Partner Example
Leverage an existing use base	Already an equipment dealer itself, ETC Agro is leveraging new technology to encourage tractor owners to rent services to outgrowers during the estimated 80-90 days per season that their equipment otherwise sits idle. This helps amplify owner demand for equipment and increases the supply of mechanization services.
Build a new user base in either the demand or the supply side first (in this case: the supply side)	<p>To accelerate ownership uptake, Hello Tractor is focusing on established value chains and actors who have the means to purchase (a fleet of) tractors and their convening power for large-scale delivery of services across their cooperative or outgrower network. Hello Tractor brings such actors together directly with equipment dealers to spur financing arrangements based on the data-backed business case made possible by their monitoring device and software (as further described below).</p> <p>TROTRO is also establishing partnerships with equipment dealers—initially AGRO Africa with whom they partnered on an AGRA-funded pilot project, and more recently Tata and others. They hope this will rapidly increase their scale of outreach by increasing the supply of equipment on their platform.</p>
Build a new user base in both the demand and supply side simultaneously	<p>Based on their experience trying to increase tractor ownership, TROTRO observed that the farmers who could afford to purchase tractors were more inclined to use them on their own farms, rather than servicing smallholder farmers. TROTRO wanted to open up ownership opportunities to smaller farmers and encourage them to make a business of renting their tractor services—thereby increasing tractor ownership and the availability of mechanization, while also creating new rural jobs. In response, TROTRO developed Decentralized Mechanization Centers (DMCs) that offer a lease-to-own program for low-income farmers interested in tractor ownership for mechanization service provision.</p> <p>TROTRO’s DMCs are physical farm equipment hubs that bring together owners, operators, financing, maintenance, training and booking for smallholders. Each DMC groups 12 operators with lease-to-own financing arrangements to serve a specific catchment area. Based on the planned total national coverage of 85 DMCs in the longer term, this is expected to lead to the creation of over 1,000 operator jobs (considered “dignified” employment), while also substantially expanding the distribution, availability and visibility of tractor hire services across Ghana. TROTRO’s DMCs are further described below.</p>

De-risking investment to increase tractor ownership

In order to increase the supply of tractors, (would-be) owners need to have access to appropriate equipment financing. All three partners have experimented with financing mechanisms, leveraging their technology and platform to de-risk owner investments and to demonstrate the viability of this market.

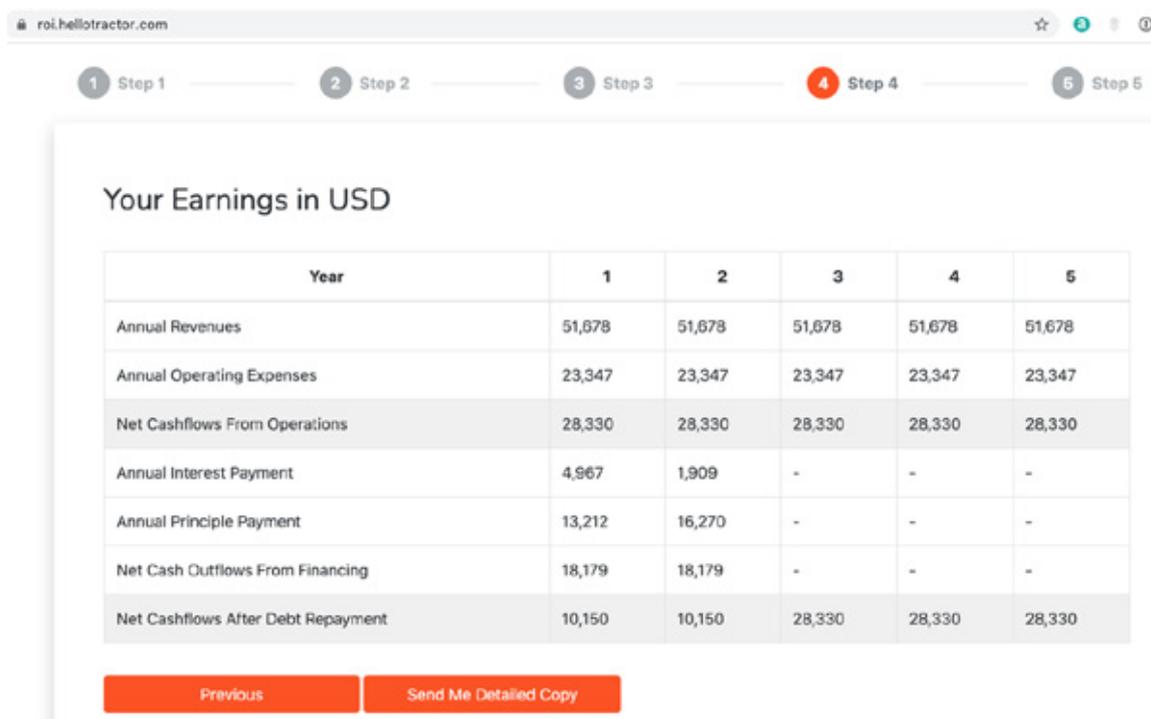
Lease-to-own: While promoting the business model of service provision to entrepreneurs who already have the means and networks is one valid angle, extending ownership to smaller farmers is another approach. TROTRO realized that farmers who can most readily obtain financing for their own tractors are more likely to use them for their own (often larger) farms, rather than risk damage, equipment unavailability and business distraction by offering mechanization services. Seeking to lower the barriers to entry for small entrepreneurs interested in service provision (including smaller farmers and non-farmers like Ghanaians in the diaspora) and operators who would like to own their own asset, TROTRO obtained technical assistance from the Frankfurt School and partnered with two local banks to test an “owner-to-operator” financing model.

