ACIAR SDIP Program

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ACIAR SDIP Annual Report

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Contents

Acronyms

ACIAR	Australian Centre for International Agricultural Research
APSIM	Agricultural Production Simulator
ASR	Aquifer Storage and Recovery
ATMA	Agricultural Technology Management Agency, India
AWD	Alternate Wetting and Drying of soils for irrigation of crops
B	Boron
BAU	Bihar Agricultural University
BWS	Best Worst Scaling
CA	Conservation Agriculture
CASI	Conservation Agriculture based Sustainable Intensification
CASPA	Conservation Agriculture Service Provider's Association, Bangladesh
CECA	Centre of Excellence for Conservation Agriculture
CGED	Centre for Green Economic Development
CHC	Custom Hiring Centre
CIMMYT	International Centre for Maize and Wheat Improvement
CRAP	Climate Resilient Agriculture Programme, Bihar
CSIRO	Commonwealth Scientific and Industrial Research Organisation
CT	Conventional Tillage
DoA	Department of Agriculture
DoA-WB	Department of Agriculture – West Bengal
EGP	Eastern Gangetic Plains
ET	Evapotranspiration
FEW	Food-Energy-Water
FGD	Focus Group Discussion
GHG	Greenhouse Gas
GW	Groundwater

GoWB	Government of West Bengal
ICIMOD	International Centre for Integrated Mountain Development
iDE	International Development Enterprises
IFPRI	International Food Policy Research Institute
IMPACT	International Model for Policy Analysis of Agricultural Commodities and Trade
IGP	Indo-Gangetic Plain
IWMI	International Water Management Institute
LSP	Local Service Provider
MAgPIE	Model of Agricultural Production and its Impact on the Environment
MoLMAC	Ministry of Land Management, Agriculture & Cooperative, Nepal
MOOC	Massive Open Online Course
MSG	Multi-Stakeholder Group
N	Nitrogen
NABARD	National Bank for Agriculture and Rural Development, India
NARC	Nepal Agricultural Research Council
NBL	National Bank Limited, Bangladesh
NFSM	National Food Security Mission, India
NGO	Non-Government Organisation
RDRS	Rangpur District Relief Services
SDIP	Sustainable Development Investment Portfolio
SNA	Solidaridad Network Asia
SPD	Science Policy Dialogue
SRFSI	Sustainable and Resilient Farming Systems Intensification project
SSCOP	Satmile Satish Club 'O' Pathagar
UBKV	Uttar Banga Krishi Viswavidyalaya
VMP	Versatile Multi-crop Planter
WB	West Bengal
Zn	Zinc
2WT	Two Wheel Tractor

1. EXECUTIVE SUMMARY

Statement of Progress

The ACIAR SDIP program goal is to **maximise agriculture's contribution to sustainable food systems in the Eastern Gangetic Plains (EGP)**, for improved food, energy and water security. Over eight years the program has transitioned from understanding and promoting sustainable farming technologies based on conservation agriculture, to include the wider context of the food system and a deeper understanding of the various external factors which influence sustainable food production.

Overall, the ACIAR SDIP program has made good progress in 2019-20 towards end of phase outcomes, which has now shifted to June 2021 (a small costed extension was approved early in 2020). ACIAR SDIP is implemented through five interlinked components. The priority for the year has been to ensure synthesis across the program's operations and outputs. Individual projects and activities have produced insights into impacts of climate change, the sustainability of soil and water use, the empowerment of women, factors affecting farmer incomes, optimal institutional arrangements, mechanisation, and explored connections to larger private sector companies.

The Foresight component has completed a series of status papers and commentary that synthesise overall trends affecting the food, energy and water nexus related to food production (see collection here), which contributes to a higher-level understanding of food systems in the EGP, including in the context of the COVID-19 pandemic. Local level work has commenced with diverse stakeholders including from the research, community and farming sectors, who have been exposed to the concept of foresight and systems approaches within their areas of research and operation, and are working on critically analysing the applicability of these approaches at different scales.

Work on institutional innovation has continued, and a conceptual element includes novel approaches to identify characteristics of effective institutions using primary and secondary data. On a practical level, there has been excellent engagement at the provincial level in Nepal, and local and state levels in West Bengal.

At the field level, emerging biophysical constraints to conservation agriculture practices in the medium term have been identified, including soil constraints (acidification and zinc deficiency) and sustainable groundwater availability. In positive news, new research has confirmed that weeds are effectively managed by men and women, with generally no additional labour burden, given availability of appropriate herbicides. Over 113,000 farmers (25% women) continue to use CASI farming techniques, with an additional 30,950 new users in 2019-20.

Analytical studies on groundwater development in the EGP have highlighted the unintended consequences of many common policy instruments used to promote groundwater development and sustainability.

We have contributed to a nuanced understanding of gender inclusion and empowerment, recognising that it is not adequate to use a single approach to helping women farmers without understanding the different patterns, outcomes and causes of defeminisation or feminisation of agriculture.

Communication of key results with higher level policy makers has been delayed on all accounts due to COVID-19, but significant effort will be devoted to this in the remaining year of the project to ensure impact.

Highlights from 2018-19

1. Continued scaling of Conservation Agriculture based Sustainable Intensification (CASI) approaches, with an increasingly nuanced understanding of the science behind the scaling. **CASI farming practices increase productivity and farm incomes and have emission reduction benefits.** In 2019-20 an additional 30,950 households began using the techniques, bringing the total to **113,851 farmers (25% female)[1] now using more productive, profitable and gender inclusive farming systems.** The cumulative impacts of this adoption over the past five years include an additional AUD $51,000,000 in farm household income.
2. **Using a food-energy-water (FEW) nexus lens, new studies have explored commonly used policies aiming to influence groundwater development and sustainability, and results indicate the links are not always as expected.** For example, increased access to electricity has not resulted in a strong change in groundwater use or productivity in West Bengal; and water savings at the farm scale do not always result in reduced groundwater use overall. In the EGP, impacts of climate change will result in delayed monsoons and increased incidence of flooding, which makes summer crops more vulnerable to water stress (both too much and too little). Groundwater resources, which are annually recharged as multiple ACIAR SDIP studies have confirmed, are more resilient to climate change and offer assured irrigation in the dry winter months.
3. **In Nepal, the Roadmaps process proved to be an effective institutional process connecting farmers' groups, policy makers, machinery owners and scientists to improve agricultural productivity** in Province 1 and 2, which have the potential to be the food bowl of Nepal. This project addressed a key demand for mechanisms to promote coordination and develop a plan for agricultural machinery use that supports CASI technologies.
4. Novel extension methods have been used to promote CASI to different stakeholders. **Over 8,000 participants joined the first ever Massive Open Online Course (MOOC) covering Conservation Agriculture-based Sustainable Intensification (CASI),** delivered by Bihar Agricultural University (BAU) in partnership with CIMMYT. This course provided a comprehensive overview of CASI to an audience ranging from farmers to extension officers and policy makers.
5. **A more nuanced understanding of climate change impacts related to CASI systems has been possible through further modelling activities.** Results indicate that under climate change, yields for Rabi (dry winter) season crops will decrease, but Kharif (wet summer season) rice yields will increase, assuming irrigation is secured. Simulated emissions were reduced by around 24% by employing CA technologies in the rice-maize and rice-wheat cropping systems.

[1] Number of farmers using CASI practices is reported by partners, who receive information from block level Department of Agriculture staff.

COVID-19 Impacts

A small costed extension until June 2021 had already been implemented prior to the major disruptions triggered by the COVID-19 pandemic in March 2020. This has allowed no-cost extensions to be agreed with ten projects, to give them more time for completion of key activities. The major impacts on these projects are in the implementation of end-of-project quantitative surveys; field visits for community level meetings and dissemination activities; and delays to planned international workshops and meetings, including the program review and the Foresight for Food Systems event which was scheduled for October 2020. All projects have re-organised their work schedule, and we are working closely with Project Leaders to monitor and update plans as required. There are alternative plans in place for all project activities, including moving to phone surveys; increased use of secondary data; and moving meetings and workshops to virtual methods as required.

Table 1 Aggregate Results Table

No.	What	Annual Result (2019-20)			Cumulative results for SDIP2 (2016 - current)			Cumulative results for SDIP (2013 - current)		
		Women	Men	Total	Women	Men	Total	Women	Men	Total
1	Numbers of farmers (women and men) who adopt sustainable agricultural practices that increase resource efficiency and climate resilience (disaggregated)	4,785	26,165	30,950	28,392	85,459	113,851	28,392	85,459	113,851[2]
2	Numbers of farmers (women and men) with increased incomes (disaggregated)	4,785	26,165	30,950	28,392	85,459	113,851	28,392	85,459	113,851
5	Numbers of women & men who have undertaken prof. development and/or technical training opportunities (short courses, study modules, exchanges, high level study tours,…) (disaggregated)	1,372	9,274	10,646	19,415	52,877	72,292	19,415	52,877	72,292
6	Numbers of women and men who have been supported to undertake specific graduate (Masters etc) programs related to water-energy-food issues (disaggregated)	1	7	8	2	9	11	5	21	26
7	Numbers of women and men that have participated in key knowledge/dialogue/policy forums (disaggregated)	1,019	853	1,872	1,014	1,024	2,038	1,021	913	1,934
8	Numbers of women and men stakeholders who have participated in stakeholder consultations regarding water-energy-food issues (disaggregated)	207	479	686	5,609	14,073	19,682	5,625	14,023	19,648
9	Numbers of women and men who have been supported to become micro-entrepreneurs (disaggregated)	14	184	185	39	406	445	39	406	445
10	Number of new knowledge products that incorporate a gender lens			1			6			6
11	Number of new knowledge products that directly address knowledge gaps on gender (and include sex disaggregated data)			7			34			34
13	Quantum of greenhouse gas emission (CO_2 equivalent) reductions (disaggregated by type):									
	(ii) agriculture resource efficiency			6,968			25,083			25,083
	TOTAL			6,968			25,083			25,083
14	Cubic metres of water saved through resource efficiency measures (disaggregated by sector):									
	(ii) agriculture			7,297,000			26,314,000			26,314,000
	TOTAL			7,297,000			26,314,000			26,314,000
15	MWh of power saved through resource efficiency measures (disaggregated by sector)									
	(ii) agriculture			30,403			109,642			109,642
	TOTAL			30,403			109,642			109,642
18	Quantum of finance leveraged from private sector/government programs (disaggregated by type):									
	i) climate change finance									$ 15,000,000[3]
	TOTAL									$ 15,000,000

[2] Number of farmers using CASI practices is reported by partners, who receive information from block level DoA staff. As the number of farmers using CASI practices increases, it is becoming more difficult to track the adoption rates.

