USAID FROM THE AMERICAN PEOPLE

BILL & MELINDA GATES foundation

CIMMYT International Maize and Wheat Improvement Center

IFPRI

IRRI

CSISA

CEREAL SYSTEMS INITIATIVE for SOUTH ASIA IN NEPAL

2015 - 2016

Semi - Annual Report

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

Semi-Annual Report
April 2016

Submitted to:

Srivalli Krishnan, USAID India

Bahiru Duguma, USAID India

Biniam Iyob, USAID Washington

Eric Witte, USAID Washington

Compiled by Mina Devkota, Scott Justice, Arun Joshi, Narayan Khanal, Gokul Paudel and Dilli KC
With support from Andrew McDonald and Cynthia Mathys

International Maize and Wheat Improvement Center (CIMMYT)

Period covered: October 1, 2015 to March 31, 2016

Grant Summary Information

Project Name: Cereal Systems Initiative for South Asia in Nepal

USAID India funded: CSISA-Nepal Mechanization & Irrigation

USAID Washington funded: CSISA-Nepal Agronomy & Seed Systems Scaling

Organization Name: International Maize and Wheat Improvement Center (CIMMYT)

USAID India Grant Amount: $1,000,000

USAID India – CSISA-Nepal Mechanization & Irrigation Project Duration (in months): 24

USAID India – CSISA-Nepal Mechanization & Irrigation Project End Date: June 2017

USAID Washington Grant Amount: $3,075,000

USAID Washington Agronomy & Seed Systems Scaling Project Duration (in months): 48

USAID Washington Agronomy & Seed Systems Scaling Project End Date: September 30, 2018

Report Period: October 1, 2015 to March 31, 2016

Report Due: April 30, 2016

Has this project been granted a no-cost extension? Not yet required.

Principal Investigator/Project Director: Dr. Andrew McDonald

Title: Project Leader, CSISA; Principal Scientist, CIMMYT

Mobile Phone: +977-9808757832

Email: a.mcondald@cgiar.org

Web site: http://csisa.org

Mailing address: CIMMYT International, South Asia Regional Office, P.O. Box 5186, Botany Division, NARC, Khumaltar, Lalitpur, Nepal

Report Prepared By: Mina Devkota, Scott Justice, Arun Joshi, Narayan Khanal, Dilli KC, and Gokul Paudel, with support from Andrew McDonald and Cynthia Mathys

Date Submitted: April 30, 2016

Mobile Phone: +977 9808040992 (Cynthia)

Email: c.mathys@cgiar.org

Table of Contents

Acronyms and Abbreviations

Acronym	Full Name
2WT	Two-wheel tractor
4WT	Four-wheel tractor
ARS	Agriculture Research Station
AVRDC	The World Vegetable Center
CIMMYT	International Maize and Wheat Improvement Center
CSISA-NP	Cereal Systems Initiative for South Asia, Nepal
DADO	District Agricultural Development Office
DOA	Department of Agriculture
DSR	Dry-seeded rice
FtF	Feed the Future
GoN	Government of Nepal
ha	Hectare
HH	Household
IRRI	International Rice Research Institute
ICM	Integrated Crop Management
Kg	Kilogram
KISAN	Knowledge-intensive Sustainable Agriculture and Nutrition project
LLL	Laser Land Leveler
MoAD	Ministry of Agriculture Development
NARC	Nepal Agricultural Research Council
NAMEA	Nepal Agriculture Machinery Entrepreneurs Association
NGLP	National Grain Legumes Program
NWRP	National Wheat Research Program
OPV	Open-pollinated variety
RARS	Regional Agricultural Research Station
SEAN	Seed Entrepreneurs Association of Nepal
SI	Sustainable intensification
SP	Service provider
ST	Strip tillage
SMEs	Small and Medium Enterprises
SQCC	Seed Quality Control Center
TL	Truthful Label
USAID	United States Agency for International Development
ZT	Zero tillage

Cereal and pulse yields in Nepal fall well below regional averages and present rates of increase won't meet long-term domestic requirements. Factors that contribute to low staple crop performance in Nepal include scarce farm labor, poor knowledge of best agricultural management practices, lack of irrigation and mechanization, and farmers' inability to take risks and invest in new technologies. Also, innovative applied research has long been underfunded 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)[1] recognizes the need for new science-led innovations, crop diversification options for income generation, strengthened input systems for seed and fertilizer, mechanization to cope with outmigration and an aging agricultural workforce, and enterprise development to create new jobs and extend essential support services to large numbers of farmers. In support of these priorities, CSISA works with partners who can help to rapidly and broadly increase the adoption of sustainable intensification technologies at scale. CSISA's partners include Feed the Future's KISAN project, government agencies, farmers' groups, service providers, agro-dealers, seed enterprises and other private sector companies.

CSISA's 'Scaling Seed and Sustainable Intensification Technologies in Nepal' project pursues the following objectives:

1. Pulse (lentil and mung bean) intensification and diversification, adopted at scale
2. Cropping system-based approaches for sustainably intensifying wheat and minimizing terminal heat stress, adopted at scale
3. Facilitation of efficient and low-risk strategies for the precise and productive use of nutrients
4. Robust seed systems that ensure timely access to elite cultivars and hybrids
5. Scale-appropriate mechanization and irrigation.

These activities are part of a four-year program funded jointly by USAID Washington and USAID India. USAID Washington has provided $3,075,000 over four years to support wheat, lentil and mung bean agronomy; the efficient use of fertilizers; and seed system scaling. USAID India has provided $1,000,000 over the first two years to support CSISA's work in mechanization and irrigation, focusing specifically on increasing the ways in which Indian agricultural technologies can support efficient and climate-smart agriculture in Nepal. The program runs from October 2014 to September 2018.

[1] Agriculture Development Strategy (ADS), 2014

AGRONOMY& SEED SYSTEMS SCALING

- **Wheat**
  - CSISA conducted **on-station experiments** in collaboration with the Nepal Agricultural Research Council's National Wheat Research Program to test three wheat varieties of different maturation classes, seeded on three different dates at two different seed rates. Visual observation indicates that we can expect **early-seeded, long-duration wheat varieties to fare better than late-seeded ones** (data to be reported in the annual report). Results will inform which varieties should be recommended for registration in the western development zones and the **value of early wheat planting in the Terai**, where terminal heat frequently lowers yields.
  - To **evaluate the performance of rainfed wheat under different seeding times in the hills**, in collaboration with farmers' groups, CSISA conducted on-farm evaluation trials in six farmers' fields in Surkhet. Treatments included three different seeding times for wheat: early (24thSeptember), medium (9thOctober), and late (24thOctober). Among the three dates, **crop performance was very good under early seeding**, followed by medium seeding, and last by late seeding. Results indicate that **early planting of wheat in the hills helps the crop take advantage of residual soil moisture from late monsoon rains,** thus avoiding drought-like conditions.
  - **To spread awareness about the importance of irrigating wheat in winter**, CSISA collaborated with the District Agriculture Development Offices in four districts to produce **seasonal community FM radio spots or "jingles" in local languages** to tell farmers that **applying irrigation to wheat during the active tillering and flowering stages can increase yields, particularly during dry winters**. The jingles also conveyed that if farmers also top-dress wheat with urea immediately after irrigating, yield can increase further.
- **Lentil**
  - Realizing the importance of suitable genotypes for lentil, CSISA collaborated with the Agronomy Division of NARC, National Grain Legume Program and ICARDA to **evaluate 100 lentil genotypes from the Mediterranean region for drought and high moisture resistant genotypes**. Current field observations show that some lines may be resistant to drought, evidenced this year as it is extremely dry.
  - CSISA conducted a **household survey of 600 farm households** in its working districts in 2014–15 to understand **lentil productivity trends under farmer management**. Results suggest that **high rainfall was the major predictor of low lentil yields** during the study year. Farmers with fields that were mid- to low-lying (i.e. more poorly drained) had much lower yields due to waterlogging compared to farmers with better-drained fields in upland areas. Additionally, sites with higher rainfall experienced greater incidence of disease like stem phylum, resulting in greater productivity losses.

- **Mungbean**
  - In collaboration with CSISA and the National Grain Legume Program, **seed companies have been evaluating the performance, yield and economic benefits of mungbean under four different cropping systems**: rice–mustard–mungbean, rice–vegetable–mungbean, rice–lentil–mungbean, and rice–wheat–mungbean. They have also been evaluating the benefits of mungbean on the subsequent rice crop in the terai and foothills.
  - CSISA is launching collaborative research with the National Grain Legume Program and a private seed company for both **on-farm and on-station evaluations of pipeline mungbean varietie**s, for example Hum-16, BARI's Mung-5and Mung-6, and prominent Indian varieties like the Pant (Pantnagar) series. **Data generated will be helpful for the registration of the potential varieties** and also to get available of seed to the farmers as seed companies participate evaluating varieties.
  - CSISA is strengthening public-private partnership across the mungbean value chain. Over 600 farmers are engaged in mungbean seed production (14 ha) and grain production (85 ha) across Banke, Bardiya, Kailali and Kanchanpur
- **Fertilizer Productivity**
  - To explore fertilizer response with respect to seeding time, variety and growing domain (whether irrigation water is available when needed), CSISA conducted **on-farm evaluations of wheat** considering the above conditions. Preliminary results show that with the same level of fertilizer (i.e., the recommended dose), the **yield advantage in a fully irrigated field (3-4 irrigations) is 35–65% compared to the partially irrigated field (one irrigation at the beginning)**, especially in dry winters.
  - In order to widely disseminate key information about the importance of applying fertilizer along with irrigation, CSISA broadcast a **radio jingle about the importance of applying a split application of fertilizer along with irrigation**.
  - CSISA has been **demonstrating and evaluating manually operated spreaders for the uniform application of seed and fertilizer**. Spreaders not only aid in the uniform application of seed and fertilizer but also reduce labor costs associated with fertilizer application. Evaluation results from the 2015 rice season show that t**he use of a precision spreader for urea topdressing in rice improves yield by 5–6%** compared with the farmers' application method. Importantly, there was almost a **50% savings in labor costs related to fertilizer application**.
  - CSISA launched an **awareness-raising campaign** about the importance of uniform fertilizer application in collaboration with District Agriculture Development Offices, farmers' groups, cooperatives, Agriculture Service Centers, agrovets and seed companies, as well as through the KISAN project. KISAN has been promoting the Earthway spreader through their on-farm evaluations of different crops, awareness-raising trainings and by providing CSISA's user-friendly guide to the Earthway spreader. The guide covers handling guidelines for seed (wheat, lentil) and fertilizer (DAP and urea) broadcasting. **CSISA has provided capacity development training for**

more than 150 farmers, who can be potential service providers for the technology. CSISA is also working with different manufacturers and traders (Crystal-India, Dahal-China and Earthway, USA) to promote market development for different models of the spreader and has placed a number of the spreaders with agro-vets on consignment.

- **Seed Systems Scaling**
  - CSISA conducted **business mentoring of 10 small- and medium- seed enterprises** on i) providing advisory services for technical problems, ii) fostering linkages with public and private service providers, and iii) strengthening the Seed Entrepreneur Association of Nepal to develop a strategic business plan. During the mentoring period, three companies were able to develop their own business plan. Also, two SMEs carried out **120 Integrated Crop Management demonstrations** in new varieties of lentil and wheat in 6 districts. More than **5,000 farmers** visited these demonstrations.
  - CSISA and the National Maize Research Program (NMRP) partnered to evaluate maize hybrids in six districts in western Nepal. Trials were conducted in the spring in the Terai and in the summer in the mid-hills and were monitored by a team of stakeholders from NMRP. The performance data for variety release and registration was shared with the National Seed Board (NSB). Four hybrids were found agronomically superior. **In response to the evaluation results, the NSB approved and registered four hybrid varieties for sale in the western region**.
  - CSISA has facilitated a new business model for scaling improved crop varieties in the hills in partnership with District Agriculture Development Offices, National Agricultural Research Council, seed companies and agricultural cooperatives. There will be **seed production in open-pollinated maize** (foundation-40ha, Truthful Label 424 ha), rice (Truthful Label-70 ha) **and wheat** (Truthful Label-70 ha) in 2016.

Mechanization and Irrigation

- **Mechanization and Market Development**
  - Following up on our earlier success jumpstarting reaper sales in the Mid and Far West in Nepal, CSISA has been working with SK Traders, Kubir & Sons, SKT, and BTL Traders to stock additional reapers in time for the 2016 wheat harvest. CSISA estimates that **at least 200 reapers will be sold in 2016,** mostly in the Terai districts of Banke, Bardiya, and Kailali.
  - CSISA supported the 2nd National Agro Machinery Exhibition, held in Banke district in March 2016, to link Nepali importers with machinery suppliers and manufacturers, including those from India, and to spread awareness among farmers and service providers about agro-machinery options. CSISA collaborator, Jay Bageshwori Tractor and Machines, immediately bought **16 Indian-made reapers for test marketing in Nepal**. By the end of March, just prior to start of wheat harvest, he had sold half his stock and was confident he would sell the rest.

