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CSISA

COVID RESPONSE AND RESILIENCE

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CSISA COVID-19 Response Activity Partners

CIMMYT International Maize and Wheat Improvement Center
IWMI
iDE

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List of Acronyms and Abbreviations

CBF	community business facilitators
CBO	community-based organization
CGIAR	*formerly the* Consultative Group for International Agricultural Research
CIMMYT	International Maize and Wheat Improvement Center
CSISA	Cereal Systems Initiative for South Asia
CU	conjunctive use
FtF	Feed the Future
FtF–ZoI	Feed the Future Zone of Influence
GESI	Gender Equality and Social Inclusion
GoN	Government of Nepal
GWRDB	Groundwater Resources Development Board
iDE	International Development Enterprises
IWMI	International Water Management Institute
LSP	local service provider
MoALD	Ministry of Agriculture and Livestock Development
MoLMAC	Ministry of Land Management, Agriculture and Cooperative
MSME	Micro Small and Medium Enterprises
NAMEA	Nepal Agricultural Machinery Entrepreneurs' Association
NARC	Nepal Agricultural Research Council
NSAE	Nepalese Society of Agricultural Engineers
ODK	Open Data Kit
NPR	Nepali rupee
PMAMP	Prime Minister Agriculture Modernization Project
RMW	return migrant worker
SP	service provider
TOT	Training of Trainers
USAID	United States Agency for International Development
WRD	water resources development
ZoI	Zone of Influence

Executive Summary

The CSISA-COVID-19 Response and Resilience Activity was originally an 18-month (July 2020–December 2021) buy-in from the USAID/Nepal Mission to the wider CSISA program. Its aim is to respond rapidly and effectively to the threats posed by the COVID-19 crisis that undermine the recovery and sustained resilience of farmers in the FtF Zone of Influence (ZoI) in Nepal, with two initial objectives:

Objective I: Enable rapid, targeted, and effective agricultural COVID-19 crisis response through scale-appropriate farm mechanization and rural services provision.

Objective II: Break the smallholder irrigation bottleneck and build rural resilience to the COVID-19 crisis.

Following the second wave of COVID-19 in Nepal during the second and third calendar quarters of 2021, a third objective was added with activities planned that will span September 2021 through June of 2023. This objective is as follows:

Objective III: Supporting rapid response and resilience-building from Nepal's second COVID-19 wave.

The passages below provide updates on Objectives I, II and III during the October 2021 through April 2022 reporting period.

Highlights

Objective I: Enable rapid, targeted and effective agricultural COVID-19 crisis response through scale-appropriate farm mechanization and rural services provision

- Since the start of work on Objective I, CSISA's market systems work and focus on entrepreneurial farm machinery services provision has resulted in 4,531 farmers (1,487 (33%) were women, and 880 (19%) were youth) gaining access to affordable machinery services for land preparation, planting, intercultural operations including irrigation, and harvest and post-harvest services.
- In this reporting period, to enhance the working efficiency of mechanics trained earlier by the Activity, CSISA provided them with toolkits. These were distributed to 40 of the most advanced mechanics through local machinery dealers established in their serving area. To increase the availability of spare parts and to facilitate the extension of their network, the Activity linked these mechanics with 18 different machinery dealers in their respective districts. During the reporting period, this resulted in a total of 817 small machinery service providers benefitting through timely access to agriculture mechanics to repair their machines and the timely availability of spare parts. Now, mechanics are able to reach a greater number of machine service providers in the peak season. A rapid telephonic survey that the Activity conducted with mechanics found that their clients increased by eight to ten percent after receiving the toolbox and trainings.
- During the reporting period, the Activity developed a record-keeping book, a simple to fill-out business record template, that helps service providers to maintain records easily. Before this, service providers tended to use a small notebook, with a higher possibility of losing business records. After testing these new record-keeping approaches with machinery service providers, CSISA finalized the design of the record-keeping book. One thousand copies of the book are being printed for distribution during the next reporting period(s).

- A total of 550 poor and marginalized households (primarily Dalit and 29% of whom were women) used two-wheel tractor reapers for rice harvesting during October 2021. Their access to machinery services was facilitated by CSISA, and was the first time that they had experienced machine-aided harvesting. Many reported that this has greatly increased farm efficiency. To assure service availability, CSISA worked with machinery owners and farmers to provide access to information, such as the contacts (mobile numbers) and working locations of service providers.

Objective II: Break the smallholder irrigation bottleneck and build rural resilience to the COVID-19 crisis

- During the reporting period, CSISA released a report that identified policy, social and institutional barriers that prevent women, smallholder farmers and members of disadvantaged groups from accessing irrigation technologies and information, and related financial and technical services. This information was discussed in a comprehensive report released by the Activity titled Understanding barriers and opportunities for scaling sustainable and inclusive farmer-led irrigation development in Nepal. The findings, which maintained a strong focus on gender and social inclusion (GESI) in planning irrigation development, were disseminated through virtual multi-stakeholder dialogue at the central and provincial levels conducted in the last quarter of 2021. The discussions in the workshops, in turn, also informed additional analysis and verification of the data and findings of the social component of the research.
- As detailed in the CSISA Annual Report (October 2020–September 2021), CSISA has partnered with Nepal's Groundwater Resources Development Board (GWRDB) to develop a digital groundwater monitoring system for the Feed the Future Zone. This system is a first of its kind in Nepal, and will replace the current approach of maintaining records on paper and in non-digital, decentralized databases. This work aims to provide decision-makers of all types with access to a publicly available database that can be used to plan improved use and management of groundwater resources. The dashboard can be accessed at https://gw-nepal.com/ until it is incorporated into the GWRDB's website. Its source code with dummy data are freely available for anybody for their own use, and to provide feedback or improvements here.
- During the reporting period, the Activity held an experience sharing workshop in Kathmandu with GWRDB officials to (1) train hydrogeologists in the Ministry of Energy, Water Resources and Irrigation on using and improving the piloted digital monitoring systems, and (2) deliberate with stakeholders about cooperation for digital groundwater monitoring to avoid resource depletion.
- During the final stage of Objective II, the Activity evaluated the three tested groundwater monitoring approaches, trained hydrogeologists of the Ministry of Energy, Water Resources and Irrigation on the learnings of the Activity and improving and scaling of the digital monitoring systems, and finally supported policy dialogues across sectors to discuss and plan future cooperation on building digital information systems and more adaptive groundwater management. The evaluation led by the GWRDB further showed that the 'Android-based monitoring method' – that is, manual groundwater level measurement with Android-based data entry – is both the most cost-effective and the lowest in terms of risk of technical failure in comparison to the use of technical logging devices.
- Optimal irrigation use is potentially influenced by factors including soil type, landscape drainage characteristics, rainfall distribution, planting dates, crop variety characteristics, and higher order interactions. In complex production environments like Nepal's Tarai, bigger data combined with advanced machine learning analytics are opening new avenues for untangling the influence of these factors to identify circumstances where there are significant opportunities for irrigation-led sustainable intensification. Data explorations suggested a five-fold higher median increase at +3 additional irrigations versus a single (+1) additional irrigation for summer season rice production.

Notably, increasing nitrogen fertilizer to non-limiting rates unlocks the value of irrigation, increasing yield up to 1 ton/ha.

- During the reporting period, the Activity also explored the spatial distribution of yield responses to irrigation and nitrogen fertilizer. The analysis helped identify locations within the terai where irrigation and improved fertilizer management are most likely to result in significant yield gains. The identified areas, which will require additional field experimental validation, are likely to be the logical focal zones for increasing access to affordable irrigation through the coordination of public and private sector investment.
- Over the last six months, CSISA also conducted multiple stakeholder workshops at the provincial and district levels within the FtF zone to identify potential irrigation and cropping system intensification scenarios that could be assessed for sustainability – with groundwater aquifer maintenance as the primary indicator – in partnership with the Texas A&M University-led FtF Innovation Lab for Small Scale Irrigation. Scenarios were developed by combining crop rotation, irrigation, and fertilizer management based on water resource availability, crop suitability and diversification potential, market access, and the interest of stakeholders, among other criteria. The model scenario results, which focused on five potential pathways for irrigation development and cropping systems management, suggest that the use of surface and groundwater will be sustainable if their flow/storage are retained dynamically for long-term, inclusive, equitable use with effective management and governance. This report provides detailed results on the range of scenarios examined, which the Activity can now use to advise irrigation and agricultural development planners to target their activities more effectively while also avoiding negative environmental consequences from groundwater over-withdrawal.
- The guiding framework developed by CSISA, entitled "*A framework for sustainable and inclusive irrigation development in Western Nepal*", was released during a stakeholder workshop (April 28, 2022) with participants from different levels of government offices, USAID, INGOs, NGOs, civil society, private organizations and donor agencies. Key investment priorities were identified in the framework: (1) Ensure adaptive technology prioritization and water management practices that respond to local resource constraints and equity considerations. (2) Build robust data and information systems to allow adaptive planning, prepare for climate change impacts, and support digital agriculture and targeted farm advisories. (3) Expand and upgrade irrigation and agricultural value chains to ensure access to water, returns on investments, and the creation of better, more inclusive jobs. In highlighting the framework's relevance, a federal ministry policymaker expressed that the lack of irrigation is a challenge for agricultural development in Nepal. The findings and recommendations presented in the framework are relevant to the Government of Nepal (April 28, 2022). Another policymaker, in their opening remarks, also acknowledged the research outputs of the CSISA Activity, remarking that it has developed a knowledge base on sustainable and inclusive irrigation development in Nepal. The research findings are relevant for planning and policymaking related to water resources and use (April 28, 2022). Printed copies of the framework will be made available by mid-June 2022.

Objective III: Supporting rapid response and building resilience to Nepal's second COVID-19 wave

- This Objective aims to rebuild effectively key elements of Nepal's agri-food systems and marginalized groups in the FtF zone, which have been disproportionately affected by the second wave of the COVID-19 crisis. During the reporting period, Activity conducted a rapid assessment and interviewed 144 respondents throughout the seven project districts – 115 agrovets, 24 machinery dealers, and five cooperatives – including agrovets working with NSAF and KISAN-II projects. At the end of 2021, 32.6% of agro-dealers reported a 25% reduction in business volume, while 31.3% said business was the same as the last year, with no growth, and 15.3% said their business volume had decreased by 25%–50%. Similarly, lockdowns in 2021 caused several supply

chain-related constraints, including difficulties in obtaining supplies of farm inputs from importers and wholesalers, price increases, and an unwillingness of wholesalers and importers to provide credit.

- The Activity facilitated several high-level meetings and interaction with the banks during the reporting period, starting with Muktinath Bikas Bank Ltd and Mega Bank Nepal Ltd, leveraging the existing partnership from Objective I. The Activity also reached out to Nepal Bangladesh Bank Ltd, Global IME Bank Ltd, and Laxmi Bank Ltd, seeking possible collaboration. Of these, the agreement with Mega Bank Nepal Ltd was finalized and the others are anticipated to be soon completed.
- To date, the Activity has identified 199 MSMEs seeking recovery loans, 34 of which have been connected to the banks for loan applications that are now in process. However, the speed at which loans have been deployed has been affected by Nepal's ongoing liquidity crisis, for which the Activity is working on alternative strategies to overcome constraints.
- During the reporting period, the Activity facilitated comprehensive training on the 'CBF Approach and Sales Skill Development' for team members (2–5 March 2022), covering recruitment and capacity building to effective management. The field-based team then coordinated with agri-input suppliers in their district to identify/recruit CBFs. A total of 40 CBFs have been recruited and trained (12 in Dang, 9 in Kapilvastu, 10 in Banke, and 9 in Bardiya districts) and linked with 23 agrovets. As well as door-to-door visits to farmers in the villages to promote and sell agricultural products/inputs, they are now holding sales meetings/presentations to trigger sales.
- Over the last six months, the Activity team has been coordinating with the district chambers of commerce, Federation of Women Entrepreneurs' Associations of Nepal district chapters, district offices of small and medium cottage industries, and *palikas* to compile a list of post-harvest enterprises in the district, and individuals (or groups) interested in starting post-harvest enterprises. It is also contacting existing post-harvest enterprises and potential farmers/enterprises directly. Up to the reporting period, 66 potential post-harvest enterprises have been listed, of which seven have been connected to the banks for loan applications that are expected to be rapidly approved following the easing of the national liquidity crisis.
- CSISA is working together with Innovative Solution Pvt. Ltd. to raise awareness and use of the KISAN Card, which can be used with a simple feature phone. KISAN Card aims to facilitate access to finance for smallholder farmers, enabling them to invest in and practice climate-smart/appropriate agricultural technologies, also assisting in commercial agriculture. So far, 21 agrovets have been onboarded as vendors; the Activity is enrolling 370 agricultural input suppliers as Kisan Card vendors. Mega Bank is a key partner for the use of Kisan Card; the Activity has met with them, and the agreement to collaborate has now been finalized. This agreement will unlock the use of more than 2,500 Kisan Cards, named 'Mega Smart Krishi Card', under this partnership, of which 500 are expected to assist in loans to individual farmers and agriculturally oriented businesses. So far, 33 farmers (15 each in Kailali and Bardiya, and three in Dang) have taken out the Kisan Card to purchase agricultural inputs and a further196 farmers have applied to do so.
- Also, during the reporting period, CSISA expanded and re-established offices and staff in the Mid-Hill district of Surkhet, making CSISA operational in seven districts.
- Through efforts in farm mechanization, 58 new returnee migrants forced to return to Nepal due to the COVID-19 crisis, purchased machines through loans with banks facilitated by CSISA and entered into fee-for-hire entrepreneurial services with farmers as clients.

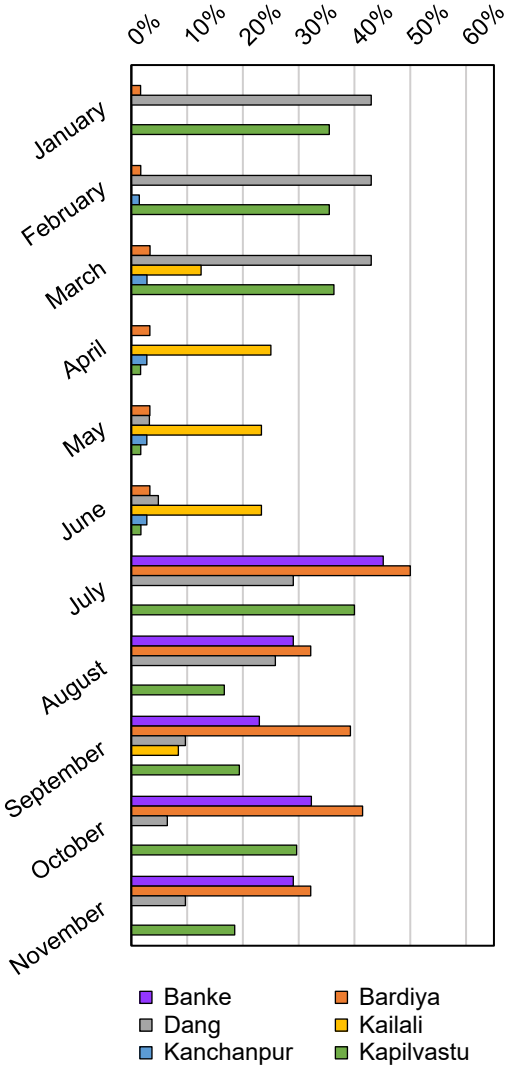
Objective I: Enable rapid, targeted and effective agricultural COVID-19 crisis response through scale-appropriate farm mechanization and rural services provision

Work Package 1: Creating' cool' jobs for young returnee migrants as machinery and irrigation service providers and entrepreneurs to support farmers affected by the COVID-19

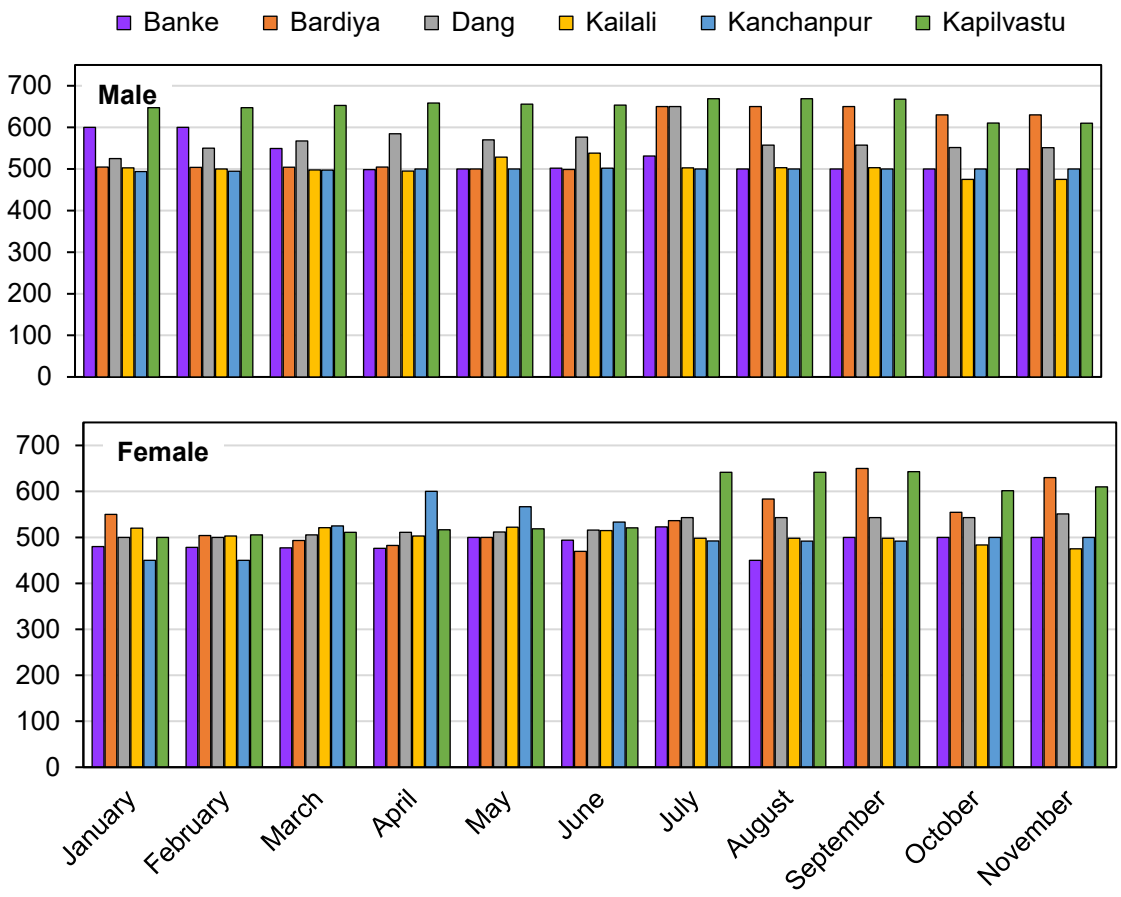
1.1 Gather information and generate data on evidence of labor availability and cost dynamics, and challenges that farmers face in the COVID-19 crisis and post-crisis period

Work Package 1 targeted districts which experienced negative economic impacts as a result of the COVID-19 pandemic in the FtF Zone. During the reporting period, CSISA conducted rapid telephone panel surveys (collecting data on a monthly basis) of farmers and service providers, to understand the effect of the COVID-19 crisis on labor costs for key agricultural activities and machinery services (inclusive of land preparation, crop establishment, irrigation and harvest). Resulting data were used to help target project interventions more effectively. The results indicated that Dang and Kapilvastu faced labor shortages in early 2021, especially related to planting and crop management (see Figure on labor shortage dynamics), which was later reduced to a greater extent during the winter harvest season and early summer season during crop sowing.