[3] Government programs influenced by SRFSI project include Climate Resilient Agriculture Program in Bihar ($11 million); DoA-WB ATMA ($3 million); UBKV ($0.5 million); Other ($0.5 million)

2. BACKGROUND

ACIAR SDIP Goals and Objectives

The ACIAR SDIP program goal is to **maximise agriculture's contribution to sustainable food systems in the Eastern Gangetic Plains (EGP)**, for improved food, energy and water security. The program has transitioned from understanding and promoting sustainable farming technologies based on conservation agriculture in SDIP Phase 1 (see summary here), to include the wider context of the food system and a deeper understanding of the various factors which influence sustainable food systems. The ACIAR SDIP Investment Strategy outlines ACIAR's contribution to Phase 2 of the SDIP, and focuses on sustainable food systems as a way of integrating different sectors at a range of scales, and ensure gender-inclusive planning processes and outcomes. The aim is to promote resilient and inclusive food systems supported by robust institutional arrangements, policies and strategic regional planning.

The ACIAR SDIP program is implemented through five interlinked components. The flexible structure of the program has allowed the ACIAR team to build a program which addresses issues where ACIAR projects can make a significant contribution to critical knowledge gaps and key policy priorities of partner countries, and respond to emerging issues. This set of complementary activities has been designed to integrate local, meso and regional level visions and engagement, to create the enabling conditions for the development and scaling of sustainable and resilient food systems. The five components contribute to the program in the following ways:

1. **Integration and Synthesis:** Ensure project activities and outputs are coordinated and communicated for maximum benefit to the end user at farmer and policy level.
2. **Foresight:** Improve collaboration between key regional partners to strengthen understanding of longer-term food systems changes and the implications for food, water and energy security; and identify transformational opportunities, particularly in the context of gender and climate change.
3. **Institutional Innovation:** Create a more conducive enabling environment for sustainable food systems by building capacity within district, state and national agencies in the EGP to identify and promote institutions that foster successful intensification, integrated decision making and inclusiveness in agriculture.
4. **Field Scale Innovation:** Optimise the learning from scaling field scale activities and local engagement to promote two-way flow of information.
5. **Analytical Studies:** Fill critical knowledge gaps to support the development of an enabling environment, and to allow better decision making.

The specific ACIAR SDIP objectives are outlined in **Table 2,** which also indicates how these objectives relate to end of program targets and the overall SDIP outcomes.

Table 2 ACIAR SDIP objectives, end of program target and alignment with SDIP outcomes

	ACIAR SDIP Objective	End of program target	SDIP Outcome
1.	Improve collaboration between key partners (regional, national, state) to strengthen understanding of longer-term food systems changes and the implications for food, water and energy security; particularly in the context of gender and climate change.	Key stakeholders (both women and men) in the EGP (including decision-makers) are engaging in regular dialogue with respect to the drivers and trends for regional food security.	Strengthened practices for regional cooperation; Improved regional enabling environment.
2.	Increase capacity within district, state and national agencies in the EGP to promote effective institutions for sustainable food systems.	Key agencies (local, state, national) have improved capacity to identify and support institutions that promote inclusive and sustainable food practices (including CASI).	Strengthened practices for regional cooperation; Improved regional enabling environment.
3.	Critical knowledge gaps identified, filled and used to support sustainable food systems, and to allow better decision making at a range of scales.	The technical and socio-economic knowledge base with respect to sustainable food systems and practices, including the role of women and men and the impact of climate change, has been strengthened.	Critical new knowledge generated and used for regional cooperation.
4.	Optimise the learning from scaling field level activities and local engagement to promote two-way flow of information for improved field – policy links.	Better links between field level learning and policy levels established	Critical new knowledge generated and used for regional cooperation.

Table 3 gives details on what was planned and achieved for 2019 – 2020.

Table 3 Planned activities and achievements for 2019-20

	Planned activities 2019 - 20	Achievements 2019 - 20
Foresight	• Implement and learn from local level Foresight projects using a structured methodology • Host local level learning events, including science-policy dialogues (SPD) • Host regional technical and leadership Foresight event in May 2020	• Training conducted in September 2019 to agree on a unified methodology • Nepal field work conducted with cross learning for Bangladesh colleagues. SPD postponed. • WB and Bangladesh activities impacted by project delay and COVID-19 restrictions • IFPRI modelling exercise underway but not completed • Regional technical and leadership Foresight event postponed until May 2021

Institutional Innovation	• Complete Delphi process and Best Worst Scaling (BWS) exercise
	• Conduct and analyse household asset and vulnerability survey
	• Business case study of machinery service providers
	• Understand electrification and the functioning of the GW market in WB
	• Analyse secondary data sets
	• Facilitate the development of provincial multi-stakeholder platforms for mechanisation, and mentor the development of a Roadmap approach
		• Delphi questionnaire process completed and BWS undertaken for experts
		• Household asset and vulnerability survey and BWS for farmers delayed due to COVID-19 restrictions
		• Solar pump study completed by MSc student; not finalised due to survey delay
		• Secondary datasets under analysis (risk management and knowledge transfer)
		• Roadmaps (a participatory process to create an agreed path for sustainable mechanisation)
		  ○ Multi Stakeholder Groups (MSG) formed in Province 1 and 2 in Nepal
		  ○ Vision and roadmaps in progress and continuing despite COVID-19 restrictions

Field scale Innovation	• Identify potential soil constraints that may hinder the performance of crop production systems, and that will be influenced by wider uptake of intensified systems • Understand the weed dynamics associated with CA adoption, and how this influences gender workload	• Soil constraints work mostly completed; and shows high likelihood of rapid acidification of soils in EGP, widespread zinc deficiency confirmed, and recommends a focus on managing nitrogen fertiliser use to improve contribution to climate change mitigation • Understanding weed dynamics and labour impacts for women documented through a process of capturing photos and qualitative surveys; weed management not seen as a barrier to adoption of CA where herbicides are available. No documented increase in women's labour. Quantitative survey delayed due to COVID-19
	• Identify lessons for successful business models that work for farmers and the local private sector • Learning from scaling through a series of activities that focus on understanding project impacts related to market actors, outreach, policy, social inclusion and adoption and impact.	• 336 qualitative surveys undertaken on scaling status and extension approaches • Novel extension methods implemented e.g. CASI MOOC which reached 8,000 participants across the world and a visual syllabus developed technologies for farmers and service providers in two languages • Continued convergence with government programs; Centre of Excellence in CA approved in WB • 75 VMP sold in 19-20 (95 total in Bangladesh; planting incentive model most popular) • Delays in quantitative surveys and policy dialogues due to project extension and COVID-19 restrictions
Analytical Studies	• Understanding water access and management projects at various scales, and links to energy and food • Understanding the regional hydrological implications of on-farm water savings • Undertake rigorous evaluation of impacts of groundwater policy reforms on agricultural and groundwater sectors with a special emphasis on sustainability issues and draw lessons for other states and countries in the EGP. • Testing managed aquifer recharge to manage both excess and scarcity of water at a local level, for improved household resilience and food security	• Yield gaps work indicates scope for increasing GW use in EGP in some locations; defines potential cropping patterns to stay within sustainable limits • Regional hydrological work indicates that reducing water application alone will not generate wider water savings, since water that moves beyond the root zone is reused by others; real savings will only come with reduced evapotranspiration which can be achieved with different cropping patterns. • Lessons from IWMI study; increased access to electricity has not had widescale impacts on groundwater use or production for farmers in West Bengal • ASR work ongoing, biophysical data collection and socioeconomic engagement completed. ASR structures installed and will be monitored over monsoon season. High engagement due to landlords present and interested in investing in such structures. High level of interest from Bihar Government to scaling out if the technology is proven

3. RESULTS IN 2019-20

Summary results are contained in this section. For more details, please see Annexe 2. A list of publications produced is included in Annexe 3.

Foresight

Objective 1: Improve collaboration between key partners to strengthen understanding of longer-term food systems changes and the implications for food, water and energy

The proposed Regional Foresight event that was to be held in 2020 has been postponed until May 2021 due to COVID-19 restrictions. In an ideal situation an in-person forum would be most effective. Given the situation, a decision will be made towards the end of 2020 about whether this event will be in-person or held virtually. A series of nine status briefs on different aspects of the food system were finalised by the Foresight component (full reports here).

Over the past year, work has focused on local level activities (Bangladesh, West Bengal, and Nepal) and national (India) to inform and improve the future of food systems in the EGP region and to strengthen local capacities for scenario-based foresight exercises through training, mentoring and supporting a learning-by-doing approach. Ideas for the local and regional level foresight activities emerged from the discussions and evidence generated in the training workshop held in February 2019 (report here). The aim of this work is to connect the big picture context with work at the local/regional level where change can happen.

In ongoing work, IFPRI have commenced work using the IMPACT model to assess potential pathways to make healthy diets more affordable in India. Three policy scenarios are being explored: 1) change in tariff and non-tariff restrictions on food trade; 2) change in food policy from distortionary subsidies to non-distortionary cash transfers to farmers and consumers; and 3) change in power tariffs for groundwater irrigation. Besides food prices, IFPRI will also assess the impact of each of these policy changes on farmers' incomes, water use in agriculture, and greenhouse gas (GHG) emissions. For more details, please see Annexe 2.1.

Institutional Effectiveness

Objective 2: Increase capacity within district, state and national agencies in the EGP to promote effective institutions for sustainable food systems.

The Institutional Innovation component has both conceptual and practical elements; the aim is to be able to use the conceptual outputs to strengthen and inform on-ground work. During 2019-20, conceptual activities progressed more slowly than anticipated, but on-ground work progressed well, building on previous experience in multi-stakeholder engagement and coordination. However, there have been several disruptions due to COVID-19.

