



Cereal Systems Initiative for South Asia in Nepal (CSISA-NP)

Mechanization and Irrigation

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Compiled by Scott Justice

With support from Andrew McDonald and Cynthia Mathys

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Acronyms and Abbreviations

Acronym	Full Name
ADS	Agriculture Development Strategy
AMPP	Agriculture Mechanization Promotion Policy
CIMMYT	International Maize and Wheat Improvement Center
CSISA-NP	Cereal Systems Initiative for South Asia in Nepal
DADO	District Agricultural Development Office
DOA	Department of Agriculture
DSR	Direct-seeded rice
FtF	Feed the Future
GoN	Government of Nepal
ha	Hectare
HH	Household
kg	Kilogram
KISAN	Knowledge-intensive Sustainable Agriculture and Nutrition project
NARC	Nepal Agricultural Research Council
NAMEA	Nepal Agriculture Machinery Entrepreneurs Association
USAID	United States Agency for International Development
ZT	Zero tillage

Program Overview

In Nepal, factors that contribute to low staple crop performance include scarce farm labor, poor knowledge of best agricultural management practices, insufficient irrigation and mechanization, and farmers' inability to take risks and invest in new technologies. Also, innovative applied research has long been under-funded and research benefits have rarely reached farmers. Nepal's Mid and Far West development regions are most acutely affected by these constraints as these regions have the highest poverty and receive the lowest investment by the private sector. As a result, the Cereal Systems Initiative for South Asia (CSISA) works in Nepal's Terai plains and mid-hills where the scope for improving farmers' lives through agriculture is greatest.

The Government of Nepal's (GoN) new 20-year Agriculture Development Strategy (ADS) recognizes the need for new science-led innovations, crop diversification options for income generation, strengthened input systems for seed and fertilizer and mechanization to cope with outmigration and an aging agricultural workforce, and enterprise development to create new jobs and extend essential development services to large numbers of farmers. In support of these priorities, CSISA works with a range partners through an innovation systems approach to help facilitate adoption of sustainable intensification technologies at scale through markets and aligned development programs. CSISA's partners include Feed the Future's KISAN project, Nepal Agricultural Research Council, trade associations, service providers, agro-dealers, seed enterprises and other private sector companies.

USAID India provided \$1,000,000 over two years to support CSISA's work in mechanization and irrigation, focusing specifically on increasing the ways in which Indian agricultural technologies can alleviate the problems listed above, as well as increase the efficiency and productivity of smallholder farming systems in Nepal. The program ran from May 2015 to September 2017.

Theory of Change and Approach

Many sustainable intensification and climate resilience technologies are machinery-based and require specialized equipment that is not commercially available for small- and medium-scale farmers in Nepal. The only way to achieve widespread access to scale-appropriate machinery among smallholders is by creating awareness on the demand side while encouraging the emergence of mechanized service provision models and the market-based supply and repair chains required to support them. Private sector importers, dealers, traders and agents need to ensure farmers' access to scale-appropriate machinery in rural areas, and the government needs to have the capacity to evaluate technology.

To address these bottlenecks and bolster the market for scale-appropriate mechanization and irrigation technologies in Mid and Far Western Nepal, CSISA: (1) held "design sprints" with Indian manufacturers of 2-wheel tractor seeders and threshers to evaluate and improve the machines for markets like Nepal, (2) supported CSISA's national partners to establish machinery testing and training centers to evaluate sustainable intensification technologies, (3) supported the emergence and capacity of service providers through technical trainings and business development services, (4) improved the availability of low-cost irrigation technologies, (5) back-stopped the machinery importers' professional association as well as business networks for agro-dealers, and (6) conducted targeted marketing campaigns at key points in the cropping calendar to generate demand for sustainable intensification technologies.

FY17 Indicators of Progress (see Appendix 2)

In FY17, CSISA's Mechanization and Irrigation project met or came within 5% of its targets for all Feed the Future indicators. The project facilitated 2,226 farmers to adopt new technologies and/or

management practices on 2,263 hectares. CSISA provided technical assistance to 309 agriculture-related firms (including service providers) on their business performance improvement.

After a rigorous testing, development, and performance verification period, the project made available five new agricultural mechanization technologies, namely a *sasto* (inexpensive) solar irrigation pump, inexpensive well-boring technology, precision fertilizer broadcasters, self-propelled reapers, and mini-tiller pump attachment. Additional details about CSISA's indicator numbers for the reporting period can be found in Appendix 2.

Major Activities and Accomplishments

- Prior to CSISA's efforts, reaper attachments for the 2-wheel tractor were not available in the Feed the Future Zone despite the high costs, delays, and drudgery associated with manual harvesting. By emphasizing private sector-led market development, **growth in reaper sales continued at an impressive pace, and is now well over 1,100 in the last two years.** Reaper service providers are now reaching approximately 5,500 ha per year in rice–wheat cropping systems, increasing average farm-level profitability by US\$ 120 when used for both crops.
- CSISA helped establish a market for 4-wheel tractor seeders. Two and a half years ago there were no commercial suppliers of four-wheel tractor seeders. As of writing, **there are over 150 4-wheel tractor seeders sold through three Nepali importers from four suppliers.** Each of these business connections was made with CSISA's facilitation. Recently, two of the Indian four-wheel tractor seed drill manufacturers also started shipping 2-wheel tractor seeders, mini-tiller seeders and hand-drawn planters to their agents in Nepal.
- CSISA helped establish two new agriculture machinery-related government centers – NARC's Agricultural Machinery Testing and Research Center and DOA's Central Agricultural Machinery Training Facility, co-located at Nawalpur in Sarlahi District. **The Nepal government's capacity to evaluate technology and train its farmers and service providers, as well as support the private sector importers and manufacturers, has been greatly enhanced.** The establishment of these new centers fulfills part of Nepal's Agriculture Mechanization Promotion Policy (AMPP 2014), as well as the larger Agricultural Development Strategy (ADS) of Nepal. **As evidence of the Nepal Government's commitment to these centers and to the growth of agricultural mechanization, NARC recently announced a US\$ 100,000 co-investment** in the Agricultural Machinery Testing and Research Center, complementing USAID's nearly US\$ 300,000 investment already made through CSISA.
- In the last year, **CSISA completed three 'design sprints' with three of India's largest seed drill manufacturers.** The manufacturing standards at these companies are high, but all past efforts to develop seed drills for small ('2 wheel') tractor platform among Indian manufacturers have failed to create commercially-viable products. The purpose was to help the manufacturers improve the design of their seed drills in order to make them market ready. Two Rajkot-based manufacturers, Khedut and Dharti, have already supplied new seed drill prototypes to CSISA and NARC for testing, and CSISA and NARC have reverted to the manufacturers with feedback. Dharti has simultaneously entered into negotiations with India's largest two-wheel tractor manufacturer, VST in Bangalore, to supply a minimum of 50 of their design sprint seeders to VST. Another manufacturer of two-wheel tractor seeders in Odisha has recently reached out to CSISA to organize a design sprint with them, offering to hold it at their expense.