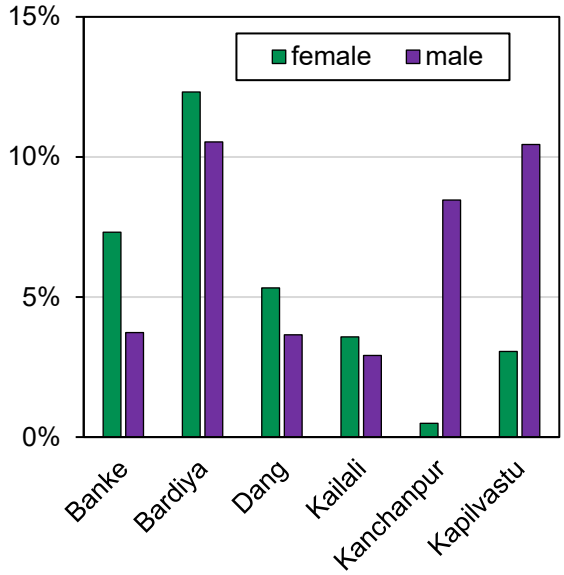
Labor shortages increased again significantly in Banke, Dang, Bardiya and Kapilvastu districts during the monsoon planting season but had reduced again by the end of the harvesting time. Kapilvastu, Bardiya and Dang reported an increase in male and women labor prices (see figure on the next page on labor price dynamics for men and women); Kailali's lower labor shortage dynamic is visible in the labor price for men but Banke's labor shortage is not visible in labor price dynamics. For Bardiya, Kapilvastu and Dang, the labor shortages were reflected in the price. Variability in labor prices was observed more among men than women in Kanchanpur and Kapilvastu, indicating that increases in labor prices mainly benefited men rather than women workers (see figure on the next page on labor price variability for men and women). A reverse trend was observed in Banke and Bardiya.



Above: *Labor shortage dynamics (% of farmers reporting labor shortages during the COVID-19 pandemic)*



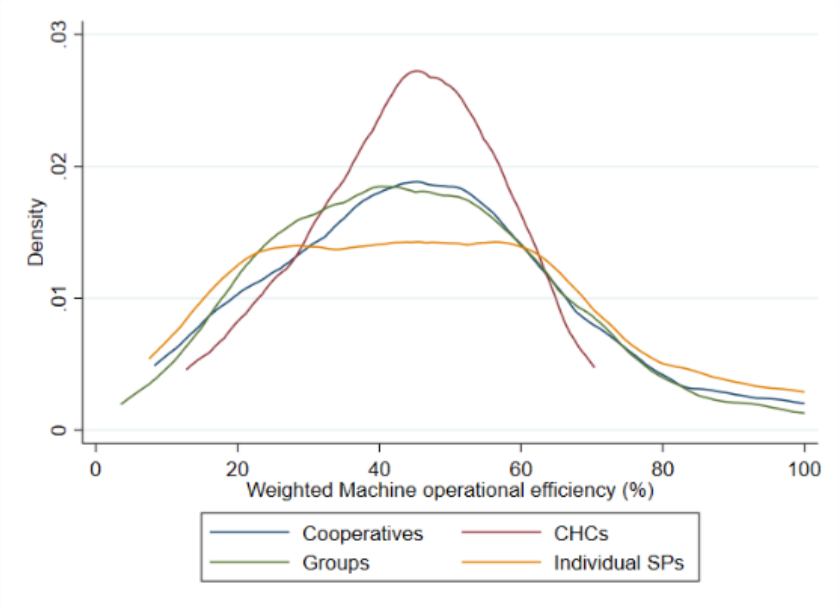
***Above**: Labor price for men (top) and women (bottom) (Nepali Rupees) in project working districts.*



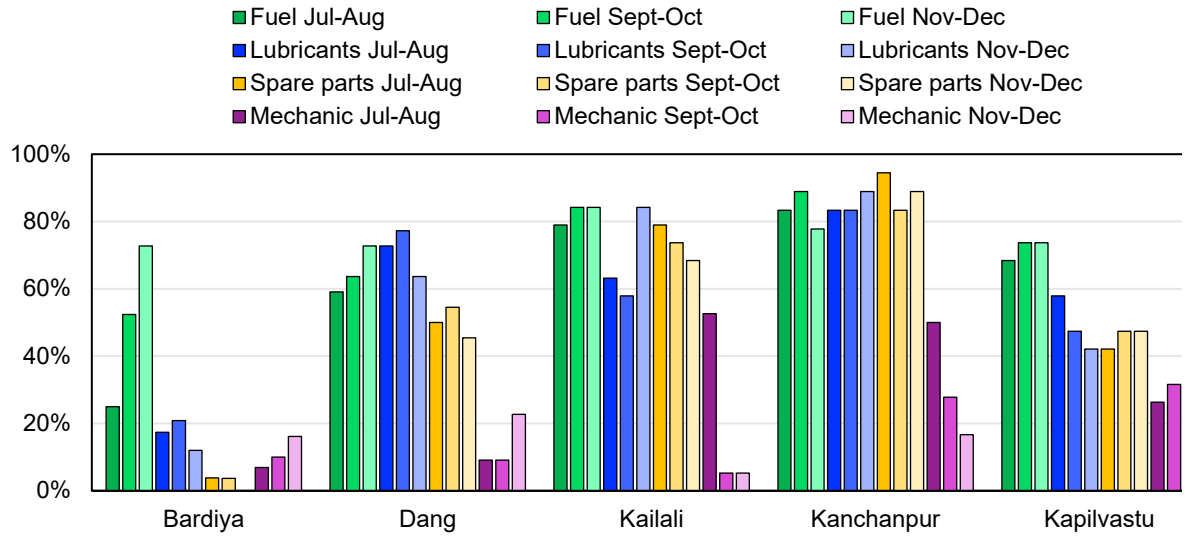
***Above**: Labor price variability for men and women (represented by the coefficient of variation)*

CSISA also conducted monthly surveys with machinery service providers to estimate their efficiency and identify opportunities for interventions to improve efficiency and farmers' access to services. The

results were presented the virtual conferences (21 June, 2021 and 31 January, 2022). Conference participants included representatives from the Prime Minister's Agriculture Mechanization Project (PMAMP), INGOs, the private sector, Nepal Agricultural Research Council (NARC) and Agriculture Knowledge Center (AKC). Farmers reported a shortage of machines in Dang during the 2021 winter harvesting period, but very few had complaints about machinery availability between July and December, 2021 (see figure on issues constraining machinery service provider). Service providers conversely reported issues of access to fuel, spare parts, lubricants and mechanics as major constraints, which were aggravated from July to December. The efficiency study pointed out that the average efficiency level is similar among different kinds of service providers but the skewness of distribution differs (see figure below).



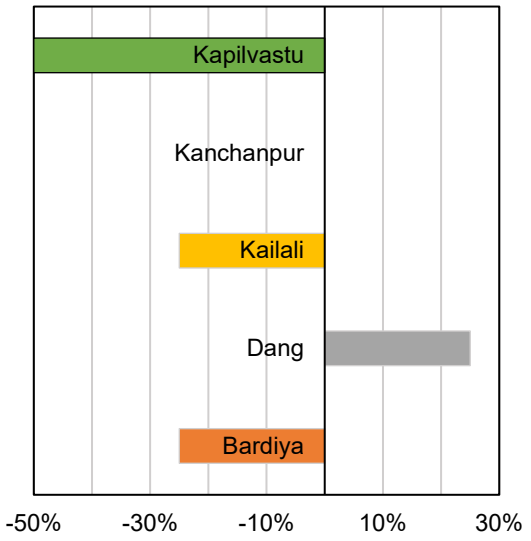
***Above**: Distribution of weighed efficiency of service providers in Nepal*



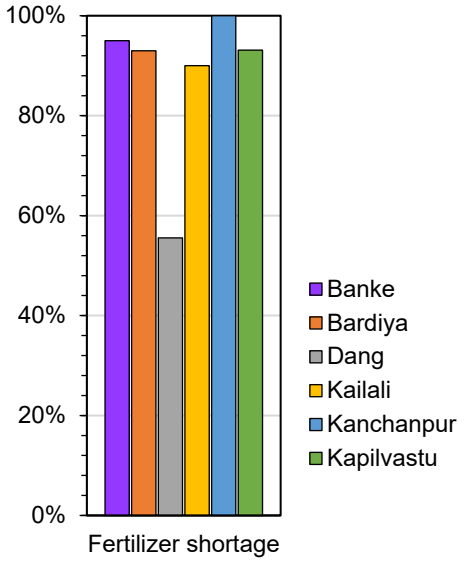
***Above**: Issues constraining machinery service providers by district (% of service providers reporting issues)*

During the monsoon and early winter season, from July to December, 2021, machinery service providers reported significant reductions in customers (see figure on reduction in customer numbers); however, regional differences of changes in machinery use need further assessment. In addition to

labor, the major issue reported by most farmers contacted by the survey was a fertilizer shortage in the winter/monsoon cropping period, except in Dang (see figure on fertilizer shortage). This is a serious concern, as persistent fertilizer shortages can impact the food security of the region, especially when combined with labor shortages. It seems that the labor shortage is not fully translated to opportunities for agricultural machinery, probably due to the increased cost of machinery service provision, which is due the costs of fuel, spare parts, lubricants and maintenance, and/or the reduced investment capacity of farmers. The results of the studies are expected to be used to inform the Government of Nepal and its agriculture machinery-related policy changes.



***Above**: Reduction in customer numbers during July to December (% of service providers reporting reductions)*



***Above**: Fertilizer shortage (% of farmers reporting fertilizer shortages during survey period).*

1.2 Turn problems into solutions by identifying returnee migrants poised to become rural entrepreneurs

Background: The objective of Work Package I Activity II was to identify at least 108 returnee migrants (21% youth) who were supported to become service providers. Returnee migrants were identified as a key group in need as Nepal experienced large-scale mass re-migration from India when workers who had been employed there were forced to return to Nepal when the pandemic began. The approach taken by CSISA in this work is described in the CSISA Annual Report (October 2020-September 2021). Despite early challenges, this work was successful. The Activity achieved 108% of its targets, with 108 returned migrants purchasing machinery and entered into rural entrepreneurial business service farmers as a result of CSISA's interventions. Fifty-nine of these obtained credit from bank loans, while 14 also obtained credit through loans from farmer cooperatives. The remainder were able to self-finance machinery purchase with the technical guidance of CSISA. The range of machinery purchase ranged from irrigation pumps , mini-tillers, power-tilers with attachable trailers or reapers, four-wheel tractors, self-propelled reapers, and wheat threshers and combined rice mills.

Finally, as part of these activities, the business model framework supporting business planning for returnee migrants that was developed in consultation with stakeholders was written-up as a training and resource manual. This manual, which was printed both in English and in Nepali, includes detailed financial investment options and business cases supporting returnee migrants to profitably enter into

agricultural machinery services provision businesses. The manual was published as Agricultural Machinery Service Provision Business: A business model for return migrant workers.

1.3 Link potential service providers to machinery dealers and financial services

After the second wave of COVID-19, the Activity identified 15 new returnee migrant workers and linked them to Megabank under a reduced interest rate loan business model developed by CSISA and the bank. Each purchased a power tiller, with CSISA providing training in technical skills, operation, repair and maintenance, and general servicing. At the time of writing, these returnee migrant workers had just started to provide services in their areas.

Similarly, in the last quarter of 2021, the Activity offered machinery and business-related training to 82 returnee migrant workers who had come back from India and elsewhere after the first wave of COVID-19. The aim was to support them to acquire different types of machine through the subsidized loan scheme offered by Mukti Nath Bikash Bank and by local Cooperatives, to establish themselves as machinery service providers and to become local entrepreneurs. CSISA also provided a three-month traineeship program to eight returnee migrants to develop them as mechanics and supported trainees with toolkits. These service providers are now working to expand the geographical area under agricultural mechanization.

Above: *Returnee migrants buying mini-tillers from Quality Agro Suppliers, Bhurigaun, Bardiya district. Photo credit: Yam Raj Adhikari, CIMMYT*

Above: *Sohan Tharu (left) and Bal Bahadur Tharu (right), both youth returnee migrants forced back to Nepal due to the pandemic, during their three-month internship at Swostik Traders, Rajapur, Bardiya district. Photo credit: Rajendra Kunjeda, CIMMYT*

1.4 Cooperatively develop business models and link emerging entrepreneurs to provide essential services to farmers in COVID-19-affected areas

In Activity 1.4, CSISA works with returnee migrants entering the field of machinery services provision to develop business models by which they can profitably offer land preparation, planting, irrigation or harvesting and post-harvest services to farmers in COVID-19-impacted areas while also reducing overall production costs for farmer clients. This Activity has been expanded through Objective III, detailed later in this report.

1.5 Beating back breakdown of agricultural machinery through deployment of COVID-19-safe mobile mechanics

The number of weeks during the calendar year in which machinery service providers can assist farmers with land preparation, planting and harvesting services is limited, because of the tight time windows provided by the confines of agricultural seasonality. As such, any machinery breakdown can have significant negative consequences. In response to this, CSISA is working to overcome lost workdays for machinery services providers – whose role has become increasingly crucial during the COVID-19 pandemic – by ensuring that mechanics are (1) well-trained, (2) available in the service watersheds of machinery service providers, and particularly new service providers who are retuned migrants, and (3) ensuring that mechanics are equipped to assist machinery service providers, while following COVID-19 safety protocols.

During the reporting period, the Activity developed eight machinery mechanics in Bardiya to overcome the issues associated with repair and maintenance of agriculture equipment in rural areas during COVID-19. It prepared a list of mobile mechanics and provided it to relevant stakeholders, in order to establish a relationship and thereby ensure a smooth channel of communication with mechanics when needed, even during the peak season.

Above: *Training mobile mechanics, Rajapur, Bardiya district. Photo credit: Rajendra Kunjeda, CIMMYT*

Toolkit distribution to machinery mechanics: In this reporting period, to enhance the working efficiency of mechanics trained earlier by the Activity, CSISA provided them with toolkits. These were distributed to 40 of the most advanced mechanics through local machinery dealers established in their serving area. To increase the availability of spare parts and to facilitate the extension of their network, the Activity linked these mechanics with 18 different machinery dealers in their respective districts. During the reporting period, this resulted in a total of 817 small machinery service providers benefitting through timely access to agriculture mechanics to repair their machines, and the timely availability of spare parts.