From 2018 through 2020, 35 AGRO Africa tractors were financed through TROTRO’s leasing model, totaling about \$1 million in combined value. TROTRO offers its digital technology as collateral to access bank loans for on-lending to operators until they assume full ownership (typically a three-year lease-to-own). By collecting and making operator and farmer profile data available on the platform, TROTRO provides lenders with operators’ past performance and their revenue pipeline. The loans require a down payment of around 20% and carry a 36-month term. TROTRO’s new DMCs in rural areas are also attempting to raise the profile of mechanization services, highlight the business opportunity, and make ownership viable to a broader market through the lease-to-own financing combined with proximate availability of training and maintenance.

Credit scoring and return on investment tools: Hello Tractor opts to partner with tractor dealers who finance the sale of their own equipment on the basis of a credit rating tool developed by Hello Tractor in partnership with Moody’s. In Kenya and other markets, Hello Tractor had found that banks were not ready to provide asset finance with only the tractor as collateral and that they charged prohibitively high interest rates. However, equipment dealers’ vested interest in increasing sales makes them more inclined to offer competitive terms.

Hello Tractor developed a detailed return on investment model to demonstrate the business case for agribusinesses and cooperatives considering purchasing farm equipment on the one hand, and for dealers providing financing, on the other. Drawing on regional industry hiring rates, the company’s own collected data and assumptions, Hello Tractor’s financing model shows, for example, how a \$34,000 investment in a tractor and plough can be repaid over two years and break even within four years by hiring out services to plough four hectares per day for 20 days per month over a four-month season each year. The model takes into account average costs of fuel, maintenance and insurance premiums, as well as commissions and fees due to Hello Tractor and to booking agents. Hello Tractor’s digital return on investment calculator (Figure 6) allows potential finance providers and owners to enter personalized parameters to estimate their return on investment— making it easier for financial partners to better assess risk and opportunity and for tractor owners to gauge the value of equipment investment.

Figure 6: Screenshot of Hello Tractor’s Return on Investment Calculator



Risk sharing: As a tractor dealer within a larger agricultural value chain company, ETC Agro realized that sales were constrained by the company’s 50% down payment requirement. Rather than revamp its internal financing to address this constraint, ETC Agro forged partnerships with several banks to spread the risk. ETC offered a 50% buy-back guarantee to attract its first two bank partners. However, once proof of concept was established, ETC signed on additional FSP partners without the buy-back guarantee. With this arrangement, equipment loan down payments were reduced first to 35% and eventually to 20-25% with the banks assuming the additional risk. ETC also provides coaching and support to buyers in collecting documentation and applying for the loans. ETC Agro says that they now receive regular requests from FSPs, and of the 140 tractors financed so far, ETC Agro has only had to “buy back” three tractors (a 2% default rate).