- Smaller self-propelled reapers (reapers that come with fixed engines and transmissions) have not sold well in Nepal due to their high costs. In an effort to reduce the costs for farmers and service providers, CSISA is working with an Eastern Nepal-based agro-machinery importer to increase the availability of reaper attachments for mini-tillers. CSISA purchased **8 Indian-made Sadar Reapers** for fitting on existing mini-tillers. The local supplier, Krishi Sansar, is working with CSISA on adjusting the reaper attachments so they can be mounted on a variety of mini-tillers. These relatively small and less expensive reapers may have applications in relatively accessible mountainous regions, where larger reapers cannot go.
- CSISA conducted a scoping visit for the "**Design Sprint**", which works with Indian manufacturers of multi-crop seeder and thresher attachments for two-wheel tractors and mini-tiller platforms to improve their design and commercial availability. With the leadership of Dr. John Colton of Georgia Tech University, CSISA will conduct three regional trainings (Rajkot, Punjab and Odisha) in June 2016 for Indian manufacturers on ways to modify existing machinery to better serve the market for two-wheel tractors and mini-tillers, including in Nepal. Three winners of the design sprint will develop prototypes and have them tested by the National Agricultural Research Council in Nepal.
- CSISA partnered with Nepal Agriculture Research Council (NARC) and Department of Agriculture (DoA) to recommend the NARC and DoA farms in Nawalpur as the new site for the proposed co-located **Machinery Testing Center (for NARC) and Machinery Training Center (for DoA)**. CSISA also has developed a list of equipment required, as well as the floorplan for the centers.
- CSISA demonstrated **axial flow pumps** and **solar photovoltaic irrigation systems** as potentially low-cost, energy efficient irrigation technologies for use in the Mid and Far Western zones of Nepal. Research into these technologies is ongoing.
- CSISA broadcast **radio jingles on FM stations** in the Mid and Far West development zones to spread messages about the **availability of reapers** in the market in time for wheat-harvesting season and the **importance of applying additional irrigations to wheat** during dry winters. The response among reaper sellers after the jingle was broadcast indicates that radio jingles have significant reach and audience in CSISA's working districts.

1 WHEAT

Wheat grows widely across Nepal's Terai plains and mid-hills regions and contributes to millions of farmers' livelihoods and household diets. In the Terai, wheat productivity is threatened by climate change through **terminal heat** – temperatures exceeding 35C during wheat's grain-filling stage, which reduces yields. In the mid-hills, wheat is vulnerable to damaging **drought** conditions if planted after the last monsoon rains. To support farmers' adaptations to rising temperatures and variable monsoon patterns, CSISA conducts strategic research into how agronomic practices can help farmers adapt to terminal heat and early-season drought and investigates the primary determinants of wheat yield in different ecologies. CSISA also aligns with strategic partners for the out-scaling of relevant messaging and scale-appropriate technologies so that farmers can adopt management practices and technologies that will allow them to sustainably intensify wheat in the face of climate change.

Increasing Wheat Yields, Coping with Climate Risks

1.1 In the Terai: Better-bet Agronomy Builds Resilience to Terminal Heat

Wheat productivity growth in the Terai is constrained primarily by the farmers' practice of sowing wheat in late November or early December, which leaves the crop to mature (e.g., go through the grain-filling stage) in March, when temperatures can exceed 35C. The 'terminal heat stress' that wheat endures at these temperatures reduces yields. In a typical year, the attainable yield potential for wheat declines by about half with delayed planting. The lesson: farmers need to plant wheat earlier.

> The most important way that farmers in the Terai can adapt to terminal heat is to plant wheat **before November 15.**

CSISA research in Bihar, India, which has similar agro-climatic conditions to the Terai, shows that early-seeded long-duration wheat varieties yield more than late-planted short-duration varieties. CSISA's objective in Nepal is to determine the better-bet agronomy that will build resilience to terminal heat stress in the Terai, and then scale up those practices across our working area.

The use of terminal heat stress-tolerant varieties, timely seeding and adjustment of plant population sizes are the major better-bet agronomy management practices that can help farmers cope with terminal heat stress. Currently, none of the Nepal Agricultural Research Council's (NARC) released varieties have been recommended as terminal heat stress-tolerant. Hence, it is important to explore the option of adjusting different agronomic interventions with available varieties to minimize the effects of terminal heat stress. In collaboration with NARC's National Wheat Research Program (NWRP) in Bhairahawa and Regional Agriculture Research Station in Khajura CSISA has initiated on-station experiments to explore better-bet agronomy with existing varieties to minimize the effect of terminal

heat stress during this wheat season. The experiments included three wheat varieties of different maturation classes, seeded on three different dates at two different seed rates. Visual observation indicates that we can expect early-seeded, long-duration varieties to fare better than late-seeded ones. The experiment will be repeated in the next wheat season to see the treatment effect across the year. Besides this, on-farm evaluation of those verities under normal and late seeding with varying fertilizer management has been conducted under different farmers' fields in Banke, Bardiya, Kailali, and Kanchanpur to validate the results under farmers managed field. Crop harvesting is ongoing and results will be presented in the annual report.

The outcome from this strategic research will be applicable throughout the Terai region of Nepal. To disseminate the outcomes of this strategic research in a larger community, CSISA will play major role in organizing campaigns through social media, and dissemination of outreach material through public and private partnerships.

Evaluating pipeline varieties for eventual registration

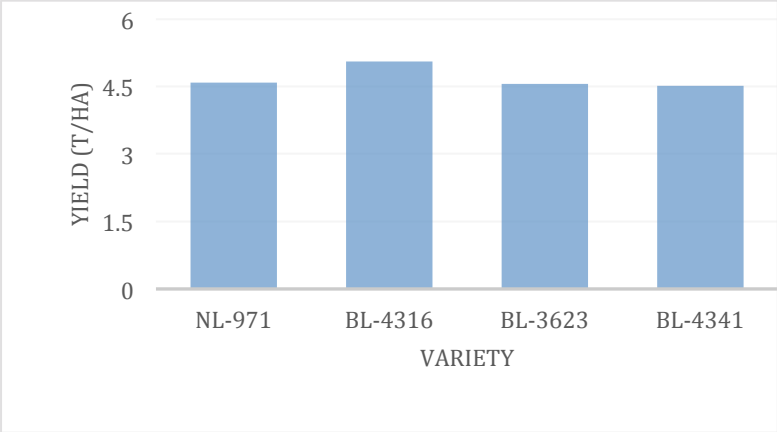

Fig. 1. VARIETAL EVALUATION FOR TERMINAL HEAT STRESS TOLERANT LINES

NARC has identified some promising new lines as heat stress-tolerant in its on station evaluation. To understand wider adaptability of those pipeline varieties, in co-ordination with NWRP and private seed companies, CSISA has evaluated three different promising pipeline varieties in different farmers' fields while comparing the commonly cultivated variety NL-971 (Fig.1). On-farm evaluations not only facilitate a faster varietal registration process but also help to speed up the scaling improved varieties. CSISA has observed that BL-4316 produced higher yield (> 500 kg/ha) compared to the commonly grown variety NL 971. In the coming wheat season, CSISA will evaluate the seeds of promising lines observed in this experiment (e.g., BL 4316) through seed companies and other private companies in a large number of farmers' fields to increase the seed volume for quick dissemination. The need for improved varieties across the wheat growing areas of the Terai is significant.

Identifying the determinants of wheat productivity in the Terai

Wheat yields in Nepal fall more than 2 t/ha below their potential under best management practices. Ample opportunity exists to increase yields if one can identify the major determinants of productivity, for example suitable genotype, seeding time/method, fertilizer and irrigation management and other management practices in different ecologies. In 2015 in selected Terai districts (Fig. 2), CSISA collaborated with the Ministry of Agriculture (MoAD), Department of Agriculture (DoA) and World Food Program (WFP) to collect information on wheat yields and its major determents to increase productivity at the household level for the 2015–16 wheat season. Outcomes from this survey will be important for planning the strategic research for the region and deployment of sustainable intensification technologies in target areas for increasing wheat productivity. Based on the outcomes of this survey, strategic research will be formulated for the next wheat season and scaling out strategies for the relevant agronomic recommendations will be developed in collaboration with different public-sector and private-sector companies. Detailed outcomes of the household survey will be presented in the annual report.

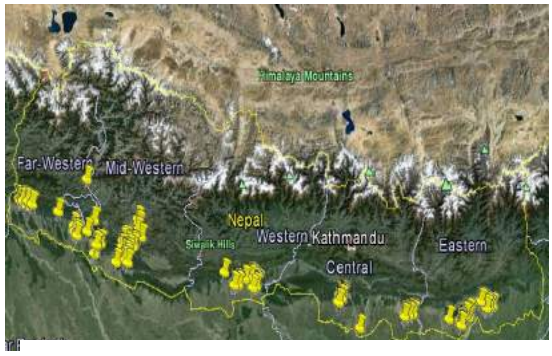

Fig. 2 LOCATING WHEAT SURVEY VILLAGES IN DIFFERENT DISTRICTS

1.2 In the Rainfed Hills: Early-seeding to Beat Dry Winters

As a winter crop, wheat is cultivated during Nepal's dry season, and in the Western mid-hills it is grown mostly in upland areas in maize–wheat cropping systems. As a dry season crop cultivated in rainfed ecologies, wheat is vulnerable to the effects of drought during its early growth stages.

Under current production systems and existing patterns of input use, maize (<2.0 t/ha) and wheat (<1.0 t/ha) productivity is very low. Wheat productivity in particular depends on rainfall amounts and distribution because it relies heavily on the moisture left in the soil from late monsoon rains, after maize has been harvested. Under current farmers' practice, even if maize is harvested early, farmers don't plant wheat before the 2nd week of October, mainly due to a lack of knowledge that wheat can be planted this early. Early seeding into moist soil facilitates proper stand establishment, leading to higher yields, especially in relatively dry winters.

In the mid-hills, **planting wheat earlier** allows farmers to take advantage of soil moisture left by late monsoon rains, before the dry winter sets in.

Figure 3. From Left to Right: PERFORMACE OF WHEAT SEEDED ON 24TH SEP (early), 9TH OCT (medium) AND 24TH OCT (late) IN SURKHET

To evaluate the performance of rainfed wheat under different seeding times in the hills, in collaboration with farmers groups, CSISA conducted on-farm evaluation trials in six farmers' fields in Surkhet. Treatments included three different seeding times for wheat: early (24thSeptember), medium (9thOctober), and late (24thOctober).

Among the three dates, crop performance was very good under early seeding, followed by medium seeding, and last by late seeding (Fig. 3). Farmers in this area were surprised that wheat could be grown successfully when planted that early. Early-sown wheat was the major attraction during a farmer's field day held in March 2016 in Surkhet, with the District Agriculture Development Office (DADO) mentioning that this information needed to be widely disseminated prior to next year's wheat season. Crop harvesting is underway, and yield performance will be presented in the annual report. This evaluation needs to be repeated in order to determine the stable yield performance of this early-seeded wheat in the rainfed hills across years, using varieties suitable for scaling out across the region. In collaboration with District Agriculture Development Offices, CSISA will organize the media campaigns to alert farmers in the hills to plant wheat early if there is no rain in early winter in the coming wheat season.

> CSISA research clearly shows that seeding wheat early can be a successful drought-risk mitigation strategy for farmers growing wheat in the rainfed hills.

Radio Jingle to Alert Farmers about the Importance of Irrigating Wheat

More than 80% of farmers in Nepal's Mid and Far West development zones irrigate their wheat only once, even if winter rains are scarce and irrigation is available. Many farmers lack awareness about the benefits of providing a second irrigation, including higher yields. If farmers apply the first irrigation during the initial growth stage, a second irrigation at the tillering stage, and perhaps an additional irrigation during the flowering stage, yields can be increased significantly.

To spread awareness about the importance of irrigating wheat in winter, CSISA collaborated with the DADOs in four districts to produce radio jingles in local languages to tell farmers that applying irrigation to wheat during the active tillering and flowering stages can increase yields, particularly during dry winters.

The jingles also conveyed that if farmers also top-dress wheat with urea immediately after irrigating, yield can increase further.

The jingles were broadcast six times per day for about three weeks on Krishna Shara FM, one of the most popular FM radio stations in the Mid West. Dinesh FM, the most popular FM for the Far West, broadcast the jingles in that development zone. Previously, CSISA partnered with two machinery dealers to produce similar radio broadcasts about the benefits for farmers of seed drills and reapers before the rice harvest, which generated demand for these technologies and contributed to increased sales by each trader. CSISA will be working to determine how to measure the impact of these jingles, as any change in behavior attributable to a jingle is proving difficult to capture precisely.

In Focus:*Zero/minimum tillage wheat – a tool for increasing wheat yieldsin the Terai*

FARMERS IN THEIR ZERO-TILL WHEAT FIELD

FARMERS OBSERVING ZERO-TILL WHEAT DURING A FARMERS' FIELD DAY

Wheat is one of the major food crops grown during winter in Nepal, as evidenced by the dominance of the rice–wheat system in the Terai. Farmers usually hand-broadcast seed on to land that has been ploughed 3-4 times, although this is expensive due to the repeated ploughing costs. This practice also delays wheat seeding as farmers have to wait for the field to dry out after the rice harvest, making the wheat more vulnerable to terminal heat stress during the grain-filling stage. The early planting of wheat is the most important tool for increasing wheat yields in a warming climate. Zero tillage wheat using 2-wheel tractor or 4-wheel tractor-mounted seed drills can facilitate the early sowing of wheat while also reducing tillage costs.