INNOVATING AND SCALING MECHANIZATION AND IRRIGATION TECHNOLOGIES

India is the regional leader in the commercial production of high-quality agricultural machinery, which is why USAID India's Feed the Future program supports the transfer of Indian innovations to other developing countries. Trade in agricultural machinery between Nepal and India has a long history, with Nepal being one of the largest importers of Indian tractors, estimated at over 5,000 per year with a value of US\$ 50 m. The market for Indian machinery is also diversifying, with around 25 combine harvesters being imported to Nepal every year. Yet much more is possible, particularly if Indian manufacturers can become more attuned to market opportunities for scale-appropriate machinery in places like Nepal, Bangladesh, and much of Africa.

For mechanization technologies to spread widely and have a beneficial impact in Nepal, three enabling conditions need to be present: (1) strong supply chains for machinery, spares and repairs; (2) widespread awareness and demand among farmers; and (3) a robust network of service providers to ensure broad access to capital-intensive technologies through custom hiring.

CSISA is working with private sector partners to increase the market for scale-appropriate machinery in Nepal, with a focus largely on seed drills and planters, reapers, and precision spreaders. To facilitate strong supply chains, CSISA has continued to focus on strengthening importers and their dealer networks through technical training, business mentoring, marketing assistance, and relationship management with Indian manufacturers. In the last year, three new importers of Indian seed drills have been established with CSISA support: Kubier and Sons importing National Agro (Ludhiana, Punjab) drills as well as UP brands and SK Traders importing Khedut drills (Rajkot, Gujarat). Habi Auto, the first Nepalese agent of National Agro Industries, has stepped up market development activities by conducting demonstrations and farmer field days with backstopping support from CSISA, which resulted in 20 zero-till drills and multi-crop planters sold in the 2015–16 wheat season. One complication for market development is the ability of farmers to purchase machinery in India at a lower cost (there is a 33% mark-up in Nepal for zero till drills). CSISA will continue to monitor this dynamic, which should dissipate with more competition in the Nepal market.

Reaper imports for both 2- and 4-wheel tractors increased over the last year with multiple importers emerging for Indian machinery. After having seen reapers displayed at the CSISA-funded National Agro Machinery Fair near Nepalgunj last year, Jaya Bageshwori Tractor and Machines, Nepalgunj, procured over 20 4-wheel tractor reapers (worth US\$ 20,000) from Anmol Reaper (Mansa, Punjab). CSISA has observed other agents outside of the Feed the Future Zone stocking 4-wheel tractor reapers as well. In CSISA's working districts in Nepal, an additional 400 2-wheel tractor reapers valued at US\$ 200,000 were sold during the reporting period due, in part, to the awareness raising and market development activities supported by CSISA. These activities included FM radio spots using simple terms to build awareness of the economic benefits of reaper and seed drill attachments.

Key lessons learned during project implementation:

- Support for private sector importers, manufacturers and suppliers is critical for strengthening supply chains and ensuring the supply of agro machinery to the Feed the Future Zone in the Mid and Far West, where supply chains were poorly-established and the cost of doing business is high.
- Once district-level sales agents who occupy the 'last mile to the farm gate' saw an opportunity to increase sales with new types of agricultural machinery, they began holding their own farmer field days to promote reapers, seed drills, and other equipment. It is important to recognize that the goals of these local agents and their importer-suppliers do not always converge (e.g., importers want agents to sell only their products, whereas agents

often want to market a diversity of brands and products), necessitating distinct approaches at both levels.

- CSISA supported the emergence of Nepal’s first trade association for mechanization, and the *Nepal Agricultural Machinery Entrepreneurs’ Association* is now a vibrant and strong organization with growing political clout but with a primary focus on importers. To make markets grow, the association needs to now emphasize business development support to local dealer networks.
- In many cases, ‘proven’ technologies may not find a place in the market even with considerable development investment. While these technologies may have potential in the future, they can be safely ‘put on the shelf’ without additional investment until conditions change that favor adoption. CSISA’s ‘shelf’ in Nepal currently includes axial flow pumps, laser land levelers, and rice transplanters.
- Reapers are an example of technology recently ‘pulled off the shelf’ and into active programming in response to increasing labor shortages, which have farmers desperate to find mechanized alternatives to hand-harvesting. Well over 1,000 reapers have been sold in the last two years with market facilitation and guidance from CSISA without any form of government subsidy.
- While relying on the private sector is the key to sustainably reaching scale, projects like CSISA need also to respect their investment timelines and appetite for risk.

New business opportunities for laser leveling, zero tillage, and mechanical harvesting defined with expected returns for all value chain actors

While India is very good at producing high-quality and low-cost four-wheel tractors and attachments like seeders, planters and laser land levelers, they are less adept at producing attachments for smaller tractor platforms (e.g. 2-wheel tractors) even though they provide the dominant form of agricultural mechanization in many parts of South Asia, including hill and some areas of the Terai in Nepal. This means that areas dominated by smaller machinery have a less diverse set of agricultural operations that can be mechanized beyond tillage because attachments are either missing from the market or poorly designed. This is not the case in East and Southeast Asia where attachment diversity for the small tractor platforms is common.

To cater to both the 4-wheel and 2-wheel tractor markets in Nepal, CSISA worked to strengthen the value chains for cutting-edge technologies from India (mostly 4-wheel tractor-based zero till drills, reapers and laser land levelers) and from elsewhere for smaller 2-wheeled tractors and mini-tillers.