Aggregating demand and maximizing tractor uptime

Increasing the supply of tractors is moot if the machinery is frequently out of order or not efficiently deployed. To achieve return on investment and continue providing services, owners need effective ways to increase client density and maximize tractor “uptime”. All of the partners recognize the need to diversify beyond land preparation (for which mechanization is currently in highest demand), in order to increase mechanization activity throughout the year; they are gradually working to expand equipment and service offerings on the platform to address seasonality. However, first and foremost, the partners are striving to instill recommended maintenance practices among owners and operators, increase the availability and proximity of skilled mechanics, promote an entrepreneurial approach to deployment, and improve the operational efficiency of tractors.

Operation and maintenance training: A major cost driver is damage to tractors in the field caused by inappropriate use or lack of regular maintenance. Following recommended maintenance and operating procedures improves equipment efficiency and uptime, enhances the business case for owning and operating a tractor, protects the dealers from undue warranty expense, provides the assurance that financial institutions require for financing, and leads to better usage of scarce mechanization resources to reach more smallholder customers and increase yields. To improve

maintenance and damage prevention practices, all of the partners incorporate owner and operator training in their services, although they struggle with sustainably covering the expense. Booking agents offer one way to scout and approve fields before ploughing, as well as to encourage regular maintenance check-ups. Some are also experimenting with SMS reminders to improve maintenance-seeking habits.

Availability of skilled maintenance: Demand for maintenance must be met by readily available mechanics. As TROTRO's services ramped up (reaching about 27,000 farmers by mid-2020), the company noticed a sticking point: tractors were often out of commission. Frequent breakdowns combined with long waits for service and spare parts led to substantial time losses during the short season for land preparation in Northern Ghana. This undermined the business case for tractor financing and rental, while also limiting the number of farms reached with mechanization services. TROTRO needed a way to keep the equipment operating more reliably, with well trained, locally available and properly equipped support available in a short timeframe.

Partly to address the maintenance service gap, TROTRO designed the DMC model (introduced above) to leverage the digital platform. DMCs are tractor hubs serving farms in a defined, local radius. Anchored by a garage/service center, the hubs offer farmers lease-to-own tractors financed by local banks, ongoing training for groups of owners and operators, and a physical presence to complement TROTRO's digital platform. With the first DMCs just getting underway in early 2021, TROTRO is continuing to learn and refine this model to meet the needs of smallholder farmers and other actors in the mechanization ecosystem.

Facing similar challenges, ETC Agro has focused on identifying and upskilling existing maintenance service providers, by training local garages and mechanics to provide better service and supplying them with spare parts. With the financial support of AGRA, ETC Agro trained a network of 25 garages and equipped them with the most common spare parts (22 are now operating, following three that were discontinued due to quality issues). ETC Agro says that this network of mechanics can now address 75% of equipment problems encountered, but additional training is needed for the more complex issues. In the meantime, 25% of tractors needing service must wait for the company to send an expert technician.

Efficient service delivery: With more tractors in the field in good working order, the next hurdle is to deploy them as efficiently as possible. Thanks to their rental platforms (TROTRO and more recently ETC Agro), GPRS mapping and data algorithms, the three partners are aggregating farm jobs and linking available tractors to farmers much more efficiently than word of mouth or call centers previously allowed. But travel time and fuel costs remain major cost drivers. According to Hello Tractor's data and analyses, fuel can account for as much as 60% of operating costs. Hello Tractor has therefore emphasized route optimization to minimize the time and fuel lost from crisscrossing large geographic areas, by using algorithms and data analytics to batch jobs and devise routes that minimize downtime and fuel usage. As a result of this optimization, Hello Tractor estimates that owners can reduce their costs by 20-25%, and when coupled with the company's advanced routing tool, revenues can increase by up to 300%.