In collaboration with The Habi, a seed drill trader, CSISA started demonstrating zero tillage (ZT) and reduced tillage wheat during the wheat season 2014–15,which was completely new to the region. In all areas, ZT wheat out-yielded conventionally seeded wheat. Attendees at a farmers' field day organized before the wheat harvest in 2015 expressed surprise at the high yields. Many farmers showed interest in ZT technology and inquired about how to get the machinery and training to operate the machine. In collaboration with The Habi in 2015, CSISA provided training for service providers on how to operate ZT machines, how to calibrate the seed and fertilizer rate, and other aspects, before the 2015–16 wheat season began. **After seeing the success of this technology last year, more than 230 ha has been seeded using the ZT seed drill in 2015 through custom-hire services**. In collaboration with private sector and government partners CSISA is working to support the emergence of and strengthen the capacity of, service providers in order to increase their access to ZT seed drills for wheat seeding in the region.

2 LENTIL

Lentil is a prioritized value chain for Feed the Future in Nepal. However, the intensification possibilities for this crop have proven difficult to identify because lentil is highly susceptible to drought, excess soil moisture and disease. In Nepal, farmers grow lentil without investing significant financial resources or agricultural inputs (such as fertilizer) precisely because yields vary so much from year to year. In most locations in the Terai, average yields fall below 1,000 kg/ha. Recent data from CSISA suggests that the adoption of **improved varieties** may improve yields by 100 kg/ha, but results are inconsistent and vary strongly across sites and years.

More promising is the potential role of **management interventions** such as precision sowing and the limited use of fertilizers to complement the adoption of improved varieties. CSISA data suggest that yields can be doubled (e.g., from 600kg/ha to 1,200 kg/ha) when better-bet management is combined with improved varieties. Comparatively little attention has been paid to options for increasing lentil production in the hills, but results from CSISA on-farm trials in 2013–14 indicate that yields above 2,000 kg/ha are achievable. Better-bet practices and varietal choices in the hills are distinct from the Terai, so CSISA places emphasis on both ecologies. Identifying interventions that can **reduce risk** for lentil cultivation in different soil textures has become the focus of CSISA's work in this area.

> For lentil, the risks posed by winter rains and disease are problematic and will continue to prevent farmers from intensifying lentil unless effectively addressed. Improved risk management is a core goal of CSISA's interventions for lentil in Nepal.

Lentil Interventions: Risk Management Options

2.1 Lentil Evaluation in Poor and Well-Drained Soils in a Dry Year

Lentil yields from available varieties in the hills and Terai vary widely and depend significantly on winter rainfall. The impact of rain depends heavily on soil texture and whether excess rain can drain off, or if rain has been scant, whether the soil can hold onto moisture. Over the last three years, lentil production in the Terai was severely affected by heavy and frequent winter rainfall. More than 80% of farmers obtained< 300 kg/ha. On the other hand, the same amount of winter rain benefitted lentil crops in the hills, where farmers obtained > 2 t/ha because the sloping topography and coarser textured soils

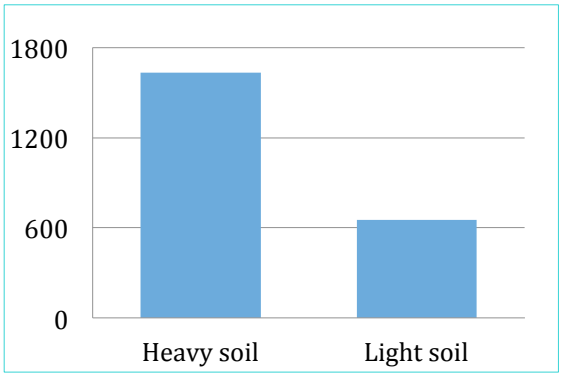

Fig. 4 LENTIL YIELD (KG/HA) ON HEAVY (POORLY DRAINED AND LIGHT SOIL (WELL DRAINED) SOIL IN TERAI IN 2015-16

facilitated drainage. Everything was reversed during the winter of 2015–16,when lentil production was severely affected in the hills and in well-drained soils in the Terai due to drought, where soil dried out severely because there had been very little rainfall from the end of August to March 2016 (the entire lentil production period). The low rainfall was favorable for Terai areas that have medium-to-heavy textured, and poorly drained, soils (Fig. 4). All of this data shows that climatic stress is one of the major constraints for lentil production and that existing germplasm has limited ability to confer resilience during wet and dry winters. In the absence of suitable genotypes, all of the agronomic effort applied for the lentil cultivation failed under unfavorable weather conditions.

Strategic research: Testing lentil genotypes

LENTIL VARIETAL SCREENING EXPERIMENT FROM MEDITERRANEAN REGION

Realizing the importance of suitable genotypes, CSISA collaborated with the Agronomy Division of NARC, National Grain Legume Program (NGLP) in Khajura in Banke district and ICARDA to evaluate 100 lentil genotypes from the Mediterranean region for drought and high moisture resistant genotypes[2]. Current field observations show that some lines may be resistant to drought, evidenced this year as it is extremely dry. Furthermore, it is important to evaluate those lines for a few more years as rainfall patterns during winter vary across the years (for example year 2013/14, 2014/15 were wet winters while 2015/16 remained dry). Therefore, further screening of these lines is needed to identify suitable genotypes for both drought and waterlogging conditions. Similarly, the promising line observed in this drought year can be further evaluated in upland condition in the coming lentil season. Once the resistant genotypes (for drought or wet conditions) is identified, on-farm evaluations of the selected genotypes will be carried out in collaboration with seed companies, seed procucer groups and government partners, which facilitate the avilability of seeds for cultivation at scale.

2.2 Is Lentil Beneficial in Wet Winters? Household Survey Results, 2015

The spatial variability of rainfall during lentil production is presented in Figure 5 and indicates a high variability, ranging from 87 mm to 657 mm. Results show that the sites with medium rainfall performed better than the sites with low or high rainfall.

[2]In a joint review and planning meeting last fall Dr. Renuka Shrestha, Chief, Agronomy Division, NARC, that historically, most lentil varieties in South Asia have been selected by national and international centers from sub-tropical nurseries. She pointed out that Nepal's winters are more of a Mediterranean type than sub-tropical.

In light of this situation, CSISA conducted a household survey of 600 farm households in its working districts in 2014–15 to understand lentil productivity trends under farmer management. Results suggest that high rainfall was the major predictor of low lentil yields during the study year. The survey also showed that the average farmer is growing lentils on ~0.25 ha. About 85% of the farmers obtained a lentil yield lower than 300 kg/ha. In 2014–15, more than 50% of the farmers harvested less than 150 kg/ha while 15% of the farmers obtained zero yield. Farmers with fields that were mid- to low-lying (i.e., more poorly drained) had much lower yields due to waterlogging compared to farmers with better-drained fields in upland areas. Additionally, sites with higher rainfall experienced greater incidence of disease like stem phylum, resulting in greater productivity losses.

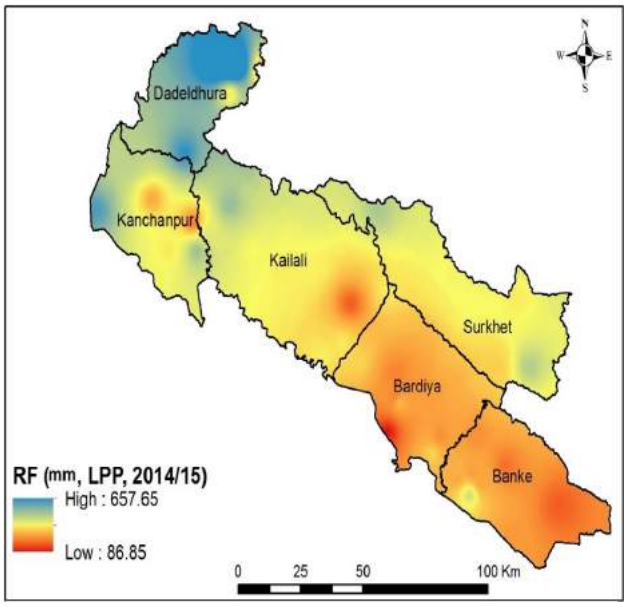

FIG 5: SPATIAL RAINFALL VARIABILITY DURING LENTIL PRODUCTION TIMES IN CSISA WORKING DISTRICTS

Economic analysis of surveyed households (n=600) showed that almost 62% of farmers ended up in financial loss from lentil cultivation (Fig 6). Results were greatly mixed as many farmers suffered from waterlogging problems and others suffered from drought. Out of 600 farmers, 128 farmers obtained no yield.

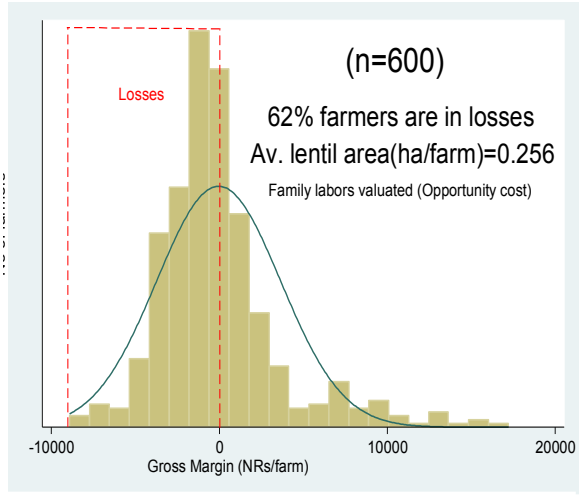

FIG 6: DISTRIBUTION OF THE GROSS MARGIN FOR LENTIL PRODUCTION IN CSSIS NEPAL WORKING DISTRICTS

Scaling Strategy

Varietal replacement rates for lentil are very low (<10%), and most farmers use their own seed, which is poor in quality (for example poor germination, mixed with off-types and weed seed) and cultivated under poor management practices. Low varietal replacement and poor management are mainly associated with the unavailability of improved seed. Also, farmers don't want to invest inputs in such a risky crop. Therefore, even in the good years, productivity of lentil is far below its yield potential (>500 kg/ha) when cultivated under typical farmers' management. With the objective of scaling out better-bet agronomic practices (for example, improved varieties (pipeline and recently released), better seeding methods, and proper fertilizer and water management practices) CSISA has facilitated on-farm demonstrations of those better-bet practices in collaboration with seed companies, service providers for mechanized line seeding, District Agriculture Development Offices and National Grain Legume Program in 120 farmers' fields in the current CSISA working districts while comparing farmers' existing practices. This practice not only provides farmers the

opportunity to observe the economic advantages of adoption of better-bet practices, but it generates demand for new varieties and ultimately increases farmers' access to those varieties at the seed dealer level as seed companies become involved in demonstrations.

3 MUNGBEAN

Mungbean can fit in as a spring crop immediately after the harvest of the winter crop (such as potato, lentil, mustard or other vegetable crops), usually occupying land that used to remain fallow. This allows farmers to generate additional profit from their land.

Although the rice–wheat rotation is the dominant cropping pattern in the Terai, with the wheat harvest in April followed by rice transplanting in July, there is a **window of opportunity for systems intensification** that is not currently utilized by farmers. Short-duration mungbean is a ideal crop for areas where irrigation water is assured. Mungbean also helps improve soil fertility by fixing atmospheric nitrogen.


MUNG BEAN FIELD IN KAILALI

Mungbean can be precision-broadcasted into a standing wheat crop, and can be sown during the post-flowering irrigation that CSISA recommends farmers give their wheat. CSISA's results from India suggest that yields of up to 1,200 kg/ha are achievable, especially when yellow mosaic virus-resistant cultivars of mungbean are also used. In Nepal, CSISA focuses on evaluating and refining production practices for mungbean so that information about best-bet agronomy can be disseminated, and the markets for high-yielding cultivars can be expanded.

Mungbean Focus: Laying the Groundwork for Expanded Cultivation

3.1 Evaluating Registered Varieties under Different Cropping Patterns

CSISA aims to introduce the cultivation of mungbean at scale by encouraging farmers to utilize land that remains fallow during spring, after the winter crop is harvested. Wheat, mustard, lentil and potato/vegetable are the major winter crops grown in the region. Sufficient time exists after the winter crops are harvested and before the rice is transplanted for seeding mungbean, which would give farmers additional benefits from the same piece of land**.** It is important to evaluate mungbean performance and its economic advantages under different cultivation systems to determine where it can sustainably fit in the cropping system. Until now, such research has not been conducted in Nepal. Therefore, in collaboration with CSISA and the National Grain Legume Program, seed companies have been conducting on-station evaluations of mungbean under four different cropping systems: rice–mustard–mungbean, rice–vegetable–mungbean, rice–lentil–mungbean, and rice–wheat–mungbean. The research will evaluate the performance, yield and economic benefits of mungbean and the rest of the cropping system. Results will be available in spring 2016.

Similarly, for scaling out mungbean cultivation, CSISA has initiated on-farm evaluations of better-bet practices in more than 300 farmers' fields in collaboration with farmers, District

Agriculture Development Offices, seed companies, seed producers group and millers in both Terai and the foothills. This collaborative evaluation with public and private partners will not only increase the demand for mungbean production, as there is buy-back assurance from the millers, but will also increase the seed availability of improved varieties from dealers. Results of these trials will be presented in the annual report.