Reapers

In the Mid and Far Western Terai, CSISA introduced the reaper in 2014 in collaboration with machinery suppliers and the Engineering Directorate, Department of Agriculture. The number of reapers and the area under reaper harvesting have significantly increased from a base near zero, due to increasing awareness about the economic benefits of using reapers, as well as building the business case for the technology with service providers. As of July 2017 at least **1,070 reapers have been sold by our private sector partners, harvesting more than 5,500 hectares on a seasonal basis**. A recent survey of reapers adopters in the Nepal Feed the Future Zone indicates that reapers increased average farm-level profitability by US\$ 120 when used for harvesting both crops

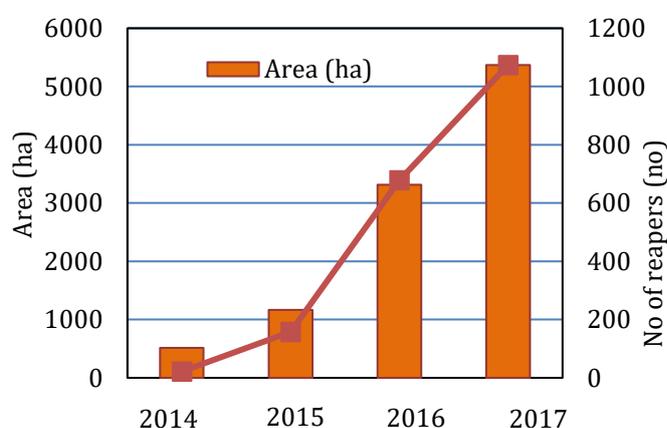


FIG. 1. ESTIMATED REAPER NUMBER AND TOTAL AREA HARVESTED FOR WHEAT IN FY17

in the rice-wheat rotation.

In collaboration with reaper suppliers, CSISA worked to capacitate service providers and facilitate repair and maintenance services, as well as increase the local availability of spare parts. The introduction and commercialization of reapers has created new business opportunities for machinery retailers and service providers in the Feed the Future Zone, particularly among returning migrants who are seeking employment opportunities beyond the farm. A primary reason for the swift spread of reapers thus far is that many Nepali farmers and service providers who are already owners of two-wheel tractors have a strong entrepreneurial spirit. As they already understand the costs, risks, and returns of owning agricultural machinery they can quickly see a strong business case for the reaper.

Another reason reaper harvesting has spread quickly is that CSISA encouraged importers to order and stock additional reapers, rather than wait for orders to accrue. This approach ensured that would-be customers could see and perhaps test a reaper at the retail level before committing to purchase. CSISA and the importers encouraged and backstopped (i.e., provided advice and even used reapers for demos) profit-motivated sales agents in the Feed the Future Zone to conduct their own independent farmer field days.

Thus far, the total investment by farmers in reaper technology is around US\$ 642,000 (avg. US\$ 600/reaper.) In the main sales districts of Bardiya and Kailali, nearly 25% of the total wheat area was harvested by 2-wheel tractor reapers in 2017 – a remarkable number given that the technology was first introduced into the Feed the Future Zone at the end of 2014.

Field reports from the 2017 rice harvest indicate that sales of another reaper technology, the lighter and smaller self-propelled reaper (which have been successful in Bangladesh and India), have increased, especially in wet and inundated early maturing rice fields, where heavier reapers and combine harvesters cannot reach. CSISA is working with sales partners to determine where this variant of the reaper technology may have the strongest market niche.

Seed drills

Since its inception, CSISA has worked with partners to facilitate the adoption of line sowing of grains and grain legumes, as well as the simultaneous banding of fertilizer. These practices ensure even crop stands with savings of both seed and fertilizer, while maintaining or increasing yields. In the case of zero till drills and better bet agronomy, benefits include higher yields due to timely crop establishment and reduced diesel energy and tillage costs while improving soil health. When seed drills are used for non-puddled 'direct seeded rice' there is an added benefit of savings in time and labor as compared to the drudgery associated with manually transplanted rice.



KARKA PUN WITH REDUCED TILL DRY DIRECT SEEDING RICE WITH A 2-WHEEL TRACTOR SINGLE PASS TILL DRILL ON HIS FARM IN CHHARBLOCK, BANKE DISTRICT, NEPAL.

While there had been minor commercial sales of 2-wheel tractor seeders in Nepal, there had been almost no commercial sales of 4-wheel tractor seeders aside from units procured by special projects. Despite increased demand from potential service providers due to CSISA's demonstrations and service provider trainings, no suppliers were coming forward.

At the end of 2014, CSISA began encouraging the Nepal Agricultural Machinery Entrepreneurs' Association (NAMEA), which CSISA help found in 2013, to bring 4-wheel tractor seed drills into

Nepal. CSISA began by facilitating connections between suppliers in India and importers in Nepal. The first commercial tie up was between Habi Auto in Nepal and National Agro in India. To solidify this arrangement, at the end of 2014 CSISA used its agri-machinery jumpstart program to leverage an advanced order of 20 seed drills through Habi Auto. Later, additional tie-ups were facilitated between importers BTL, SKT and Kubier and Sons and suppliers from Rajkot (Gujarat, India) and elsewhere. Two of the Indian companies, Khedut and Dharti, have even started supplying the importers with two-wheel tractor, mini-tiller and manual hand drawn seeders to market in Nepal.



A NATIONAL AGRO ZERO TILL DRILL FARMER FIELD DAY AIDED BY THE SUPPLIER, HABI AUTO, NEAR BHAIRAHAWA, NEPAL

With guidance and an order from CSISA, the importer BTL also has started supplying a 3-row precision maize planter with vertical plate seed metering.

On the back of this approach, **cumulative sales over the last two and a half years have now exceeded 150 4-wheel tractor and approximately 40 2-wheel tractor seed drills.** Of these, importers report that about 60–70% of 4-wheel tractor seeder sales, and a slightly higher percentage of 2-wheel tractor seeder sales, have been partially supported by Nepal government cost-sharing, indicating strong buy-in from the Nepal government for this

technology.

At present, four Indian machinery manufacturers supported by CSISA are exporting seeders and planters through three different importers in Nepal. These importers are learning the nuances of the various models and can now better advise and market the benefits and applications of their new machinery. They have begun holding their own farmer field days to generate awareness and demand. Even more promising are the four additional drill importers who have been motivated by the successes of CSISA-supported importers and who have started commercial activities in the Feed the Future Zone without our active engagement.

Lastly, CSISA has begun monitoring the use patterns and profitability of drills being deployed on both 2 and 4-wheel tractors by service providers. This knowledge will help inform future scaling and marketing strategies.

Laser land leveler

Despite an initial, positive farmer reception, favorable cost and returns data due to irrigation water savings at the field level, and many demonstrations and trainings, significant demand for laser land leveling services has not materialized in Nepal. CSISA assessed that this was principally due to the high purchase cost of the equipment and the fragmented nature of landholdings. In spring 2016, CSISA suspended making any significant new investments in this technology, beyond acting in a facilitation role.