Above: *Govinda Acharya (left), a mobile mechanic, receiving a CSISA toolkit from Bipin Pratap Rajaure, owner of Mahalaxmi Traders, Dang District, Lumbini Province. CIMMYT Traders were involved in training mechanics and handed over the toolkits supplied through their partnership with CSISA at the end of the training. Photo credit: Jyoti Rai, CIMMYT*

Mechanics in Dang who received toolkits from CSISA reported that they are now able to provide mechanic services for machine owners more easily and efficiently. Previously, they would request machine owners to arrange a toolkit for repair services, which was extremely difficult for the machine owners to manage. Further, the most important tools were not always available to mechanics or in markets when and where they were needed. With CSISA's support, mechanics now have access to a full set of tools, enabling them to provide more extensive, efficient and timely repair services and to overcome machinery breakdowns during lockdowns and other periods of time in the agricultural calendar. This has led to increased working efficiency, such that mechanics are able to reach a greater number of machine service providers in the peak season. A rapid telephonic survey that the Activity

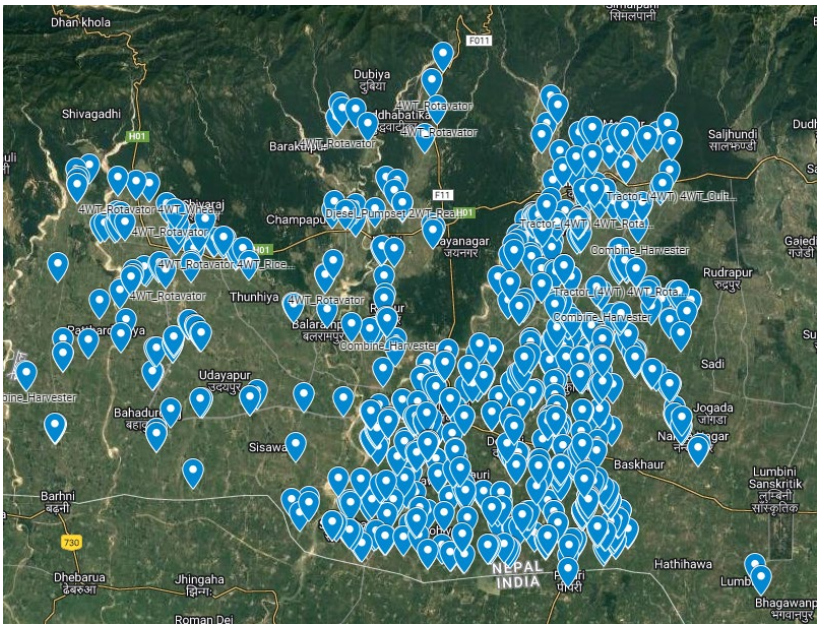
conducted with mobile mechanics found that their clients increased by eight to ten percent after receiving the toolbox.

These mechanics therefore had a significant role in terms of repairing machinery and delivering home services during the COVID-19 pandemic period. Getting machinery repair services when they needed them allowed farmers to plant, irrigate and harvest their crops on time, which eventually increases their profitability from the cropping systems. However, the capacity of mobile mechanics needs to be further enhanced in various resource conservation machinery; additional work is needed to identify improved ways to involve women and marginalized to become machinery mechanics, which has the potential to create job opportunities, especially for youth in rural areas.

Work Package 2: Minimizing the economic impacts of COVID-19 for very poor and women farmers through linkages to established service providers and custom hiring centers

2.1 Track the availability and movement of agricultural machinery in the FtF zone and advise government, development partners and machinery owners on how to channel services to locations where they are most needed

Expanding service provider database and linking farmers to businesses: Nepal benefits from a relatively high concentration of two-wheel tractor driven reaper-harvesters, as well as farmers' knowledge of and demand for harvesting services. Combines are also increasingly popular for rice and wheat, both of which can experience significant yield losses if left too long in the field when social distancing or labor shortages prevent harvesting. Similarly, land preparation and planting equipment popularized by CSISA are gaining traction.



***Above**: Mapping of machinery service providers in Kapilvastu district, embedded in Google Maps.*

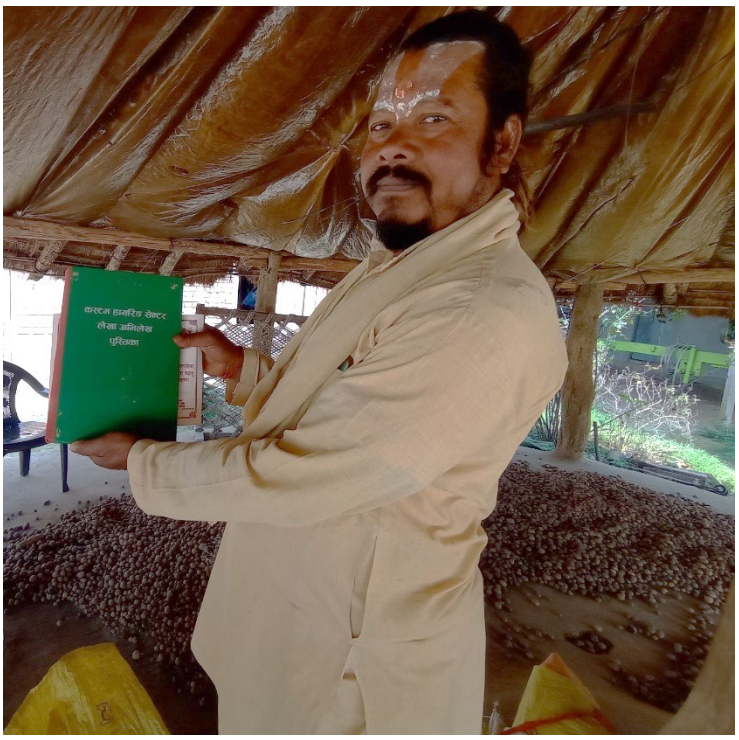
CSISA has been gathering the phone numbers and location of machinery service providers involved in these services, with the objective of providing information on the nearest machinery service provider to farmer upon request. This is important as machinery services provision has expanded well beyond CSISA's introduction of these unique business models over ten years ago. Entrepreneurial machinery services providers are starting to sprout up in many locations, even without involvement of the Activity,

Information about an additional 1,442 machinery service providers was collected in the reporting period 2020–21 in Dang and Kailali districts, increasing the total number of service providers in CSISA's database to 4,300, which has now been mapped. This list of service providers can be provided as needed to farmers via the phone and Facebook groups prepared by CSISA. More service providers

are also being tracked in the newly added Surkhet district, a district that will be reported in the next annual report.

Improving machinery hiring service efficiency and profitability: Work to educate entrepreneurs on the importance of maintaining business records has a vital role in making machinery custom hiring centers and service providers more efficient and profitable. Similarly, if the service provider keeps business transactions with their machines, they can track its availability and respond to demand immediately. The CSISA COVID-19 Response and Resilience Activity has therefore been working with service providers to improve their skills in monitoring transactions, costs, and profitability. To achieve this aim, CSISA provided different options and data recording books to custom hiring centers and service providers to enable them to keep records safe and to access their business profit and loss data.

In Kailali, Kanchanpur and Bardiya districts, record keeping books were distributed to 26 service providers. The Activity found that the recording-keeping book contained all the required information which helped service providers to maintain records easily, and prevented records from going astray. Having a record of machinery servicing helped them with the proper timing of machinery, increasing the life span of the machines. Before this, service providers tended to use a small notebook, with a higher possibility of losing business records. After testing these new record keeping approaches the machinery service providers, CSISA finalized the design of a book for machinery booking and recordkeeping, which will help service provider to keep proper booking records, instead of the current and much more haphazard approach. One thousand copies of the book are being printed for distribution during the next reporting period(s).



Above: *Machinery service provider Nathuram Chaudhary from Nawalpur, Kailali district, showing the record-keeping book for hiring out machinery services. CSISA developed this data recording format and provided it to service providers to get feedback during its design. Photo credit by Hari Prasad Acharya, CIMMYT*

2.2 Link harvesting equipment owned by PMAMP or by farmers' cooperatives, and individual service providers, to farmers demanding services in COVID-19-affected districts

During the reporting period, CSISA shared the insights obtained from its machinery tracking to the government stakeholders including Prime Minister's Agriculture Modernization Project (PMAMP) and Agricultural Knowledge Centers on a weekly basis. The most promising information was the availability of combine harvesters in districts where government officials had assumed there to be just a couple of dozen. CSISA also identified more than 120 combine harvesters service providers in the district,

providing harvesting services to rice and wheat farmers. Government offices have now realized the scope of machinery repair training and facilitation services to the combine harvester service providers in order to strengthen their capacity to provide services with their own machinery operators.

2.3 Improve service providers' access to emergency mechanics' services in COVID-19-impacted districts

Regardless of the quality of agricultural machinery, breakdowns and service interruptions are inevitable, and when this happens, machinery service providers – who assist farmers during the relatively short time windows in the agricultural calendar allotted to land preparation, planting, irrigation, harvesting and post-harvest – need rapid access to support from mechanics. Work Package II responds by linking competent mechanic repair services to equipment operators who can provide services in COVID-19-affected areas and who may be unfamiliar with local options for spares and repairs.

The original goal of Activity 2.3 was to assist mechanics in the provision of movement permission passes within and across districts in the event of continued social distancing and movement restrictions during lockdowns. As Nepal was not in lockdown until March 2021, and second lockdown (approximately 1.5 months of strict restrictions in movement between April and May) was over before the repairing season, Activity 2.3 did not need to be implemented. Instead, the CSISA team focused on providing more general training to mechanics and ensuring that mechanics were prepared and able to provide COVID-19-safe services as described above and in the CSISA Annual Report (October 2020-September 2021).

2.4 Create demand for and facilitate access to machinery services for very poor and women farmers in locations most impacted by the COVID-19 crisis

A total of 550 poor and marginalized households (primarily Dalit and 29% of whom were women) used two-wheel tractor reapers for rice harvesting during October 2021. Their access to machinery services was facilitated by CSISA, and was the first time that they had experienced machine-aided harvesting. Many reported that this has greatly increased farm efficiency. A study conducted by CSISA in 2017 on 100 reaper users in Banke, Bardiya, Kailali and Kanchanpur found that a farmer saves NPR 5,592 (~US$ 44.5) per ha from rice harvesting and NPR 6,313 (~US$ 50.3) per ha from wheat harvesting by using a reaper rather than harvesting manually (Poudel et al., 2018). It takes one day for 15 people to harvest a hectare of rice/wheat manually, which is completed by a reaper in 3-4 hours.

This Activity had a special focus to target those farmers with less than 0.33 ha of land, earning less than a USD1.25 per person per day, and who have never used agricultural machinery before. This resulted in a database of potential beneficiaries – most of whom came from Dalit communities – that could be linked to machinery service providers who, with the support of the Activity, provided discount 'first time customer' services for farmers. The use of agricultural machinery is expected to scale up this year, both among last year's target beneficiary farmers and new farmers, through knowledge transfer and dissemination of information. Farmers who used farm machines for wheat harvesting and have expressed their commitment to pro-actively purchase machinery services without CSISA's support during the forthcoming rice season. To assure service availability, CSISA worked with machinery owners and farmers and as to provide access to information, such as the contacts (mobile numbers) and working locations of service providers.

This was a one-time discount offer (40% of the total cost of using agricultural machines was supported by the Activity) made by the CSISA program. However, all recipients have shown a willingness to use

agricultural machines in the forthcoming rice and wheat seasons. This has resulted in an additional outcome – that of local employment generation, with the machine operators/service providers securing a source of income in their villages. Some service providers are migrants who returned to Nepal during the COVID-19 pandemic and became service providers through the facilitation of the CSISA Activity. Under CSISA's work with returnee migrant workers, some of the beneficiaries of harvesting services were so convinced that they bought machinery through CSISA-facilitated loan schemes and participated in training on the operation and maintenance of agricultural machinery.

***Above**: A machinery service provider harvesting paddy under CSISA's voucher scheme activity that allowed poor and marginal farmers – many of whom from Dalit communities – to affordably access machinery services for the first time in Banke district. Photo: Pankaj Maurya, CIMMYT*

Objective II: Break the smallholder irrigation bottleneck and build rural resilience to the COVID-19 crisis

Along with high-yielding crop varieties and broad use of fertilizers, expansion of irrigation has provided a core foundation for agricultural intensification in South Asia since the 1960s. For more than 50 years, development programs to support irrigation in South Asia have been driven primarily by the idea of area expansion. Access to irrigation has become crucial in building farmers' resilience to climate variability and long-term climate change, and specifically to variable monsoon precipitation patterns, drought, and heat stress, all of which can undermine sustained agricultural productivity. Irrigation can also play an important mediating role to assist farmers in stabilizing or even increasing productivity in the face of the COVID-19 crisis. Nepal's irrigation potential is however largely untapped, with very low amounts of available water used for irrigation. Only 30 percent of Nepal's irrigated land has year-round irrigation facilities using surface water resources. Groundwater aquifer structure, and how and where groundwater can be used to sustainable expand irrigation, remains an under-researched area. Given this complicated context, an integrated assessment is needed to assure rational natural and sustainable resources management. Such analysis must also consider the current COVID-19 crisis and its medium- to long-term effects on Nepal's agricultural systems and economic growth, with implications for irrigation development as a pathway to increase productivity and hedge against climatic risks with resilience enhancing irrigation.

In response, Objective II consists of four work packages that culminate in an integrated irrigation sustainability framework to assist in inclusive water resources planning and management in Nepal's FtF ZoI. The first package collects the necessary data to inform a sustainable irrigation planning assessment. The second and third work packages focus on groundwater monitoring and analysis, and the social and biophysical targeting of appropriate irrigation interventions. The final work package is the sustainability framework, which will inform COVID-19 crisis and post-crisis water resources development investments aimed at efficient, equitable and rational use of irrigation.

Importantly, the development of this framework is informed by detailed background research, literature review, and multi-stakeholder dialogue. Options for appropriate response and recovery from the COVID-19 crisis are from participating stakeholders and will be accounted for in the sustainability framework. By integrating these activities and building local capacity in hydrological modeling, sustainability assessment, interpretation of model scenarios for policy formulation and crisis response, the work packages in Objective II aim to prioritize self-reliance by developing the capacity of Nepali stakeholders over time.

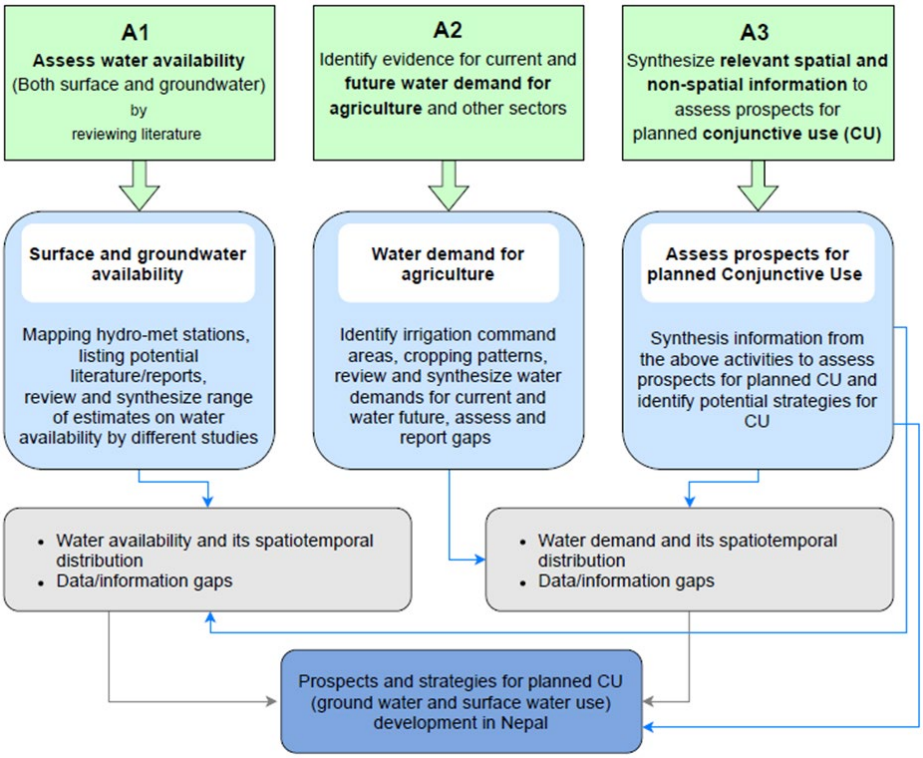
Work Package 1: Towards a systemic framework for sustainable scaling of irrigation in Nepal

1.1 Develop a sustainable groundwater use framework to support conjunctive use as a response to water access challenges in Nepal

Background: This Activity focused on the biophysical aspects of irrigation development with emphasis on hydrology. It undertook a comprehensive review and analysis of available secondary data and literature with specific focus in the FtF ZoI of the Terai.

Outputs within the reporting period: The figure below depicts the finalized conceptual framework applied as part of the Activity's biophysical research. In order to develop the framework, the Activity first

conducted a rigorous review of the available literature related to water availability, water demand and water infrastructure development, from the perspective of conjunctive use potential. The findings of this research were presented in two multi-stakeholder workshops, and the final research report, entitled "***Towards conjunctive use of surface water and groundwater resources as a response to water access challenges in the Western Plains of Nepal***" was prepared after review by policymakers, irrigation development practitioners, government and NGO agricultural and engineers, and USAID Mission staff in Nepal. The research report was approved by USAID and other partners and made available online. A research paper based on this report was also developed and submitted to the Agricultural Water Management Journal, and is under review.