Mechanization management training: Of course, technology is only one part of the equation. The partners have found that training owners and operators in entrepreneurship, proactive business development and using the application tools is critical to maximizing tractor productivity and efficiency. Hello Tractor's experience in multiple countries has led to the finding that farmers' profit maximization is partly cultural; in some markets, such as Nigeria, owners are more inclined to organize and densely pack their service calendars, whereas in other places, more training and sensitization is needed to spur an emphasis on productivity. Training therefore needs to be tailored to local contexts. All of the partners embed some training on efficient business management and mechanization practices for owners and operators into their models—often subsidized by donor funds and complemented by public or NGO agricultural extension services.

DEMAND SIDE LEVERS

Building awareness and demand among rural populations is critical to motivating supply and driving use of mechanization of services to increase outputs and income. Farmers—especially smallholders with scant resources who predominantly rely on manual labor and animal traction—need to be aware of the benefits and accessibility of mechanization and prepared to mechanize their farming appropriately for their crops and land conditions. Farmers need to come into contact with the means to mechanize and be able to access the services. Finally, the matching of farmers to tractors needs to be efficient, on-time, affordable and effective, so that farmers realize value from mechanization and the digital platform can be sustained. Below is the partners’ learning so far on the demand side.

Reinforcing interest in and justification for mechanization

Smallholders do not need much convincing that mechanization is beneficial. Mechanical ploughing, for example, takes a fraction of the time required for manual labor and costs less in the long run than hiring farm hands—especially in some areas where labor is increasingly scarce. According to ETC Agro’s survey in Tanzania, mechanization costs about 60% of the usual manual labor expense for the season; in Ghana, TROTRO estimates that mechanical ploughing costs about 71% of manual labor charges. Farmers who mechanically prepare and plant can also take advantage of denser plant spacing (for higher yields), as well as mechanical harvesting, which reduces post-harvest losses (compared to the slow, manual process that undermines produce quality and increases the risk of fire) and pilfering (due to laborers skimming some of the harvest). In addition to such productivity benefits for smallholders in general, mechanization can be especially attractive to marginalized groups, such as women and youth.

In regions where rural households are often headed by women whose husbands have migrated to urban areas for work, women and the local economy stand to gain considerably from increased access to mechanization. Women’s competing responsibilities (e.g., household cooking, childcare and chores), and traditional social status (i.e., challenge of hiring manual labor or being taken seriously by male equipment owners), make it difficult for them to enhance farm production. Such barriers increase the value to them of mechanization. TROTRO leadership perceives digital technology as an equalizer when it comes to women’s access to mechanization. The objective, first-come-first-served aspect of TROTRO’s digital reservation process means that women’s plots are serviced more readily than before, stemming the entrenched culture of favoring larger farms and more lucrative crops (typically owned by men). Both ETC Agro and TROTRO estimate that at least 30% of their mechanization customers are women, and about 20% of mechanization services employing Hello Tractor’s technology are provided to female farmers.

Mechanization and the application of digital technology also have the potential to rejuvenate interest in farming and increase agri-employment opportunities among youth. Mechanization substantially reduces drudgery—a characteristic of manual farming that disproportionately affects female smallholder farmers and also emphatically deters youth. But the mechanization ecosystem also attracts youth, who often bring skills and enthusiasm for new technology. All three partners report that the majority of tractor operators, mechanics or assistant mechanics, and booking agents in their networks are youth. As the need for food production continues to grow over coming years, it is critical to engage youth in the agricultural sector. Mechanization and digital technology can serve both as incentives and tools for youth-driven agricultural innovation.

Fostering access to, trust in and usage of mechanization rental services

While many farmers would be open to affordable mechanization services, hands-on support is needed to raise awareness about the service, build trust, register users and troubleshoot. All three companies have discovered that the human touch is “mission critical,” as Hello Tractor’s founder put it. They have experimented with direct, usually donor-supported training for lead farmers and groups of farmers, as well as booking agents and mechanics—typically youth with an interest in technology. Success in reaching female farmers is mixed, and the fact that mobile phones tend to be registered in men’s names makes

this hard to track. The partners continue to experiment with finding the right approach to get users on the platform successfully, serve them sustainably, and ensure quality services.