A TIPPING BUCKET: "NON LASER" LAND LEVELER BEING USED FOR POND EXCAVATION.

Yet, there seems to be a budding market for 'non laser' land leveling emerging in Kapilvastu District. This is being done via a less precise, mechanical (not hydraulic powered) 'tipping bucket' excavator to level farmland.

Initial investigation has found that the levelers on Indian-registered tractors are coming to level land in Kapilvastu. According to some of the drivers, the cost of these attachments is approximately US\$ 1,600, as opposed to US\$ 6,000 for a laser land leveler. Rental prices are also cheaper at US\$ 9.50/hour, although the renter must also pay the border-crossing fee.

If follow up investigations find that these land leveling services are spreading in Nepal, and do indeed offer similar benefits at lower costs as the laser land leveler, then CSISA will reconsider supporting land leveling.

Improving capacity for machinery evaluation and design improvement among NARES and NAMEA partners in Nepal

AND

Strengthening training facilities and programs for rural- and urban-based agro-machinery repair

CSISA has improved the government's capacity to test innovative, scale-appropriate agricultural machinery and conduct associated training programs for local farmers, machinery operators and mechanics with the establishment of two new government centers in Nepal: the Agricultural Machinery Testing and Research Center, established by the Nepal Agricultural Research Council (NARC), and the Central Agricultural Machinery Training Facility, established by the Department of Agriculture's Directorate of Agricultural Engineering.

To achieve this result, CSISA undertook multiple meetings and trips to proposed sites for the centers with NARC, Department of Agriculture (DoA) and Agriculture Ministry officials in the first 1.5 years. The project sponsored key national partners to visit established agriculture machinery testing and training facilities in Thailand and India, followed by visits to manufacturers of machinery testing equipment to ensure that the equipment selected was correct.

The Agricultural Machinery Testing and Research Center is designed to greatly improve NARC's capacity to evaluate agricultural machinery in order to identify design improvements as well as to allow NARC to certify the quality of imported and locally manufactured agricultural machinery as a service to agricultural machinery importers, manufactures, and Nepal's farmers. The Central Agricultural Machinery Training Facility aims to strengthen the Directorate of Agricultural Engineering's capacity to conduct training programs on agricultural machinery operation and maintenance for service providers and agricultural machinery repair for mechanics. The establishment of these new centers fulfills part of the critical national needs for agricultural development that are highlighted in Nepal's Agriculture Mechanization Promotion Policy (AMPP 2014), as well as the larger Agricultural Development Strategy (ADS) that establishes development goals for Nepal for the next twenty years.



RECENTLY RENOVATED OFFICE BUILDING OF THE AGRICULTURAL MACHINERY TESTING AND RESEARCH CENTER IN NAWALPUR, SARLAHI DISTRICT

Both NARC and the DoA wanted the centers to be co-located in order to facilitate collaboration, dialogue and knowledge sharing. Nawalpur, in Sarlahi District, was selected so that NARC and the Engineering Directorate could utilize two contiguous farms for their centers. The NARC center was granted in May 2017 a 10-hectare parcel of underutilized research farmland overseen by a separate NARC research program. The selection of a nearby site has also been finalized by the Directorate of

Agricultural Engineering and is presently with the Ministry of Agriculture and Development for approval.

Following site selection, CSISA, NARC and the Engineering Directorate began the procurement of machinery for the Testing and Research Center and the Machinery Training Facility. NARC's Testing and Research Center began with the renovation of three existing buildings to create office and storage space, and constructed a new facility to house testing equipment including a dynamometer (one of the center's more important testing machines) which calculates exact power ratings for petrol, diesel and electric motors used in agriculture. Additional equipment procured for the center includes mechanical vibration testing equipment and various sensors for measuring torque, RPM, drawbar force, along with digital telemetry for data transfer from the machinery being tested. An additional sub-grant of approximately US\$ 20,000 was provided to enable NARC to immediately start lab and field-testing of new two-wheel tractor seeders and planters.

For the Engineering Directorate's Machinery Training Facility, a wide variety of tools and equipment were procured to support agricultural trainings. The equipment included diverse hand tools, power tools, field equipment, tractors, tractor attachments, and specialized training devices such as small agricultural machinery cutaways. Such machinery will be used to train service providers in the use and maintenance of scale-appropriate machinery, as well as to train technicians, mechanics and blacksmiths in machinery manufacturing and repair.

The establishment of these new centers represents a deepening of support by USAID and CIMMYT in scale-appropriate mechanization research and development in Nepal, and highlights long-standing cooperation with the Government of Nepal to make investments in training and innovation. As evidence of the Nepal Government's commitment to these centers and to the growth of agricultural mechanization, NARC recently announced a US\$ 100,000 co-investment in the Agricultural Machinery Testing and Research Center, complementing USAID's nearly US\$ 300,000 investment already made through CSISA.

Advancing attachment design and commercial availability for the 2-wheel tractor and mini-tiller platforms

'Sprinting' towards better machinery design

During the inception of CSISA-Nepal Mechanization and Irrigation, it was observed that 2-wheel tractor owners had not adopted seeder or planter attachments on a wide scale anywhere in the world – largely because existing models are either too expensive or poorly designed. To address the need for better two-wheel tractor attachments, CSISA began to work with Indian manufacturers to better tailor their designs to the needs of small-scale farmers. CSISA conducted a series of 'Design Sprints' in India that helped manufacturers of two-wheel tractor seed drills and planters tweak and modify their machinery designs to better suit the needs of small-scale farmers, including in Nepal's hill and Terai ecologies.

During a series of 3–5 day Design Sprints, CSISA provided manufacturers with technical feedback on their current designs and facilitated discussions about the merits and demerits of various seed



'DESIGN SPRINT' AT NATIONAL AGRO IN LUDHIANA, PUNJAB, GOING WELL INTO THE EVENING DUE TO LIVELY DEBATES AND DISCUSSIONS

drills currently on the market (worldwide there are over 40 design offerings from private and public sectors). Groups considered various incremental changes to their existing models, as well as entirely new designs with usability, durability, and cost as foundational evaluation criteria.