Figure 7. FACT SHEET ON MUNGBEAN PRODUCTION & BETTER-BET AGRONOMY

In Nepal, **basic guidance on better-bet agronomic management practices** is either lacking or only available in piecemeal fashion, often in inaccessible formats. To increase the capacity of extension agents, development partners and others to advise farmers on good practices that are proven to increase yields and profitability of mungbean production, CSISA in collaboration with NGLP/NARC, produced a simple guide to mungbean production that covers the importance of mungbean production, management aspects from 'seed to seed' in Nepali. It has been distributed by seed companies and District Agriculture Development Offices.

3.1 Evaluating pipeline varieties for eventual registration

To date only two mungbean varieties – Kalyan and Pratikcha – have been released in Nepal. Hence, farmers have limited choice for mungbean cultivation and the potential for significant area expansion is constrained. Considering the importance of varietal development, especially with synchronized maturity type, CSISA is launching collaborative research with the National Grain Legume Program and a private seed company for both on-farm and on-station evaluations of some pipeline mungbean varieties, for example Hum-16, BARI's Mung-5and Mung-6, and prominent Indian varieties like the Pant (Pantnagar) series. Data generated from this collaborative evaluation will be helpful for the registration of the potential varieties and also to get available seed to the farmers as seed companies participate in the evaluation of varieties. The outcome of the research will be presented in the annual report.

In Focus: Public-Private Partnership for Mungbean Scaling

Mungbean is a short-duration (70-80 days), promising, leguminous crop that can help diversify and sustainably intensify the rice–wheat cropping system of Nepal. In Nepal, mungbean is grown on about 12,000ha, but has significant potential for scale-out across the Terai. Marketing, source seed, irrigation facilities and technical know-how are the key constraints to mungbean commercialization.

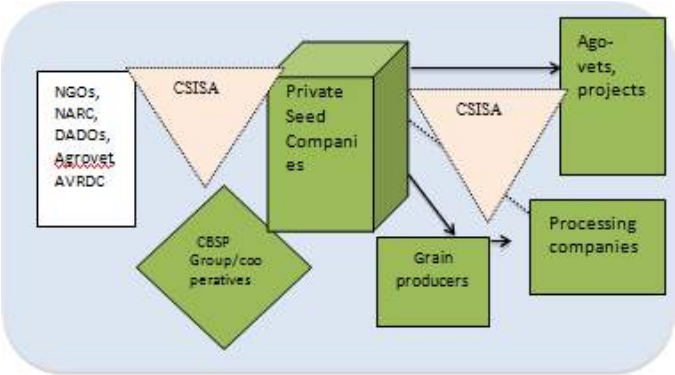

Fig.8. MODEL FOR PUBLIC-PRIVATE PARTNERSHIP IN MUNGBEAN PROMOTION

CSISA developed a public-private partnership model to link the major value chain actors including millers, seed companies, farmers and service providers. The seed company is the central point of this model as shown in Figure 8. CSISA is strengthening backward linkages between the seed companies, input suppliers and producer groups and cooperatives by providing technical backstopping and by facilitating interactions and networking. Likewise, forward linkages are being strengthened between seed companies and millers, grain producers and agrovets. CSISA facilitated "GATE Nepal" to implement contractual arrangements with five agriculture cooperatives for producing "Truthful Label" seed in 13 ha in four Terai districts (Banke, Bardiya, Kailali and Kanchanpur). GATE provided technical training to the cooperatives in collaboration with the District Agriculture Development Officers; source seed was provided by the National Grain Legume Program, and technical backstopping for best-bet agronomic practices was provided by CSISA.

Similarly, GATE evaluated a half-dozen newly released and pipeline varieties through nine participatory varietal trials on-station in partnership with the National Grain Legume Program (3), and on-farm with millers and cooperatives (6). Similarly, GATE is evaluating 20 new mungbean lines supplied by The Asian Vegetable Research and Development Center (AVRDC) at its own farm. In addition, CSISA facilitated interactions between mungbean processors with rice millers for market development, seed companies for seed supply, and District Agriculture Development Offices and the Knowledge-based Integrated Sustainable Agriculture and Nutrition (KISAN) project for extension support.

Millers have realized that they could realize benefits from two sides while engaging in mungbean promotion. First, they could earn cash income from mungbean trading, and second they could receive more rice for their mills from the mungbean-planted fields. Millers have also agreed to set up a grading machine to produce mungbean as per the market requirement (bold grain for dalmot companies, small but uniform grain for the supermarket, and the rest for dal mills). During 2016, spring CSISA provided subsidized (75%) seed (600 kg) of new mung varieties, training and a seed drill to the millers for demonstrations across Banke, Bardiya, Kailali and Kanchanpur districts. Millers and GATE Nepal also encouraged the District Agriculture Development Offices to allocate resources for mungbean production. Overall, 600 farmers are engaged in mungbean production on 100ha.

4 FERTILIZER PRODUCTIVITY

The poor availability and high prices of fertilizer pose a binding constraint to improving agricultural productivity and rural livelihoods in Nepal. The Agricultural Development Strategy estimates that the Government of Nepal is only able to supply 20% of current demand and that the partial subsidy program coupled with black market imports from India and insufficient knowledge (i.e., demand) of the value of fertilizers have constrained private investment in import and distribution. As a consequence, insufficient access to fertilizer constitutes a severe threat to national-scale food security and household-level welfare.

There are several pathways for improving the present scenario based on better management that will also serve to build demand and compel private investment. Current fertilizer use recommendations in Nepal are outdated and applied across very broad areas of the country with few guidelines in place to improve the efficiency of use (e.g., nutrient balance, timing, placement, formulation). Further, existing recommendations were developed on experiment stations under conditions that have very little to do with the realities of on-farm production and the variation that exists at nested scales from the village, to landscape, to region.

Evidence from central hills of Nepal demonstrates the power of 'getting it right', with net returns from maize increasing by approximately $400/ha with sensible investments in fertilizer. Three factors play a dominant role in determining how much fertilizer is required to optimize crop growth and economic yield: attainable yield potential at the farm level, indigenous soil fertility, and the efficiency of use of applied nutrients.

In Nepal, every unit of fertilizer applied counts, yet application technologies are imprecise and commonly result in 10–30% reductions in crop yields that can be obtained through improved management. CSISA is testing **simple technologies** such as precision broadcasting that can be deployed through service provider entrepreneurs.

Farmers in Nepal receive very mixed messages from development partners on the value of fertilizers, including some messages that are hostile. Yet there is no faster way to intensify yields while building the quality of depleted soils through higher levels of crop-based organic inputs achieved through higher productivity levels. Farmers also are generally not aware of the profitability and productivity Implications of under-fertilizing their fields. With NARC and the Department of Agriculture, CSISA endeavours to launch a **social mobilization campaign to correct these misperceptions** and to create an enabling environment for farmers to adopt precision application techniques and rate recommendations. This campaign is informed by quantitative performance data (e.g., gross margin, yield) achieved on-farm through participatory trials that are co-supervised by NARC scientists.

4.1 Site-Specific Fertilizer Management for Wheat Intensification

A household survey conducted by CSISA during the 2014–15 wheat season showed that farmers under-fertilized their wheat fields relative to the government recommendation by almost half, obtaining an average productivity of ~2 t/ha, which is below the national

average of 2.5 t/ha. Also, only a limited number of farmers applied potassium Fertilizer requirements depend mainly on the soil type, availability of irrigation, seeding time and wheat variety. Effective fertilizer management can be a significant contributor to improved crop productivity.

CSISA research indicates that **effective fertilizer management** can be one of the major entry points for wheat intensification.

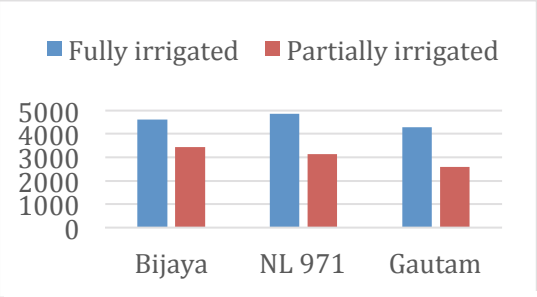

Fig. 9.WHEAT YIELD (KG/HA) UNDER RECOMMENDED FERTILIZER UNDER TWO IRRIGATION SYSTEMS

To explore the fertilizer response with respect to seeding time, variety and growing domain (whether irrigation water is available when needed), CSISA conducted on-farm evaluations of wheat considering the above conditions. Preliminary results show that with the same level of fertilizer (i.e., the recommended dose), the yield advantage in a fully irrigated field (3-4 irrigations) is 35–65% compared to the partially irrigated field (one irrigation at the beginning), especially in dry winters.

In order to widely disseminate key information about the importance of applying fertilizer along with irrigation, CSISA broadcast a radio jingle at the beginning of the wheat season for about three weeks through a popular local FM radio station, i.e., Krishna Shara FM in the Mid-West and Dinesh FM in the Far West about the importance of applying a split application of fertilizer along with irrigation. The impact of the radio jingle on the adoption and create awareness among the farmers community is currently being discussed.

4.2 Awareness on Importance of Potassium Fertilizer for Wheat

Balanced use of chemical fertilizers is very important to increase crop productivity. A household survey conducted by CSISA during the 2014–15 wheat season showed that farmers under-fertilized their wheat field, and even applied an unbalanced rate, -- used only nitrogen and/or phosphorus fertilizer with no or limited use of potassium fertilizer (Fig. 10). Research conducted in different parts of the world suggests that potassium fertilizer is very important for wheat to increase in both yield and quality.

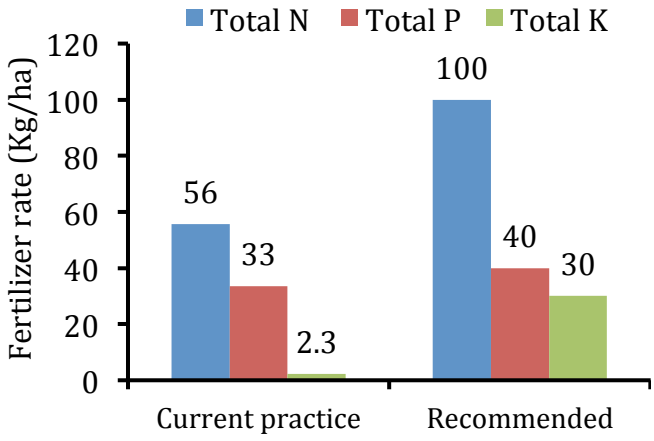

Fig. 10. STATUS OF FERTILIZER USE UNDER FARMERS PRACTICE FOR WHEAT IN CSISA WORKING DISTIRCTS, 2015

Realizing the importance of potassium fertilizer for wheat, CSISA has initiated activities to increase farmers' awareness of the importance of potassium fertilizer for wheat yield and

quality, in collaboration with District Agriculture Development Offices, through trainings and several on-farm demonstrations. Research conducted by CSISA compares the new practices to conventional practices, and visual observation identified variations in the response of wheat across farmers' fields. Crop harvesting is ongoing; details will be reported in the annual report. Similar awareness-raising campaigns will be conducted before the wheat season in 2016 through trainings, social media and printed material in collaboration with different public and private partners.

4.3 Evaluation of Improved Varieties under Different Fertility Levels

Use of improve varieties together with appropriate fertilizer management is one of the major drivers governing the yield potential of wheat, but yields are highly depended on site, management and crop cultivar used. In Nepal, fertilizer is considered an expensive input, and therefore the cost and profitability of production must considered in relation to achievable yields. CSISA has initiated on-farm evaluations of improved wheat varieties (Vijay, Gautam and NL 297) in the Terai and improved varieties in the mid-hills (Dhaulagiri, Danfe, WK 1204) under two fertility levels – high fertility (100:50:50 kg/ha NPK for the Terai and 60:30:30 kg/ha NPK for the hills) and low fertility, which is farmers' practice (63:35:9 kg/ha NPK for the Terai and 0:0:0 kg/ha NPK for the hills) in different farmers' fields in CSISA working districts. To understand the yield potential and economic benefits of fertilizer management, the N application rate was further split into 125 and 150 kg N /ha. The preliminary results showed that wheat responds well up to 150 kg N/ha, but we still need to analyze the economic advantages of the additional N fertilizer. Detailed outcomes of the experiment will be presented in the annual report.

ON-FARM EVALUATIONS OF WHEAT VARIETIES IN THE HILLS

Furthermore, in collaboration with seed companies, DADOs and NARC, CSISA has initiated, under the seed companies' leadership, on-farm evaluations of improved wheat varieties on 120 farmers' fields both in the mid-hills and in the Terai while comparing fertilizer response of the improved varieties under research-managed and farmer-managed fields, while comparing results to those achieved through current farmers' practice. This initiative provides an opportunity for farmers and seed companies to evaluate the economic benefits using improved varieties and improved fertilizer management. These activities also increase the adoption rate for the technology and increase the availability of seed of improved varieties in particular areas, as seed companies become involved in the evaluations. Results of these trials will be presented in the annual report.

4.2 Earthway Spreader for Precision Fertilizer Broadcasting

Since last year, CSISA has been demonstrating and evaluating manually operated spreaders for the uniform application of seed and fertilizer in the CSISA working districts. Spreaders not only aid in the uniform application of seed and fertilizer but also reduce labor costs associated with fertilizer application. Evaluation results from the 2015 rice season show that the use of a precision spreader for urea topdressing in rice improves yield by 5–6% compared with the farmers' application method. Importantly, there was almost a 50% savings in labor costs related to fertilizer application. The Earthway spreader has been strongly preferred by participating farmers, especially women.