***Above**: WP1/Activity 1 – Methodological framework for biophysical analysis of conjunctive surface and groundwater use.*

The key conclusions generated from this study related to the four key study areas that addressed namely, water availability, water demand, status of irrigation development, and conjunctive use (CU) planning in the FtF–ZoI region (Terai districts). The intended audience for this report includes policymakers, irrigation development practitioners, agricultural and engineers of the GON and NGOs, and USAID Mission staff in Nepal, to enable them to gain an insight into the current and future water availability, to evaluate current and future water demands, and to assess prospects for planned CU in the FtF–ZoI districts (Terai) and potential strategies for planned CU. Some of the research findings were also used to iteratively develop and complete a sustainability and scaling framework for inclusive irrigation development in Nepal's FtF–ZoI. Further detail on the report can also be found in the CSISA Annual Report (October 2020-September 2021).

1.2 Understanding systemic barriers, socio-economic and institutional challenges, and opportunities in scaling water access and irrigation technologies

Background: The limited access and use of ground and surface water in Nepali agriculture remains largely related to various socio-economic, policy, institutional, investment and gender and social inclusion challenges faced by rural communities. Where these challenges are not systemically analyzed or understood, major opportunities are missed to strengthen water and irrigation access aimed at agricultural development in Nepal. These challenges have likely been exacerbated by the COVID-19 crisis and by the necessary national policies put into place to prevent further infection.

The overall objective of this social research is to assess systemic barriers, and opportunities in scaling water access and irrigation technologies that can increase resilience and generate income for smallholder and women farmers in COVID-19 crisis-affected districts of the FtF Zone. Based on an extensive secondary literature review, and interviews with private sector and government actors, a research report on "understanding barriers and opportunities for scaling sustainable and inclusive farmer-led irrigation development in Nepal' was prepared, finalized by the International Water Management Institute (IWMI) and approved by USAID.

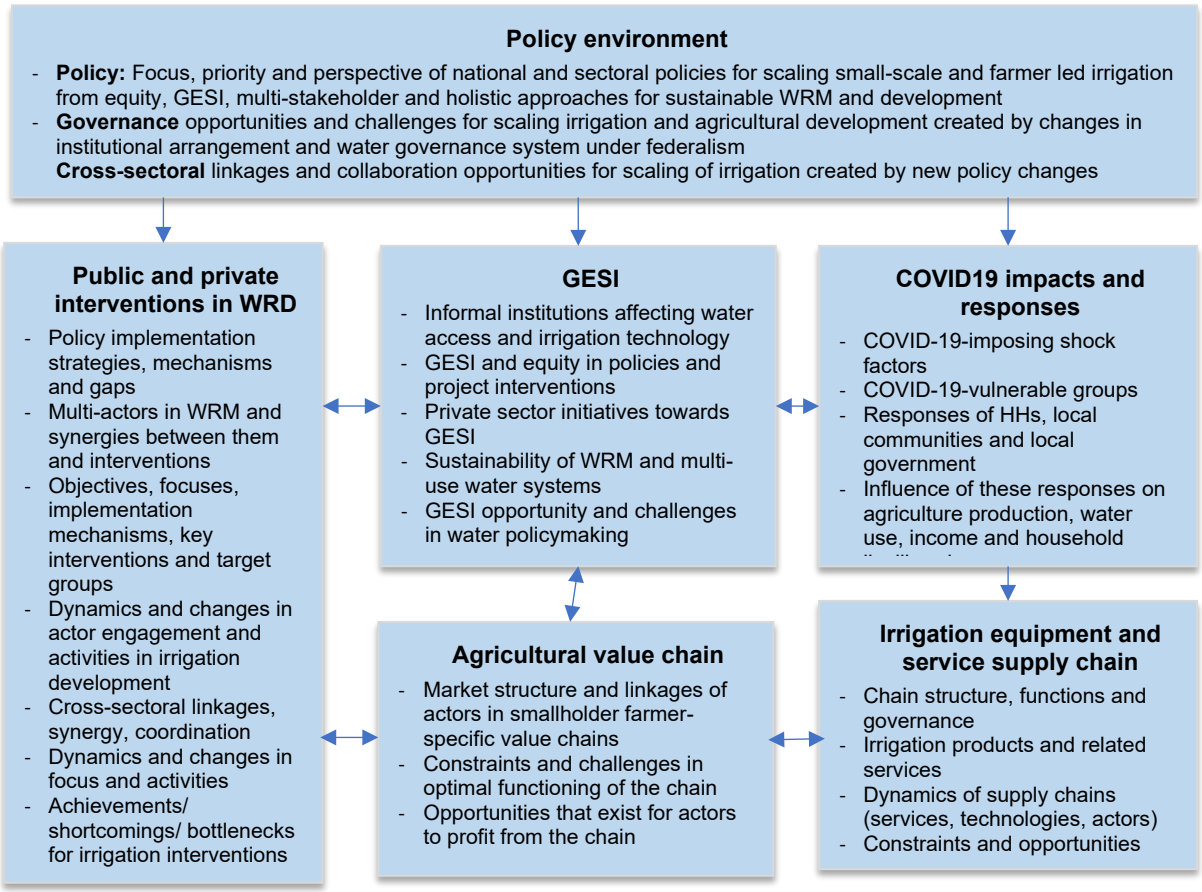
Research approaches: Understanding barriers and opportunities that influence sustainable and inclusive irrigation development in Nepal requires a comprehensive analysis of the current agriculture and irrigation systems, as well as the multiple contexts in which these systems are embedded. The Activity therefore adapted the tools for analyzing the enabling environment to the context of sustainable and inclusive irrigation development in Nepal, as well as to the COVID-19 pandemic.

The figure below illustrates the social analysis framework, which has six dimensions: the long-lasting drivers and COVID-19-related impacts and responses, policy environment, agricultural value chain, irrigation equipment and service supply chain, public and private interventions in water resources development, and gender equity and social inclusion (GESI).

The Activity identified policy, social and institutional barriers that prevent women, smallholder farmers and members of disadvantaged groups from accessing irrigation technologies and information, and related financial and technical services. These social groups have limited voices and influence in irrigation decision-making and social networks.

The research concludes that to achieve the vision needed to improve income, nutrition, health, knowledge, and the representation and voices of smallholder farmers, especially women, youth and disadvantaged groups through sustainable and inclusive farmer-led irrigation (FLI) development, the following five strategies are essential to focus on:

- Enable a supportive policy and institutional environment and governance mechanisms for the scaling of sustainable and inclusive FLI development along irrigated agricultural value chains and public and private investment.
- Capitalize upon private sector investment into irrigation equipment and input supply chains; in addition, mainstreaming gender and social inclusion (GESI) in the private sector by partnering with I/NGOs could offer an opportunity to achieve GESI outcomes at the project-implementation level as women's social networks are key to technology adoption.
- Enhance adaptive interventions to support small-scale irrigation and FLI development.
- Support collaborative scaling ecosystem in responding to dynamics and driving changes needed for scaling FLI development.
- Transform the irrigation and agricultural development system (facilitation of inclusive policy process, creation of multi-stakeholder dialogue platforms, institutional capacity development).



Above: *Analytical framework for scaling irrigation development in Nepal (adapted from Minh et al., 2020).*

The findings were disseminated through virtual multi-stakeholder dialogue at the central and provincial level. The discussions in the workshops, in turn, also informed additional analysis and verification of the data and findings of the social component of the research. Based on the social science report, a journal article looking at a systemic analysis of farmer-led irrigation development has been finalized and submitted to a relevant journal for consideration.

The results are useful in providing a holistic understanding of farmer led irrigation development and center-staging smallholder irrigation in Nepal's irrigation development narrative. As the ideas were widely discussed with various stakeholders (private sector, local, national and provincial policymakers, development partners, farmer groups and cooperatives among others) during the research phase, CSISA reached at least 217 (women=49, men=168) such stakeholders directly through interviews, virtual consultations, and the final dissemination workshop. Overall the study has very strong GESI linkages and implications, as it considers it as one of the primary elements affecting inclusive farmer led irrigation development. Among research respondents for the irrigation supply chain, 2 out of 12 respondents were female and hailed from national farmer groups and cooperatives. The findings helped inform stakeholder understanding on the interconnected dynamics of farmer led irrigation development and what linkages need to be carefully considered when further designing new interventions.

Work Package 2: Preliminary development of a digital groundwater monitoring system to inform sustainable irrigation development and management strategies

2.1 Identify groundwater wells appropriate for spatially accurate groundwater monitoring

Background and context: Although much is known about surface water resources and hydrological and meteorological linkages between the Terai, Mid-Hills and Himalaya regions, Nepal currently lacks a comprehensive system for groundwater resource monitoring. Seasonal monitoring of groundwater levels is crucial for current and future sustainable irrigation development and increasing farmers' resilience to climatic risks. What little data is available is not centralized and often not available in digital form. Work Package II responds to this crucial information gap through two associated activities to develop and pilot a preliminary groundwater monitoring system. This Activity was reported in the CSISA Annual Report (October 2020–September 2021).

Above: *Groundwater monitoring data collection assistant Mr. Yogendra Prasad Sundrat sharing his experience and knowledge gained during pilot with government hydrogeologists at the digital groundwater monitoring training and stakeholder discussion workshop, Kathmandu, Nepal, 21 March, 2022. The workshop was the first event in Nepal to (1) train hydrogeologists in the Ministry of Energy, Water Resources and Irrigation on using and improving the piloted digital monitoring systems, and (2) deliberate with stakeholders about cooperation for digital groundwater monitoring to avoid resource depletion. Source: CIMMYT*

2.2 Set up and kickstart of a digital groundwater monitoring system

During the final stage of Objective II, the Activity evaluated the three tested monitoring approaches, trained hydrogeologists of the Ministry of Energy, Water Resources and Irrigation on the learnings of the Activity and improving and scaling the digital monitoring systems, and finally supported policy dialogues across sectors to discuss and plan future cooperation on building digital information systems and more adaptive groundwater management. The GWRDB finally centered on the use of digital tablets for data collection from monitoring wells as their preferred technique. As part of the Activity's sustainability strategy, these activities were led by Nepal's Groundwater Resources Development Board (GWRDB) with the Activity team providing technical support. As a result, 14 government hydrogeologists were trained, three of whom were women.

The dashboard can be accessed at https://gw-nepal.com/ until it is incorporated into the GWRDB's website. Its source code with dummy data are freely available for anybody for their own use, and to provide feedback or improvements at https://github.com/csisarep/groundwater_dashboard. The repository also provides a short overview of the design choices which were made to keep coding requirements to a minimum and accessible to researchers with basic coding and computer skills. Interested researchers, government officials and practitioners from other low income countries may use the system for their own purposes as it is published under an open-source MIT License.

The evaluation led by the GWRDB further showed that the 'Android-based monitoring method' – that is, manual groundwater level measurement with Android-based data entry – is both the most cost-effective and the lowest in terms of risk of technical failure in comparison to the use of technical logging devices. The Android-based method requires more labor but is less technology- and capital-intensive, and is likely to remain the preferred method until labor costs in Nepal have risen significantly. Based on the Activity's experience, evaluation process and training, GWRDB is now able to guide digital groundwater data system and monitoring development, and implement additional scaling of the groundwater systems, with minimal technical guidance.

Given the success of the pilot project, other stakeholders including officials from the drinking water sector, national parks sector, and irrigation sector as well as Sagar Kumar Rai, the Joint Secretary of the Department of Water Resources and Irrigation, have expressed strong interest in scaling the piloted dashboard to a national digital and open groundwater information system. Most stakeholders stated that groundwater levels and other groundwater information are critical to guide their activities – and the pilot dashboard provides a good initial overview in the pilot districts – but also that sharing their own data (e.g. from National Parks) would be a great starting point for collaboration.

To achieve more sustainable and adaptive groundwater management, further scaling and development is now required on both the technical side and on capacity building, to ensure that the data is best utilized across local, provincial and national level planning across different sectors.

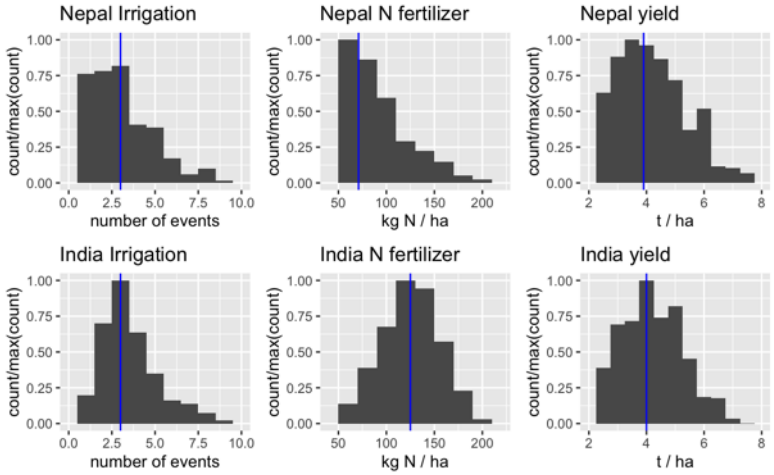
Work Package 3: Provide local, district and provincial level assessments of sustainable water use and development options including risks of unintended consequences at a watershed (and basin) scale, and communicate assessments effectively through training and workshops

3.1 Generating insights into targeting irrigation-led sustainable intensification with machine learning analytics

Background: For decades, programs to support irrigation in South Asia have been driven primarily by the idea of irrigated area expansion. Massive gains in irrigated area have been achieved, increasingly through private investment in shallow tubewells powered by diesel pump sets. Yet despite dramatic irrigated area expansion in Nepal (more than 80% of the almost 6,000 surveyed rice fields in Nepal receive some irrigation), it is generally recognized that many regions are chronically water-stressed and that significant gains in climate resilience, crop productivity and profitability can be achieved through more judicious use of existing irrigation infrastructure while also extending access to unreached households, including women-headed families and other marginalized groups. Nevertheless, the benefits of irrigation intensification are not uniform in time and space; policymakers, development practitioners, and farmers need better guidance on optimal water management practices so that only those regions and farmers that will achieve significant gains are encouraged and supported to increase the use of irrigation.

Approach: Optimal irrigation use is potentially influenced by a host of factors including soil type, landscape drainage characteristics, rainfall distribution, planting dates, crop variety characteristics, and higher order interactions. In complex production environments like in the Terai of Nepal, bigger data combined with advanced machine learning analytics are opening new avenues for untangling the influence of these factors to identify circumstances where there are significant opportunities for irrigation-led sustainable intensification.

Towards this goal, this research workstream combines data from three sources: (1) digital soil maps produced by the USAID-funded Nepal Seed and Fertilizer Activity, (2) a large-farmer sample (>5,900 farmers) landscape diagnostic survey of rice production fields collected from the 2016, 2019 and 2020 harvest seasons by the USAID/Washington Cereal Systems Initiative for South Asia (CSISA), and (3) satellite-estimated daily rainfall (see https://www.chc.ucsb.edu/data/chirps). The field survey data were collected from 14 Terai districts, covering the entire FtF ZoI. As with all data-driven methods, the power of machine learning for predicting systems behavior under different scenarios of change (e.g. increased irrigation intensity) is contingent on the diversity represented in the underlying data. To expand the inference space for the analysis in Nepal, the Activity incorporated similar crop survey and soil property maps from the adjacent rice production ecologies in the Indian states of Bihar and Uttar Pradesh where the CSISA project is also active (see figure below).

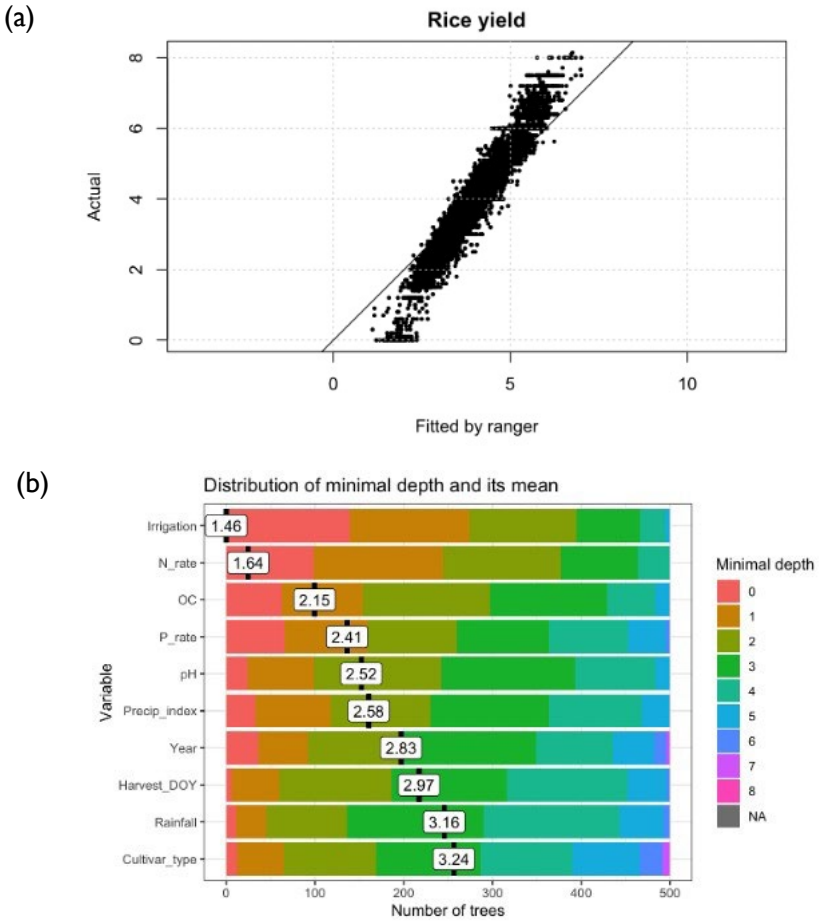


Above: *Distributions of irrigation, nitrogen fertilizer rate, and rice yield outcomes from Nepal and adjacent production regions in India.*

Sub-Activity 1: Construct machine learning-based prediction models for rice productivity

A machine learning model for rice yield prediction was built in the R statistical computing environment using the Random Forest algorithm as implemented in the Ranger package. Sixteen different predictor variables were included in model development, including soil (e.g. texture, drainage class, organic carbon), management (e.g. planting dates, cultivar type) and weather information (e.g. seasonal precipitation, duration of dry spells).