After a series of visits to interested manufacturers by CSISA in 2016, the Design Sprints began in earnest in early 2017. The Sprints were intended accelerate the prototyping, testing and ‘getting to market’ of at least three new models of two-wheel tractor planters from Khedut Agro and Dharti Agro, both located in Rajkot, Gujarat, and National Agro in Ludhiana, Punjab. CSISA wanted to give the manufacturers’ designers wide creative berth to be as innovative as possible in solving existing agronomic and ergonomic limitations. Therefore, CSISA provided only a few stipulations – any new design should aim to:

- reliably and precisely place both seed and fertilizer
- cost less than the current models
- be lighter weight and easier to turn
- fit easily on the two-wheel tractors that are prevalent in Nepal and Bangladesh (and many places in India):
- be driven safely and comfortably on the road so that service providers can move quickly between jobs (farmers’ fields).

The above conditions were derived from years of feedback received by CSISA about farmers’ experiences with various two-wheel tractor seed drills. Farmers conveyed that although many drills were agronomically sound in the field, they were ergonomically problematic for the operator, and too expensive for many small-scale two-wheel tractor service providers.



NEW DHARTI PROTOTYPE FOR LIGHTWEIGHT, ROAD TRANSPORTABLE, 2-WHEEL TRACTOR PLANTER-SEEDER THAT EMERGED FROM THE DESIGN SPRINT

Three manufacturers have completed their prototypes (see photo inset for design from Dharti Agro), and CSISA is facilitating the testing prototypes by the new Nepal Agricultural Research Center (see above). Dharti has entered

negotiations with India’s largest 2-wheel tractor manufacturer, VST in Bangalore, to supply a minimum order of 50 of their Design Sprint seeders to VST. Also, another manufacturer of 2-wheel tractor seeders in Odisha has reached out to CSISA to organize a Design Sprint conducted entirely at their own expense.

Ultimately, the strength of the Indian agricultural machinery industry is now poised to enable millions of 2-wheel tractor-based farmers around the developing world to enjoy the same economic and agronomic benefits of increased input productivity from mechanized sowing that hundreds of thousands of 4-wheel tractor-based farmers now enjoy in South Asia.

Identifying technologies for overcoming energy and cost bottlenecks to irrigation expansion

Overcoming the energy and cost bottlenecks to irrigation expansion was one of CSISA-Nepal Mechanization and Irrigation’s key objectives. Mid and Far Western Nepal lag behind Central and Eastern Nepal in irrigation and groundwater development. CSISA initially identified a few technologies that, if developed, could help overcome current bottlenecks. While these three – axial flow pump, cheaper solar irrigation, and shallow tubewell boring attachment for 2-wheel tractor – are still to be commercially developed, a fourth technology unseen at project start-up – the mini-

tiller irrigation pump – has, with CSISA facilitation, become widely available to hill farmers searching for a cheaper irrigation pump.

Mini-Tiller Irrigation Pump

Prior to the USAID-funded CSISA Earthquake Recovery Support Program (June 2015–Sept 2016), irrigation pumpsets, especially larger capacity pumps for field crops, were virtually non-existent as attachments to small tractors. One of the lessons learned from the program was that mini-tillers, with their diesel or petrol engines, could be easily utilized for moving water in the mountains. Earlier versions of pumps in the market were small – one inch in diameter – orchard sprayer pumps with high pressure but a very low water volume. Though the importers touted them as irrigation pumps, CSISA weighed in that they were not sufficient, nor economic, for irrigation purposes anywhere. CSISA encouraged importers to bring in a larger, 2-inch diameter, pump.



A 2 INCH OUTPUT DIAMETER IRRIGATION PUMP (SILVER COLOR) ATTACHED TO THE PTO SHAFT AT THE REAR OF A MINI TILLER ON DISPLAY IN SKT'S SHOWROOM BHAKTAPUR, NEPAL.

The cost of a mini-tiller pump attachment (including suction pipe and delivery pipe) is now just over US\$ 100 USD. This offers significant cost savings as compared to purchasing a new 5 HP petrol or diesel pumpset at approximately US\$ 300. By the beginning of 2017 at least four importers had brought 2-inch irrigation pumps to market that have a capacity to pump up to 15,000 liters per hour. To date, BTL has imported 50 pieces; Shreshtha Agro has imported approximately 300 pieces;. AMC has imported approximately 50 pcs; and SKT brought approximately 200 pieces of these pumps, for a total of 600.

While the importers report promising sales of approximately 50 pumps thus far, better targeting, more demonstrations and stronger marketing could greatly boost the sales of these pumps.

Sasto Solar Sichai: Inexpensive solar irrigation

While market prices for solar panels continue to decline, European-sourced pumps and their controllers are not getting any cheaper. Without government subsidies farmers are not willing to purchase solar pumps. CSISA embarked on the rapid development and testing of a 1 kilowatt *Sasto Solar Sichai* (cheaper solar irrigation) pumps that could be used for the irrigation of field crops like wheat, maize and rice. Using off-the-shelf 48 volt DC motors and charge controllers that were already being used in the transport sector in Nepal (e.g. battery-powered three wheelers) and connected to 2–3 inch centrifugal pumps and powered by 1,200 watt solar PV panels, CSISA had brought down the cost of a 1 kilowatt system from over US\$ 2,500 to less than US\$ 1,500. By the summer of 2017, two systems had been built and tested in farmers' fields. Yet the still-high initial investments costs kept the farmers from purchasing without a significant 50% subsidy. Discussions with the government's renewable energy subsidy provider, AEPC, revealed that they could not provide subsidies for off-the-shelf, locally made systems.



48 VOLT DC OFF-THE-SHELF E-RICKSHAW MOTOR WITH CONTROLLER ATTACHED TO OFF THE SHELF 2-INCH PUMP. TOTAL PRICE: UNDER US\$ 300.

CSISA will attempt one more iteration and, rather than offer a US\$ 1,500 system to new buyers of solar technologies, CSISA will offer (through our two partnering dealers) only the pump, motor and

controller, which will be marketed to existing solar panel owners who might be lured to purchase a US\$ 250–300 solar pump “add on.”

Two-wheel tractor-based shallow tube well drilling kits

Bottlenecks to groundwater utilization in the Feed the Future Zone include the high costs associated with tubewell installation. Most shallow tube wells in Nepal are drilled manually (by hand) and can take up to a week to complete. CSISA is working to decrease the time and costs associated with tubewell installation and has successfully tested a simple and inexpensive 2-wheel tractor drilling kit, completely built with locally-procured components. The kit allows for much faster drilling of shallow tube wells and basically turns the 2-wheel tractor into a low cost wench that easily and quickly lifts and drops the drill pipe. With just the 2-wheel tractor shown in the photo to the right, CSISA staff were able to drill down to 90 feet within a few hours on the first well and over 110 feet on the second well. The kit costs approximately US\$ 450 (see below), and well within the financial reach of many of the 30,000 2-wheel tractor owners in Nepal. While the kit is now available commercially, market development is just starting with demonstrations and test marketing prioritized in Dang District where there are comparatively high numbers of 2-wheel tractors and a shortage of STWs.