WOMAN FARMER APPLYING UREA FERTILIZER USING EARTHWAY SPREADER IN WHEAT

To promote scale out, CSISA launched an awareness-raising campaign about the importance of uniform fertilizer application in collaboration with District Agriculture Development Offices, farmers' groups, cooperatives, Agriculture Service Centers, agrovets and seed companies, as well as through the KISAN project. KISAN has been promoting the Earthway spreader through their on-farm evaluations of different crops, awareness-raising trainings and by providing CSISA's user-friendly guide to the Earthway spreader. The guide covers handling guidelines for seed (wheat, lentil) and fertilizer (DAP and urea) broadcasting. **CSISA has provided capacity development training for more than 150 farmers**, who can be potential service providers for the technology. CSISA is also working with different manufacturers and traders (Crystal-India, Dahal-China and Earthway, USA) to promote market development for different models of the spreader and has placed a number of the spreaders with agro-vets on consignment though the Agro Machinery Jump Start program.

EARTHWAY SPREADER IN AGROVET FOR SALE

In Person:*Precision Broadcasters – Innovations in Fertilizer Application*

Purna Bahadur Sahi with his Earthway precision broadcaster

Purna Bahadur Sahi, 42, lives and farms in Neulapur, Bardiya district. Sahi used to practice traditional techniques in his fields, which generally did not include chemical fertilizers. One day, he visited CSISA's wheat plots in Sirkoiya during a farmers' field day. During the visit, he came to know that soils need balanced fertilizers just like people need food. He also witnessed a demonstration of the precision broadcaster (Earthway Spreader Model 2750). He was intrigued by the little red bag, which had a very simple mechanism and could be used with a little practice. Sahi brought himself a broadcaster from Tharu Agrovet, Bhurigaun.

Sahi says, "Earlier I did not apply any fertilizers to my wheat. Seeing the wheat fields during the farmers' field day, I felt I should use fertilizers in my fields too." CSISA provided Sahi training regarding the use of the Earthway Spreader and fertilizer dosages for various crops. Sahi then used the precision broadcaster in 13 bighas (approximately 8.67 hectares) of wheat to broadcast urea. Neighboring farmers were skeptical, but once Sahi was in action, other were intrigued by the spreader, seeing the efficient application of fertilizer. Soon, his neighbors came asking for the bag to use in their own fields.

However, it was not easy for some of his neighbors. Some had fertilizer landing on their feet and some had accidentally broadcast their fertilizer outside of their field boundary. Sahi decided to teach them the proper way to use it, which he learned from CSISA. Sahi says, "They did not know the proper balance between walking and cranking speed, resulting in loss of valuable fertilizer. Some went all the way to the end of the field, which spread fertilizers 3 meters outside the field. After learning the right technique, they were doing fine."

Sahi says he appreciates that the zipper on top of the bag does not let the fertilizer spill out, or let water in. He adds, "Urea is evenly spread in the fields and crop establishment is even." Sahi says, "The spreader applies urea 4 meters on both sides and I don't have to reach the end of the field boundary to apply fertilizer. Since it took me approximately 2.5 hours to fertilize 1 ha of wheat, I fertilized a total of 8.67 ha, which took me approximately 25 hours. In contrast, when I compared with my neighbor who practiced hand broadcasting, he took well over double the time to fertilize the same area."

5 SEED SYSTEMS

Enabling Nepali farmers to adopt improved crop varieties is fundamental to raising productivity and developing greater resilience to biotic and abiotic stresses. Timely access to quality seed with locally-relevant genetic traits (e.g., high yield potential, resilience to biotic and abiotic stresses, nutritional quality) in combination with best agronomic practices and reliable inputs can significantly improve crop productivity, livelihoods, and profit margins of smallholder farmers in the food-insecure West and Mid-west of Nepal.

> Improved seed distribution must be accomplished through strengthened **seed systems** – 'one off' interventions such as seed giveaways rarely have lasting benefits.

For wheat and rice, most farmers in Nepal grow improved rather than 'local' varieties. That said, the varietal replacement rate is very low and the most commonly cultivated varieties are very old, disease-prone, and have comparatively low yield potential. For maize, there is some market penetration of high-yielding hybrids in the Terai but cultivation in the hills is almost non-existent, even though productivity gains of around 1 t/ha are possible with no change in management under rainfed conditions. Pulse areas, in general, continue to be dominantly sown with local landraces.

Most seed initiatives for staples face the daunting challenge of trying to develop markets while they invest in R&D and production capacity. Simply put, most farmers in Nepal are not aware of the yield and economic benefits achievable with varietal replacement and at the seed company and dealer levels, varieties chosen for multiplication or sale are not choices that are evidence-based. CSISA works to **close knowledge gaps** about the yield performance of elite pulse (lentil and mungbean) and wheat cultivars, and registered maize hybrids, **through networks of community-based evaluations** that provide crucial science-led insights and demand generation for seed companies, seed dealers, and among farmer-clients for these businesses. Whenever feasible, these evaluations are co-sponsored by seed companies, the Department of Agriculture, and the Nepal Agricultural Research Council.

Scientists from the relevant commodity programs at the Nepal Agricultural Research Council (National Grain Legume Research Program, National Maize Research Program, and National Wheat Research Program) collaboratively contribute to the design and assessment of these trials. As part of this exercise, we seek to match different varieties to distinct production environments which provide 'business intelligence' to GoN producers of foundation seed and the companies who multiply it. Pipeline varieties and maize hybrids from AVRDC (for

mungbean), CIMMYT (maize and wheat), and the national breeding programs are included in the community-based evaluations. Information on best-bet seed choices are disseminated through communication campaigns targeting seed dealers and district-level offices of the DoA.

In the past decade, six **micro-scale seed enterprises** have emerged in the central and western Terai. These companies remain in the nascent stages of development and do not have a significant market presence in the Feed the Future zone. CSISA works to **create enabling conditions** for their expansion. We work directly with those enterprises who wish to growth their business. These companies are given marketing advice, inclusive of branding and strengthened distribution channels, as well as guidance on quality control and best production practices.

At the seed dealer level, CSISA works to **improve distribution channels** for seed from regional companies (e.g., for maize hybrids) and from Nepali companies (wheat, lentil, and mungbean). This are achieved in consultation with KISAN and other market development initiatives that prioritize dealer strengthening. In addition to deepened relationships with seed companies, CIMMYT has strong relationships with all the major maize seed companies that have registered hybrids in Nepal (e.g., Bayer, Bioseed, Monsanto, etc.). These companies are eager to expand their market presence in Nepal's Western development regions and rely on our science, development, and business contacts in the Mid and Far-West to play an important brokering role in this process. **Demand** for new seeds is being be generated in partnership with KISAN, DoA, and seed companies through advertising and social marketing campaigns that alert farmers to the economic and yield gains associated with varietal replacement.

5.1 Business Mentoring for SMEs: An Innovative Tool for Scaling New Varieties

In Nepal, seed enterprises selling cereals are nascent and most of them emerged from development projects that focused on philanthropic activities such as group formation and mobilization, input distribution and awareness raising rather than enterprise management. As a result, many of these enterprises have weak business models. CSISA has adopted a **business mentoring** approach to introduce business management tools and crop variety scaling strategies into these small- and medium-sized enterprises (SMEs).

CSISA conducted business mentoring of 10 SMEs on i) providing advisory services for technical problems, ii) fostering linkages with public and private service providers, and iii) strengthening the Seed Entrepreneur Association of Nepal (SEAN) to develop a strategic business plan. During the mentoring period, three companies were able to develop their own business plan. Also, two SMEs (Unique Seed and GATE Nepal) carried out 120 Integrated Crop Management demonstrations in new varieties of lentil and wheat in 6 districts. More than 5,000 farmers visited these demonstrations. These enterprises have

realized the value of these demonstrations for market creation and requested technical support from CSISA to organize similar demonstrations next year.

During the mentoring period SMEs have made significant progress in changing their institutional policies such as increasing incentives to seed growers, including by paying seed transportation costs from the field to the processing plant and deputing SME staff for the removal of inferior, defective or plants of other varieties from a crop to preserve the quality of the crop being grown. Three SMEs (Lumbini Seed, Unique Seed and GATE Nepal) recruited new technical staff to bolster their R&D and leveraged additional financial resources from development projects. SMEs have started contract seed production where cost and seed quality are advantageous. Three companies increased seed transactions (in volume) by 70% compared to the last five years. The proportion of new varieties (Vijaya in wheat, and Sukkha series in rice) has also increased significantly (>20%). Associations' membership increased from 600 to 900, and two new district chapters were initiated.

5.2 Expanding the Registration Domain for Maize Hybrids

Maize contributes approximately 25 percent of Nepal's food basket and occupies around 26 percent of the total cropped area. Maize productivity at 2.3 tons per hectare in Nepal is still quite low compared to the global average of 5.5 tons per hectare. Growing demand from the poultry industry in Nepal cannot be met by the cultivation of open-pollinated seed varieties alone. As a result, higher-yielding hybrids have become increasingly popular among farmers because of their productivity, quality and profitability. However, most maize hybrids are only approved for sale and cultivation in the central and eastern Terai, east of the Narayani River. Farmers in many areas, especially in western Nepal, sometimes purchase non-approved hybrid seeds to meet market demand. These hybrid seeds are not registered at the Seed Quality Control Centre and are traded through informal channels.

With a potential risk of penalty from the government for violating the seed policy, traders have not distributed many high-performing hybrids, thereby restricting their local production, fair distribution and widespread availability, which otherwise could benefit large numbers of farmers in Nepal. It is estimated that annually about 2,500 tons of hybrid maize is grown in Nepal, of which only 1,000 tons are registered hybrids.

Catalyzing change

In 2014 and 2015, CSISA and the National Maize Research Program (NMRP) partnered to evaluate maize hybrids in six additional districts (Banke, Bardiya, Kailali, Kanchanpur, Surkhet and Dadeldhura) in western Nepal. Trials were conducted in the spring in the Terai and in the summer in the mid-hills and were monitored by a team of stakeholders from NMRP. The performance data for variety release and registration was shared with the National Seed Board (NSB).

Of the ten hybrids that were evaluated, four (Rajkumar, TX 369, Bioseed 9220 and Nutan) were found agronomically superior, producing more than 6 tons per hectare, and having a

tight husk cover and providing moderate resistance to northern leaf blight and grey leaf spot. **In response to the evaluation results, the NSB has approved and registered four hybrid varieties for sale in the western region**.

To increase the availability of these hybrids in the market, CSISA is working with NIMBUS, a Nepalese poultry feed company which is interested to increase farmers' access to improved agriculture technologies including seeds, bio-fertilizers, machines and advisory services, and will buy back the outputs from farmers through its feed mill. During the reporting period, NIMBUS bought 3tonnes of Rajkumar, Bioseed 9220 and TX 369 from Bioseed of India. These varieties are being scaled-up through different platforms (e.g. high value agriculture projects, District Agriculture Development Offices, cooperatives) and networks. CSISA is providing technical support to NIMBUS through protocol refinement for testing of these hybrids, and training farmers and extension workers. It is estimated that about 2,000 farmers will be involved in the field demonstration of these hybrids in 150 ha during the summer maize production season of 2016.

In Focus: A New Business Model for Seed Scaling in Nepal's Hill Ecologies

The average seed replacement rate for cereal crops in Nepal is around 13%; in the hills it is half that. Therefore, farmers have not been able to realize the gains from R&D on improved varieties. Hurdles to increasing replacement rates include limited infrastructure (including road networks and irrigation facilities) and poorly developed market networks.

In recent years, agriculture cooperatives have started producing cereal seed using technical support from District Agriculture Development Offices and development projects. However, limited availability of source seed, poorly developed storage and marketing facilities and poorly managed seed subsidies are the major constraints to their growth. Seed companies operating mainly in the Terai do not see any incentives for seed production in the hills due to low profit margins, driven down by high transportation and overhead costs and risk factors such as inconsistent demand.