Although the model does not fully predict rice yield variability (OOB R^2 = 0.29), general productivity trends are well-captured including at the low and high ends of the yield distribution (see graph below, panel a). The relative importance of different predictor variable was also assessed by calculating minimal average depth across prediction trees (see graph below, panel b), with lower numbers indicate higher overall importance. Number of irrigations emerged as the single most important production factor to rice yield outcomes across > 14,000 site-years of data.

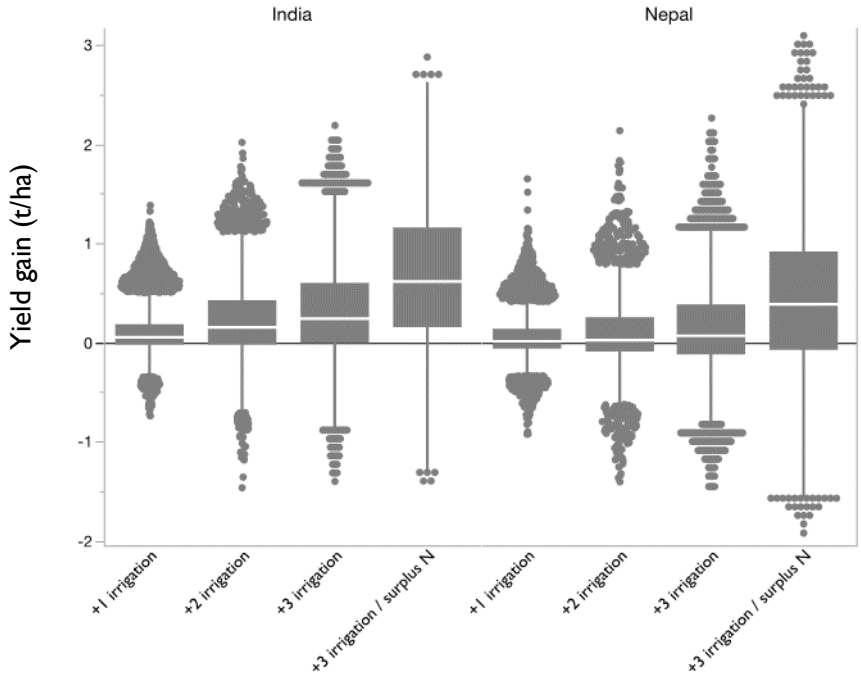


Above: *Rice yield model evaluation, (a) predicted versus measured productivity, and (b) variable importance to prediction for fertilizer rates, soil characteristics, crop management information, and precipitation, as well as irrigation.*

Sub-Activity 2: Scenario analysis to understand the spatial distribution and causal factors associated with responses to increased irrigation

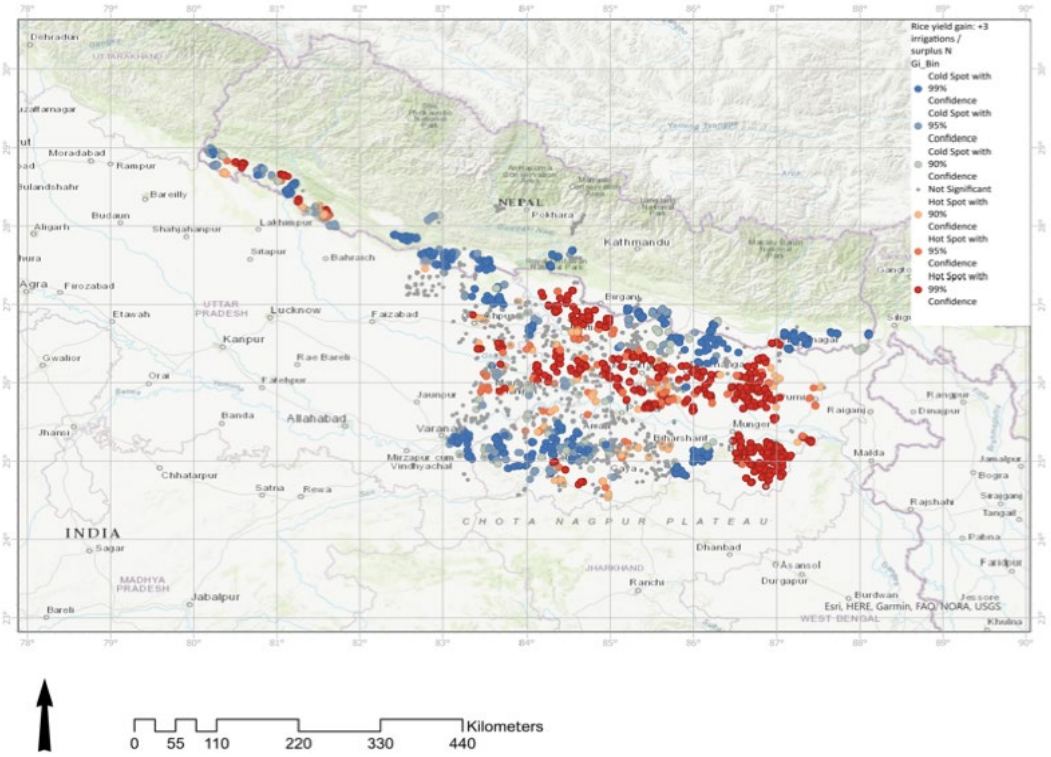
With the yield model developed in Sub-Activity 1, CSISA's scientists then asked a series of 'what if' questions to explore how changes in irrigation intensity and interactions with other agronomic management practices would affect rice yield outcomes. As the median number of irrigations is currently two events per season in Nepal, the analysis was constrained to focus on plausible intensification pathways by estimating advantages of an additional 1, 2, or 3 irrigations above current farmer practices (i.e. S1, S2 and S3). We also explored the interactions between irrigation intensification and soil fertility management by contrasting yield gains achieved with +3 irrigation events coupled with a non-limiting rate of nitrogen (S4) versus the same change in irrigation with existing farmer fertilizer practices. Model simulations were run at the scale of individual farm fields, with prediction results generated for all entire 14,198 sites in the field survey database (5,947 for Nepal).

Yield gains associated with increased irrigation intensity were similar for Nepal and India, with a five-fold higher median increase at +3 additional irrigations versus with a single (+1) additional irrigation (see figure below). Notably, increasing nitrogen fertilizer to non-limiting rates unlocks the value of irrigation, with yield gains among the top quartile of fields in Nepal projected to exceed 0.9 t/ha when irrigation and fertilization use are intensified together (simulation S4).



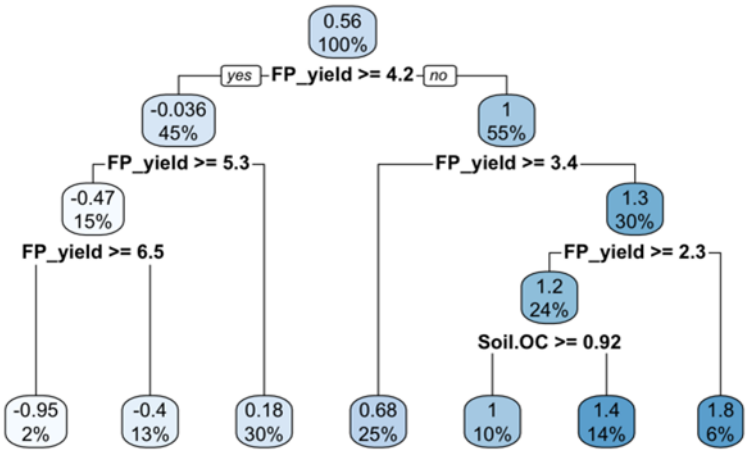
Above: *Model predicted rice yield gains associated with irrigation intensification (S1, S2, S3) and irrigation + nitrogen fertilizer intensification (S4).*

Despite the clear advantages achievable with irrigation, CSISA's analysis also suggests that many farmers in Nepal will not benefit from increased irrigation intensity. The challenge then becomes one of identifying the geographies and specific rice production contexts where investments in irrigation offer the prospect of transformative gains. To address this question, the Activity first explored the spatial distribution of yield responses to irrigation and N fertilizer (i.e. S4) through 'hot spot' analysis with the Getis-Ord Gi* algorithm in ArcGIS Pro. This statistic reveals the level of spatial clustering of yield gains. In the below map, locations with consistently high and positive response to irrigation and nitrogen fertilization are marked in deep red whereas areas with consistently low responses are noted in deep blue. Areas with a lack of field-to-field uniformity are noted in gray, implying that responses to irrigation are heterogenous. In Nepal, the most consistently favorable rice yield responses are present in pockets of the western Terai in Provinces 5 and 7. These areas are the logical focal zones for increasing access to affordable irrigation through the coordination of public and private sector investment.



Above: *Hot spot analysis identifies spatial response consistency to irrigation-led intensification. Areas in red are anticipated to have a strongly positive response that is similar across fields.*

Beyond broad geographic targeting, there is a need to identify site and management characteristics associated with responsiveness to irrigation to guide behavioral change at the scale of individual fields. During the reporting period, the Activity did this by applying classification regression tree (CART) analysis (RPART Package) to the simulated rice yield responses to S4 (i.e. +3 irrigation with non-limiting nitrogen fertilizer).

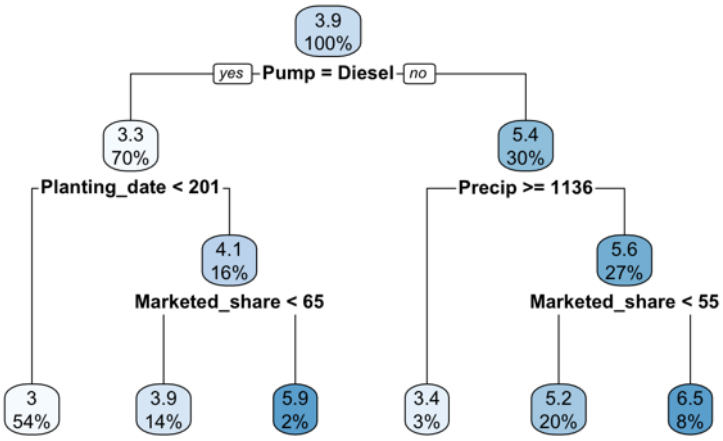


The results suggest that the level of productivity farmers attain before implementing a change of practice can be a good guide for precision management. In CSISA's dataset, farmers with yields greater than 4.2 t/ha are predicted to have very modest gains, whereas farmers with yields lower that 4.2 t/ha (55% of study population) are predicted to gain 1 t/ha, on average, from investments in water and nitrogen. Interestingly, neither cross- or within-year precipitation variability between field sites

emerge as strong predictors for responsiveness to irrigation-led intensification. This analysis provides initial targeting criteria at the geographic and field scales, but insights must be validated through additional on-farm trials that were delayed in this project due to COVID-19 restrictions.

Sub-Activity 3: In areas predicted to be highly responsive to increased irrigation, implement additional field diagnostic surveys that highlight opportunities and constraints that farmers may face in intensifying irrigation.

As an adaptation to COVID-19 lockdown restrictions, additional diagnostic surveys were implemented by telephone among known survey respondents from previous seasons for the 2021 rice crop. The instrument was designed to characterize irrigation decision processes, operational considerations, and resource constraints among farmers with a broad range of prior water management practices. Surveys were implemented as planned, but the atypically strong monsoon in 2021 meant that irrigation intensity and lessons learned were very limited. These surveys will be repeated in 2022.



Above: *Predictors of irrigation intensity (# per season), including pump type, planting date, and share of rice marketed as identified by CART analysis*

To gain some level of insight into irrigation practices before additional data can be collected, we re-analyzed a dataset from adjacent areas of India developed by the CSISA team to explore predictors of irrigation intensity in rice systems with CART (above figure). The resulting data suggest that the pump power source has an very strong effect on irrigation intensity, with farmers availing electric rather than expensive-to-operate diesel pumps irrigating two more times per season. For those using diesel pumps, earlier planting is associated with lower irrigation intensity, presumably due to reduced water requirements for crops that are planted on-time. Lastly, farmers who are well-integrated with output markets invest more in irrigation.

Take-home messages

- Irrigation intensity is the primary driver of rice yield outcomes in the Nepal Terai and, more generally, in the Eastern Ganges Plain.
- However, responses to increased irrigated are not uniform across fields.
- Geographic and field targeting can be used to guide action.
- Nevertheless, transformative rice production gains will only be achieved at scale if companion investments in N fertilizer are also prioritized.
- Farmers have diverse incentives for using irrigation that can supersede yield considerations; understanding incentives and constraints will be key for enabling motivated farmers to implement irrigation-led rice intensification practices.

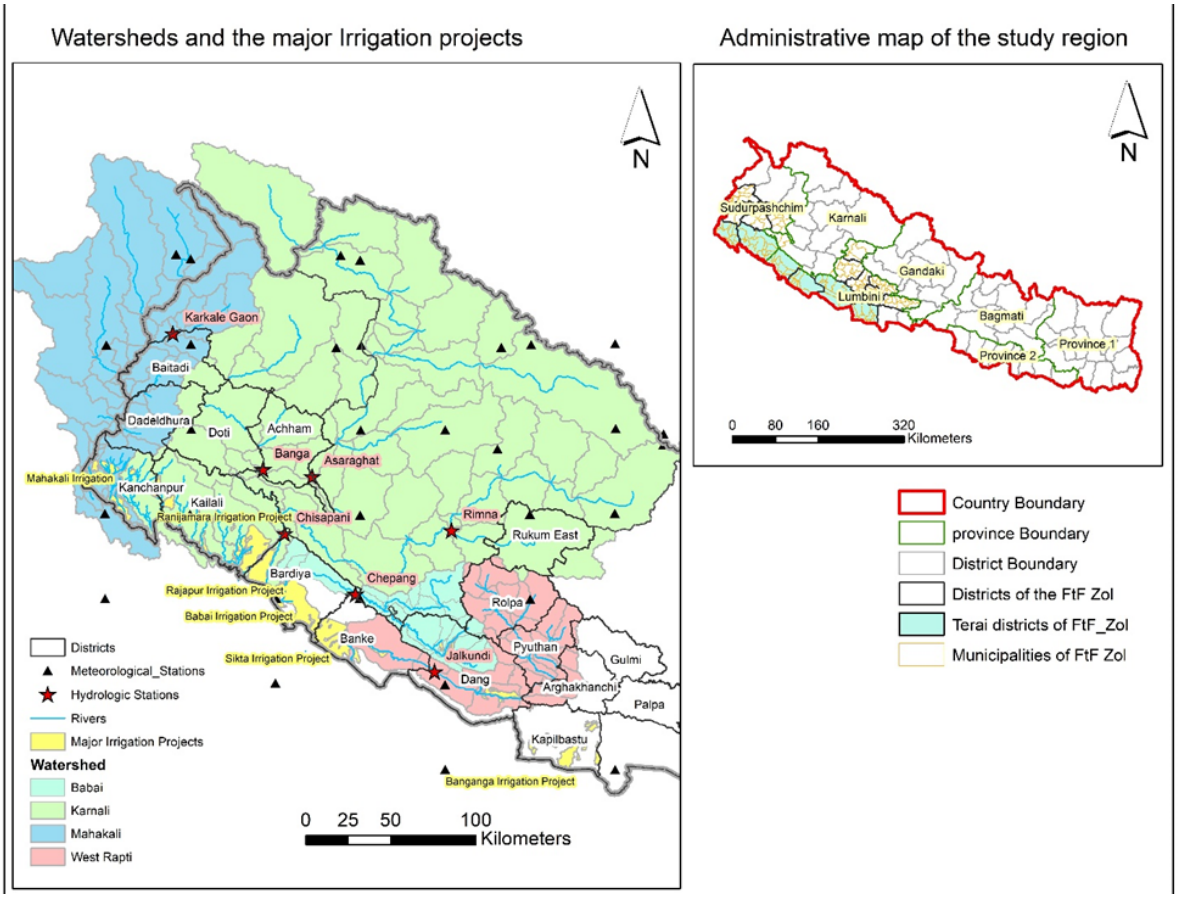
3.2 Integrated crop and hydrological set-up and scenario analysis for sustainable irrigation development

Background: Using insights from Objective I Activity I and II, as well as the data-driven modeling work described above, Work Package 3.2 integrates data sources to develop modeling scenarios that can provide integrated assessments of (a) field, watershed, and basin-level water balances, (c) existing

crop productivity estimates, and (c) economic performance of existing farming systems. This is accomplished using SWAT, a basin-scale physically based model which is used to estimate changes in climate, land use and land management on water, soil and nutrients. APEX is a biophysical model which analyzes the productivity and water/nutrient balance of farming systems. This work is a partnership with the Texas A&M University-led FtF Innovation Lab for Small Scale Irrigation to assess the impact of different farming systems on agricultural production, environmental sustainability and income and nutrition at different geographic scales.