Call centers: All three partners experimented with call centers for matching farmers with tractors, and they ultimately replaced them with a digital platform approach. The challenges faced by ETC Agro, which ran a call center from April 2017 until August 2019, are illustrative of the kinds of inefficiencies that all three partners encountered with their call centers. Farmers could call a number to be linked to a tractor owner, and a call center manager would identify an available tractor, inform the farmer and then connect the two. Frequent breakdowns, scheduling issues and distances made the process of finding an appropriate tractor less than straightforward. This was also a cumbersome circuit of communication, and mobile phone connectivity posed challenges to reaching and connecting all the parties in a timely manner. Once the tractor operator arrived at the farm, disagreements sometimes ensued regarding the price of the service due to the terrain or quality of service delivery, leading to frustration and management obstacles, as well as lost time and fuel. Moreover, the payments took place in the field between the farmers and owners or operators, making it difficult for the call center to recover its commission. For these and similar logistical reasons, call centers proved untenable and have since been replaced with digital platforms by the three partners.

Users' mobile capacity: As TROTRO's partner AGRO Africa worked with its network to register farmers on the platform, they found that they had overestimated farmers' tech savviness. On top of the persistent challenges of reliable rural network connectivity and the dearth of smart phones, implementers found that training and hands-on support were needed on short code and basic use of the digital system.

Booking agents: Agents can fill the gap in (smart) phone access and technological capability, but the thin margins make this a difficult model to sustain. ETC Agro conducts village-level meetings for smallholder farmers to inform them about the service and train them to utilize the platform. In early 2021, they launched their new rent-a-tractor application using 14 booking agents equipped with smart phones to register 26 tractor owners and around 170 smallholder farmers. The farmers receive SMS messages on the service and can pay from their mobile phones. ETC Agro hopes that the booking agents will earn enough in commissions to incentivize their ongoing engagement and make the service sustainable; but so far, the company still covers the agents' daily transportation for conducting outreach and ongoing support.

AGRA's support also allowed Hello Tractor to experiment with booking agents. Hello Tractor deems this ground-up approach to be valuable for promoting the service and signing on both owners/operators and farmers. Nevertheless, the booking agents are expensive to sustain without subsidy. In response, Hello Tractor is focusing on batching jobs through farmer cooperatives and corporate value chain actors. While women only comprise around 3% of the tractor owners they serve, working with dairy cooperatives has helped them reach more female farmers. Hello Tractor is also exploring how to combine in-person coaching with SMS follow-up to reduce customer acquisition and training costs while reinforcing impacts.

Training and quality control: The partners continue to explore ways to ensure the delivery of high quality mechanization services, as a vital element of building customer trust and sustainability of the business model. The quality of the farm equipment and dealers' after-sales services are an important starting point. ETC Agro provides training to maintenance providers and then monitors the garages to ensure quality services. The knowledge and skills of owners and operators also directly affect quality and customer confidence. The partners are providing training for equipment owners on business, entrepreneurship, financial management and using their digital tools, as well as agronomic skills so that both owners and operators can gauge the best combination of services for their customers. Enabling farmers to rate the quality of the operators and services is a feature that requires further testing.

TROTRO discovered that in addition to the supply side training needs, it is vital to sensitize smallholders to the services and build awareness around the appropriate use of mechanization. TROTRO tried a cascading training-of-trainers (TOT) method, training 20-25 people in each farmer-based organization (FBO) so that they could in turn train their members (for instance 150 others). They now hope that the DMC model will provide a focal point for gathering groups of actors for relevant training, rendering it more sustainable over the longer term. Further experimentation is needed to find the optimal training approach and to cover the costs associated with training and quality control measures.

Making farm mechanization affordable and effective

Of course, the platform must prove affordable and effective in order for farmers to keep using the service. Influential factors include: the platform's payment function, timing and modalities, as well as market linkages and environmental impact, to successfully increase farmers' resulting income margin and protect against climate-related risks.