From a conceptual perspective, the University of South Australia are using novel approaches to identify institutions that foster intensification, integration and inclusiveness. The focus is on three main areas: the institutions for transferring knowledge to farm households; risk mitigation by rural households; and water property rights. A Delphi[4] study has been completed to extract from experts their knowledge of existing institutions that impact on rural households' well-being and their key characteristics. These have shaped a Best-Worst Scaling (BWS) survey, which will allow a measure of institutional effectiveness to be generated. Parallel work has also been undertaken using secondary data to inform statistical analysis of production and welfare impacts of different interventions, with a focus on women and tenant farmers. A major primary survey has been designed to collect data on the effectiveness of knowledge transfer, different property right regimes and risk management across four jurisdictions and a range of transfer approaches/institutions, but has been unable to be implemented due to COVID-19 restrictions. A decision to proceed or not with the survey will be made in September 2020.

Other projects are demonstrating practical approaches to improving institutional effectiveness and building capacity, focusing on multi-stakeholder coordination. The Roadmaps project is using a strategic planning process to facilitate the development and implementation of 'participatory roadmaps' to create an enabling environment for sustainable agricultural mechanization in Province 1 and 2 of Nepal. The project has undertaken establishment meetings, drafted roadmaps, partners have implemented field level interventions, cross border capacity development and contributed to a national symposium on sustainable agricultural mechanisation. Roadmaps has provided a forum for more than 30 organisations to come together and discuss key and emerging issues and a platform for needs of different stakeholders to be communicated. Despite all activities being affected by COVID-19 restrictions, virtual meetings have continued at the request of group members, and this resulted in some field activities being implemented in the Kharif season. **For more details, please see Annexe 2.2.**

Field Scale Innovation

Objective 3: Optimise the learning from scaling field level activities and local engagement to promote two-way flow of information for improved field – policy links.

The work in the current component has helped up to 113,000 farm households in total adopt more productive and sustainable farming techniques that improve profitability and reduce the emissions footprint of food production systems in the EGP by 6 – 18% (Gathala et al., 2020), with the potential for significant impact if widely adopted. Alongside distilling the lessons from scaling, work is ongoing to understand constraints to these new systems in terms of soil and weed management, and sustainable groundwater use. **Key lessons demonstrated from work in this component include the need to promote and work with multi-stakeholder arrangements for outscaling; effective field-policy links result in convergence with government programs; and groups continue to provide opportunities that are not possible for most individual smallholders to capitalise on.**

[4] Delphi is a technique which consists of a structured communication technique or method, originally developed as a systematic, interactive forecasting method which relies on a panel of experts

The Science of Scaling CASI Systems

The **SRFSI project** has focused on the science of scaling, to identify key lessons from the SRFSI experience that are being preserved as legacy documents to enable longer term communication and dissemination with relevant stakeholders. **Research** has been undertaken to create a comprehensive and unique qualitative dataset of 336 interviews, which are being analysed to create new understanding on how to scale Conservation Agriculture in South Asia. A separate evaluation of Innovation Platforms has been undertaken. With CSIRO, the team have contributed to evaluating the potential adoption of new innovations and examining the characteristics of earlier innovations and subsequent adoption rates using the Smallholder ADOPT tool. In response to a government directive banning the use of Glyphosate in West Bengal, trials have contributed to a new set of protocols based on results that show Glufosinate @ 500 g a.i/ha + Flucetosulfuron @ 30 g a.i./ha may be an alternative for Glyphosate. Several publications have been completed (see **Annexe 3**).

Extension and legacy materials have been created to synthesise and communicate project results. This includes the world first 'CASI Massive Open Online Course' with BAU, in which more than 8,000 participants from 22 countries participated; the completion of chapters 1 and 2 of the 'CASI visual Syllabus', and development of a structure for the 'SRFSI online knowledge repository'. In Bangladesh, iDE are developing survey tools for self-assessment and contextual analysis of social enterprises using CASI machinery. **CASI Networks** are being formalised through a CASI Service Provider Digital Network in Bangladesh and West Bengal.

Scaling requires alignment with existing government and development programs. **Successful convergence** with existing programs has been achieved in several locations, which is the ultimate demonstration of strong field – policy links. In West Bengal, a Centre of Excellence for Conservation Agriculture (CECA) has been approved by the GoWB to be located at UBKV. The CECA will increase the number of people professionally trained in CASI across the state and the eastern region of India and improve the quality of information available to farmers and service providers. This centre will establish the infrastructure to further promote CASI beyond the scope of SRFSI and beyond the life of the project, a great development for CASI training infrastructure for long term capacity impact. The GoWB have approved the operating funds for this centre to ensure sustainability outside of SRFSI.

Substantial demonstrations (>50 sites across the region) have continued for CASI, mostly from non SRFSI funds highlighting convergence with other programs (ATMA, RDRS Federations, DeHaat, CRAP). In 2019-20, UBKV sponsored three state level and six district level policy dialogues to finalize CASI related policies. Block level initiatives by the DoA officers for CASI technology are now visible in most of the blocks in the northern districts of West Bengal. In Bihar, the technologies validated by the SRFSI project were integrated into government plans and schemes like Mera Gaon Mera Gaurav, Zero Budget Farming and NABARD, in the form of demonstrations and machinery subsidies. The AUD$12 million state project Climate Resilient Agriculture Programme (CRAP) is being implemented in nine districts of Bihar, and each district has a target of covering about 250 acres using various CASI technologies. During the 2020-21 year, all districts of Bihar will be integrated under CRAP.

The **Pilot Project on Commercialization of Small Holders' Conservation Agriculture-based Planters in Bangladesh** aims to promote small scale mechanization of CA planting operations using the Versatile Multi-crop Planter (VMP) at a commercially viable scale. The project is implemented by Murdoch University and is a collaboration between Hoque Corporation (a manufacturer), the Conservation Agriculture Service Provider Association (CASPA), and the National Bank Ltd (NBL). In 2019 – 20, 75 VMPs and 20 2WTs have been sold under two business models; (i) 69 VMP under a Planting Incentive Model (where the new VMP owners get a one-off payment for up to 50 bigha of service, which ensures business for the first season while the technology is still unfamiliar to both farmers and the LSP) and (ii) 26 VMPs and 26 2TWs under a Tri-party Investment Model (a cost sharing arrangement between the LSP/farmer, NBL bank loan and project support, with agreed 60 bigha to be planted within two seasons to create demand). In total since the start of the project, 95 VMPs and 26 2WT have been sold. During the project, a partnership with Solidaridad Network Asia (SNA) has been developed, which has helped expand the VMP use into a new area. SNA are an international NGO working in south-east regions of Bangladesh, and currently working with 26,000 soybean farmers. Twenty units of VMP and 19 units of 2WT have been purchased by farmers in this area during 2019-20, most taking advantage of a soft loan organised by SNA in conjunction with the Social Islami Bank Ltd. The total benefit for soybean farmers was AUD$547/ha relative to conventionally planted soybean.

Understanding constraints to CASI: soil and weed management

An external review of SRFSI (Reeves et al., 2018) identified soil health as an area of particular concern following initial work in the project, with soil pH and associated toxicities, trace element deficiencies (zinc (Zn), copper (Cu), boron (B)), low organic carbon levels, and soil structural problems identified as key issues associated with intensification (rather than CA alone). The University of Queensland is working with local partners to determine the extent of these problems. Results confirm that the soils of the EGP are at risk of acidification due to product removal (i.e. crop harvest) and nitrogen (N) fertilizer use. The predicted time for soil pH to drop to 4.5 (a critical level) is less than 10 years for the majority of sites, irrespective of whether CA or conventional techniques are used. Irrigation with alkaline groundwater has the potential to account for as much as half of the acidity generated but further work is needed to verify this. Zn deficiency in soils is known to be widespread in the EGP, but Zn fertiliser is not commonly used. In this study, the addition of Zn and B fertilisers generally increased yields by around 0.5 – 1.0 t/ha, although this was not observed at all sites. Thus, there is a need for agricultural extension projects to ensure that adequate Zn fertilisers are applied to crops in order to maximise productivity.

Although weeds are often cited as a major issue when farmers use CA farming techniques, preliminary findings from CIMMYT indicate that in the SDIP sites in Nepal, West Bengal and Bangladesh, the use of CASI systems seem to have positive impacts on how farmers manage weeds. Due to the use of herbicides before seed sowing, farmers in general did not report weeds as a problem. Little to no difference in knowledge was observed between men and women for chemical application and weed identification. Many households across three countries utilized time savings to grow fresh vegetables for both sustenance and selling produce. **For more details, please see Annexe 2.3**.

Analytical Studies – Sustainable Groundwater Development

Objective 4: Critical knowledge gaps identified, filled and used to support sustainable food systems, and to allow better decision making at a range of scales.

Initial work within ACIAR SDIP looked at the context for groundwater use in agriculture in the EGP, both in terms of availability and access (for a summary of findings see here). Governments in the region use a range of policy instruments to increase accessibility of irrigation, and ensure sustainability of groundwater resources. Alternative – and cheaper – sources of energy are one option to reduce the cost of irrigation. At the same time, based on experiences in the western IGP, many policy makers are concerned about preventing declining watertables and the implied unsustainable use of groundwater. There is significant scope to develop sustainably intensified farming systems based on groundwater in these regions with the right institutional arrangements. **The new studies undertaken in 2019-20 look at the impacts of changing one part of the system, particularly keeping a framing of the FEW nexus.** This work has demonstrated that **common policies for managing groundwater development do not always achieve the intended outcomes.**

A study implemented by IWMI shows that **the impacts of groundwater and energy policy reforms have had a much lower than intended impact on water use and agricultural productivity and profitability in West Bengal, India**. Over the past two decades, the state has undertaken three important policy reforms related to groundwater and electricity, which helped remove barriers to the electrification of agricultural wells and tube wells. This resulted in a more than threefold increase in the number of electric pumps – from 86,776 in 2007 to 303,018 by 2018. In this study, the impact of the increase in the number of electric pumps on agriculture- and groundwater-related outcomes was analysed using government (block level) data and community inputs. It was expected that electrification of wells and tube wells would lower the costs of irrigation. However, despite the positive effect of the groundwater policy reform on the number of pumps electrified, the effect on agricultural outcomes such as cropping pattern, cropping intensity, cropped area, production and yield was not evident.