Considering these challenges and opportunities, CSISA has introduced a new business model for seed scaling of cereals in partnership with GATE Nepal (a private company), a District Agriculture Development Office and eight seed producer cooperatives in Surkhet. In this model, the District Agriculture Development Office provides technical training and subsidized (at 50%) breeder seed to agricultural

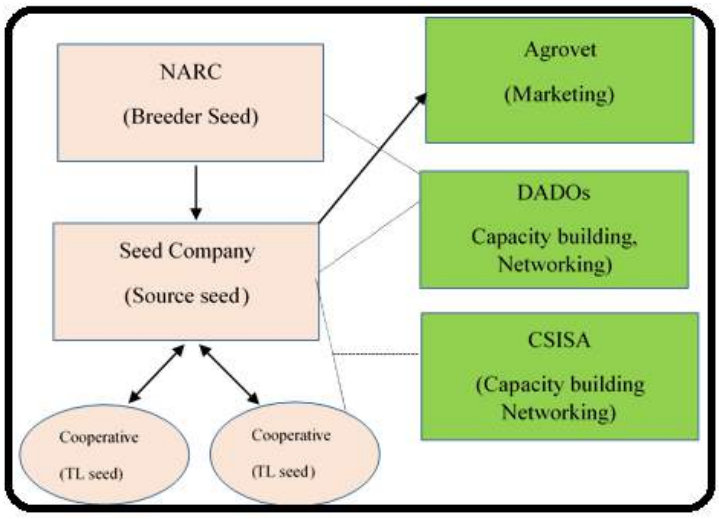

Fig. 11. A BUSINESS MODEL FOR SEED SCALING IN THE HILLS

cooperatives through GATE Nepal. Source seed produced by cooperatives will be purchased by GATE Nepal and distributed to cooperatives for *Truthful Label* seed production. Truthful Label seed will be marketed through agrovets, District Agriculture Development Offices and other development projects. A tripartite agreement has been signed by the District Agriculture Development Office, GATE Nepal and eight cooperatives (Shambridhi, Jagganath, Pabitra, Srijansil, Jana Apechha, Sana KISAN Satakhani, Sana Kisan Kunathari and Bheri Agriculture Cooperative) for the production of maize (foundation-40ha, Truthful Label 424ha), rice (Truthful Label-70ha) and wheat (Truthful Label-70ha) seed in 2016. From this model, a total of 1,208t of Truthful Label seed worth NRs. 31.6 million will be produced, which is sufficient to cover 50,367ha (15,000 farmers). Participants of this model have claimed that it has strengthened the relationships among seed value chain actors, minimized potential risks from unmanaged seed subsidies, and created a learning platform. Upon the request from the District Agriculture Development Office and the cooperatives, the seed company has agreed to open a seed-processing unit in Surkhet.

6 MECHANIZATION AND MARKET DEVELOPMENT

India has made great strides in developing effective agricultural technologies and innovations, which is why USAID India's Feed the Future initiative supports the development, scaling, and transferring of Indian agricultural innovations to other developing countries. Trade in agricultural machinery between Nepal and India has a long history and has reached high levels in certain products. Historically, Nepal has been one of the largest importers in South Asia of Indian tractors, estimated at over 5,000[3] per year on a 15-year average, **putting this market at approximately US$ 50m per year.** With over 40,000 threshers in Nepal (90% imported from India), it's estimated that approximately **5,000 threshers (US$ 4M in sales) are imported from India every year.** In the last ten years the Indian combine grain harvester market has picked up and now approximately 25 **(nearly US$ 750K in sales)** are imported per year. These are not insignificant numbers. Yet, more precision machinery and implements and scale-appropriate machinery are needed from India and elsewhere if Nepal is to keep pace with others around the region.

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 among farmers (demand 'pull'); and 3) a robust network of service providers to ensure broad access to capital-intensive technologies through custom hiring.

To facilitate strong supply chains, CSISA has continued to focus in the last year on strengthening importers and their dealer networks as well as training service providers in collaboration with public, private, and development partners like KISAN. CSISA will continue to leverage these partnerships, especially the private sector, to achieve scale. Encouragingly, many of the private sector companies that we work with have started to sponsor their own farmer field days based on new agro-machinery technologies, several of which were introduced to the Nepal market by CSISA. For example, a Nepalese agent of National Agro Industries (an Indian company) – Habi Auto – conducted demonstrations and farmer field days in CSISA's working areas, selling 24 zero-till drills and mult-crop planters in the past season. Eastern Nepal-based agro-machinery dealer Krishi Sansar purchased 8 mini tiller reapers for CSISA from Sadar Reapers of Mansa, Punjab. Jay Bageshwori Tractor and Machines, Nepalganj, procured 4-wheel tractor reapers from Anmol Reaper of Mansa, Punjab (see more details of all these below). The farmer field days, which are often

[3]Sales have been extrapolated by numbers of machinery in use from National Sample Census of Agriculture, CBS, 2012 and from the CSISA 2015 report, Spread of Combine harvester in Western Terai of Nepal. There are some reports (http://www.ktm2day.com/2010/10/18/vehicles-on-nepali-roads-grow-thirteen-times-in-20-years/) that give tractors and power tillers a much higher sales levels nearly equal to sales to cars, jeeps and vans.

supported by CSISA, are a key pathway in our scaling strategy for Indian and other imported agricultural machinery.

On the demand side, CSISA has also been very active in awareness-raising and demand generation for scale-appropriate agricultural technologies through demonstrations, farmer field days, FM radio spots targeting 2 and 4-wheel tractor reaper attachments, and sponsorship of the 2nd National Agro Machinery Expo, held in March (more information follows below).

The facilitating of service provision in this reporting period has focused on 4-wheel tractor seeders and laser land levelers. For instance in Yadov Gaon, Bardiya District, a farmer field day was held late last year and has resulted in the sale of one laser land leveler to Krishna Chandra Yadav (see *In Person: Zero-tillage seed drill eases farmer's worries about labor*). He has additionally bought one National zero till drill from Habi Auto from a much earlier exposure visit to a CSISA farmer field day in 2013 in nearby Mainapokhar Village.

Increasing the Availability of Sustainable Intensification Technologies

CSISA aims to increase the availability of **specialized equipment that is not commercially available for small and medium-scale farmers** in South Asia who sometimes rely on four-wheel tractors, but increasingly on two-wheel tractors, or more recently their even smaller 'mini tiller' counterparts, as their primary sources of traction.

6.1 Reaper Attachments

The rapid sale and spread of two-wheel tractor reapers is a highlight of CSISA's Mechanization and Irrigation work in Nepal thus far. There is also promising movement on reapers for four-wheel tractors and mini-tillers.

Two-wheel tractor reaper attachments

As reported in last year's annual report, reapers exploded onto the market in the 2015 wheat season. CSISA and the DoA had spent considerable time and effort over the previous two years in the Mid and Far West demonstrating reapers for two-wheel tractors and training service providers on how to use them. Through CSISA's Jumpstart of Agro-Machinery Markets' program, CSISA ordered 20 two-wheel tractor reapers from an importer in January 2015 and placed them on consignment with various local agents in the Mid and Far West. This initial influx of machines generated interest among farmers and spurred dealers to import and stock even more, which resulted in sales of over 100 two-wheel tractor reapers during the last wheat harvest season (March–April 2015). Again, sensing the potential market demand opportunity, SK Traders, Kubir & Sons, SKT, and BTL Traders ordered more reapers, but the fuel shortages and border blockade kept sales down to around 100. Although each one still had dozens of reapers in stock, the companies were so impressed by the demand from 2015 rice harvest season, they reported in January 2016 to us that they were importing additional reapers. By the time wheat-harvesting season rolled

around this March (2016), SK Traders claims to have had 250 reapers, BTL Pvt. Ltd. had 150, and Kubir & Sons reportedly had over 300 in stock.

CSISA noted that the importers of various machinery, but especially importers of reapers, took advantage of their participation in the 2nd National Agricultural Machinery Expo held in Kohlapur in the Mid West to enlarge their networks of dealers and even sub-dealers in the Mid and Far West. Some were not even in the agro-machinery business. For example, BTL's main dealer in Dhangadhi, Dinesh Auto, a large dealer of BTL's two-wheel tractors and attachments, created one such sub-dealer, Changadhi and Anant Partibahr Traders and Suppliers in Chaumala, Rajipur, in Kailali District. The owner, Chabhi Sapkota, told CSISA that he had never sold agricultural machinery before (he was a motorcycle dealer), but that Dinesh Motors had convinced him that sales of reapers were going to be good. Mr. Sapkota planned with Dinesh Motors to have several days' of reaper demonstrations and mini-trainings (aka farmer field days) to capture the interest of local two-wheel tractor owners to purchase the machine and to create demand for services from farmers.

Fig. 12. NB Traders new show room in Bardiya District and using the banner from the Expo for advertizing

Another instance is NB Traders of Attariya Bazaar in Kailali who is one of Kubir & Sons' biggest dealers in Nepal. Last year, NB claimed to have sold over 100 reapers in two seasons (wheat and rice) and were told CSISA they were planning to sell at least 100 more during the 2016 wheat season alone. They intended to do so by establishing 3 additional sales' outlets. One of NB's showrooms was set up less than 2 kms west of Dahit Traders (see *In Person: The Reaper Man*) just after the Agro-Machinery Expo in March 2016 and with the equipment that they had brought to display at the Expo.

CSISA is closely monitoring the growing networks and sales and currently estimates that at least 200 reapers will be sold mostly in the Feed the Future districts of Banke, Bardiya and Kailali for the 2016 wheat harvest season (March–April 2016). We will conduct a survey with the dealers in June to get a better understanding of what is going on in the market and how CSISA can help increase sales in the lagging districts of Kanchanpur and Dang.

Indian Four-wheel tractor reaper attachments

From Jay Bageshwori Tractor and Machines, Mr. Mahesh Agrawal became interested in reapers after seeing them at the 2nd National Agro Machinery Exhibition and after talking to reaper importers and dealers. He immediately bought 16 pieces from India for test marketing in Nepal. By the end of March, just prior to start of wheat harvest, he had sold half his stock and was confident he would sell the rest.

Fig. 13. Jay Bageshwori Tractor and Machinery in Nepalganj with the 16 reapers for sale.

Mini-Tiller Reapers

Working with an Eastern Nepal-based agro-machinery importer, Krishi Sansar, CSISA purchased 8 Indian-made Sadar Reapers[4] for fitting on existing mini-tillers. Despite initial technical glitches, CSISA, along with help from Krishi Sansar and Sadar Reapers India, have been working on adjustments to be made in mounting the reapers across different makes and models of mini-tillers.

A Sadar reaper successfully being tested in a wheat field in late March in Dhangadhi

These mini-tiller reapers are less expensive than the sole-purpose "self-propelled" reapers that are permanently mounted to a mini-tiller and cannot perform other work like tillage. The self-propelled reapers are also very expensive and, although available in the Nepal market for the last 3-4 years, have suffered low sales due to their high price. If this reaper "attachment" that is one-third of the price of the self-propelled version, can be made to work across the 5-6 models of mini-tillers found across Nepal, they would have good potential in both the hills and the Terai.

[4] http://www.sardarreaper.com

In Person:*The Reaper Man*

Chullu Ram Chaudhary with his two-wheel tractor-driven reaper

Chullu Ram Chaudhary, 44, is the proprietor of Dahit Traders in the Mid West development region of Nepal. CSISA helped Chaudhary establish his business at the end of 2014. In the year since, he is even more determined to grow his agro-machinery business. CSISA spoke with Chaudhary while he was busy with customers at his office in Munabasti, Bardiya District. Chaudhary spoke of the importance of reapers in crop production as they save significant time during harvesting and reduce the impact of labor scarcity. He had convinced many farmers of the benefits of reapers, and despite the 'bandhs' and blockades, sold over 40 pieces during the last rice-harvesting season.

Chaudhary said, "Many of the young men go to the Gulf in search of steady income. As a result, there is a shortage of agricultural labor in the country. Reapers are an important way to ensure that crops are harvested on time." Seeing the importance and potential of the reaper and other scale-appropriate machinery, Chaudhary approached CSISA staff in late 2014, who suggested that he establish a sales office near his home. Besides providing reapers and other machinery on "consignment basis", CSISA also helped him establish a relationship with national-level importers and suppliers. Now, he is a member of the regional agro-machinery dealer association and sells a variety of machines, including the reaper.

To support reaper sales for the coming wheat harvest season, CSISA has begun to broadcast radio jingles regarding the importance of reapers through FM radio and identified Chaudhary as one of the local dealers of reapers. Chaudhary said, "Radio jingles helped me to link with interested farmers." He estimated that he received over 40 calls from interested buyers and that approximately 10 of them followed through in purchase of reapers. Furthermore, he added, "Two-wheel tractor-driven reapers have a comparatively higher demand than reapers operated by four-wheel tractors as the latter requires a higher initial investment accompanied by tedious operation of a large machine in small fields – more time turning and less time cutting." Individual farmers and farmers' groups visit his service center in Kanthapur, which is ideally located for farmers from both Banke and Bardiya. And he is confident that he will sell even more reapers, perhaps close to 100 this wheat harvest season, as compared to the 40 pieces he sold last rice harvest season.

Improving the Design of Sustainable Intensification Technologies

6.2 Collaborative Design Sprint

CSISA's initiative to advance multi-crop seeder and thresher attachment design and the commercial availability of the two-wheel tractor and mini-tiller platforms, or "Design Sprint" activities, began in earnest during March 2016 when Dr. Jonathon Colton (Professor of Industrial Design, Georgia Tech), Scott Justice and Jasbir Singh, Ag Engineer, CSISA India) travelled to Rajkot, Gujarat to meet with four of the 11 manufacturers located in Rajkot. The team has planned with the manufacturers to hold a "design sprint" training workshop and this coming summer to improve current 2-wheel tractor and mini-tiller seed drill designs.

Professor Jon Colton, center, and team visiting Mausam Agro Machinery factory in Gujarat, India

As a result of the trip, Dr. Colton and CSISA will conduct three regional trainings (Rajkot, Punjab and Odisha) in July-August 2016 for Indian manufacturers on potential ways to modify existing machinery to better serve the market for two-wheel tractors and mini-tillers. Participating companies first qualify for a small development grant that allows them to design a seeder or thresher prototype on paper. Three companies would then be chosen to receive a larger grant to build the prototypes, which would then be tested and test marketed in Nepal. The goal is to improve overall sales of 2-wheel tractor and mini-tiller seed drill designs, for which CSISA will then promote the best designs in Nepal, Bangladesh and India.