Platform payments: Understanding the structure of the existing ecosystem is critical to adapting the technology or influencing the actors' behavior so that incentives are appropriately aligned. The payment system must accommodate not only owners and operators (protecting them from fraud, carrying cash and other risks, and rendering the services objective and transparent), but also must fit farmers' cash flows and technological capability.

TROTRO's platform calls for the farmer's payment to be uploaded and held in escrow upon reserving the service. The platform partners with Airtel and MTN for this in-app mobile payment service. After the service is satisfactorily delivered, the payment is released to the owner. This system protects owners, operators and farmers alike. TROTRO's partner, AGRO Africa, realized however that their farmers were unaccustomed and unwilling to pay upfront for land preparation. The local approach has long been to have the same operator who prepares the land also return to provide mechanized harvesting, and for the farmer to pay him then and at least partially in kind (e.g., with harvested grain). This did not work with TROTRO's upfront digital payment system. AGRO Africa ended up finding a workaround by floating the upfront payments to TROTRO on behalf of farmer groups who could not pay before harvest, and then recuperating the payments at the end of the season, (although AGRO Africa was ultimately unable to recuperate about 10% of the value due to price disputes, farmer dissatisfaction or insufficient yields).

The modalities of payment are another challenge. While TROTRO's experience with in-app payments is generally positive in Ghana, Hello Tractor found the mobile money linkage to be too expensive in Kenya (3%-6% on each transaction). These mobile network company commissions offset too much of the farm productivity gain for small farmers, so Hello Tractor reverted to cash payments. Like TROTRO, Hello Tractor also requires farmers to pay 50% in advance of the service.

Market linkages: Ensuring that farmers have a ready buyer is another critical ingredient for bolstering the ecosystem. ETC Agro has a built-in assurance through its offtaking parent agribusiness company, ETG. Hello Tractor is focusing on promoting its digital solution to larger actors in well-established and organized commercial value chains that can more readily batch farmers with direct links to buyers. AGRO Africa partnered with offtakers to have some upfront payments made directly to TROTRO to pay equipment owners and operators for land preparation. Market linkages are key to making the mechanization ecosystem work, and digital technology offers a unique advantage for facilitating connections between agribusinesses and smallholders.

Farmer training: Farmers need training on best practices in agriculture and mechanization—not only to help them see and achieve the diverse uses and value of mechanization (for example uses beyond ploughing), but also to build environmental resilience. Mechanical ploughing, planting and harvesting allow for detailed calculations and planning, which facilitate higher productivity. But farmers need to better understand the economic potential and learn to plan for, invest in and utilize mechanization

effectively to realize higher yields. Moreover, while mechanization has the potential to replace the use of chemicals, increase production and improve soil quality, when used incorrectly, it can also lead to adverse impacts such as erosion or soil depletion that decrease yields over time. Farmers require more information, training and patient capital to invest in recommended mechanization and resilience practices that may not increase productivity and profits in the short term, but that are important for testing new farming techniques, improving soil health, protecting against environmental risk and ensuring strong production in the future.

AGRA's partners are still grappling with how to sustainably address the training needs of farmers, as well as equipment owners and operators, especially when it comes to environmental protection. TROTRO is partnering with public-sector partners in Togo (Government of Togo) and Benin (GIZ) to extend resilience training to farmers, owners and operators. Others are experimenting with SMS-based reminders about good agricultural practices, mechanization schedule and equipment maintenance. So far, the partners view such training as falling largely outside their business plans, and training at the farm level still depends on subsidy and/or partnership with organizations that bring expertise and capacity in behavior change and agronomic training.

IV. Conclusion

While AGRA and its partners continue to push the frontier of mechanization through ongoing investment and experimentation, this survey of recent experience offers a glimpse of learning and results to date. Drawing on the work of TROTRO and AGRO Africa in Ghana, Hello Tractor in Kenya and ETC Agro in Tanzania, this technical note has explored six important levers for stimulating supply of and demand for farm mechanization services. These experiences provide some preliminary responses to several overarching questions.

1. Agricultural production: Can digital technology successfully increase access to mechanized services for smallholder farmers?