A 2WT BEING USED AS A WENCH IN LIFTING AND DROPPING A DRILL PIPE TO SPEED THE DRILLING OF SHALLOW TUBE WELLS. TOTAL COST OF THIS DRILLING RIG IS UNDER US\$ 500, THE SAME PRICE AS A REAPER—HARVESTER ATTACHMENT.

Axial flow pumps

CSISA brought approximately 20 axial flow pumps (AFPs), an energy-efficient low-lift irrigation technology, to Nepal from Bangladesh for technical testing and preliminary marketing. From the outset this technology seemed to have less potential in Nepal compared to counties where they pumped water from surface sources in low-lying deltaic geographies. For AFPs to work, surface water must be no lower than 5 meters from source to fields. Especially in the Mid and Far West development Zones of Nepal, it was found that there are even fewer sources of surface water within the AFP’s range. After initially acquainting and training staff to its purpose and usage, CSISA searched for potential locations, with some limited success and interest by farmers. About 1.5 years ago, due to low levels of response (and less area for application) CSISA scaled back AFP activities and only continued occasional low-level programming to capture pocket areas in the Feed the Future Zone in the Mid and Far West.



LOW LIFT AXIAL FLOW PUMP IRRIGATION INTO SMALL LINED CANAL VIA LOW COST LAY-FLAT PLASTIC DELIVERY PIPE. MAHADEVPUR, BANKE DISTRICT

CIMMYT will provide the remaining stock of AFPs partner institutions in the Terai where the potential for use is relatively high. In the eastern Terai, government colleagues interested in AFPs include the Agricultural Engineering Campus, Dharan, the new Department of Agriculture’s national agri-machinery training center, NARC’s national agri-machinery testing center in Sarlahi, the Agriculture Implement Research Center in Birganj and the National Fisheries Research Farm in Bhairahawa. Hopefully these centers will launch R&D activities on AFPs in these relatively favorable areas.

Market development for importers and manufacturers of agricultural machinery

NAMEA

CSISA understands well that any success in scaling agricultural machinery depends on a vibrant, knowledgeable and fully engaged private sector. To this end, CSISA helped form and continuously supported the Nepal Agricultural Machinery Entrepreneurs Association (NAMEA). Through continuing education programming, CSISA helped to build awareness within member companies of new machinery technologies and to alert them where policy interventions may be required to facilitate adoption. CSISA also facilitated NAMEA members to extend their market reach into the Feed the Future Zone by introducing them to district-level agents and dealers.

The best example of this effort was the establishment of Dahit Traders in Munabasti, Bardiya District. Dahit Traders was founded at the end of 2014 in response to CSISA's encouragement. Dahit's owner, Mr. Chullu Ram Chaudhary, was a leading service provider for the 2-wheel tractor-operated seed drill and reaper. Within two years of establishing Dahit, it has become one of the largest sellers of 2-wheel tractors and their attachments in the Feed the Future Zone. Chaudhary quickly convinced local farmers of the importance of reapers in crop production as they save significant time during harvesting and reduce the harsh impact of labor scarcity. Dahit subsequently sold nearly 100 reapers in the last 2.5 years.



CHULLU RAM CHAUDHARY, OF DAHIT TRADERS, SECOND FROM RIGHT, STANDING IN A FIELD OF DSR RICE THAT ONE OF HIS RECENTLY SOLD 2WT SEED DRILLS HAD PLANTED.

Agro Machinery Exhibition

CSISA was the prime sponsor of the Second National Agro Machinery Exhibition, held in Kohalpur, Banke District in March 2016. The exhibition attracted over 80 agro-machinery importers, manufacturers and dealers from Nepal and India. CSISA displayed machinery that other traders did not, such as Dashmesh's Happy Seeder and precision fertilizer spreaders. NAMEA organizers reported that companies exhibited to over 35,000 people, and over US\$ 500,000 worth of goods were either sold or booked during the exhibition.



GLIMPSES OF THE NATIONAL AGRO MACHINERY EXHIBITION

Jingles

CSISA undertook a campaign to distribute marketing messages via local FM radio stations, with jingles and mini-dramas written in local languages. Jingles have played an important role in increasing sales of CSISA-supported technologies. For example, CSISA developed jingles about reapers in the local Tharu language for airing in the Far West. In the 2016 rice harvest season, Dahit Traders reported that after CSISA aired a jingle using their phone number they received over 100 calls about reapers, resulting in demand outpacing supply. FM radio is shown to be a low

cost and highly effective platform for raising awareness about machine technologies.

Market assessments

CSISA conducted the exercise shown in Table 1 to help clarify the market for scale-appropriate machinery, taking into consideration the number of farmers who could use a particular machine given agro-ecological conditions, relevant crops and the installed capacity of complementary

agricultural machinery, such as diesel engines and two-wheel tractors. The table considers a time period of five years and four products – 2-wheel tractor reapers, 2-wheel tractor seeders, 4-wheel tractor seeders and precision fertilizer and seed spreaders.

Table 1: Potential Machinery Market Size in the FtF and other Zones. ¹

	Area Far-West Terai (Wheat 67,000 ha)	Area Mid- West Terai (wheat 33,000 ha)	Area West Terai (wheat 68,000 ha)	Area East Terai (wheat 74,000 ha)	Potential market size (total)	Potential market value (\$)
# of Reapers	Area x .3 / 10 ha per reaper= 2,000 reapers	Area x .3 / 10 ha per reaper= 990 Reapers	Area x .3 / 10 ha per reaper= 2,000 reapers	Area x .3 / 10 ha per reaper = 2,220 reapers	7,210 2WT reapers	@ 600 US\$ / pc = US\$ 4.3 M
# of 4WT Seeders	Area x .3 / 30 ha seeder= 670	Area x .3 / 30 ha seeder= 330	Area x .3 / 30 ha seeder= 680	Area x .3 / 30 ha seeder= 740	2,400 4WT Seeders	@ 1000 USD / pc = US\$ 2.4 M
# of 2WT seeders	Area x .3 / 30 ha / seeder= 670	Area x .3 / 30 ha / seeder= 330	Area x .3 / 30 ha / seeder= 680	Area x .3 / 30 ha / seeder= 740	2,400 2WT seeders	@ 700 US\$ / pc = US\$ 1.7 M
# of Spreaders	Area x .5 / 5 ha / spreader= 6,700	Area x .5 / 5 ha / spreader= 3,300	Area x .5 / 5 ha / spreader= 6,800	Area x .5 / 5 ha / spreader= 7,400	24,200 spreaders	@ 35 US\$ / pc= US\$ 850,000
					TOTAL SALES	US\$ 9.25 M