Work from CSIRO demonstrates that policies that promote farm level water savings do not always reduce overall water use or improve groundwater levels at a regional scale. When irrigation water is applied, it is common for some of it to pass below the rootzone as drainage and/or runoff the field. In groundwater dependent areas with good quality, shallow water tables, this drainage is not lost but rather replenishes the aquifer and is available for other users. In the northwest of Bangladesh, the Government policy responses to prevent further decline of groundwater tables focus on more efficient irrigation. It has been demonstrated that without reducing the actual crop evapotranspiration, adoption of any water-saving technologies (e.g., AWD, deficit irrigation, conservation agriculture) to reduce seepage and percolation loss of water will have little impact on improving the declining groundwater levels in the region (Mainuddin et al., 2020). This study has been extended to the rest of the EGP. Early modelling suggests that the key comparisons between cropping systems options (e.g. CT vs CA) should be based on total evapotranspiration (ET = soil evaporation + crop transpiration), not on the amount of irrigation water applied and its subsequent drainage component.

Groundwater recharge is an effective mechanism to store excess rainwater and flood waters that are a common problem in the EGP. **Nalanda University are testing a model of indigenous aquifer storage and recovery (ASR) technology in the new location of Nalanda, Bihar, India.** This technology helps to store rainfall during extreme rainfall events and floods and makes it available during the dry winter season. Sites have been installed and are being monitored for biophysical and socio-economic impacts.

Quantifying sustainable water yields and their interaction with food production shows that physiological crop yield gaps are greater in the EGP compared to the western IGP, and confirms there is opportunity to increase use of groundwater in some locations with the right mix of crops and farming techniques. There is a clear trend for over-exploitation of groundwater in the western IGP, and under-exploitation in the east. Modelling allows us to look at different crop and farming system combinations to find the most appropriate mix for both productivity, groundwater sustainability and economic returns.

This work recognises that access to groundwater and the wider scale implications of its use are critical, including interactions with energy and food security. These interactions are becoming more important as climate change impacts on rainfall timing, quantity and intensity. In all projects, there is an intention to communicate results to policy makers at the local and state scales, but COVID-19 restrictions are preventing us from holding the intended science-policy dialogues. This will be a priority for the remainder of the project up to June 2021.

For more details, please see Annexe 2.4.

Gender inclusion and understanding impacts for women

Most projects in the portfolio continue to incorporate gender across their research and development activities, although much of the work is ongoing and hence specific results are not yet available from 2019-20.

Late in 2019, two status briefs were published by the Foresight component, which look specifically at gender (full reports here). Building on previous work undertaken in ACIAR SDIP, (Sen et al., 2019) try to unravel the spatial and temporal pluralities that exist with respect to gender and work in agriculture across the EGP. A complementary report by Joshi et al. (2019) on Women's labour force participation in rural India shows that the share of women engaged in agriculture and labour has fallen from 36% in 2004-05 to 21% in 2015-16.

The local level Foresight projects have engaged Professor Sucharita Sen as a gender advisor, to help the team develop a better understanding and appreciation of ways to carry out gender-inclusive studies of farming communities. The Institutional Effectiveness project are looking specifically at women's preferences for institutional arrangements related to water markets, knowledge transfer and risk management, and a comprehensive survey has been developed to capture these from 2,000 farming households. The survey includes a specific component that teases out the empowerment of women. Coupling this information with the other data gathered in the primary survey (e.g. insight into preferences for knowledge transfer), including households' ratings of policies and delivery institutions, may elucidate links between different institutional settings and women's wellbeing.

The Implications of Sustainable Intensification on Weed Dynamics in the Eastern Gangetic Plains project analyses the response of men and women farmers to changing weed dynamics under CASI farming systems, to explore the impacts on women's and men's workloads, as well as document their knowledge, attitude and practices around weed management. Through qualitative interviews and Photodiaries, preliminary findings indicate use of CASI systems seems to have positive impacts on how farmers manage weeds, and no difference was observed in knowledge between men and women for chemical application and weed identification.

Experiences in several ACIAR SDIP projects working with large, national level data sets highlight that the way data is collected in national surveys and census makes it difficult to disaggregate results to understand the impacts on women. The secondary data that is currently on hand from the various jurisdictions is not sufficiently nuanced to answer questions related to women's empowerment. In some cases no separate data on women or woman-headed households is available; or the data on some gender concepts (e.g. empowerment) is on hand but cannot be meaningfully traced to other data that would act as proxies for wellbeing. A regional workshop is proposed, to be co-hosted by ICIMOD to discuss specific experiences and generate recommendations to be communicated to relevant national agencies, however this has been delayed and is likely to be moved to a virtual meeting in light of COVID-19 restrictions. **For more details, please see Annexe 2.5.**

Climate adaptation and mitigation results

In total, **farm level reductions in GHG emissions** due to use of CASI based systems was 6,968 tCO_2-e in 2019-20, and 25,083 tCO_2-e in total for the life of the program.

Using the APSIM model that was validated at ten locations in the EGP during the SRFSI project, **CSIRO have conducted a further study (report here) to explore the effect of future climate change scenarios on crop production and greenhouse gas emissions** under a range of Conventional (CT) and Conservation Agriculture (CA) management interventions. The findings suggest that in the future, the general trends are for increased Rabi crop yields (maize and wheat) and slightly reduced kharif rice yields under CA practice compared with CT. Yields for Rabi season crops (wheat and maize) tend to decrease with harsher climate scenarios and with increasing timeframes. However, wet-season rice yields are predicted to increase in future years. Simulated emissions were reduced by around 24% by employing CA technologies in the rice-maize and rice-wheat cropping systems, averaged across the SRFSI sites using historical climate data. As well as being impacted on by the changing climate, the agriculture sector is a significant contributor of emissions. Management practices that can minimise emissions and prevent the loss of soil carbon are important considerations in minimising wider scale impacts. As noted in Section 2.3.2, efficient use of N fertilizer will have a positive greenhouse gas impact, and in the long-term this may be more important than the soil carbon dynamics in the system. Future studies undertaken should consider the greenhouse gas impacts of improving N use efficiency, both in terms of reducing the amount of N applied, hence reducing emissions associated with N fertiliser manufacturing, and the amount of N lost from the soil.

Focused work on groundwater, as reported earlier, offers an option to improve climate change adaptation and resilience, given likely impacts on rainfall timing, quantity and intensity. At present, groundwater in the EGP is an underutilised resource, and so a better understanding of availability and the implications of its management alongside energy and food policies is critical to maintain sustainability. **For more details, please see Annexe 2.6.**

4. Sustainability

Sustainability in the ACIAR SDIP program is generated by two key approaches – multi-stakeholder engagement, and strengthening field to policy links. Together, these create buy-in from a range of partners, and demonstrate impacts at different levels, which ultimately leads to convergence with existing programs and can inform new management and policy decisions.

Multi-stakeholder approaches are used by several projects, which acknowledges that the different actors in any system need to work together to solve problems and make change. For example, in the SRFSI project, Innovation Platforms have resulted in economic gains (improved distribution of income and purchasing power) as well as social gains, through improved self-empowerment for both men and women farmers. The benefits for women included more economic power, more independence and social agency; they believe they can now do something for themselves. This reflects the common assertion of project partners that the focus on training of females (goal at 30% of total training) has had lasting institutional effects and has helped to refocus other programs on the need to do this. The Roadmaps project in Nepal has provided a forum to discuss key and emerging issues and a platform for needs of different stakeholders to be communicated. In total, more than 30 organisations have participated in activities that align with government programs and will contribute to sustainable agricultural mechanisation. In Bangladesh, the VMP project is bringing together local manufacturers, research, farmer groups and banks to facilitate purchasing of VMP machines and promote their use to create demand. These projects have demonstrated that bringing together stakeholders who would not normally connect can support sustainable scaling and development of agricultural systems.

Field – policy links have been strengthened by demonstrating impacts at different levels (field, farm, community, district). The integration of learnings from the SRFSI project and CASI technology promotion with the Indian national agricultural development programs and the state government programs in Bihar and West Bengal, which have large budgets for agricultural development, has created opportunities to scale out across the states. Where project partners have demonstrated increased incomes, cost savings, positive climate change impacts and institutional support for men and women to adopt enterprises around agriculture, there has been support from higher levels. For example in West Bengal, CASI technologies have been integrated into the state government programs that fund subsidies for CASI machinery and block level extension programs. SRFSI technical recommendations are used for all state government CASI promotion in northern WB. The GoWB are investing funds to create a Centre of Excellence for CA training and machinery testing that will serve the whole eastern region of India. In Bihar, CASI has been integrated into other state government programs, i.e. Climate Resilient Agriculture Program, and demonstration sites persist even without project funding. In Bangladesh, BARI continue to train and maintain CASI demonstration sites despite no project funding. RDRS are promoting CASI within other development programs. Long term, a web-based repository of information on CA in South Asia is being developed that will centralise project outputs and ensure that information is accessible to farmers, researchers and service providers in an appropriate format.

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Annexe 2: Detailed Results 2019-20

A2.1. Foresight

Objective 1: Improve collaboration between key partners to strengthen understanding of longer-term food systems changes and the implications for food, water and energy

The Foresight work over the past year has focused on local level activities (Bangladesh, West Bengal, and Nepal) and national (India) to inform and improve the future of food systems in the EGP region and to strengthen local capacities for scenario-based foresight exercises through training, mentoring and supporting a learning-by-doing approach. Ideas for the local and regional level foresight activities emerged from the discussions and evidence generated in the training held in February 2019 (report here). The aim of this work is to connect the big picture context with work at the local/regional level where change can happen.

At the local level, the team in Nepal are using foresight approaches as a policy dialogue tool to understand the implementation of agricultural development at different levels: community, municipal, and provincial. They have collated and validated secondary data on different aspects of the food system in Province 2, and organized 12 participatory foresight activities with farmers including women and near landless farmers and other stakeholders in different parts of the province 2. These activities used a food systems framework and scenario building approach. The team also plans to organize a stakeholder dialogue to share their findings with provincial and local level officials and other key actors in the food system of the province, but this is delayed by COVID-19 restrictions. The BAU team in Bangladesh proposed to explore the potential for high-value crops for a diversified food system using both primary and secondary data, and as the basis for conducting participatory foresight exercises with farmers, researchers and key actors in the food value chain. The collation and analysis of secondary data is being undertaken, and the team has also prepared protocols for participatory foresight activities and key informant interviews. The field activities will start as soon as COVID-19 restrictions are relaxed. In West Bengal, the UBKV team have worked closely with Dr Sucharita Sen to plan a mixed-methods study in the state. They have prepared interview schedules for primary survey of women and men farmers and protocols for participatory foresight activities with women and youth farmers. The survey instruments and FGD protocols have been validated in the field. They will start the field activities once COVID-19 restrictions are relaxed.

