1 Introduction

Current food production systems are under pressure from many sources: the population explosion, environmental demands, increased competition for water from other sectors, physical water scarcity due to climate variability, and a greater demand for biofuels and renewable energy among them. In the broader context, these pressures occur within complex biophysical and socioeconomic settings and have impacts on social, economic, ecological and political outcomes. Often decisions made about the management of food, water or energy are not considered in relation to the other interlinked elements, and so perverse outcomes are experienced. For any given circumstance there may be synergies and/or conflicts between the sectors. This is true at a range of levels, from the field or farm through to community, policy and regional levels. We need ways to understand and manage the food-energy-water nexus at different scales, and to communicate these understandings to generate action for widespread transformation of sustainable food systems.

The Eastern Gangetic Plains of Bangladesh, India and Nepal is home to 450 million people, with the world's highest concentration of rural poverty and a strong dependence on agriculture for food security and livelihoods. The Eastern Gangetic Plains has the potential to become a major contributor to South Asian regional food security, but rice and wheat productivity remain low, and diversification is limited because of poorly developed markets, sparse agricultural knowledge and service networks, and inadequate development of available water resources and sustainable production practices. Labour shortages are becoming more acute. These factors lead to smallholder vulnerability to climate and market risks that limit farmer and private sector investments in productivity-enhancing technologies. Options are needed to sustainably improve food systems in the region.

Managing the interactions between food, water and energy at different scales is of critical importance to sustainable development. To address these challenges, the Sustainable Development Investment Portfolio (SDIP) was an Australian Government initiative, coordinated by the Department of Foreign Affairs and Trade (DFAT). SDIP aimed to improve the integrated management of food, energy and water in South Asia, to facilitate economic growth and improve the livelihoods of the poor and vulnerable, particularly women and girls, and address climate risks. The SDIP focused on the Indus, Ganges and Brahmaputra river basins. These basins are shared by several countries in the region and are highly vulnerable to conflicts over the management of increasingly scarce resources. SDIP ran in 2 phases: Phase 1 from 2013 to 2016 (AUD$45 million), and Phase 2 from 2016 to 2021 (AUD$47.9 million), although it was initially designed as a 12-year investment.

In the SDIP, DFAT worked in a partnership arrangement[1] with 7 Australian and regional partners (ACIAR, CSIRO, Integrated Mountain Development, International Centre of Water Resources Management, International Finance Corporation, The Asia Foundation, South Asia Water Initiative – World Bank). Partners were engaged to advance the goal and objectives of the SDIP according to their mandate and expertise, meaning that the portfolio worked on a range of areas, including integrated water resource management, management of floods and other water-related disasters, new knowledge of food-energy-water systems and the impact of climate change, renewable energy, sustainable food systems and improved resource efficiency. With all partners, SDIP worked towards the following outcomes:

1. **Strengthened mechanisms for regional cooperation:** operating at a regional, national and/or sub-national level in the sub-region.
2. **Critical new knowledge generated and used:** within the priorities acknowledged by regional forums, governments and national bodies, and addressing said knowledge gaps through science and/or well evidenced and reflective practice.
3. **Improved enabling environment:** within the policies, regulations, market systems and investment conditions for cross-border management of shared water, food and energy resources.

As a partner, ACIAR focused on food and agriculture elements of the food-energy-water nexus. The ACIAR SDIP program goal was to maximise agriculture's contribution to sustainable food systems in the Eastern Gangetic Plains, for improved food, energy and water security. The framing of the food system broadens the scope of work within the program, because although it necessarily focuses on the agricultural part of the food system given the ACIAR mandate, it includes the connections between farming systems and other components of the food system, such as markets, community and government institutions, finance, and public policies. The program transitioned from understanding and promoting sustainable farming technologies based on conservation agriculture in SDIP Phase 1 (see **Chapter 2.1**), to the wider context of the food system and a deeper understanding of the various factors which influence and enable sustainable food systems in Phase 2. The ACIAR SDIP investment strategy focused on sustainable food systems as a way of integrating different sectors at a range of scales, and ensuring gender-inclusive planning processes and outcomes. The aim was to promote resilient and inclusive food systems supported by robust institutional arrangements, policies and strategic regional planning. The specific ACIAR SDIP Phase 2 objectives are outlined in Table 1, which also indicates how these objectives relate to end of program targets and the overall SDIP outcomes.

1 See Appendix 1 for more details.

Table 1 ACIAR SDIP Phase 2 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 Eastern Gangetic Plains (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 Eastern Gangetic Plains 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. 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.
4. 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 socioeconomic 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.

This report provides a high-level overview of the findings from the ACIAR SDIP Phase 2 program. Detailed reports on the various outputs from projects are available at aciarsdip.com. The focus of this report is:

- the approach taken within the ACIAR SDIP program during SDIP Phase 2
- the context for work in the Eastern Gangetic Plains
- the outputs and outcomes associated with the research
- reflections on lessons learned from implementing a program approach.

The work undertaken in SDIP Phase 1 provided a strong base of farming systems research, partnerships and emerging impacts from which to build the following program of work.

2 Implementing the ACIAR SDIP program

The ACIAR SDIP program focused on maximising agriculture's contributions to food systems, while working towards food, energy and water security in the Eastern Gangetic Plains (Figure 1). In Phase 1, the focus was on understanding local systems, and testing and promoting sustainable and resilient farming systems. In Phase 2, the scope expanded to situate those farming systems in the wider food system, and explore how changes impact on, and are constrained by, institutional settings and natural resources, both now and under future pathways. This chapter describes the evolution of ACIAR SDIP (Figure 2) and its current structure (Figure 3). A list of the projects that correspond to the components, and their main focus, is presented in Table 2.