Data preparation: Geospatial data such as Digital Elevation Model (DEM), Land use and land cover (LULC), soil, climate and agricultural management data were collected and prepared according to the SWAT model requirements. A void filled Shuttle Radar Topography Mission (SRTM 2021) DEM of 1 arc-second (30 meters) resolution downloaded from USGS Earth Explorer (USGS 2021) was used for watershed delineation. LULC data for entire study area was prepared combining crop mask for different crops (Rice and wheat) obtained from CIMMYT and available LULC map obtained from International Center for Integrated Mountain Development (ICIMOD 2010). Soil data were prepared from 1 km ISRIC global soil grid in which soil physical and chemical properties were determined using Saxton and Rawls (2006) pedotransfer function. Climatic variables required for model setup such as precipitation, maximum/minimum, temperature, solar radiation, relative humidity, and wind speed for the study area were obtained from Department of Hydrology and Meteorology, Kathmandu (DHM 2021). Precipitation data for the study areas was also extracted from the global precipitation satellite grid (Climate Hazards Group InfraRed Precipitation with Station data (CHIRPS) as an alternative source (Funk et al. 2015) and was blended with the precipitation data obtained from DHM. Similarly, streamflow data required for model calibration and validation were obtained from the Department of Hydrology and Meteorology in Kathmandu (DHM 2021). Agricultural management practice data such as dates of planting/harvesting, irrigation amount and dates, tillage types and dates, and fertilizer rates and dates were obtained from CSISA farm level surveys and expert opinion working in the area.

Model setup and calibration: The SWAT model was setup for the Mahakali, Karnali, Babai, and West Rapti watersheds using a DEM, land use and land cover (LULC), soil, climate, and agricultural management data (Figure 1). Four models Mahakali, Karnali, Babai, and West Rapti were calibrated and validated for streamflow using streamflow data obtained from multiple gauging stations located within the watersheds. Calibrated model parameters from these gauged watersheds were transferred to nearby southern watersheds that did not have observed flow data. The models were also calibrated for rice and wheat yield using the district wise national crop production data.



Above: Location of Watersheds, Major Rivers, Hydrologic, and Meteorologic Stations in the study area for SWAT modeling of irrigation development scenarios.

3.3 Integrated crop and hydrological set-up and scenario analysis for sustainable irrigation development COVID-19 response at the local, district and provincial levels

Scenario development: Multiple scenarios were developed after series of provincial/national level workshops and meetings with other stakeholders. Scenarios were developed by combining crop rotation, irrigation and fertilizer management based on water resource availability, crop suitability and diversification potential, market access, interest of stakeholders, among other criteria. The calibrated and validated SWAT model was used to assess the impact of these scenarios on groundwater resource, surface water resource, crop production, and environmental sustainability. Each scenario was implemented in certain districts within project area according to the feasibility of determined based on experience of the expertise working in the field. Final list of scenarios that were analyzed for the respective districts and provinces are summarized below.

Sustainability of groundwater resource use: The model scenario results suggest that the use of surface and groundwater will be sustainable if their flow/storage are retained dynamically for long-term, inclusive, equitable, use with effective management and governance. Using maintenance of groundwater aquifers as the primary indicator for sustainability, the scenario of closing yield gaps in rice-wheat irrigation system through increased intensity of surface and groundwater irrigation was sustainable in the Mahakali and Karnali watersheds since this scenario did not rely on a single water resource. This scenario used 50% of the irrigation requirement from surface water source and 50% from groundwater source. Such integrated surface and groundwater use can lessen the impact that would have happened if farmers would have relied on either the surface or groundwater. Since Karnali and Mahakali are

large perennial rivers, terai region of Kanchanpur, Kailali and Bardiya districts with irrigation projects such as Mahakali, Ranijamara, and Rajapur irrigation projects can be supplied with year-round surface irrigation. On the other hand, Babai and West Rapti rivers, having very low flow during pre-monsoon and post-monsoon seasons, do not have sufficient water to divert water into canal after leaving 30% of the flow in the river as environmental flow.

List of scenarios and districts for SWAT modeling of irrigation development in the FtF Zone.

Scenario	Description	Districts	Area affected by scenario (ha)
Scenario 1	Closing yield gap in rice-wheat system	Dang, Banke, Bardiya, Kailai, Kanchanpur	724,940
Scenario 2	Vegetables between kharif and spring rice	Bardiya and Kanchanpur	63,243
Scenario 3	Irrigated maize replaces rainfed lentil and fallows	Dang and Kailali	73,653
Scenario 4	Intensified triple cropping instead of double cropping system	Kailali and Banke	375,046
Scenario 5	Replacing rainfed rabi crops by horticultural crops	Rolpa and Argakhanchi (Hilly Districts) Dang (Terai Districts)	9,9061

For this reason, the yield gap closing scenario may not be sustainable for the groundwater resources in the Babai and West Rapti Watersheds as both the supplemental irrigation for the monsoon and irrigation for winter season crops rely on groundwater for irrigation. The scenario may be sustainable in these watersheds if the cultivated area during dry season was reduced by 40% and supplementary irrigation was applied in monsoon season in suitable areas. However, this is a short-term solution; groundwater sustainability can only be achieved through implementation management practices to reduce evaporation such as mulching, conservation agricultural techniques, etc. to reduce water loss and promote groundwater recharge. Such practices could help to enhance the groundwater recharge and reduce risks of groundwater overexploitation over time.

Simulations also suggest that groundwater irrigation was sustainable for the rice-vegetable-rice system when the dry season crop (i.e vegetable and spring rice) was provided with groundwater irrigation and the monsoon season crop (i.e., monsoon rice) received supplementary irrigation from surface water sources. If all the irrigation requirements need to be fulfilled by groundwater source alone, only 48% to 52 % of the total land in Babai watershed, 63% of the cultivated land in the Mahakali watershed, and 45% to 61% of cultivated land in the Karnali Watershed can be irrigated sustainably.

Since lentils required less water than maize, the rice-lentil system was sustainable with current water resource, but the rice-irrigated maize system was sustainable only when dry season crop (maize) was provided with ground water irrigation and the monsoon season crop (i.e., rice) was either provided with surface-water irrigation or rainfed. If all the irrigation requirements need to be fulfilled by groundwater source alone, only 61 to 81 % of the total land can be irrigated sustainably.

In the same way, for the rice-mung bean-wheat system, only 27% to 39% of current cultivated land in the Karnali watershed and 36% to 44% of current cultivated land in West Rapti Watershed can be provided with groundwater sustainably. Those suitable croplands can sustainably extract groundwater

if dry season crop was provided with groundwater irrigation and supplementary irrigation from the surface water sources for the monsoon season crops.

Crop Productivity: In the scenarios, which also included projection of the potential impacts of climate change, average yield of rice and wheat may increase by 17% to 80% and 30% to 217%, respectively if irrigation facilities were expanded in suitable areas for irrigation in Nepal. Of the scenarios, the Rice-Vegetable-Rice and not the Rice-Wheat combination showed the highest increase in production in both current and future climates. Cultivation of Rice-Vegetable-Rice instead of Rice-Wheat, increased total rice equivalent production by 51% in current term (2000-2021), 17% during the near term future (2021-3035), and 34% during the midterm future (2035-2050). Similarly, the scenario of cultivation of Rice-Irrigated Maize instead of Rice-Lentil decreased the total rice equivalent production by 5% in current term (2000-2021), 11% during near term future (2021-3035) and18% during midterm future (2035-2050) because of higher price of lentil than corn.

Similarly, the triple crop scenario instead of current Rice-Wheat increased total rice equivalent production by 130% in current term (2000-2021), 84% during near term future (2021-3035) and 266 % during mid-term future (2035-2050) due to the higher price of mung bean in comparison to rice and wheat. Likewise, the scenario for cultivation of horticulture crops instead of wheat showed that the total rice equivalent production was increased by 61% in current term (2000-2021), 65% during near term future (2021-3035) and 35 % during mid-term future (2035-2050). This was due to the higher price of potato, which affected calculation of rice yield equivalence. In general, however, crop yield and production for winter and spring season crops were lower than desirable in the model, even after sufficient irrigation and fertilizer application. This was due to the generally short growing period and high temperature stress observed, especially under climate change.

Cultivating crops that have a short growing period such as lentils appears to have benefits for groundwater maintenance, particularly given the economic and environmental benefits. Lentil is however climatically sensitive and will require careful disease management and agronomic interventions to significantly raise yield. Similarly, a decrease in crop yield and production during near and midterm future compared to current period was observed due to temperature stress.

In summary, although climate change may increase rainfall, and groundwater recharge is generally sufficient to support large-scale irrigation use, drops in the groundwater table in the dry season (even if aquifers are fully recharged during the monsoon) may cause negative socio-ecological impacts; maladaptation could ultimately decrease farmers' ability to use small irrigation pumps and shallow tube-wells, as well as impacting household access water for domestic purposes, or ecological needs for forests and wildlife. Overall, improving the capacity for groundwater monitoring is required as an early warning system – which can be enabled through consistent monitoring as discussed in Work Package 2 – for groundwater depletion and the potential impact of climate change. Expanding irrigation without monitoring systems in place risks increased water insecurity and maladaptation to climate change.

Work Package 4: Sustainability framework for irrigational development in Nepal's Feed the Future Zone completed

4.1 Move towards self-reliance through training and communication of research insights

Background: Work Packages 1, 2 and 3 closely involved stakeholders in (1) the selection of scenarios for irrigation and multi-use water resources development assessments, and (2) the interpretation and fine-tuning of model scenario outputs, respectively. Activity 4.1 is focused on complementing these efforts through capacity building. Key actions taken during the reporting period include those described below.

TAMU presented modeling results from Work Package 3 in meetings and contributed written inputs into the irrigation sustainability framework that is being released by the Activity in June 2022. Research results indicate that local institutions and farmers require training on improved agronomic practices, ideally in coordination with private sector development efforts that provide local jobs. Further, reliable access to irrigation is critical for improved agricultural productivity, but it is not sufficient. Seed and fertilizer provision must be more reliable, and labor available, or alternative options must be developed to overcome these challenges. This does not mean prescribing specific management rules across all contexts, but rather enhancing local capacity to implement context-specific technologies based on a menu of options relevant to local and individual preferences and suitability.

Combining insights from all Objective II work packages, research also indicated that in some areas, irrigation schemes are unlikely to provide affordable or sufficient surface water irrigation or groundwater recharge, but there may be substantial, deeper groundwater that could be tapped through deep tube wells. As illustrated across all scenarios, the mere provision of canals is unlikely to suffice for irrigation-led transformation. Research shows that groundwater supply chains require strengthening to ease pressure on the canal distribution system and to supply upland areas.

However, across all cases, farmers require access to information about cost-effective and efficient pump choices (e.g. diesel, electric, and solar systems) that best suit their local biophysical conditions and farm's water requirements. Developing community capacity for GESI sensitive coordination for sharing existing infrastructure will furthermore be required to make the most effective access to irrigation water for a broader range of users. Coordinated efforts across the irrigation agencies, Water User Associations (WUAs), cooperatives, local governments, private sector are required to ensure that irrigation water distribution proactively incorporates GESI provisions and user needs.

4.2 Iteratively develop and complete a sustainability and scaling framework for inclusive irrigation development in Nepal's Feed the Future Zone

Background: Conducted in close dialogue with public and private sector stakeholders, this Activity is the ultimate product of Objective II and will identify plausible and equitable irrigation and water development pathways for Nepal's Feed the Future Zone. It achieved the development of a Nepal-specific sustainable and inclusive scaling framework for irrigation development to (a) cooperatively identify high-potential locations for public and private sector interests and incentives to overcome systemic barriers and strengthen sustainable water governance, thereby working to increase farmer's resilience and de-risk private sector agricultural investments. Such efforts also link the model results to

incorporate learnings on the policy implications of farming practices changes resulting from the COVID-19 crisis and other stresses. As described above, the necessary work needed to prepare to begin Activity 4.2 was undertaken during the reporting period.

Results: The CSISA team led developed a Table of Contents for the sustainability and scaling framework for inclusive irrigation development in Nepal's FtF zone. This was then shared with CSISA USAID for comments, after which different CSISA team members were designated to lead the six different components, including the four cross-cutting agenda items of the framework (see figure below). Contributions from different team members were then edited and streamlined to be submitted for further comments from the entire team. The prepared first draft of the framework was then submitted to the relevant stakeholders and USAID for comments, which were addressed.

The final framework report was entitled "*A framework for sustainable and inclusive irrigation development in Western Nepal*" and shared in a stakeholder workshop (28 April, 2022) with participants from different levels of government offices, USAID, INGOs, NGOs, civil society, private organizations and donor agencies. The main purpose of the framework is to guide the Government of Nepal, USAID and other development partners and implementing agencies in investment in sustainable and irrigation development policy and practices in Western Nepal.

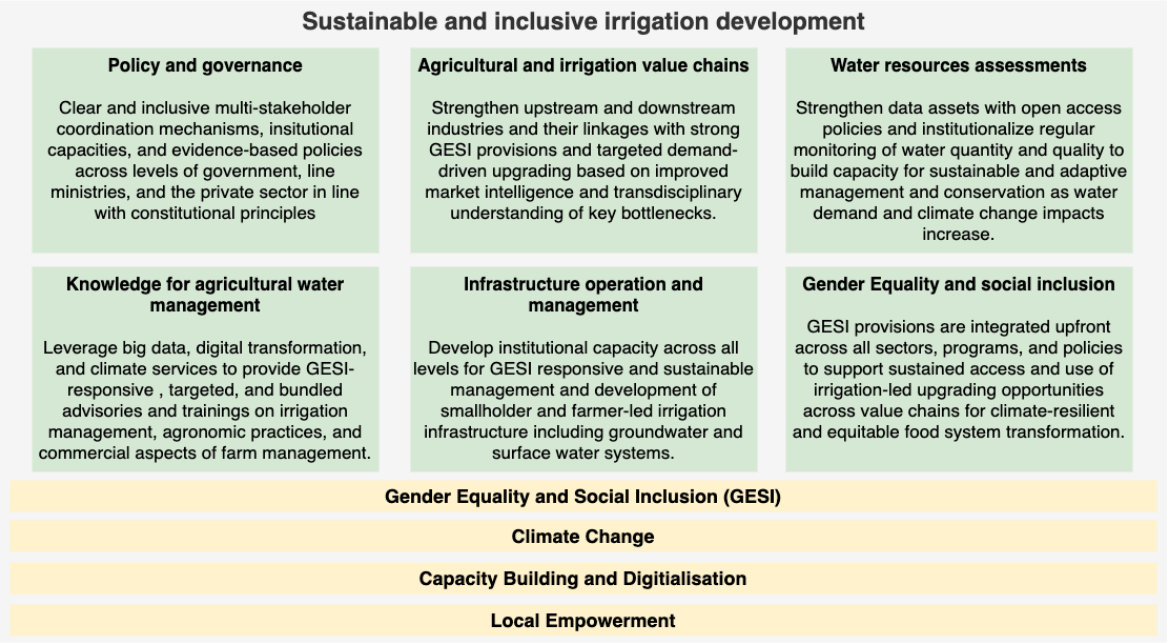
The executive summary of the framework is as follows:

Growing water risks threaten to severely derail Nepal's agricultural development ambitions, requiring substantial investments in better water resources management to meet food security targets, strengthen resilience, and encourage inclusive and private sector-driven growth in agriculture to support Nepal's transition to middle-income status by 2030.

Currently, irrigation development in Nepal focuses primarily on large-scale infrastructure with insufficient data resources to support more adaptative and targeted coordination across sectors and stakeholders. As a result, irrigation development remains expensive and with limited reach relative to the country's needs, while missing opportunities to leverage the private sector, civil society, women and youth.

In response, building climate resilience and boosting agricultural productivity will require more adaptive and inclusive water management approaches, and this report outlines interlinked investment priorities informed by extensive country experience and more than one year of research. The three identified investment priorities are summarized as:

1. Ensure adaptive technology prioritization and water management practices that respond to local resource constraints and equity considerations.
2. Build robust data and information systems to allow adaptive planning, prepare for climate change impacts, and support digital agriculture and targeted farm advisories.
3. Expand and upgrade irrigation and agricultural value chains to ensure access to water, returns on investments, and the creation of better more inclusive jobs.