At a national level, IFPRI are using the IMPACT model to assess potential pathways to make healthy diets more affordable in India. Three policy scenarios are being explored: 1) change in tariff and non-tariff restrictions on food trade; 2) change in food policy from distortionary subsidies to non-distortionary cash transfers to farmers and consumers; and 3) change in power tariffs for groundwater irrigation. Besides food prices, IFPRI will also assess the impact of each of these policy changes on farmers' incomes, water use in agriculture, and greenhouse gas (GHG) emissions. They are also using the MAgPIE model to understand the potential impact of changes in power pricing policies for farmers on land and water use, cropping patterns, GHG emissions, and a whole range of economic outcomes. The results will be available in the coming months.

The proposed Regional Foresight event that was to be held in 2020 has been postponed until May 2021 to allow time for COVID-19 restrictions to be eased in case an in-person forum can still be convened. A decision will be made towards the end of 2020 about whether this event will be in-person or held virtually.

A2.2. Institutional Effectiveness

Objective 2: Increase capacity within district, state and national agencies in the EGP to promote effective institutions for sustainable food systems.

The Institutional Innovation component has both conceptual and practical elements; the ultimate aim is to be able to use the conceptual outputs to strengthen and inform on-ground work. During 2019-20, conceptual activities progressed more slowly than anticipated, but on-ground work progressed well, building on previous experience in multi-stakeholder engagement and coordination. However, there have been several disruptions due to COVID-19.

From a conceptual perspective, the University of South Australia are using novel approaches to identify institutions that foster intensification, integration and inclusiveness. The project focuses on three main areas: the institutions for transferring knowledge to farm households; the institutions and activities related to risk mitigation by rural households; and those institutions and practices related to water property rights. A Delphi study has been completed to extract from experts their knowledge of existing institutions that impact on rural households' well-being and their key characteristics. These have shaped a Best-Worst Scaling (BWS) survey, which will allow a measure of institutional effectiveness to be generated. This can be implemented online and will be undertaken in July 2020. To match the outputs from experts, the project will conduct a similar BWS survey with farmers, to understand how well expert and farmer preferences match. Collectively, the two activities will allow the research team to identify: (a) those institutions/characteristics that are most important in the minds of experts; and (b) those that are most appealing or important to farmers.

Parallel work has also been undertaken using secondary data to inform statistical analysis of production and welfare impacts of different interventions, with a focus on women and tenant farmers. A major primary survey has been designed to collect data on the effectiveness of knowledge transfer, different property right regimes and risk management across four jurisdictions and a range of transfer approaches/institutions, but has been unable to be implemented due to COVID-19 restrictions. This survey is an essential part of Objective 2, and additional time has been granted to allow this to be implemented in 2021. The inability to complete these milestones has had a flow on effect to some milestones in Objective 3 and 4 that relate to circulating and disseminating findings. Contingency plans are in place, and a decision to proceed or not with the survey will be made in September 2020.

Other projects are demonstrating practical approaches to improving institutional effectiveness and building capacity, focusing on multi-stakeholder coordination. The Roadmaps project is working to facilitate the development and implementation of 'participatory roadmaps' to create an enabling environment for sustainable agricultural mechanization in Province 1 and 2 of Nepal. Roadmaps has had to build completely new relationships beyond SRFSI which took considerable time and effort. However, these have now been overcome and common visions and declarations have been finalised in both provinces. The project has undertaken establishment meetings, drafted roadmaps, partners have implemented field level interventions, cross border capacity development and contributed to a national symposium on sustainable agricultural mechanisation. Before Roadmaps, there were no formal linkages or forums for larger cooperatives and various departments within each provincial Ministry of Land Management and Cooperatives (MoLMAC), or between provincial and municipal government stakeholders. Roadmaps has provided a forum to come together and discuss key and emerging issues and a platform for needs of different stakeholders to be communicated. In total, more than 30 organisations have participated in activities. Formal roadmaps were drafted to guide future activities and interventions, some of which have begun to be actioned. Technical support was provided to agricultural cooperatives for machinery testing and demonstration, and for analysing subsidy programs for agricultural machinery, which are an important part of agricultural support in South Asia. Extension activities included demonstrations in both Rabi and Kharif cropping seasons, although financial support was very limited to ensure buy in from participating partners, with CIMMYT providing primarily technical support. Despite all activities being affected by COVID-19 restrictions, virtual meetings have continued at the request of group members, and this resulted in some activities being implemented in the Kharif season. Roadmap finalisation and implementation was however limited by COVID-19 lockdowns, although virtual meetings have continued at the request of project partners. This work has resulted in new working relationships, wider sensitization to potential mechanization options relevant to Province 1 and 2, and a set of extension activities co-funded by key change making organizations and individuals.

A2.3. Field Scale Innovation

Objective 3: Optimise the learning from scaling field level activities and local engagement to promote two-way flow of information for improved field – policy links.

The farming systems improvements tested in ACIAR SDIP are based on Conservation Agriculture based Sustainable Intensification (CASI), which is a broader form of Conservation Agriculture (CA) that incorporates agronomic, socio economic and institutional aspects of food production, including more sustainable agroecosystem management, increased input use efficiency and increased biological and economic productivity. These are based on the CA principles of minimizing soil disturbance, ensuring soil cover and diversification through rotations – and include improved varieties, better irrigation practices and improved crop management techniques. Proof of concept of CASI for the EGP was the focus of ACIAR's work in Phase 1 (Gathala et al., 2020; Gathala et al., 2020; Islam et al., 2019).

The work in the current component has helped up to 113,000 farm households in total adopt more productive and sustainable farming techniques that improve profitability and reduce the emissions footprint of food production systems in the EGP by 6 – 18% (Gathala et al., 2020), with the potential for significant impact if widely adopted. Based on socio-economic survey data (n=1,313) (Rola-Rubzen et al., 2019), the aggregate value of production of CASI adopters for Kharif, Rabi and summer seasons was significantly higher than non-CASI adopters. The value of production of CASI farmers was higher by AUD$222 per ha, with males experiencing a higher value of production by AUD$190 per ha and females an even higher value of production by AUD$538 per ha compared to their non-CASI counterparts. Also, the net income for CASI farmers was also significantly higher by AUD$115 per ha. Female CASI farmers had a higher net income by AUD$509 per ha compared to their non-CASI counterparts. Alongside distilling the lessons from scaling, work is ongoing to understand constraints to these new systems in terms of soil and weed management, and sustainable groundwater use.

Key lessons demonstrated from the work in this component include the need to promote and work with multi-stakeholder arrangements for outscaling; effective field-policy links result in convergence with government programs; and groups continue to provide opportunities that are not possible for most individual smallholders to capitalise on.

The science of scaling CASI systems

The **SRFSI project** has progressed through several phases, from proof of concept of CASI systems, to actively scaling using a capacity building approach; and most recently focusing attention on the science of scaling, to identify key lessons from the SRFSI experience that are being preserved as legacy documents to enable longer term communication and dissemination with relevant stakeholders. For SRFSI, strong progress has been made in finalising lingering activities and creating legacy products, while working towards institutionalisation for sustained impact. Notwithstanding the critical impact and implications of COVID-19 and subsequent lockdowns which have severely limited field level activities, stronger efforts have been put in to academic analysis and publication, an important deliverable for the successful closure of the project. An ongoing focus on successful integration and convergence in line with maintaining and sustaining impacts has also continued.

Research has been undertaken to create a comprehensive and unique qualitative dataset of 336 interviews, which are being analysed to create new understanding on how to scale Conservation Agriculture in South Asia. A separate evaluation of Innovation Platforms has been undertaken. Four successful 'hands-on' workshops and two seminars on evaluating adoption drivers were held with end-users and project teams in Nepal and India in January 2020. These involved evaluating the potential adoption of new innovations and examining the characteristics of earlier innovations and subsequent adoption rates using the Smallholder ADOPT tool. In response to a government directive banning the use of Glyphosate in West Bengal, trials have contributed to a new set of protocols based on results that show Glufosinate @ 500 g a.i/ha +Flucetosulfuron @ 30 g a.i./ha may be an alternative for Glyphosphate. Several publications have been completed (see Annexe 2).

Extension and legacy materials have been created to synthesise and communicate project results. This includes the completion of chapters 1 and 2 of the 'CASI visual Syllabus', development of an outline for the 'SRFSI online knowledge repository', contribution to the world first 'CASI Massive Open Online Course' with BAU, in which more than 8,000 participants from 22 countries participated. In Bangladesh, iDE are developing survey tools for self-assessment and contextual analysis of social enterprises using CASI machinery. In West Bengal, the Satmile Satish Club has expanded to a usually forgotten area of the state, Sitai Block, through a cost sharing 50:50 arrangement with SRFSI. This has seen Satmile working with a women's Farmer Producer Club to establish a seedling factory and demonstration sites.

CASI Networks are being formalised through for example a CASI Service Provider Digital Network in Bangladesh, which has established a Facebook group and are communicating their ideas and experience to share their proven knowledge. A CASI Service Providers Union in West Bengal is in the final stage of development.

Successful convergence has been achieved in several locations, which is the ultimate demonstration of strong field – policy links. In West Bengal, the government has made CA machineries a compulsory part in new Custom Hiring Centres that receive government subsidies, which means that every new CHC has CA machineries to outscale CASI technologies. To support this mandate, a Centre of Excellence for Conservation Agriculture (CECA) has been approved by the GoWB to be located at UBKV. Given the rate of adoption within the state, and aligned with government subsidies for machinery purchase, it is necessary to ensure that at the same time there are enough people trained in CASI principles and practical elements, to ensure good quality operations for farmers. The CECA will increase the number of people professionally trained in CASI across the state and improve the quality of information available to farmers and service providers. This centre will establish the infrastructure to further promote CASI beyond the scope of SRFSI and beyond the life of the project, a great development for CASI training infrastructure for long term capacity impact. The GoWB is also providing the operating funds for this center to ensure sustainability outside of SRFSI. In 2019-20, UBKV sponsored three state level and six district level policy dialogues to finalize the CASI related policies described here.

Block level initiatives by the DoA officers for CASI technology are now visible in most of the blocks in the northern districts of West Bengal. Previous advanced CASI training for Department of Agriculture (DoA) personnel undertaken through SRFSI is now paying dividends, as these staff have confidence to take challenges to demonstrate the technology on different crops in their respective areas, and are using other programs (for example ATMA, NFSM) to promote and scale CASI without project support.