The numbers are impressive, particularly as we have left out the Central Development Region and parts of eastern Development Terai Region. If we had scaled the numbers to include the much larger rice area, the ‘potential’ totals of reapers sold would nearly double. In other case studies the potential market size has been a critical issue, potentially because the potential size was considered to be too small for suppliers (and governments, donors and projects) to see the technology as profitable. More analysis needs to be done but this data, paired with the current sales data of reapers, is will be shared with all stakeholders' and especially importers, and should be useful for them to see and understand the very positive market outlook in Nepal for scale-appropriate machinery.

Sustainability of the interventions, opportunities for further investment

Though many of CSISA’s technologies and agronomic practices are already spreading, the CSISA exit strategy to sustain these interventions was clear from the project’s inception: build strong institutions. First, the Nepal Agricultural Machinery Entrepreneurs Association and its district-level agents have improved access to scale-appropriate agro-machinery and have been essential in creating a strong market-based supply of spares and repairs. NAMEA companies have stood up markets for 1,100 reapers, 150 4-wheel tractor seeders and over 1,000 fertilizer broadcasters, three of CSISAs’ key technologies. In a very short time NAMEA has become a vibrant and strong organization with growing political clout and is now a leading voice in national policy debates about agricultural development priorities.

NARC’s agro-machinery testing center and DOA’s agro-machinery training center have recently been established and resourced with large amounts of testing and training equipment, but it is clear that the establishment of these new centers fulfills part of Nepal’s Agriculture Mechanization Promotion

¹ Area data from the Nepal SBS National Sample Census of Agriculture Nepal 2011/12. We pull in Eastern Development region as importers report that the first sales of reapers occurred there (30 pc).Its

Policy and the larger Agricultural Development Strategy. These centers will greatly enhance the Nepal government's capacity to evaluate technology as well as to train its farmers and service providers as well provide support to the private sector importers and manufacturers.

Even with these advancements and successes in agriculture and rural mechanization there are still large geographic areas (hills and Terai), development and research gaps in our understanding the socio-economic and household impacts of the spread of agricultural machinery technologies.

- **Seeders and planters:** While there are remarkable and measurable increases in commercial sales and markets for services, seeders and planters are still an emerging technologies that have spread mostly in current and former CSISA project areas. Opportunities exist to move this technology further from the Terai to the hills. The latest evidence indicates that maize farmers in Dang and Bara/Parsa Districts (former CSISA working areas) are now showing interest in line sowing with multi-crop planters. Alternatively, some recent reports from the far Eastern Terai that seeder sales are being affected by failures in direct-seeded rice demonstrations from the private sector and extension agents not knowing how to use seeders properly. Such negative demonstrations could slow the spread of seeders and reapers.
- **Harvester and reapers:** While initial numbers are impressive, and even the sales of self – propelled reapers have recently ticked up, the actual “foothold” or main sales area is limited to Bardiya, Kailali and Rupandehi Districts. Much more could be done to aid in the spread of this technology but also to extend efforts to 4-wheel tractor reapers, which are showing signs of spreading.
- **Mechanization in hills:** CSISA has noted the growing interest in, and spread of, mini-tillers and other small powered equipment (e.g., threshers, shellers, mills) in the hills. This might be one of the only examples in the developing world where such levels of mechanization technologies are spreading in such difficult hill geographies. Districts around Kathmandu like Kavre District have thousands of mini tillers, peddle rice threshers, small electric combo rice dehusker/flour mills and maize shellers. More needs to be done to increase the spread of these machines to the hills in the east and west, including new attachments like the minitiller irrigation pumps, seeders and planters.

Appendix 1. Project subcontractors and key partners

NEPAL				
PARTNER	PARTNERSHIP OBJECTIVE	ALIGNMENT WITH THEMES	LEVERAGING OPPORTUNITY	STATUS OF PARTNERSHIP
Government of Nepal				
Ministry of Agricultural Development	Technical guidance for GoN investments in agricultural development	All	New Agriculture Development Strategy approved by GoN in Fall of 2015. CSISA acts as a technical partner to shape the loan and investment programs associated with ADS, which may exceed \$100 m USD.	Active and sanctioned by CIMMYT's host country agreement
Nepal Agricultural Research Council (NARC)	Strategic and applied research on SI technologies	Innovation towards impact	NARC is responsible for providing the science basis of all state recommendations; their endorsement and ownership of emerging sustainable intensification technologies is essential.	Active and long-standing
Department of Agriculture (DoA)	Front line extension and support to farmers, service providers, and private sector	Achieving impact at scale	DoA has staff at the district level across Nepal and considerable budgets to support programming; CSISA assist in improving the quality of extension messaging and works to deepen linkages to private sector.	Active and long-standing
Nepali private sector				
Machinery importers (BTL, SK Traders, Dhahal, etc.)	Introduction and market development for scale-appropriate machinery	Achieving impact at scale	Rapid expansion of investment in scale-appropriate machinery and support for emerging service provision markets.	Active and long-standing
NIMBUS	Introduction and market development for new crop varieties and hybrids	Achieving impact at scale	Registration and market development for hybrids in the Feed the Future Zone from a base of zero in 2015.	Active since 2015
NGO				
NAMEA	Trade association formed with the help of CIMMYT to create an enabling environment and policy dialogue for scale-appropriate mechanization in Nepal	Systemic change towards impact	Important voice for private sector with GoN as the Agriculture Development Strategy support programs take shape.	Active since 2014

Appendix 2. CSISA-Nepal Mechanization and irrigation Indicator Numbers through September 2017