Increasing the Capacity of our Government Partners

6.3 Improving Capacity for Machinery Valuation and Design at NARC, Strengthening Training Facilities for Agro-Machinery Repair, DoA

CSISA aims to increase the **capacity within the national research partners (DoA and NARC) to technically evaluate** and offer advice on design improvements that may be required to adapt innovative machines to Nepal's conditions. We are also working to support the **establishment of a training center for repair technicians** with the DoA's Agriculture Engineering Directorate that will include a focus on innovative sustainable intensification machinery such as zero-till drills.

Overview of the visited sites and their geographical location – A) Oilseed/Horticulture Center, B) Maize Research Program, C) Sericulture Farm, D) Fisheries Center, and E) AIRC Birganj Facility

The development of these two facilities is the most complicated, time consuming and ambitious activities in the CSISA-NP Mechanization and Irrigation portfolio. CIMMYT's close historical relationship with NARC has made the process for getting approvals for site selection fairly smooth. For the Department of Agriculture's Engineering Directorate, this is the first time CIMMYT has had a sizable joint project with them and so the movement of forms and letters of permission have taken longer than expected. However, partners on both sides are enthusiastic about establishing the proposed centers and are working hard to finalize the plans.

CIMMYT's Head of Agriculture Engineering, Jelle Van Loon, traveled with the NARC and DoA partners to all potential sites and the team has agreed recommend the DOA and NARC farms in Nawalpur to be the site for the two co-located centers. He has also recommended specific testing equipment for NARC's Machinery Testing Center and DOAs Machinery Training Center, as well as the equipment layout or floorplan within the centers.

Equipment procurement will begin in May and approval for site selection should be completed by the end of June. Work will then quickly commence on site development and renovations for offices, testing and training halls, garages, equipment sheds, etc.

NARC will use their facility in part to evaluate the Indian two-wheel tractor seeder and thresher attachment prototypes emerging from the Design Sprint described above.

Increasing the Capacity of the Private Sector

6.4 Market development for importers and manufacturers of agricultural machinery

For agricultural mechanization, the path to scaling is though the private sector. In Nepal, CSISA's role is to support importers and their professional associations, such as the Nepal Agricultural Machinery Entrepreneurs Association (NAMEA), and to help facilitate the formation of agro-dealer associations. Through continuing education programming, CSISA helps to build awareness within these companies and associations of new machinery technologies, to highlight where policy interventions may be required, and to facilitate access to commercial finance. CSISA also helps to facilitate networking and coordination amongst the diverse actors in the Nepali agro-machinery sector, including between service providers and potential service providers and private sector companies selling scale-appropriate technologies.

Second National Agro Machinery Exhibition

NAMEA, which CSISA and its government partners help form and which was registered only 1.5 years ago, successfully organized and ran the **2nd National Agricultural Mechanization Machinery Exhibition-2016** in Kohalpur, Banke, on March 6-10, 2016.

Inaugurated by Hon. Minister for Agriculture Development, Government of Nepal, Haribol Prasad Gajurel, the Exhibition attracted 75 agro-machinery importers, manufacturers, dealers, sub-dealers and agents, from Nepal and India. A wide range of farm machinery was available, as was a communication and farmer-learning center where projects gave presentations and held discussions.

Glimpses of Agro Mechanization Exhibition, Kohalpur, Banke

CSISA displayed machinery that other traders were not bringing, such as Dashmesh's Happy Seeder, Earthway's push-row planter and precision seed and fertilizer spreader, and a powered open-drum thresher. CSISA also displayed machinery brochures for DSR, Seed and fertilizer spreader. While NAMEA organizers are still to write the final report, they have given the following tally for the exhibition: 1) 81 companies exhibited; 2) 35,000 people attended; and 3) US$ 500,000 worth of goods were either sold or booked during the exhibition.

CSISA will be following up with further assessment of this Expo, but indications are that NAMEA has made some profit from the Expo through stall rentals and the various grants received. They have communicated that this, along with the valuable experience of managing an Expo of this size, may enable them to sponsor and manage this fair on a more regular (yearly) basis.

6.5 Strengthening Local Agro-Machinery Agents, Dealers and Agro-vets

Creating and strengthening national and local level professional associations of agro-machinery dealers and agents is a key CSISA strategy for the commercialization of agricultural mechanization. Especially in a country like Nepal where the agro-machinery industry is in an early developmental phase and institutions are not mature, this

strategy intends to empower and improve the business acumen of these actors by increasing their access to public services (e.g., new agro-machinery subsidy programs in DOA) that will contribute in scaling up appropriate-scale machinery. With this strategy, CSISA continues to aid and facilitate the national-level association, NAMEA, for its institutional development through different integrated activities such as awareness raising for strategic business plan development, networking at national and international levels, and building their membership base. More recently, CSISA has turned its attention to regional and district level businesses – dealers, sub-dealer and agents who really are the last mile in delivery and sales of agro-machinery.

The first meeting of the Mid-West Agro-Machinery Dealers and Agents was held on the in January 2016 in Nepalganj in association with NAMEA and CSISA. Fifteen machinery entrepreneurs along with representatives from the District Agriculture Development Offices in Banke and Bardiya, Regional Agriculture Research Station, NARC; and CSISA project staff participated. Participants discussed the strengths, weaknesses, opportunities and threats of the machinery sector in Nepal; machines validated by CSISA and their scaling strategies in the Mid and Far West; and possible institutional frameworks and working modalities of a district- or regional-level NAMEA.

Participating entrepreneurs agreed to form the Mid Western chapter of NAMEA and it was formalized from the succeeding meeting. This regional NAMEA's first major achievement was to help organize the 2nd National Agricultural Mechanization Exhibition, discussed above. CSISA will continue to backstop the new regional NAMEA, including by helping the association develop a strategic business plan, a yearly work plan including technical and business training for their members, resource sharing mechanisms and ways to sort out the power dynamics between the central NAMEA and regional associations.

Increasing the Capacity of Service Providers

6.6 Leveraging Existing Service Provider Associations

Through technical training and business development services, CSISA is working to build the capacity of a new cadre of service providers for zero-tillage wheat, laser land leveling, and mechanized harvesting technologies. CSISA is also working to increase the availability of sustainable intensification technologies that lend themselves to service provision. During the reporting period, CSISA provided capacity development training for more than 150 farmers who can be potential service providers for precision fertilizer broadcasting. CSISA is also working with different manufacturers and traders to promote market development for different models of the precision broadcaster and have placed a number of spreaders with agro-vets on consignment. CSISA also supported the 2nd National Agro Machinery Exhibition to link Nepali importers with machinery suppliers and manufacturers, including those from India, and to spread awareness among farmers and service providers about agro-machinery options, including reapers for the 4-wheel tractor and 2-wheel tractor. CSISA and the DoA demonstrated reapers for 2-wheel tractors in the Mid and Far West demonstrating reapers and trained service providers on how to use them.

CSISA provided training for service providers on how to operate zero tillage machines, how to calibrate the seed and fertilizer rate, and other aspects, before the 2015–16 wheat season began. After seeing the success of this technology last year, more than 230 ha has been seeded using the ZT seed drill in 2015 through custom-hire services. In collaboration with private sector and government partners CSISA is working to support the emergence of and strengthen the capacity of, service providers in order to increase their access to ZT seed drills for wheat seeding in the region.

With the objective of scaling out better-bet agronomic practices for lentil (for example, improved varieties (pipeline and recently released), better seeding methods, and proper fertilizer and water management practices) CSISA has facilitated on-farm demonstrations of those better-bet practices in collaboration with seed companies, service providers for mechanized line seeding, District Agriculture Development Offices and National Grain Legume Program in 120 farmers' fields in the current CSISA working districts while comparing farmers' existing practices.

The facilitating of service provision during the reporting period has focused on 4-wheel tractor seeders and laser land levelers. For instance in Yadov Gaon, Bardiya District, a farmer field day was held late last year and has resulted in the sale of one laser land leveler to Krishna Chandra Yadav (see *In Person* below). He has additionally bought one National zero till drill from Habi Auto from a much earlier exposure visit to a CSISA farmer field day in 2013 in nearby Mainapokhar Village.

In Person: Zero-tillage seed drill eases farmer's worries about labor

With a smile, Krishna ChandraYadav says, "I never imagined that I could use a ZT machine in my wheat fields."

Krishna Chandra Yadav, 40, is a progressive farmer and resident of Bardiya district, Nepal. Yadav has been a farmer for the last 15 years. With labor availability declining and his fertilizer prices increasing, Yadav began searching for technologies that could help address his agricultural constraints. In 2013, he visited Mainapokhar, Bardiya where he saw CSISA's wheat demonstration plots, planted with a zero tillage (ZT) seed-cum-fertilizer drill. Yadav was impressed by what he saw, so the next year he sought technical assistance from CSISA to plant ZT wheat using a 4-wheel tractor ZT machine. Encouraged by the ease of sowing his wheat, as well as the CSISA's radio jingles aired on Radio Krishna Shar FM, highlighting the availability of ZT-seed-cum-fertilizer drills in his area, Yadav purchased a ZT drill from The Habi Auto Traders, which imports National ZT drills from India. This wheat season, Yadav used his new drill for sowing 18 hectares in his village of Yadav Gaon, in Bardiya District.

Increasing agricultural labor shortages and increasing daily wage rates have pushed farmers towards agro-mechanization. Not only can mechanization help farmers utilize resources optimally, but it can also facilitate the timely sowing of crops. Yadav says, "Normally I need 6 laborers at NRs 500 per labourer per day to sow wheat on my 3.5 ha, and I have even had to wait for laborers, causing a delay in wheat sowing. But this season, I am able to sow wheat quickly using only two laborers."He adds, "Hand broadcasting of farm inputs is the common practice in this region. I used to sow 120 kg seed of wheat per hectare." Due to uneven placement of seed, patchy crop establishment occurs in field but using this seed drill, there is a uniform crop-establishment. In addition, uniform fertilizer placement through this drill has increased the number of tillers and the crop vigor, which I could not get before. This season I think I will get over 1.5 ton more in yield then I used to," says Yadav.

Yadav also has rented out his seed drill to other farmers and has covered an additional 14 hectares as a local service provider. Sharing insights on the business of service provision, Yadav says, "A lot of farmers are apprehensive at the time of seeding, so I am only charging Rs.1000 ($10) initially to create demand. Now that they have seen the standing wheat in my field, they are willing to use it in the coming season."Not only does this service give Krishna additional income, it helps smaller farmers who can't afford to buy machines themselves.

Expanding Affordable and Energy-Efficient Irrigation

Overcoming the energy and cost bottlenecks to irrigation expansion is one of CSISA's key objectives. Mid and Far Western Nepal lag behind Central and Eastern Nepal in irrigation and groundwater development. CSISA has identified a few technologies that, if developed, could help overcome current bottlenecks.

6.7 Axial Flow Pump

Axial flow pumps (AFPs) are found in large numbers in much of East Asia's deltaic systems where the lift of surface water is less than 4 meters. Scope for the use of AFPs in similar deltaic–coastal areas of South Asia is high, yet in landlocked (higher lift environs) Nepal, AFP potential is limited. However, AFPs can gain in popularity in some niche areas with surface water sources and among fish farmers.

CSISA demonstrated AFPs in coordination with the Fisheries Development Centre, Kailali in January 2016. The objective of the demonstration was to show the staff there that the axial flow pump can pump more water with less diesel in comparison to the standard centrifugal pump. Twenty-two participants were present from 5 different districts (Dang, Banke, Bardiya, Kailali and Kanchanpur). After the demonstration, the pump was retained there for two days to drain the entire pond, which gave participants more time to observe the performance of the axial flow pump. Altogether the pump was operated for 2 hours to draw water to 1.2 meters deep from the 1,000 square meter pond. The discharge rate of 41 liters per second was faster than the conventional centrifugal pump of about 15-20 liters per second.

Axial flow pump demonstration in Fisheries Development Centre, Kailali

Additionally, through our colleagues in the Agricultural Implement Research Center, Birgunj, CSISA sold an AFP to JP Gupta in Bara District and has recently been contacted by other fish farmers in Rupandehi interested in purchasing this machine.

6.8 Lower-Cost Photo Voltaic Irrigation Systems

Currently in Nepal, solar photo voltaic (PV) irrigation systems are very expensive and few are sold without significant subsidy. Most are in the range of .2 to .5 KW and can only be used for smaller plot high-value vegatbles. The larger .7 to 2 KW systems[5]that can irrigate crops cost anywhere from US$ 4,000–10,000. CSISA has begun investigating why the cost of solar PV panels in Nepal are nearly double the price in Bangladesh.[6] A second activity has begun to reduce the price of the DC motors that run the pumps. Currently, most of the DC electric pumps are imported from Europe and the larger kilowatt motors cost overUS$ 1,000. In January 2016, CIMMYT approached Clean Energy Nepal P. Ltd., about developing low-cost DC electric pumps, using the inexpensive DC electric motors from the battery-powered tuk-tuks that are being imported from India and are spreading rapidly across Nepal. Potential costs savings from this are in the range 80%.