In Bihar, the technologies validated by the SRFSI project were integrated into government plans and schemes as part of convergence like Mera Gaon Mera Gaurav, Zero Budget Farming and NABARD, in the form of demonstrations and machinery subsidies. The AUD$12 million state project Climate Resilient Agriculture Programme (CRAP) is being implemented in nine districts of Bihar, and each district has targets of covering about 250 acres using various CASI technologies. During the 2020-21 year, all districts of Bihar will be integrated under CRAP.

Substantial demonstrations (>50 across the region) have continued for CASI, but mostly from non SRFSI funds highlighting convergence with other programs. In Rangpur, Bangladesh, RDRS implemented various programs to enhance capacity of staff, farmer's hub committee members, service providers, machine operators and farmers. Trainings and community to community exchange visits were organized to enhance the capacity of relevant stakeholders. CASI is now being intreated into normal RDRS federation work. In Rajshahi, despite no financial or technical support from the project, BARI are linking with the private sector (e.g. DASCOH foundation, CCDB) to outscale laser land levelling technology in the Barind area, where reducing irrigation water use is a target. Machinery subsidies of up to 50% are available, and an Agricultural Machinery Fair was held as a promotional activity.

The Pilot Project on Commercialization of Small Holders' Conservation Agriculture-based Planters in Bangladesh aims to promote small scale mechanization of planting operations using CA practices. Two business models are being tested to create sales of the Versatile Multi-crop Planter (VMP) at a commercially viable scale. The project is implemented by Murdoch University and is a collaboration between Hoque Corporation (a manufacturer), the

Conservation Agriculture Service Provider Association (CASPA), and the National Bank Ltd (NBL). In this project, Hoque Corporation leads the VMP manufacturing, and piloting of VMP commercialization models, and is working with CASPA to identify new and prospective local service providers (LSP) of VMP. NBL, along with CASPA and HC, work together to help new LSP to secure loans for purchasing machinery (VMP and/or Two Wheel Tractor, 2WT). In 2019 – 20, 75 VMPs and 20 2WTs have been sold under two business models; (i) 69 VMP under a Planting Incentive Model (where the new VMP owners get a one-off payment for up to 50 bigha of service, which ensures business for the first season while the technology is still unfamiliar to both farmers and the LSP) and (ii) 26 VMPs and 26 2TWs under a Tri-party Investment Model (a cost sharing arrangement between the LSP/farmer, NBL bank loan and project support, with agreed 60 bigha to be planted within two seasons to create demand). in total since the start of the project, 95 VMPs and 26 2WT have been sold. A study on Policies and roadblocks for small scale CA farm machineries is also underway, with the aim of influencing future CA-based and smallholders' farm mechanization policy and investment in Bangladesh.

During the project, a partnership with Solidaridad Network Asia (SNA) has been developed, which has helped expand the VMP use into a new area. SNA are an international NGO working in south-east regions of Bangladesh, and currently working with 26,000 soybean farmers. Twenty units of VMP and 19 units of 2WT have been purchased by farmers in this area during 2019-20, most taking advantage of a soft loan organised by SNA in conjunction with the Social Islami Bank Ltd. The total benefit for soybean farmers was AUD$547/ha relative to conventionally planted soybean, including a total of AUD$165/ha saving from the cost of land preparation (AUD$48/ha), seed sowing cost (AUD$82/ha) and seed saving (AUD$35/ha), while they have obtained higher soybean grain yield by about 600 kg/ha in VMP planted plots.

Understanding constraints to CASI: soil and weed management

At the field level, technical constraints to CASI implementation at scale often include those associated with soil health; 'new' weeds, pests and diseases; water management; and agronomic management (Reeves et al., 2018). Several projects have been implemented to explore these constraints.

An external review of SRFSI (Reeves et al., 2018) identified soil health as an area of particular concern following initial work in the project, with soil pH and associated toxicities, trace element deficiencies (Zinc, Copper, Boron), low organic carbon levels, and soil structural problems identified as key issues. The University of Queensland is working with local partners to determine the extent of these problems. Acid soils cause problems with nutrient availability and nodulation of legume crops, threatening agricultural productivity; and as there are no specific symptoms the issue can go unnoticed until the problem becomes crtical. Results confirm that the soils of the EGP are at risk of acidification due to product removal (i.e. crop harvest) and nitrogen (N) fertilizer use. The predicted time for soil pH to drop to 4.5 (a critical level) is less than 10 years for the majority of sites. Irrigation with alkaline groundwater has the potential to account for as much as half of the acidity generated in the conservative system modelled, and this needs further work to understand what the true effects of this are. A major strategy to halting acidification is better management of N fertiliser use efficiency, to ensure minimum losses from the system. Efficient use of N fertilizer will have a positive greenhouse gas impact, and that in the long-term this may be more important than the carbon dynamics in the system. Any studies undertaken should consider the greenhouse gas impacts of the remediation approach. For example, remediation measures (applying lime to soils) to overcome acidification developed through poor N fertilizer management, would result in a very poor greenhouse gas outcome.

Zinc deficiency in soils is known to be widespread in the EGP, but Zn fertiliser is not commonly used. In this study, the addition of Zinc and Boron fertilisers generally increased yields by around 0.5 – 1.0 t/ha, although this was not observed at all sites. Thus, there is a need for agricultural extension projects to ensure that adequate Zn fertilisers are applied to crops in order to maximise productivity. In Nepal, the work was extended to citrus at the request of the National Agricultural Research Council (NARC). Preliminary data shows that substantial increases in yield can be obtained from the addition of inorganic fertilisers. Of particular importance were Zn and N, with 98% of the leaf tissue samples having Zn concentrations lower than that considered to be marginal (81% below the value considered to be deficient), whilst 67% had N concentrations lower than that considered to be marginal (57% below the value considered to be deficient).

Although weeds are often cited as a major issue when farmers use CA farming techniques, preliminary findings from CIMMYT indicate that in SDIP sites in Nepal, West Bengal and Bangladesh, the use of CASI systems seem to have positive impacts on how farmers manage weeds. Due to the use of herbicides before seed sowing, farmers in general did not report weeds as a problem. Little to no difference in knowledge was observed between men and women for chemical application and weed identification. Initial findings also suggest substantial time savings in weeding under CASI except for an increase in personal weeding hours by male farmers in Bangladesh, where women do not traditionally work in the field. Many households across three countries utilized this additional time to grow fresh vegetables for both sustenance and selling produce.

A2.4. Analytical Studies – sustainable groundwater development

Objective 4: Critical knowledge gaps identified, filled and used to support sustainable food systems, and to allow better decision making at a range of scales.

Initial work within ACIAR SDIP looked at the context for groundwater use in agriculture in the EGP, both in terms of availability and access (for a summary of findings see here). Groundwater potential and surface water availability (including tanks and river) were assessed. Groundwater is used by more than 90% of farmers, and hence surface water is a minor source of irrigation. Physical groundwater resources were found to be underutilized in most of the project's study sites. However, there are pockets where groundwater use is over-committed. 75% of farmers have access to irrigation through private, informal rental markets. These markets play a major role in ensuring irrigation access, but costs are high due to widespread use of diesel pumps, and hence high diesel costs and low efficiency of diesel pumps in general. However, in many areas, access to electricity is occurring quickly, and this has implications for pumping costs. Water buyers, who are often smaller and poorer farmers, feel the high prices acutely. Most farmers practice deficit irrigation and do not grow rabi crops due to the high costs of irrigation, despite a relative abundance of water and labour in relation to land availability.

From the SRFSI project, **farm-level water savings have been confirmed when CASI techniques are used**, with total water use reduced by 5 – 13%; and irrigation water use by 11% when CASI techniques are used (Gathala et al., 2020). At the same time, yields can be maintained and profit increased. Higher water savings were recorded in wheat, maize and lentil. Diversification of rice-rice systems to an alternate winter crop could have major impacts on water use.

Governments in the region use a range of policy instruments to both increase accessibility of irrigation, and ensure sustainability of groundwater resources. Alternative – and cheaper – sources of energy are one option to reduce the cost of irrigation. At the same time, based on experiences in the western IGP, many policy makers are concerned about declining watertables and the implied unsustainable use of groundwater. There is significant scope to develop sustainably intensified farming systems based on groundwater in these regions with the right institutional arrangements. **The new studies undertaken in 2019-20 look at the impacts of changing one part of the system, particularly keeping a framing of the FEW nexus.** This work has demonstrated that **common policies for managing groundwater development do not always achieve the intended outcomes.**

A study implemented by IWMI shows that **the impacts of groundwater and energy policy reforms have had a much lower than intended impact on water use and agricultural productivity and profitability in West Bengal, India**. Over the past two decades, the state has undertaken three important policy reforms related to groundwater and electricity. These were: (i) universal metering of electric-run agricultural tube wells starting in 2007; (ii) change in the groundwater law in 2011, which removed the requirement of farmers having to procure a prior permit from the groundwater department to get an electricity connection; and (iii) provision of a capital cost subsidy for the electrification of groundwater pumps in 2012. These three policy measures helped remove barriers to the electrification of agricultural wells and tube wells. This resulted in a more than threefold increase in the number of electric pumps – from 86,776 in 2007 to 303,018 by 2018. In this study, the impact of the increase in the number of electric pumps on agriculture- and groundwater-related outcomes was analysed using government (block level) data and community inputs.

It was expected that electrification of wells and tube wells would affect agricultural and groundwater outcomes through lowering the costs of irrigation. Per unit costs of pumping groundwater with electric pumps is much lower than pumping with diesel pumps. Therefore, it was expected that farmers with access to electric pumps would operate their pumps for longer hours and grow more water-intensive crops. However, despite the positive effect of the groundwater policy reform on the immediate outcome in terms of the number of pumps electrified, the effect on agricultural outcomes such as cropping pattern, cropping intensity, cropped area, production and yield was not evident. There was a positive effect of the policy on the summer (boro) paddy area and production, and a negative effect on the area under pulses. Yet, these effects were not robust and were found only in a limited number of blocks. It was found that groundwater policy changes led to slight improvements in groundwater levels in the period after 2011, as compared to the period before. The expectation was that groundwater levels would decline further, but given that cropping patterns and crop water use had not changed significantly in the post-2011 period, there was no overall acceleration in the pace of groundwater extraction either.