Above: *Key recommendations and cross-cutting issues for inclusive and sustainable irrigation development in Western Nepal.*

Investments in these interlinked areas are expected to contribute to inclusive and sustainable irrigation development in Nepal that fosters resilient and equitable food systems transformation. Subsequently, farmers may gain assured access to irrigation with incentives in place to keep consumptive water use within an ecologically safe and socially just 'operating space'. As a result, more resilient and higher agricultural production and farm incomes can be achieved while safeguarding the rights of other water users and encouraging biodiversity conservation in neighboring ecosystems.

Objective III: Supporting rapid response and building resilience to Nepal's second COVID-19 wave

Background: From April to late September 2021, Nepal experienced its second large and then its third minor wave of COVID-19, resulting in additional and significant threats to agri-food systems and livelihoods. These have occurred due to lockdowns, transportation and marketing disruption, social distancing (which decreased the ability of farmers and value chain actor to interact with each other) and increased infection rates (which significantly reduced crucial farm labor availability, especially among marginal and women farmers). At the same time, small and medium scale enterprises throughout the FtF ZoI have suffered economically. National food/nutrition security has been undermined by increased costs for imported staples, the unreliability of cross-border trade, and shortfalls in national production both before and during the crisis. The pandemic and resulting lockdowns have also exacerbated the need for reliable and timely information about input and output market access, crop diseases and pests, and insurance and credit, while recognizing the inequalities which limit women's and marginalized groups' access to information and their disproportionate economic burden.

In response, USAID/Nepal provided an additional USD 3 million buy-in as part of the wider CSISA portfolio to support rapid response and continued resilience building in Nepal's agri-food systems. These activities include, firstly, immediate response activities being put into place from September 2021 until June 2023, aim to rebuild effectively key elements of Nepal's agri-food systems and marginalized groups in the FtF zone which have been disproportionately affected by the second wave of the COVID-19 crisis. Key areas of intervention focus on provision of access to finance for small- and medium-scale agricultural input and services provision businesses, recovery, and response in the post-harvest value chain, with emphasis on financial products to benefit businesses involved in perishable farm product marketing and distribution, and expansion of digital banking services supporting socially distanced agricultural finance transactions. In addition, interventions focus on scaling-out agricultural mechanization services through geographical expansion to new districts in which CSISA is not currently working in as part of Objective I activities, while also working to increase national food security and bolster agricultural economies in times of crisis. Lastly, Objective III works to focus on assuring that recovery from the shock of COVID-19 is complete, while at the same time building the resilience of key elements of the agri-food system to better withstand future shocks, including but not limited to COVID-19.

Objective III of the CSISA COVID-19 Response and Resilience Activity has four primary Work Packages described briefly below.

Work Package 1: Assuring small- and medium-scale input and services provision business recovery and rehabilitation through access to finance

Background: This work package develops customized business models for financing and facilitate rapid access to response and recovery loans from financial institutions from the second and third wave of COVID-19, with emphasis on specialized products for women and marginalized groups. The agreements with banks held on behalf of CSISA developed as part of Objective I are being leveraged to offer quick opportunities to facilitate access to finance for other agricultural businesses, including agrovets, agricultural machinery dealers, and businesses associated with agricultural inputs or services owned or operated by women or members of marginalized groups that have suffered from lockdown and COVID-19-induced losses. As such, CSISA is deepening these relationships to develop customized

COVID-19 response business models, banks providing input business support loans to small- and medium-scale agricultural inputs, machinery-dealing businesses, or agriculturally oriented businesses owned by women or members of marginalized communities (or which employ these groups).

1.1 Develop customized business models for financing and facilitate rapid access to response and recovery loans from the second wave of COVID-19, with emphasis on specialized products for women and marginalized groups

Agricultural businesses (including agro-vets, agricultural machinery dealers, and businesses associated with agricultural inputs, or services owned/operated by women or members of marginalized groups) have been greatly impacted by COVID-19-induced economic losses, in both the first and second waves. A rapid assessment was conducted at the beginning of the Activity to identify the impact of COVID-19 on these small/medium scale agricultural input enterprises. The assessment interviewed a total of 144 respondents throughout the seven project districts – 115 agrovets, 24 machinery dealers and five cooperatives – included agrovets working with NSAF and KISAN-II projects. At the end of 2021, 32.6% of agro-dealers reported a 25% reduction in business volume while 31.3% said business was the same as the last year, with no growth, and 15.3% said their business volume had decreased by 25%–50%.

Similarly, lockdown has caused several supply chain-related constraints, including difficulties in obtaining supplies of farm inputs from importers and wholesalers, price increases, and an unwillingness of wholesalers an importers to provide credit. The study showed that compared to the first wave of COVID-19, restrictions in the second wave had a less severe effect on businesses. This may be attributable to the increased adaptive capacity of the business community and the early preparedness of the government system. At the same time, it was observed that micro and small enterprises (mainly those newly established) have been most affected by COVID-19 restrictions, in both phases. This is partly because of their narrow range of networking with supply chain agents and their inadequate experience and skills for dealing with business-associated risk.

Inception meetings: From December 2021 to January of 2022, the Activity held inception meetings in each district, with the objective of informing stakeholders about its activities and focus area. In-person meetings with a total of 233 people were held in all the districts; in Kapilvastu and Surkhet, inception meetings were virtual due to the lockdown resulting from the third wave of COVID-19. Participants were from the *palikas*, key government offices in the districts, district branches of the Chamber of Commerce and Industry, banks and financial institutions, and private sector actors, as well as other projects and non-governmental organizations. The inception meetings were very conducive not only to sharing Activity information with stakeholders but also for future collaboration.

Identifying and facilitating micro, small and medium-scale agri-input enterprises to link with banks: Following inception meetings, the Activity coordinated with local *palikas*, Agriculture Knowledge Center, PMAMP, the Department of Cottage and Small Industries, and local Cooperatives, to identify COVID-19-affectedinput suppliers, machinery dealers and service providers who were in need and willing to take out a loan. CSISA facilitated individual coaching and hands-on support to go through the loan processes and procedures, including assistance with the documentation needed to demonstrate business solvency. To date, the Activity has identified 199 MSMEs seeking loans, 34 of which have been connected to the banks for loan applications that are now in process. However, the speed at which loans have been deployed has been affected by Nepal's ongoing liquidity crisis, for which the Activity is working on alternative strategies to overcome constraints.

Collaboration with banks: A primary focus of Objective III is to improve access to finance for small- and medium-scale agricultural input and services provision businesses and post-harvest enterprises, and the expansion of digital banking services to smallholder farmers. During the reporting period, the Activity facilitated several high-level meetings and interaction with the banks, starting with Mukti Nath Bikas Bank Ltd and Mega Bank Nepal Ltd, leveraging the existing partnership from Objective I. The Activity also reached out to Nepal Bangladesh Bank Ltd, Global IME Bank Ltd and Laxmi Bank Ltd, seeking possible collaboration. Of these, the agreement with Mega Bank Nepal Ltd was finalized[1]. To expedite collaboration in the field, district-level interaction with bank staff from all the branches in the Activity district was conducted. So far, 6 orientations have been conducted in 6 districts. Altogether, 75 representatives from different branches of 27 banks participated in those meetings. These interaction meetings have been pivotal in orienting bank staff to the Activity's objectives and its interventions to support MSMEs and farmers. From each meeting, several of the banks showed interest in working with the Activity and requested the application files.

1.2 Expand and scale access to recovery and resilience-building loans following the second wave of COVID-19

Develop/strengthen last-mile supply chain actors linking them with agrovet enterprises: The majority of local input retailer outlets (agrovets) are located in Nepal's rural areas, with a considerable supply chain gap between market town retailers and end-user smallholders in remote villages. Part of CSISA's work is to develop and strengthen last-mile supply chain actors as 'community business facilitators' (CBFs), linking them with farm input enterprises to promote access to inputs and finance. CBFs are individual entrepreneurs who travel and work within a designated territory of rural communities, selling agricultural products/inputs and paid commission by the input retailers. The Activity facilitates their training enabling them to provide private-sector extension services, to assist their customers to improve, intensify and expand market-oriented agricultural production smallholders with technical services, ensuring they use the products correctly.

During the reporting period, the Activity facilitated comprehensive training on the 'CBF Approach and Sales Skill Development' for team members (2–5 March, 2022), covering recruitment and capacity building to effective management. The field-based team then began coordinating with agri-input suppliers in their district to identify/recruit CBFs. A total of 40 CBFs have been recruited and trained (12 in Dang, 9 in Kapilvastu, 10 in Banke and 9 in Bardiya districts), and linked with 23 agrovets. As well as door-to-door visits to farmers in the villages to promote and sell agricultural products/inputs, they are now holding sales meetings/presentations to trigger sales. The Activity plans to train CBFs in the remaining districts and to train all CBFs in climate-smart agriculture practices, enabling them to promote climate-smart agriculture inputs and technologies to farmers.

[1] During the time of writing, the CSISA-COVID Response Activity signed the agreement with Mega Bank Ltd. Further details on the signature event can be read here: https://csisa.org/csisa_COVID-megabankagreement2022/

Above: *Participants during the 'CBF Approach and Sales Skill Development' in Bardiya district. Photo credit: Khadga Jung Gurung.*

Work Package 2: Specialty financial products and services to reduce post-harvest losses in at- risk perishable farm product value chains

Background: This work package works to increase response to and recovery from the second wave of the COVID-19 crisis for farmers and businesses involved in producing, distributing, and selling perishable and healthy commodities. Specifically, this work package focuses on developing and deploying specialty financial products from banks and lending institutions suitable for unique perishable value chains. Activities will target at-risk businesses owned by women and/or members of marginalized communities which deal in post-harvest horticultural, drying operations, dairy processing, canneries, essential oil distillers, and packaging operations. An additional sector that may be targeted is dairy marketing cooperatives.

2.1 Increase response and recovery from the second wave of the COVID-19 crisis for farmers and businesses involved in the production, distribution and sale of perishable and healthy commodities

To kickstart this work package, a rapid study was conducted within the rural/urban municipalities of four districts (Kailali, Banke, Surkhet and Dang) to reduce losses to farmers cause by the COVID-19 crisis. Its main objective was to identify and assess the prospects of various post-harvest enterprises (mainly in the vegetable, horticulture, and dairy sectors) in the Activity districts in terms of their feasibility, viability and desirability for the development of an appropriate business model. It mainly targeted specific enterprises able to (1) provide post-harvest services to rural communities, and (2) engage more women and/or members of marginalized communities.

The study identified as the most potential and common enterprises in all four districts as (1) pickle-making, (2) dairy and dairy processing, (3) cold storage systems for vegetable and fruits, and (4) packaging materials for fruit and vegetables, and hermetic bags for cereal grain storage.

Identifying potential (existing and new) post-harvest enterprises to link with banks: Over the last six months, Activity team has been coordinating with the district chambers of commerce, Federation of Women Entrepreneurs' Associations of Nepal district chapters, district offices of small and medium cottage industries, and *palikas* to compile a list of post-harvest enterprises in the district, and individuals (or groups) interested in starting post-harvest enterprises. It is also contacting existing post-harvest enterprises and potential farmers/enterprises directly. Up to the reporting period, 66 potential post-harvest enterprises have been listed, of which seven have been connected to the banks for loan applications that are expected to be rapidly approved following easing of the national liquidity crisis.

Training of Trainers on Enterprise and Business Model Development: During the reporting period, the Activity facilitated Training of Trainers on 'Enterprise and Business Model Development' for field team members in Nepalgunj, Banke district, Nepal (25–29 April, 2022). The main objective was to enhance team member's competence in entrepreneurship, devising bankable business plans for local entrepreneurship and entrepreneurs, and their possible roles in strengthening the agricultural entrepreneurship ecosystem at large, with a focus on post-harvest enterprises.

The training followed the concept of a 'boot camp', with participants working together on 'case-based simulations' of seven business cases – essential oils, *sinki* (fermented vegetables), a grain dryer, cold storage, dairy, pickle and tomato ketchup. The Activity is now working with potential post-harvest enterprises, providing them with technical support to prepare business plans.

Above: *Participants during the 'Enterprise and Business Model Development' training practicing a business pitch on essential oils. Photo credit: Ashta Prajapati, iDE Nepal*

2.2 Build resilience to the second wave of the COVID-19 crisis for farmers and businesses involved in the production, distribution and sales of perishable and healthy commodities

The Activity's next step under this work package is to follow up with the banks and entrepreneurs to ensure the loans are disbursed and utilized as per each applicant's business plan. Various capacity-building activities are now underway for those entrepreneurial businesses, such as business management, technical training, and others. Details on outcomes from these trainings will be provided in the CSISA annual report.
The Activity also aims to provide initial backstopping for the marketing and promotion of those post-harvest enterprises. This will include linking them with the target market in coordination with the district chapter of the chamber of commerce and industries and other stakeholders. CSISA is also likely to provide a 1:1 cost-share to support for their products' promotion (e.g., the printing of promotional materials for advertising, etc.). The overall outcomes of these efforts, including quantitative results on impact targets, will be discussed in the CSISA Annual report.

Work Package 3: Digital banking services to support immediate response to businesses and consumers affected by the COVID-19 crisis

Background: Leveraging CSISA's burgeoning partnership with Mega Bank, Nepal's only woman-led banking institution, the Activity is now working to scale a "farmer credit card" product that will capitalize on the context of the existing CSISA COVID-19 Response Activity. This QR-coded, mobile digital card, linked to the buyer's mobile phone, can be used to purchase a range of products related to farming, including small machinery at pre-identified vendors, up to a total of up to USD 2,000. The card has been designed as part of a business model to provide highly competitive interest rates (currently 5.14% with the government subsidy) and long payback periods. In addition, Nepal's Agricultural Development Bank has been working to support similar digital financial services that could be used as part of the immediate response to COVID-19 by facilitating mechanisms for socially distanced money transfer.

3.1 Rapidly increase agro-vet access to digital tools enhancing the sale and purchase of agricultural inputs and commodities in key locations suffering from the economic shock of the second wave of COVID-19 in the Feed the Future Zone

Lack of access to finance creates a significant bottleneck for agriculturally oriented businesses and smallholder farmers in Nepal. Despite the government's introduction of a subsidized interest credit program for the agriculture sector, banks are reluctant to provide loans to smallholder farmers, particularly to those from marginalized communities or women headed households that may not have land title information or sufficient capital to back loans. Estimates suggest that than 99% of small and marginal farmers are in need of capital to access finance and increase productivity.

To address these challenges, CSISA is working together with the company Innovative Solution Pvt. Ltd. to raise awareness and use of the KISAN Card, which can be used with a simple feature phone. KISAN Card aims to facilitate access to finance for smallholder farmers, enabling them to invest in and practice climate-smart/appropriate agricultural technologies, leading them from subsistence to commercial agriculture. The KISAN Card is in the process of being to the banks' subsidized loan schemes; an application needs to be accompanied with a personal PAN number, a photocopy of proof of citizenship, family details, and one-page business idea or plan following a pre-designed format.

Farmers can use the card with registered input suppliers/vendors who use the KISAN credit app on a smartphone. These processes are now being developed by the Activity, with card use intended to ensure controlled financing, as farmers cannot use it to withdraw cash or purchase non-agriculture-related products.

To move towards achieving these goals, the Activity has had rounds of discussions and brainstorming with Innovative Solution and has signed an agreement with the company to facilitate activities. A virtual orientation program briefed the Activity team about the Card and its working modality. During the reporting period, CSISA also approached agrovets, agriculture machinery dealers and farm machinery service providers individually to get them onboard with the Kisan Card as vendors/merchants. So far, 21 SMEs have been onboarded as vendors; the Activity is in the process of enrolling 370 agricultural input suppliers as Kisan Card vendors. Mega Bank is also a key partner for the use of the Kisan Card; the Activity has met with them and agreement to collaborate has now been finalized. This agreement will unlock use of more than 2,500 Kisan Cards, named 'Mega Smart Krishi Card', under this partnership, of which 500 are expected assist in loans to individual farmers and agriculturally oriented businesses.

CBFs will now promote the Kisan Card while visiting farmers to promote climate-smart agriculture technologies and inputs. It could be through direct door-to-door visits (direct sales presentations) or group sales presentations. In the following months, CSSIA will conduct target group meetings in some places identified by ward members, key persons and CBFs, support listed farmers to prepare the relevant documents and submit them to the bank and identify and enroll individual interested farmers. So far, 33 farmers (15 each in Kailali and Bardiya, and three in Dang) have taken out the Kisan Card to purchase agricultural inputs and a further196 farmers have applied to do so.

Above: *Sample of the 'Mega Smart Krishi Card' issued to Mr. Ram Bahadur Chaudhari with support from the Activity.*

3.2 Scale-out access to digital tools enhancing the sale and purchase of agricultural inputs and commodities in the Feed the Future Zone

Work Package 4: Geographical expansion of socially-distanced and COVID-19-safe agricultural mechanization services

4.1 Horizontally expand socially-distanced and COVID-19-safe agricultural mechanization services in the Feed the Future Zone

The key activities in Work Package 4 during this reporting period were: (1) expansion and re-establishment of offices and staff in the Mid-Hill district of Surkhet, making CSISA operational in seven

districts, (2) the recruitment of additional staff (two market systems specialists, based in Dang and Surkhet, and a finance and logistics assistant, based in Surkhet), and (3) assessment and refinement of the Activity for GESI-responsive programming. The actions taken in response included an assessment of policies and procedures of partners (including banks, machinery suppliers and dealers) for input related financial products, with bottlenecks divided into short-term/immediate, medium-term and long-term actions.