Through the three AGRA partners profiled and their work in Ghana, Kenya and Tanzania, nearly 90,000 smallholder farmers have gained access to farm mechanization rental services, and close to 200,000 hectares of land have been ploughed thanks to the digital solutions. About 1,000 equipment owners are using digital tools offered by TROTRO, Hello Tractor and ETC Agro to aggregate farmer demand for mechanization and deliver services. Most farmers are not utilizing the platforms directly to schedule services, relying instead on booking agents or other representatives who interact with the digital applications on their behalf. In the case of Hello Tractor, fleet owners use the digital solution to optimize efficiency in delivering mechanization to their outgrower networks. Based on these still small-scale experiences, the digital solutions appear successful in building and aggregating supply and demand for mechanization services.

Ultimately farmers need to see increased farm productivity and net income in order to achieve the goals of all actors and keep the farm mechanization ecosystem functioning. There exists extensive industry evidence of the positive impacts of mechanization thanks to reduced input costs, increased farm output and higher agricultural income. The partners' experience supports this evidence: for example, farmers on TROTRO's platform realized an average savings of \$70 per hectare for land preparation; and ETC Agro documented a 50% increase in harvests on farms using mechanized land preparation in place of power tillers. Hence there are already positive indications that digital solutions can align actors and incentives, and that smallholder farmers are achieving net gains from digitally facilitated mechanization services. Nevertheless, the value addition for farmers and equipment owners and the financial sustainability of digital platforms bear further examination as these solutions gradually achieve scale.

2. Finance: Do the models reduce risk for FSPs, leading to increased farm equipment financing, and how could this be further improved?

The digital platforms show promise for de-risking equipment investments and attracting previously reluctant FSPs to the farm equipment market. Their experience so far remains small, with 175 tractors financed to date through coordination by TROTRO and ETC Agro, and 26 deals expected by Hello Tractor in 2021. ETC Agro reports growing interest on the part of local banks, and all three partners plan to expand their equipment financing efforts over the coming years. By leveraging the digital sharing economy and using the Internet of Things to increase transparency, these three companies are offering a more solid business case for tractor investors, owners and operators to generate income through rental services. The growing body of business data collected by the platforms provides valuable assurance to equipment owners, as well as finance providers, on service provision and revenues—which appears to be reducing the need for collateral or guarantees. The training provided to owners, operators and mechanics also helps to reduce the risk of insufficient earnings and default. By reinforcing market linkages and the overall ecosystem, the digital platforms do appear to make financing for mechanization more viable for equipment dealers, banks and owners alike. As they continue to scale up the platforms and demonstrate the viability of asset financing for mechanization rental services, these partners and other models can crowd in new FSPs seeking viable finance opportunities in the agricultural sector.

3. Gender: What is known about women’s use of the service, the proportion of end clients who are female, the value proposition for them as compared to men and the potential that this innovation holds for female smallholders?

Digitally enabled mechanization appears to hold strong potential for engaging female smallholder farmers. Gender-disaggregated data remains insufficient, due to regulatory and cultural factors that lead, for example, to women’s SIM cards being registered in their husband’s names. But women stand to gain from labor-saving mechanization and the equalizing anonymity of ordering services via mobile phone. The partners estimate that women comprise 3%-20% of tractor owners in their networks and 20%-40% of farm mechanization customers, although this is difficult to track since many women manage tractors purchased in their husbands’ names. As such services increase in scale, further analysis is needed on the outcomes and impacts that mechanization has on women smallholders, as well as female ownership of mechanization equipment.

4. Youth: What is the role of youth in this ecosystem and the potential for engaging youth in agricultural livelihoods?

Evidence points to agricultural technology and mechanization as important opportunities for rural youth employment and for attracting youth to a new generation of agricultural livelihoods. Young men comprise the vast majority of mechanics, operators and booking agents trained and employed in conjunction with the partners’ mechanization models. While the current generation of youth in sub-Saharan Africa tends to eschew traditional farming livelihoods, the new dimensions of mechanization, digital technology and mobile phones appear to offer an attractive entrée to the agricultural sector for youth. This represents a new opportunity to create jobs for young people, while also attracting much needed new energy and ideas to galvanize the agricultural sector in Africa.