Work from CSIRO demonstrates that policies that promote farm level water savings do not always reduce overall water use or improve groundwater levels at a regional scale. This work aims to better understand how field scale water savings impact on the local and regional water balance and groundwater recharge. When irrigation water is applied, it is common for some of it to pass below the rootzone as drainage and/or runoff the field. In groundwater dependent areas with good quality, shallow water tables, this drainage is not lost but rather replenishes the aquifer and is available for other users. In the northwest of Bangladesh, the Government policy responses to prevent further decline of groundwater tables focuses on more efficient irrigation. It has been demonstrated that without reducing the actual crop evapotranspiration, adoption of any water-saving technologies (e.g., AWD, deficit irrigation, conservation agriculture) to reduce seepage and percolation loss of water will have little impact on improving the declining groundwater levels in the region (Mainuddin et al., 2020). Work being undertaken in ACIAR SDIP will extend the findings to the rest of the EGP, and is underway. Early modelling suggests that the key comparisons between cropping systems options (e.g. CT vs CA) should be based on total evapotranspiration (ET = soil evaporation + crop transpiration), not on the amount of irrigation water applied and its subsequent drainage component. Simulations thus far using the APSIM model, indicate that in rice-wheat, rice-maize and rice-rice systems, although CA results in reduced amount of irrigation pumping requirement, there is very little difference in overall ET between CT and CA practices. If anything, CA is likely to result in higher ET due to enhanced rooting and better Rabi crop production. In this sense, claims that CA will result in reduced water use and groundwater drawdown in the EGP on a wider scale are likely to be baseless, although they will still contribute to reduced costs and emissions associated with groundwater pumping.

Groundwater recharge is an effective mechanism to store excess rainwater and flood waters that are a common problem in the EGP. **Nalanda University are testing a model of indigenous aquifer storage and recovery (ASR) technology by applying the Bhungroo® model in the new location of Nalanda, Bihar, India.** This technology helps to store rainfall during extreme rainfall events and floods and makes it available during the dry winter season. Sites have been installed and are being monitored for biophysical and socio-economic impacts.

Quantifying sustainable water yields and their interaction with food production shows that physiological crop yield gaps are greater in the EGP, and confirms there is opportunity to increase use of groundwater in some locations with the right mix of crops and farming techniques. There is a clear trend for over-exploitation of groundwater in the western IGP, and under-exploitation in the east. Modelling allows us to look at different crop and farming system combinations to find the most appropriate mix for both productivity, groundwater sustainability and economic returns. For the vast majority of the IGP, the real measure of sustainable irrigation is a balance between ET (soil evaporation + crop transpiration) and groundwater recharge. A simplistic response might assume that a GW overexploitation of (for example) 30% means that irrigation pumping should be decreased by 30% to bring it into sustainability. Our simulations have shown that a reduction in irrigation pumping by 30% in Haryana will decrease ET by less than 10%, and that to achieve a reduction in ET of 30% would result from reduced pumping of over 50%, and a rice yield reduction of around the same amount (50%), with even greater decreases in economic returns to farmers. Alternative options include different cropping patterns in combination with water conservation measures would be more appropriate in addressing multiple constraints such as productivity, profitability and water management.

This work recognises that access to groundwater and the wider scale implications of its use are critical, including interactions with energy and food security. These interactions are becoming more important as climate change impacts on rainfall timing, quantity and intensity. In all projects, there is an intention to communicate results to policy makers at the local and state scales, but COVID-19 restrictions are preventing us from holding the intended science-policy dialogues. This will be a priority for the remainder of the project up to June 2021.

A2.5. Gender inclusion and understanding impacts for women

Most projects in the portfolio continue to incorporate gender across their research and development activities, although much of the work is ongoing and hence specific results are not available from 2019-20.

Late in 2019, a series of status briefs were published by the Foresight component, two of which look specifically at gender (full reports here). Building on previous work undertaken in ACIAR SDIP, (Sen et al., 2019) try to unravel the spatial and temporal pluralities that exist with respect to gender and work in agriculture across the EGP. They show that the way work is measured in the three countries makes women's work more invisible both in Bangladesh and India relative to Nepal, as activities like collection of water, fuel and fodder carried out specifically by women are not counted as work. The context for this work is derived from the generally accepted view that feminization of agriculture is typical of most developing countries which primarily stems from male-selective outmigration. While the macro level data published by government sources in Nepal and Bangladesh reveal feminization of the agricultural labor force, a consistent de-feminization has been observed in the Indian sites (Bihar and West Bengal). This note, other than pointing out the plurality in levels and trends in rural female workforce participation (WPR) across the three countries, finds that firstly, feminization in rural areas is not a necessary outcome of male selective outmigration, and secondly, the widely accepted reasons for defeminization in India cannot entirely explain the missing working women in rural EGB in India.

A complementary report by (Joshi et al., 2019) on Women's labour force participation in rural India shows that the share of women engaged in agriculture and labor has fallen from 36% in 2004-05 to 21% in 2015-16. Simultaneously, the share of women who are out of the labor force has increased from 51% in 2004-05 to 67% in 2015-16. It uses the nationally representative dataset National Family Health Survey – 4 to predict the labour force participation (LFP) of sample women in rural India based on sixteen demographic and socio-economic variables. Education and LFP have a U-shaped relationship: women with median levels of education (7 to 10 years) are the least likely to work, which means that wealthy educated women and poor uneducated women have the highest LFP. The combination of wealth and education also matters in determining women's LFP; educated wealthy women and the uneducated poor women who have the highest LFP. At middle-income levels, education does not seem to matter. Working women face higher chances of domestic violence, likely due to unobserved socio-cultural norms. Women who are out of the labor force have a greater number of young children (<5 years of age), and also have lower levels of autonomy and mobility outside the house. Women whose husbands have out-migrated are less likely to be working than those who are living with their husbands, which challenges the normal assumption that outmigration leads to increased LFP for women.

The local level Foresight projects being undertaken ask different questions that are key to each location. An initial workshop in September was used for training of all participants in mainstreaming gender in food systems research, the use of mixed methods for research, and different tools and techniques that can be used to conduct participatory foresight for food exercises with communities. Professor Sucharita Sen has been engaged as a gender advisor, to help the team develop a better understanding and appreciation of ways to carry out gender-inclusive studies of farming communities. In West Bengal, the study will focus on changes due to mechanisation, and the impacts at the community level with a particular focus on women and youth. The CGED team in Nepal have organized participatory foresight activities with farmers including women and near landless farmers and other stakeholders in different parts of Province 2, with 40% female participation. These activities used a food systems framework and scenario building approach.

The Institutional Effectiveness project are looking specifically at women's preferences for institutional arrangements related to water markets, knowledge transfer and risk management, and a comprehensive survey has been developed to capture these from 2,000 farming households. The survey includes a specific component that teases out the empowerment of women. Coupling this information empirically with the other data gathered in the primary survey (e.g. insight into preferences for knowledge transfer), including households' ratings of policies and delivery institutions, has the opportunity to explain the link between different institutional settings and women's wellbeing.

The Implications of Sustainable Intensification on Weed Dynamics in the Eastern Gangetic Plains project analyses the response of men and women farmers to changing weed dynamics under CASI farming systems, to explore the impacts on women's and men's workloads, as well as document their knowledge, attitude and practices around weed management. Through qualitative interviews and Photodiaries, preliminary findings indicate use of CASI systems seems to have positive impacts on how farmers manage weeds. Due to the use of herbicides before seed sowing, farmers in general did not report weeds as a problem. We observed little to no difference in knowledge between men and women for chemical application and weed identification.

The SRFSI project are working on understanding the impacts of CASI on women and their decision-making approaches, through a series of qualitative interviews that are currently being analysed. Gender and Social Inclusion research has been integrated into training programs on qualitative research tools and methods, including training of partners on considerations for interviewing females and other intersectional populations. They have continued to specifically target women's self help groups as a way to scale CASI. In the past year, SRFSI and Satmile Satish Club have expanded to a usually forgotten area of Sitai Block, where CASI technology has been introduced for the first time through an all-female Farmer Producer Company (FPC), including setting up a seedling factory for mechanical rice transplanting. A case study on such seedling factories was included in the Gender Learning Project prepared by IODPARC (2020), as an example of integrating gender at the client/community level.

Experiences in several ACIAR SDIP projects working with large, national level data sets (e.g. National Sample Survey in India, Nepal Living Standards Survey, Bangladesh Integrated Household Survey) highlight that the way data is collected in national surveys and census makes it difficult to disaggregate results to understand the impacts on women. This is an important gap to fill. The secondary data that is currently on hand from the various jurisdictions is not sufficiently nuanced to answer these types of questions. In some cases no separate data on women or woman-headed households is available. In other cases the data on some gender concepts (e.g. empowerment) is on hand but cannot be meaningfully traced to other data that would act as proxies for wellbeing. A regional workshop is proposed, to be co-hosted by ICIMOD to discuss specific experiences and generate recommendations to be communicated to relevant national agencies, however this has been delayed and is likely to be moved to a virtual meeting in light of COVID-19 restrictions.

A2.6. Climate adaptation and mitigation results

In total, **farm level reductions in GHG emissions** due to use of CASI based systems was 6,968 tCO_2-e in 2019-20, and 25,083 tCO_2-e in total for the life of the program.

Using the APSIM model that was validated at ten locations in the EGP during the SRFSI project, **CSIRO have conducted a further study (report here) to explore the effect of future climate change scenarios on crop production and greenhouse gas emissions** under a range of Conventional (CT) and Conservation Agriculture (CA) management interventions. The findings suggest that in the future, the general trends are for increased Rabi crop yields (maize and wheat) and slightly reduced kharif rice yields under CA practice compared with CT. Yields for Rabi season crops (wheat and maize) tend to decrease with harsher climate scenarios and with increasing timeframes. However, wet-season rice yields exhibit the opposite trend and are predicted to increase in future years, primarily as a function of increased CO_2 fertilisation, which overshadows any losses due to increased temperatures and shorter seasons. This is under the assumption that irrigation water can meet any rainfall shortages. Purely rainfed crops would likely also be challenged by rainfall variability, which will increase in the future (Dawson, 2019).