Indicator / Disaggregation	2017	2017	2017	Comment	Deviation Narrative
	Target	Actual	Deviation		
Feed the Future - CSISA Seed Technology Program (PIO buy-in)					
EG 3.2-18: 4.5.2(2): Number of hectares under improved technologies or management practices as a result of USG assistance	2,000	2,263	13%	This number counts area (ha) under improved agricultural technologies such as adoption of improved cultural practices, soil fertility management, water management and postharvest handling	Farmers have adopted improved soil management practices, postharvest handling of crops and improved cultural practices
Technology type	2,000	2,263	13%		
cultural practices	60	67	12%	This number counts area (ha) under various cultural practices activities such as drill use, rice planting and crop intensification	Many farmers have used seed drills for sowing crops.
soil-related fertility and conservation	30	34	14%	This number counts area (ha) under soil fertility management activities such as use of spreader, and fertilizer management aspects etc.	Many farmers, especially women, have adopted spreader to broadcast the fertilizer
water management (non-irrigation)	30	33	9%	This number captures area (ha) under laser land leveler for agricultural land development	
other	1,880	2,128	13%	This number primarily counts the area (ha) of reapers used for wheat harvesting and thresher	Large number of beneficiaries used the reaper to harvest wheat
total w/one or more improved technology	2,000	2,263	13%	This number counts the total area (ha) under various technologies (cultural practices, soil fertility mgt., water mgmt and postharvest) adopted by the farmers.	
Sex	2,000	2,263	13%		

Indicator / Disaggregation	2017	2017	2017	Comment	Deviation Narrative
	Target	Actual	Deviation	Activities/ Interventions summary	If actual is +/- 10% of target
Male	70	113	62%	This number captures area (ha) operated by male farmers under improved agri technologies such as cultural practices, soil fertility mgmt, water management and postharvest handling etc.	Percentage of actual seems very large which is primarily due to a low target set for male category compared to disaggregation not available category.
Female	25	41	65%	This number captures area (ha) operated by female farmers under improved agri technologies such as cultural practices, soil fertility mgmt, water management and postharvest handling etc.	Percentage of actual seems very large which is primarily due to a low target set for female category compared to disaggregation not available category.
Association-applied	25	45	82%	This number captures the decision on area (ha) under improved technologies such as cultural practices, soil fertility, water management and postharvest handling etc. to follow by group or association members.	Percentage of actual seems very large which is primarily due to a low target set for association category compared to disaggregation not available category.
Disaggregates Not Available	1,880	2,063	10%	This number captures the decision on area (ha) under improved technologies such as cultural practices, soil fertility, water management and postharvest handling etc. irrespective of sex.	
EG.3.2.7: 4.5.2(39): Number of technologies or management practices in one of the following phases of development: (Phase I/II/III)					
Phase 1 Number of new technologies or management practices under research as a result of USG assistance					
Phase 2 Number of new technologies or management practices under field testing as a result of USG assistance					

Indicator / Disaggregation	2017	2017	2017	Comment	Deviation Narrative
	Target	Actual	Deviation	Activities/ Interventions summary	If actual is +/- 10% of target
Phase 3 Number of new technologies or management practices made available for transfer as a result of USG assistance	5	5	0%	All targeted five technologies such as <i>sasto</i> (inexpensive) solar irrigating pump, shallow tube well boring kit for 2WT, PTO driven 2 inch irrigation pump for minitiller, hand cranked fertilizer broadcaster, self-propelled reaper are available for transfer.	
EG 3.2-17: 4.5.2(5): Number of farmers and others who have applied improved technologies or management practices as a result of USG assistance	2,000	2,226	11%	This number counts farmer who have applied improved agricultural technologies such as adoption of various cultural practices, soil fertility activities, water management and postharvest handling activities.	
Producers	2,000	2,226	11%		
Sex	2,000	2,226	11%		
Male	350	525	50%	This number counts male farmers who have applied improved agricultural technologies such as such as adoption of various cultural practices, soil fertility activities, water management and postharvest handling activities.	Percentage of actual seems large which is primarily due to a low target set for male category compared to disaggregation available category.
Female	150	283	89%	This number counts female farmers who have applied improved agricultural technologies such as such as adoption of various cultural practices, soil fertility activities, water management and postharvest handling activities.	Percentage of actual seems large which is primarily due to a low target set for female category compared to disaggregation not available category. And also more women have adopted improved technologies.
Disaggregates Not Available	1,500	1,418	-5%	This number counts the decision on new agri technology technologies such as cultural practices, soil fertility, water management and postharvest handling etc. adoption irrespective of sex.	
Technology type	2,000	2,303	15%		

Indicator / Disaggregation	2017	2017	2017	Comment	Deviation Narrative
	Target	Actual	Deviation	Activities/ Interventions summary	If actual is +/- 10% of target
cultural practices	225	244	8%	This number counts farmers adopting cultural practices activities such as drill use, crop intensification etc.	
soil-related fertility and conservation	125	139	11%	This number counts farmers adopting soil fertility management activities such as use of spreader, and fertilizer management activities etc.	Many farmers, especially women,` have adopted spreader to broadcast the fertilizer
water management (non-irrigation)	75	81	8%	This number captures farmer adopted laser land leveler for agri land development.	
post-harvest - handling and storage	1,575	1,839	17%	This number captures farmer used reaper to harvest wheat.	Large number of beneficiaries used the reaper to harvest wheat by reaper
total w/one or more improved technology	2,000	2,226	11%	This number counts the total area (ha) under various technologies (cultural practices, soil fertility mgt., water mgmt and postharvest) adopted by the farmers.	
Disaggregates Not Available					
EG.5.2-1: Number of firms receiving USG-funded technical assistance for improving business performance (O)	300	309	3%	This number counts the agricultural firms have received technical assistance to improve their business performance.	
Type of Firm	300	309	3%		
Formal	25	90	260%	This number counts the formal firms (registered in public organization) received technical assistance for business performance improvement.	Percentage of actual seems large which is mainly due to less target set for formal organization category compared to informal.
Informal	275	219	-20%	This number counts the informal firms (not registered in public organization) received technical assistance for business performance improvement.	Because of increasing trend of enterprise registration (establishment of more formal organizations)
Duration	300	309	3%		

Indicator / Disaggregation	2017	2017	2017	Comment	Deviation Narrative
	Target	Actual	Deviation	Activities/ Interventions summary	If actual is +/- 10% of target
New	100	115	15%	This number counts the firms those received technical assistance from the CSISA Project for the first time during reporting period to improve their business performance.	Increasing trend of joining new organizations.
Continuing	200	194	-3%	This number counts the firms those received technical assistance from the CSISA Project to improve their business performance during last reporting period and continued in this period.	Six firms did not continue in 2017 those received support from CSISA in 2016