5. Environment and employment: What are the adverse effects of mechanization and how can they be mitigated?

Two potential risks emerge from this examination of innovations to increase mechanization. First, there is a risk of environmental degradation if mechanization is not used properly and when complementary measures are not taken to protect soil health and improve climate resilience. The training of owners, operators and farmers on sustainable mechanization and farming practices needs to accompany the growth in mechanization. Secondly, there is mixed

evidence on the impact that mechanization has on rural employment. As TROTRO pointed out, a single tractor can accomplish in one hour what otherwise takes four laborers to do in a day or longer—which may threaten manual farm labor jobs. But mechanization also creates both direct and indirect jobs. Direct employment includes equipment operators, mechanics and booking agents. Indirect jobs then follow from increased yields – for crop/food processing and other downstream VC activities. Moreover, these jobs are viewed as dignified, as opposed to the drudgery of subsistence farming, and often come with greater job security and workforce protections. Mechanization is expected to add net value and jobs to rural economies in the long run, but ongoing innovation and rollout of mechanization need to incorporate safeguards to boost employment, rather than replace paid labor with technology, in the shorter term, as well.

6. Role of subsidy: What did AGRA's investment enable and de-risk, and where are donor funds still critical to fostering mechanization?

AGRA's investment in organizations pursuing innovations in mechanization has fueled the development of private sector solutions to improving ecosystem cohesion and building a business case to serve smallholder farmers. The funding provided operational running room for experimentation, which incentivized and enabled the partners to test riskier ideas, deepen their understanding of smallholder farmer needs and better tailor their services to reach a more grassroots market. AGRA also helped the partners cover research and development costs for new digital technology that they expect to be self-sustaining going forward. The partners leveraged AGRA's grant funds and technical assistance to establish value chain and financial linkages that might not otherwise have occurred but are likely to endure. AGRA's contributions also went toward: developing and delivering training to upskill mechanics; building the business and agronomic capacity of owners and operators; and sensitizing and training farmers to utilize the platform and apply mechanization appropriately.

Still, these asset rental marketplace business models remain nascent, and further experimentation and analyses are needed to hone their sustainability and investigate their impacts. Enabling environment support remains important to fuel ongoing innovation and achieve greater scale without losing sight of social and environmental outcomes. The following are important areas for further investment:

- Follow-up support is needed to refine the mechanization service business model, including pilot-testing of adjustments that can enable scaling, accompanied by research and documentation of the benefits and limitations according to context, and the impacts of the services on agricultural production, smallholders and the rural economy.
- Training at all levels (FBOs, cooperatives, lead farmers, booking agents, owners, operators and farmers) is integral to successful mechanization, but its sustainability is not yet assured by the current business models. Further donor, investor and technical support are needed to develop self-sustaining or cross-subsidizing models to offer training on the digital tools, agribusiness management, mechanization efficiency and recommended mechanization practices.
- Digital technology cannot replace human engagement to organize and sensitize farmer groups. Support from government, non-governmental organizations, community- and farmer-based organizations and private sector value chain actors is needed to bring together disparate actors and raise their awareness of and capacity to use digital platforms for farm mechanization.
- Particularly when it comes to environmental resilience, there is a role for donors and the public sector to play in linking mechanization efforts to sustainable agriculture initiatives and/or covering the cost of such training, which can “piggyback” on the private sector vehicle of mechanization to ensure positive long-term benefits for the public good. Investment is also still needed to identify the appropriate equipment and mechanization activities for specific agro-ecological systems to reinforce climate resilience.
- Finally, there is strong potential to leverage mechanization to enhance youth job creation and rural women's livelihoods. Investor and donor funds and technical assistance can play a critical role in maximizing this opportunity to scale up youth employment and women's more formal participation in the agricultural sector.

As these and other farm mechanization innovators continue to explore strategies for enhancing smallholder mechanization, AGRA plans to keep advancing the state of the practice through strategic investments in promising models and the exchange of lessons learned.





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