Simulated emissions were reduced by around 24% by employing CA technologies in the rice-maize and rice-wheat cropping systems, averaged across the SRFSI sites using historical climate data. This represents emissions due to plant-soil-fertiliser-residue processes in the field only. A changing future climate slightly reduces the benefits from CA, with historical, 2050, 2070, and 2090 climates revealing a 20 - 24% benefit. There was no particular protective effect on future grain yields of CA under climate change, compared to CT. The yield gains from implementing CA technologies in wheat under historical, 2050, 2070, and 2090 climates (averaged over all SRFSI sites simulated) ranged from 6 - 2%, and illustrate a declining value of CA on yield as the climate became harsher. Maize follows an opposite trend, ranging from 1 – 4%. These results will be incorporated into the existing Climate Synthesis Report for a comprehensive account of climate change work within ACIAR SDIP.

As well as being impacted on by the changing climate, the agriculture sector is a significant contributor of emissions, and hence management practices that can minimise emissions and prevent the loss of soil carbon are important considerations in minimising wider scale impacts. Soil organic matter is crucial for soil fertility, water retention and maintenance of crop productivity (Awale et al., 2017), and is heavily influenced by management practices such as tillage, residue retention and fertiliser regimes. Impacts on soil carbon have been monitored within the life of the program, with CASI systems appearing to have a positive impact on both the amount and types of carbon present in the upper soil layers. However, changes in soil organic carbon (SOC) are often variable in the early stages of using CA techniques, and stronger trends are often only seen in the longer term. This is supported by modelling results which show potential for 150% increase in SOC over a 35 year time frame. As noted in Section 2.3.2, efficient use of N fertilizer will have a positive greenhouse gas impact, and in the long-term this may be more important than the soil carbon dynamics in the system. Future studies undertaken should consider the greenhouse gas impacts of improving N use efficiency, both in terms of reducing the amount of N applied, hence reducing emissions associated with N fertiliser manufacturing, and the amount of N lost from the soil.

Focused work on groundwater, as reported earlier, offers an option to improve climate change adaptation and resilience, given likely impacts on rainfall timing, quantity and intensity. At present, groundwater in the EGP is an underutilised resource, and so a better understanding of availability and the implications of its management alongside energy and food policies is critical to maintain sustainability.

Annexe 3: Publications list 2019-20

Journal papers

1. Agrawal, S., Kumar, S., Singh, D., Dutta, S., & Kumar, S. (2019). Growth and yield enhancement of rabi maize through identification of best timing for herbicide application. International Journal of Chemical Studies, 7(4). Retrieved from http://www.chemijournal.com/archives/2019/vol7issue4/PartT/7-3-767-214.pdf [Impact Factor [5]]
2. Bell, R., Haque, M., Jahiruddin, M., Rahman, M., Begum, M., Miah, M., Islam, M.A., Hossen, M.A., Salahin, N., Zahan, T., Hossain, M.M., Alam, M.K., & Mahmud, M. (2019). Conservation Agriculture for rice-based intensive cropping by smallholders in the Eastern Gangetic Plain. Agriculture, 9(1). Retrieved from https://www.mdpi.com/2077-0472/9/1/5 [Impact Factor 2.1]
3. Gathala, M.K., Laing, A.M., Tiwari, T.P., Timsina, J., Islam, S., Chowdhury, K., Chattopadhyay, C., Singh, A.K., Bhatt, B.P., Shrestha, R., Barma, N.C.D., Rana, S., Jackson, T.M., & Gerard, B. (2020). Enabling smallholder farmers to sustainably improve their food, energy and water nexus while achieving environmental and economic benefits. Renewable and Sustainable Energy Reviews, 120. https://doi.org/10.1016/j.rser.2019.109645 [Impact Factor 12.11]
4. Gathala, M.K., Laing, A.M., Tiwari, T.P., Timsina, J., Islam, S., Bhattacharya, P.M., Dhar, T., Ghosh, A., Sinha, A.K., Chowdhury, A.K., Hossain, S., Hossain, I., Molla, S., Rashid, M., Kumar, S., Kumar, R., Dutta, S.K., Srivastwa, P.K., Chaudhary, B., Jha, S.K., Ghimire, P., Bastola, B., Chaubey, R.K., Kumar, U., & Gérard, B. (2020). Energy-efficient, sustainable crop production practices benefit smallholder farmers and the environment across three countries in the Eastern Gangetic Plains, South Asia. Journal of Cleaner Production, 246. https://doi.org/10.1016/j.jclepro.2019.118982 [Impact Factor 7.2]
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6. Islam S., Gathala, M.K., Tiwari, T.P., Timsina, J., Laing, A.M., Maharjan, S., Chowdhury, A.K., Bhattacharya, P.M., Dhar, T., Mitra. B., Kumar, S., Srivasta, P.K., Dutta, K.S., Shrestha, R., Manandhar, S., Shrestha, S.R., Paneru, P., Siddiquie, N., Hossain, A., Islam, R., Ghosh, A.K., Rahman, M.A., Kumar, U., Rao, K.K., & Gérard, B. (2019). Conservation agriculture for sustainable intensification: An opportunity to increase crop, system yields and water productivity for smallholders of the Eastern Gangetic Plain. Field Crop Research, 238 (February), 1–17. https://doi.org/10.1016/j.fcr.2019.04.005 [Impact Factor 4.3]
7. Jat, M.L., Chakraborty, D., Ladha, J.K., Rana, D.S., Gathala, M.K., McDonald, A., & Gerard, B. (2020). Conservation agriculture for sustainable intensification in South Asia. Nature

[5] Local journals often do not have an assigned Impact Factor, but it is important to publish in openly accessible sources.

Sustainability, 3(4), 336–343. https://doi.org/10.1038/s41893-020-0500-2 [Impact Factor still under calculation – new journal]

8. Kumari, A., Kumar, S., Ghosh, M., Chandini, Dutta, S., Kumar, V., Pradhan, A.K., & Behera, S. (2020). Effect of Tillage, Sowing Time and Irrigation Levels on Nutrient Uptake and Yield of Maize (Zea mays L.). International Journal of Current Microbiology and Applied Sciences, 9(3). Retrieved from ijcmas.com/abstractview.php?ID=16309&vol=9-3-2020&SNo=34 [Impact Factor*]
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10. Miah, M., Haque, M., & Bell, R. (2019). Impact of multicrop planter business on service providers' livelihood improvement in some selected areas of Bangladesh. Bangladesh Journal of Agricultural Research, 44(3). https://www.banglajol.info/index.php/BJAR/article/view/43475 [Impact Factor*]
11. Mitra, B., Bhattacharya, P., Sinha, A., Chatterjee, R., & Chowdhury, A. (2020). Zero Tillage Technology in Jute Cultivation: A Successful Venture in West Bengal. International Journal of Current Microbiology and Applied Sciences, 9(5). Retrieved from https://www.ijcmas.com/9-5-2020/Biplab Mitra, et al.pdf [Impact Factor*]
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14. Thingbaizam, L., Ghosh, A., & Das, K. (2019). Differential pattern in labour use on male vs female managed farms and its economic consequences: a case study from Manipur, India. Agricultural Economics Research Review, 32(1). Retrieved from https://econpapers.repec.org/article/agsaerrae/292209.htm [Impact Factor*]

Book chapters

1. Araüjo, A., Sims, B., Desbiolles, J., Bolonhezi, D., Haque, E., He, J., Abdalla Fayad, J., Kienzle, J., Wildner, L., Li, H., Zanella, M., El-Gharras, O., Bell, R., Peiretti, R., Mkomwa, S., Duiker, S., & Friedrich, T. (2020). Status of mechanization in Conservation Agriculture systems. In A. Kassam (Ed.), Advances in Conservation Agriculture Volume 1: Systems and Science. Retrieved from http://dx.doi.org/10.19103/AS.2019.0048.11
2. Darbas, T., Brown, P., Das, K., & Datt, R., Kumar, R.,Pradhan, K., & Rola-Rubzen, F. (2020). The Feminization of Agriculture on the Eastern Gangetic Plains Implications for Rural Development. In Bihar: Crossing Boundaries. Delhi: Primus Books.

Technical reports

1. Ajmani, M., Choudhury, V., Kishore, A., & Roy, D. (2020). ASEAN, SAARC, and the Indomitable China in Food Trade: A Gravity Model Analysis of Trade Patterns. New Delhi, India.
2. Ajmani, M., Choudhary, V., Kishore, A., & Roy, D. (2019). Food Trade in Bangladesh, India and Nepal. New Delhi, India.
3. Brown, P., Darbas, T., Kishore, A., Rola-Rubzen, M., Murray-Prior, R., Anwar, M., Hossain, M.S, Siddique, M.N-E-A, Islam, R., Rashid, M., Datt, R., Kumar, U., Pradhan, K., Das, K.K., Dhar, T., Bhattacharya, P.M., Chowdhury, A.K., Ghosh, A., & Tiwari, T. (2020). Implications of conservation agriculture-based sustainable intensification technologies for scaling and policy: Synthesis of SRFSI Phase 1 socioeconomic studies (2012-17). Canberra.
4. Choudhary, V., & Kishore, A. (2019). Diets in the Eastern Gangetic Plains. Brief assessment of sources and a comparison with the EAT-Lancet recommendations. New Delhi, India.
5. Dawson, B. (2019). Climate change in South Asia. Projected trends and impacts on agriculture in the Eastern Gangetic Plains. Delhi.
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7. Gaydon, D., Chaki, A., Dutta, S., Laing, A., & Poulton, P. (2020). APSIM Modelling for on-farm SRFSI trials in the EGP. Brisbane, Australia.
8. Joshi, K., Joshi, C., & Kishore, A. (2019). Women's labour force participation in rural India. Current status, patterns and drivers. New Delhi, India.
9. Kishore, A. (2019). The changing energy-irrigation nexus in Eastern India. New Delhi, India.
10. Kumar, A., & Saroj, S. (2020). Credit in the Eastern Gangetic Plains. Brief assessment of sources and uses of loans in rural areas. New Delhi, India.
11. Mukherji, A., Buisson, M., Mitra, A., Banerjee, P. S., & Chowdhury, S. Das. (2020). Does increased access to groundwater irrigation through electricity reforms affect agricultural and groundwater outcomes? Evidence from West Bengal, India. New Delhi, India.
12. Sen, K., Dave, H., & Krishnan, S. (2019). Groundwater quality in the Eastern Gangetic Plains. How important is it, and what needs to be the response? New Delhi, India.
13. Sen, S., Mondal, S., Daniel Raj, A., Chatterjee, S., & Jain, S. (2019). Rural women at work or out of work? A gendered analysis of rural employment in the Eastern Gangetic Plains. New Delhi, India.