Bharat Paudel, testing the 48 V 850 watt DC motor powering a 3 inch centrifugal pump.

In March, Clean Energy Nepal began testing an 850 watt 48 volt DC motor from a tuk-tuk in Birgunj and in Anamnagar, Kathmandu. Though there are some overheating and electronic control problems we are confident we can work through the problems in the coming months.

A third activity around pump price reduction strategies began in November in discussions with iDE Bangladesh. Instead of using DC motors we intend to use Indian inverters and batteries to power standard 1,000 watt or higher AC electric motor pumps. This solves a big problem with low voltage DC systems where the panels must be located near the pump (Ohm's law of electrical resistance issues), which means the panels and electronics are much more vulnerable to theft and vandalism. In higher voltage systems the panels and electronics can be kept at or near the household. Also with AC systems mini grids can be created and surplus power sold to neighbors.

6.9 High-lift Pumps and Lay-flat Pipes in Mid-hills

Irrigation in the mid-hills is a real challenge. The majority of donor-funded programs are around small-scale catchments targeting high-value crops. For larger-scale field crops, which are CSISA's target, the majority of schemes are expensive diversions with canals that are susceptible to landslides. CSISA is interested in exploring the utilization of electric pumps or the mini-tillers' and two-wheel tractors' diesel engines for high lift, high capacity pumps. An

[5]Systems from Alternative Energy Promotion Center (AEPC) , Interational Center for Integrated Mountain Development (ICIMOD), Internatioal Water Management Institute (IWMI)

[6]Despite there being no import taxes and tarriffs the average price in Nepal is over US$ 1 per watt wherein Bangaldesh it is .50 cents per watt

initial scoping visit was paid to a high lift water pump system in Finnikot-11, Dadeldhura in January 2016. The high-lift water pump was built by a Nepal Flood-victim Rehabilitation Program funded by USAID's NEAT project in 2012. Total budget of the program was NRs 3million excluding labor cost. It was completed in a period of six months. A motor of 15 hp is kept in the riverbank where the water to be lifted is collected. It lifted water to the top of the hill about 120 m high at 3-liters per second (calculated by bucket method), where a main pond was constructed for storing the lifted water. The water was then distributed to irrigate a vegetable cultivating area through other ponds and pipes. The system is irrigating 4 ha owned by 90 households.

Top left and bottom left showing intake and its position and photo top right and bottom right showing position of the water tank.

Although the cost of operating the system is not very high (NRs 30 per hour) the capital cost of US$ 30,000 is simply not practical. We are discussing with engineering colleagues and providers about reducing the price of the system by 90% utilizing off-the-shelf high-lift pumps, motors and pumps and moving the water laterally with inexpensive lay-flat pipes.

Scaling Strategy: Moving the Curve Higher for Supply and Demand

6.11 Increasing Supply Through Backstopping

CSISA will identify additional potential two- and four-wheel tractor agents and dealers and will be monitoring sales and use of both four- and two-wheel tractor attachments including reapers in the next few months to gauge their spread, better backstop the agents and understand better how to achieve scale.

Jay Bageswori and another hardware company in Dhangadhi selling four-wheel tractor reapers, International Agriculture Machinery, were also featured in the various FM radio jingles that CSISA aired in early March in an effort to boost their markets.

6.12 Increasing Demand Through Disseminating Simple Messages

CSISA aims to increase demand and capacity to meet demand through strengthened distribution channels in collaboration with public and private sector partners. CSISA focuses on **disseminating simple messages** on the yield and profitability gains associated with new technologies, as well as the opportunity to intensify cropping through simple, timely interventions.

6.11 FM Radio Broadcasts

Although the impact can be hard to quantify, advertising new technologies via local FM community radio stations, with jingles and mini-dramas written by the radio stations and

CSISA staff, have had increased awareness of resource-conserving management practices and increased sales of CSISA-supported technologies. For example, CSISA developed jingles in the local Tharu language for airing in the Far West touting reapers. In the last rice harvest season, Dahit Traders reported that after CSISA aired a jingle using their phone number they received over 100 calls enquiring about reapers. Sadly, due to the blockade, they had fewer reapers to sell than they had demand for. For wheat harvest this year, CSISA has redoubled its FM radio advertizing in the Mid and Far West and are trying to include ever more suppliers' and dealers' contacts. CSISA also used FM spots to create awareness about the optimal window for irrigation and N topdressing during the wheat season. More use of FM for awareness building among farmers about new agronomies like direct-seeded rice and seed drills are being discussed as well. Community FM seems to be a low cost and easy avenue to help advertize and get the word out about new technologies. Yet, its impact is currently difficult for CSISA to quantify. CSISA understands well that estimating impact from FM radio spots and jingles is beyond our capacity and we will be searching for ways to estimate the impact of these FM radio spots.

7.0 New CSISA office established in Dang

Dang District is situated in the Mid Western development region and falls with the Feed the Future zone. The district has a diversified geography. The lower "inner Terai" valley is scattered with Shallow Tube Wells and has a high potential for rice, spring maize, wheat, lentil as well as mungbean. The mostly rainfed upper valley has a mid-hill ecology with high potential for summer maize and wheat and mustard. Dang is also the entrance to Salyan and Rolpa Districts, and it is a prime base from which to stage activities into these districts.

The private sector is fairly well established in Dang. For example, Rapti Feed Industry is a large feed mill in the final stages of construction and is rated at 10t/hour of maize-based poultry feed and other products. This will provide opportunity for commercial pocket development for maize through strengthening the producers group with assured output market, which is highly important for scaling out technologies to a larger area. There are also established agro-machinery traders who report that business is slower than they would like. Strengthening through co-ordination and capacity development of those traders will be highly effective for scaling out CSISA-supported technologies.

In Focus: *Challenges Faced During the Reporting Period*

Scenes like this long queue for petrol (and diesel) in Lalitpur were common everyday sight.

Trucks bound for Nepal lined up for weeks incurring huge demerge losses for importers (courtesy Agence France-Presse)

Reeling from two massive earthquakes in April and May 2015 that killed over 8,800 and left over 3 million Nepalese homeless, the ruling parties felt they needed to fast track the draft constitution saying that whatever flaws remained could be easily amended later. Members of traditionally marginalized groups fearing such a constitution might never be amended began a five-month violent trade and energy blockade, with the backing of India, starting in the third week of September, 2015.The result was a catastrophe for all. And in this humanitarian disaster, once again it was the marginal and poorest suffered the most. (See https://en.wikipedia.org/wiki/2015_Nepal_blockade).
While Nepal normally receives over 300 fuel tankers per day, for much of the blockade newspapers reported tankers crossing in single digits spurning a massive growth in smuggling and black marketed fuel.

Like most other projects, CSISA was not immune to the strikes and petroleum shortages. Field staff were greatly hindered and even blocked in getting to the fields due to lack of fuel and violence that affected the Mid and Far West Regions. Fertilizer and even seed for trials was difficult to obtain and finding fuel for project vehicles and tractors was always an adventure usually in the black market.

Our project partners, including the government but especially the private sector, were greatly affected. The private sector was not able to supply key machinery on time like the reapers and missed a whole sales season as their trucks and containers were stuck for 3-5weeks at the Raxaul border, incurring demurrage fees over 100 USD per day per truck or container. Fuel shortages for tractors and irrigation pumps obviously had a significant effect on farmers and overall production as well. Delaying planting for zero till trials meant the loss of residual soil moisture and weed control.

On top of input shortages, drought like conditions from the El Nino impact to farmers is yet to be quantified.

It is very difficult to quantify the impact to the project and development efforts as well. Agricultural machinery importers reported that 100s of reapers, 2 and 4-wheel tractors, and mini tillers were stuck in the border during the major fall sale season.

Annex A. Tentative Indicator Numbers Covering October 2015 through March 2016 for CSISA-Nepal Scaling (USAID Washington Investment)

4.5.2(11): Number of food security private enterprises (for profit), producers organizations, water users associations, women's groups, trade and business associations, and CBOs receiving USG assistance	305	164
Type of organization	305	164
Private enterprises (for profit)	160	68
Producers organizations	100	60
Water users associations		
Women's groups	30	28
Trade and business associations	15	8
Community-based organizations (CBOs)		
Disaggregates Not Available		
New/Continuing	305	164
New	280	139
Continuing	25	25
Disaggregates Not Available		
4.5.2(2): Number of hectares under improved technologies or management practices as a result of USG assistance	2,850	1,292
Technology type	2,850	1,292
crop genetics	1,050	318
cultural practices	700	480
pest management		
disease management		
soil-related fertility and conservation	200	95
irrigation	300	152
water management (non-irrigation)	600	324
climate mitigation or adaptation		
other		
Total w/one or more improved technology	2,850	1,292
Disaggregates Not Available		
Sex	2,850	1,292
Male	1,710	607
Female	428	285
Joint	570	279

Association-applied	142	120
Disaggregates Not Available		
4.5.2(37) Number of Micro, Small, Medium Enterprizes (MSMEs), including farmers, receiving business development services from USG assisted sources	425	221
MSME Size	425	221
Micro	420	218
Small	5	3
Medium		
MSME Type	425	221
Agricultural producer	120	63
Input supplier		
Trader	5	2
Output processor		
Non-agriculture		
Other	300	156
Sex of producer	425	221
Male	255	148
Female	85	42
Joint	85	31
Dis-integration not available		
4.5.2(5): Number of farmers and others who have applied improved technologies or management practices as a result of USG assistance	6,600	3,446
Producers	6,600	3,446
Sex	6,600	3,446
Male	4,620	1,778
Female	1,980	1,668
Disaggregates Not Available		
Technology type	6,600	3,446
crop genetics	2,160	1,754
cultural practices	1,600	1,330
livestock management		
wild fishing technique/gear		
aquaculture management		
pest management		
disease management		

soil-related fertility and conservation	800	609
irrigation	600	467
water management (non-irrigation)	1,200	1,024
climate mitigation or adaptation		
marketing and distribution		
post-harvest - handling and storage	240	170
value-added processing		
other		
total w/one or more improved technology	6,600	3,446
Disaggregates Not Available		
Others		
Sex		
Male		
Female		
Disaggregates Not Available		
Technology type		
crop genetics		
cultural practices		
livestock management		
wild fishing technique/gear		
aquaculture management		
pest management		
disease management		
soil-related fertility and conservation		
irrigation		
water management (non-irrigation)		
climate mitigation or adaptation		
marketing and distribution		
post-harvest - handling and storage		
value-added processing		
other		
total w/one or more improved technology		
Disaggregates Not Available		
4.5.2(7): Number of individuals who have received USG supported short-term agricultural sector productivity or food security training	400	263

Type of individual	400	263
Producers	250	193
People in government	75	35
People in private sector firms	40	22
People in civil society	35	13
Disaggregates Not Available		
Sex	400	263
Male	325	193
Female	75	70
Disaggregates Not Available		

Annex B. Tentative Indicator Numbers Covering October 2015 through March 2016 for CSISA-Nepal Mechanization and Irrigation (USAID India Investment)

4.5.2(2): Number of hectares under improved technologies or management practices as a result of USG assistance	1,500	742
Technology type	1,500	742
crop genetics		
cultural practices	60	51
pest management		
disease management		
soil-related fertility and conservation	30	26
irrigation		
water management (non-irrigation)	30	15
climate mitigation or adaptation		
other	1,380	687
total w/one or more improved technology	1,500	742
Disaggregates Not Available		
Sex	1,500	742
Male	70	45
Female	25	13
Joint		
Association-applied	25	16
Disaggregates Not Available	1,380	668
4.5.2(37) Number of Micro, Small, Medium Enterprizes (MSMEs), including farmers, receiving business development services from USG assisted sources	200	112
MSME Size	200	112
Micro	200	112
Small		
Medium		
MSME Type	200	112
Agricultural producer	35	30
Input supplier	30	12
Trader	5	2
Output processor		
Non-agriculture		
Other	130	68
Sex of producer	200	112
Male		
Female		
Joint	70	23
Dis-integration not available	130	89
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	4	4
Phase 2 Number of new technologies or management practices under field testing as a result of USG assistance	5	3
Phase 3 Number of new technologies or management practices made available for transfer as a result of USG assistance		

Disaggregates Not Available		
4.5.2(5): Number of farmers and others who have applied improved technologies or management practices as a result of USG assistance	1,500	759
Producers	1,500	759
Sex	1,500	759
Male	350	210
Female	150	103
Disaggregates Not Available	1,000	446
Technology type	1,500	759
crop genetics		
cultural practices	225	138
livestock management		
wild fishing technique/gear		
aquaculture management		
pest management		
disease management		
soil-related fertility and conservation	125	75
irrigation		
water management (non-irrigation)	75	28
climate mitigation or adaptation		
marketing and distribution		
post-harvest - handling and storage	575	441
value-added processing		
other	500	210
total w/one or more improved technology	1,500	759
Disaggregates Not Available		
Others		
Sex		
Male		
Female		
Disaggregates Not Available		
Technology type		
crop genetics		
cultural practices		
livestock management		
wild fishing technique/gear		
aquaculture management		
pest management		
disease management		
soil-related fertility and conservation		
irrigation		
water management (non-irrigation)		
climate mitigation or adaptation		
marketing and distribution		
post-harvest - handling and storage		
value-added processing		
other		
total w/one or more improved technology		

Disaggregates Not Available		