Considering the Activity's short life cycle, 'immediate actions' were taken care of in the reporting period. This included the orientation of partners and stakeholders to GESI-responsive programming, advocacy for prioritizing women, and poor and disadvantaged people in the services and offer that they provide and securing institutional commitments to adopt a GESI-sensitive approach, (4) preparation of an inventory of potential target beneficiaries (dealers and suppliers, service providers and returnee migrant workers), and (5) linking farmers needing loans to banks to purchase farm machines. These included 58 new returnee migrants forced to return to Nepal due to the COVID-19 crisis who purchased machines and entered into fee-for-hire entrepreneurial services with farmers as clients, and (6) demand creation through awareness-raising campaigns using mass media (broadcasting jingles from local radio stations/FM, distribution of flyers and flex danglers, visiting suppliers' and dealers' shops) was deployed.

Above: *promotional board of Mr. Ramlal Tharu (machine service provider) from Ghodaghodi Municipality, Kailali district. Photo credit: Surya Bahadur Khadka.*

Besides Surkhet, this work package also focused in Bardiya and Kapilvastu districts. In Surkhet, a key challenge has been time spent in building relationships with stakeholders and partners with, until the end of April, a very limited number of staff. Scaling of mechanization is also anticipated to be a relatively slower process than in Terai districts due to the topography and small size of land parcels – our assessment shows that while there is some appetite for mini tillers and other small-sized machines

such as water pumps; there is none for larger machines such as power tillers or harvesters. Another challenging district is Kapilvastu where, despite ongoing operations since last year, no substantive progress has been observed. For this year therefore, Kapilvastu may be dropped in consultation with USAID.

Above: *Business facilitation linkage group meeting to identify interested youths to become farm machine service provider entrepreneurs. Mr. Tulsi Prasad Chaudhary, Field Supervisor, explained the benefits of working as a machine service provider. Photo credit: Janga Bahadur Gurung.*

In the course of the pandemic and lock-downs in 2021, the Activity facilitated the provision of technical assistance via phone calls. CSISA also supported on-farm demonstrations of new machinery, seed drill calibration, and the repair and maintenance of maize seed drills. Radio jingles had a crucial role in demand creation. As a result, coverage of directly seeded rice was 12 ha of land, mechanical rice transplanting covered 15 ha of land, and mechanized wheat and maize coverage was 13 ha and 16 ha respectively. This was achieved through custom hiring centers, cooperatives and individual service providers, all observing COVID-19 safety protocol. In addition, Individual service providers supported by PMAMP were trained in the troubleshooting of power tillers and their attachments (such as reapers and seeders), the optimum time of servicing to increase the life of machinery, and seed and fertilizer calibration of seed drill machines (which saves time, energy and money at the time of seeding). The Activity facilitated three days of training (12–14 December, 2021), delivered by RCT custom hiring center, Jhalari Kanchanpur, financially supported by PMAMP, the Ftf Rice Super Zone, technically supported by CSISA. Participants were also trained in the multiple use of the power tiller (ploughing, seeding, transportation and irrigation). Participating custom hiring centers were Nabodaya Shahakari, Udayadev Sahakari and Shanti Shahakari from Bhimdutta and Samhautaa Sahakari, Belauri, all from Kanchanpur district. The total number of participants was 17.

4.2 Deepen socially distanced and COVID-19-safe agricultural mechanization services scaling

Currently, there are few women in the agricultural machinery value chain workforce, despite a generally expressed interest in it following the COVID-19 crisis. CSISA's GESI assessment showed that barriers include socio-cultural and gender norms run contrary to activities such as machinery operation. To address these gaps, the Activity carried out awareness-raising programs, advocating that

machinery suppliers and dealers, custom hiring centers, Nepal Government's Prime Minister Agriculture Modernization Project (PMAMP), AKCs and other donor-funded programs in these districts take affirmative action, and have special provision in the subsidy policy to motivate women to participate.

The Activity also provided an advice service on types of machine with high potential for scaling; among women, and as a result, 34 loan request documents were submitted. CSISA also drafted a "Challenge Fund Program" document to involve private sector organizations – machinery dealers and suppliers – in demand creation and service provision of different farm machines.[2] The intention is to get targeted funds to companies which genuinely need them and can use them effectively to realize the Activity's broader aims, and to do so on a competitive expression of interest and co-design basis, with a 1:1 cost share.

At the time of rating, CSISA is reviewing business applications to advance them to the next level. They are being scored for their ideas which should have a positive impact on the rural poor, delivering increased employment and income, reduced costs and improved productivity for their businesses. The competition rules favor ideas that focus on profitable and sustainability in enterprise development, and the provision of evidence that the companies involved have the technical and financial capacity to deliver. These ideas should be innovative, promote resource-conserving technology and strengthen/develop a mechanism for repair, maintenance and after-sales services. Further details will be provided in the CSISA Annual Report, although the Activity mainly anticipates proposals and co-design to facilitate markets for farm machinery of high potential (viable and profitable for end uses) but which still need a 'push' to increase purchase and adoption. This could be (but are not limited to) seed drillers, mini combine harvesters, dehuskers, weeders, chaff cutters, electronic rice threshers, poultry feed makers and jab planters.

[2] A challenge fund is a mechanism for allocating and disbursing funds effectively and fairly. Private sector organizations are invited to bid for scarce resources, not unlike a tender but where the quality of response is more important that the price. Rules cover eligibility, the bidding process and the way bids will be evaluated. To avoid any possible conflict of interest, two separate bodies administer the process and decide who gets an award.

Challenges Faced During the Reporting Period

No major constraints, challenges, or problems were encountered **in Objective I** in the reporting period. This was because most of Objective I's activities concluded in the third quarter of 2022.

Objective II was constrained by a lack of reliable hydrological data at multiple stations in the Activity areas (lack of recent hydrologic observation data and lack of reliable hydrologic data at seasonal river gauges). In addition, COVID-19 restrictions limited travel and in-person engagement, which limited communication between project partners, reduced the depth of in-person workshops for scenario development, and required an adapted approach to training workshops.

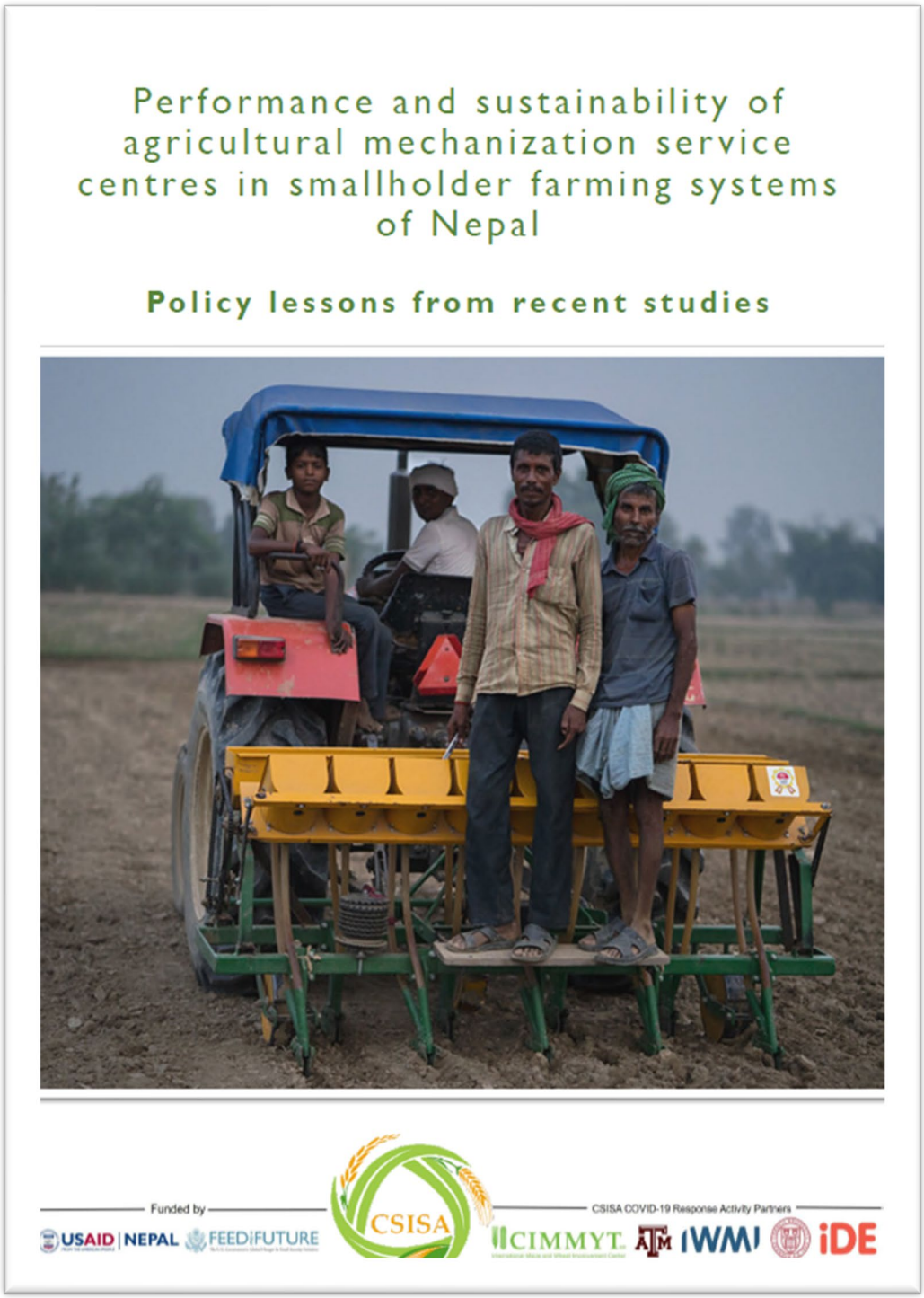
Considering **Objective III**, Nepal's liquidity crunch started at the end of 2021 and resulted in banks being forced to reduce overall loans, including to the productive sector. This has significantly affected CSISA's efforts in Objective III, with many banks reluctant to take risks on new agreements of innovative loan products such as those encouraged by CSISA. As such, progress towards targets in Objective III, in which all work packages depend on cooperation with financial service providers, has been slow.

Some of the key contributing factors are Nepal's increased dependence on imports of goods coupled with the drop in remittance inflow in recent months. Remittances are a leading contributing factor in the increased disposable income of individuals and a country's GDP (in Nepal's case, constituting about 30% of GDP). The steep drop in remittances as a result of the COVID-19 crisis has raised concerns that any further decline in the figure could lead to a structural imbalance at the macro level. Liquidity problems may also be affected by the Russia-Ukraine crisis, and resulting speculation, inflation, and use of FOREX reserves to secure staple foods.

In order to ease the liquidity crisis, Nepal's central bank has taken several measures, from injecting additional money into the financial market, imposing a requirement upon importers to deposit 100% cash in banks to open letters of credit for imports of luxury goods (including vehicles), as well as a temporary ban on the import of various products. However, the situation has not improved significantly at the time of writing. For this reason the Activity is now in discussion with USAID about a potential change in strategy to expand loan services provision to include agricultural cooperatives, increased focus on the most receptive banks, and a range of other mechanisms. However, some of the Activity's quantitative targets, most of which will be met by unlocking access to finance, may need to be refined given the ongoing crisis. Further updates on these issues will be provided in the 2021-22 Annual Report.

Annex I – Performance and sustainability of agri-mech centers workshop report

The online workshop on 'Performance and sustainability of agricultural mechanization service centres in smallholder farming systems of Nepal: Policy lessons from recent studies' was held via zoom on January 31, 2022. The workshop summary report can be found here: Virtual Workshop Summary Report.



Annex 2 – CSISA-COVID Response Key Leadership Staff

Name	Role	Institution	Duty Post	Email
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Annex 3 – Key Partners

Partner	Partnership objective	Alignment with Objectives	Leveraging opportunity	Status of partnership
Government of Nepal				
Ministry of Agriculture and Livestock Development	Technical guidance for Government of Nepal investments in agricultural development	All Objectives	The government's Agriculture Development Strategy (2015–2035) was approved in late 2015. CSISA acts as a technical partner to shape the loan and investment programs associated with the strategy, which may exceed USD100 million.	Active and sanctioned by CIMMYT's host country agreement
Nepal Agricultural Research Council (NARC)	Strategic and applied research on sustainable intensification technologies, crop diversification, and crop management practices	All Objectives	NARC is responsible for providing the scientific basis for all state recommendations, their endorsement and the ownership of emerging sustainable intensification technologies	Active and long-standing
Groundwater Resources Development Board (GWRDB)	Strategic and applied research on the digital groundwater data system and monitoring development, and implement additional scaling of the groundwater systems.	Objective II	GWRDB existing monitoring wells were installed as part of a wider project to characterize groundwater resources, suggesting that substantive investigation to ensure appropriate siting could be conducted.	Active
Provincial government	To strengthen provincial-level policies and provincial government support for agricultural development activities	All Objectives	Provincial governments are the middle tier of government under the new federal constitution and have a large degree of independence. They have important policy-making and oversight roles on agricultural development. The CSISA-COVID Response Activity engaged with the Karnali, Sudurpashchim and Lumbini Provinces.	Active

Local government	To strengthen local government support for agricultural development activities	All Objectives	Local governments are the local tier of government under the new constitution. They have significant roles for implementing agricultural development in their areas and are thus important stakeholders that the project seeks to engage.	Active
Nepali private sector				
Mahalaxmi Traders (farm machinery importer and dealer)	Introduction and market development of scale-appropriate machinery	Objective I & III	The rapid expansion of investments in scale-appropriate machinery and support for emerging service provision markets.	Active and long- standing since CSISA-II
Swostik Traders (farm machinery importer and dealer)	Introduction and market development of scale-appropriate machinery	Objective I & III	The rapid expansion of investments in scale-appropriate machinery and support for emerging	Active and long-standing since CSISA-II
Muktinath Bikas Bank Ltd. (MNBBL)	Access to finance	Objective I & III	Developing risk-reducing financial services arrangements that could facilitate increased access to loans for agricultural machinery.	Active since 2020
Nabil Bank	Access to finance	Objective I & III	Developing risk-reducing financial services arrangements that could facilitate increased access to loans for agricultural machinery.	Active since 2020
Mega Bank Nepal Ltd.	Access to finance and digital banking	Objective I & III	Developing risk-reducing financial services arrangements that could facilitate increased access to loans for agricultural machinery.	Active since 2020
Muktinath Bikas Bank Ltd. (MNBBL)	Access to finance	Objective I & III	Developing risk-reducing financial services arrangements that could facilitate increased access to loans for agricultural machinery.	Active since 2020

Century Commercial Bank	Access to finance	Objective I & III	Developing risk-reducing financial services arrangements that could facilitate increased access to loans for agricultural machinery.	Active since 2020
R&D Innovative Solution Pct. Ltd.	Access to finance and digital banking	Objective I & III	Developing risk-reducing financial services arrangements that could facilitate increased access to loans for agricultural machinery and promotion of digital banking services.	New and active
Partners				
Knowledge-based Integrated Sustainable Agriculture and Nutrition (KISAN)	Strategic partnership to co-support the large-scale deployment of extension information and technologies	Objective I & III	The KISAN project, part of USAID's global Feed the Future initiative, is a USD 20 mi five-year program to advance food security by increasing agricultural productivity. KISAN uses CSISA's technical and extension materials and advice to improve the uptake of better-bet sustainable agriculture production and post-harvest practices and technologies for cereals. KISAN reaches hundreds of thousands of farmers and exposes them to CSISA information, materials, and technologies.	Active since KISAN's first phase
Nepal Seed and Fertilizer Project (NSAF)	Strategic partnership to co-support the large-scale deployment of extension information and technologies	Objective I & III	The USAID Nepal-funded NSAF project (USD 15 mi for 2016–22) focuses on the applied science-to-development continuum, including market facilitation to expand private sector-led fertilizer and seed sales. CSISA is disseminating the better-bet technologies at scale through NSAF's networks.	Active since 2016/17

The CSISA-COVID response Activity is a buy-in from the USAID/Nepal mission to the broader CSISA program. It aims to rapidly and effectively respond to the threats posed by the COVID-19 crisis that undermines the recovery and sustained resilience of farmers in the Feed the Future (FtF) Zone of Nepal.

The first objective expands the use of scale-appropriate farm machinery to generate employment, lower production costs for farmers, and create new entrepreneurship opportunities in the context of a COVID-19 affected Nepal. The second objective focuses efforts to develop appropriate and sustainable irrigation planning and development in Nepal, while also considering how irrigation can increase resilience and generate income for smallholder farmers The third objective aim to effectively rebuild key elements of Nepal's agri-food systems and marginalized groups in the FtF zone that have been disproportionately affected by the second wave of the COVID-19 crisis. Key areas of intervention focus on the provision of access to finance, expansion of digital banking services and scaling-out agricultural mechanization services through geographical expansion to new districts.

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