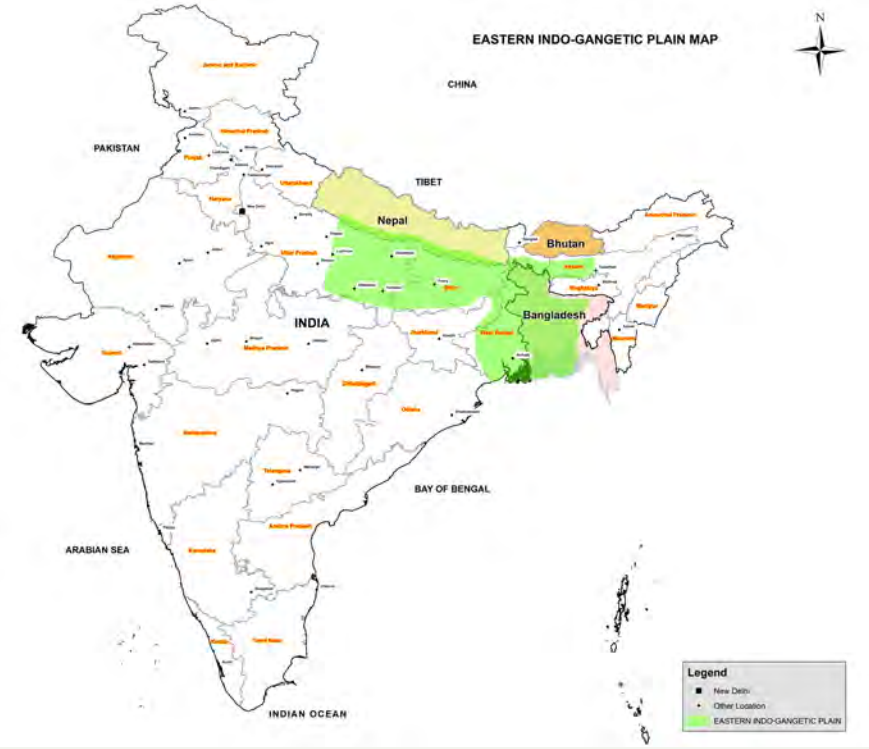


Figure 1 The ACIAR SDIP program focus of the Eastern Gangetic Plains

2.1 A phased approach

The SDIP portfolio was designed in 4-year stages, and the way ACIAR contributed changed throughout the course of the program, as shown in Figure 2.

ACIAR SDIP Phase 1 (see the *ACIAR SRFSI Synthesis Report 2018–2020* (Jackson et al. 2018)), consisted of one large project, the Sustainable and Resilient Farming Systems Intensification (SRFSI) project, managed by CIMMYT and involving more than 20 partners from Bangladesh, Bihar and West Bengal (India), and Nepal. This project focused on understanding local systems, demonstrating the contribution of Conservation Agriculture based Sustainable Intensification approaches (together referred to as CASI) to smallholder farming systems, and at the same time exploring the enabling environments that were required to support and scale out these technologies. This was focused mainly at the farm and community levels. This work built on 2 decades of research exploring sustainable intensification and resource conservation options in the north-west Indo-Gangetic Plains region of India. In 2011, the Government of India requested ACIAR to focus on the Eastern Gangetic Plains where the experience and expertise developed in the north-west could be applied in the eastern region with modifications.

The CASI approach is a broader form of conservation agriculture that incorporates agronomic, socioeconomic 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 conservation agriculture principles of minimising soil disturbance, ensuring soil cover and diversification through rotations – and including use of improved varieties, better irrigation practices and improved crop management techniques. The 4 pillars of the SRFSI project were:

- farmer participatory technology generation
- strong local innovation systems to help overcome value chain bottlenecks
- enhanced capacity of market and service agents to support farmer innovation
- farmer-to-farmer knowledge exchange.

Extensive work was also undertaken to understand the local context from agroecological, socioeconomic, institutional and policy angles.

Figure 2 The evolution of ACIAR SDIP, 2012–2021

The research and development activities under the project were conducted in 8 districts in the Eastern Gangetic Plains:

- Rajshahi and Rangpur in Bangladesh
- Malda and Coochbehar in West Bengal, India
- Purnea and Madhubani in Bihar, India
- Sunsari and Dhanusha in Nepal.

These locations were chosen specifically to test techniques in a range of agroecological settings, as well as to enable cross-border comparison of results, and to explore the effects of institutional and policy settings. The project developed activities in 40 locations across 8 districts, and then used these activities as training grounds for up-scaling of project methodologies and out-scaling of technologies.

Proof of concept of CASI has been widely published (Dutta et al. 2020; Gathala n.d.; Gathala et al. 2021; Gathala et al. 2020; Islam et al. 2019; Jat et al. 2020), and a summary of the work undertaken in Phase 1 can be found in the synthesis report (Jackson et al. 2018). In Phase 2, an extension of SRFSI to September 2021 (despite initial plans to end in 2017) allowed the focus to shift to scaling of project technologies, as well as understanding the science of scaling and the impacts and extent of CASI adoption. Work undertaken within the timeframe of SDIP Phase 2 (2018–2021) is described in this report (Brown 2021), as it formed a key foundation from which to build the other elements of the program, as well as offering locations where other research could be grounded in truth.

In Phase 2, the ACIAR SDIP began working with a wider range of stakeholders from policymakers and implementers, including food policy and gender researchers, to understand constraints to, and impacts of, scaling sustainable farming systems. This included deepening understanding of how institutional and social factors, markets and technologies interact to constrain or enable the adoption of sustainable intensification technologies. Additional work explored biophysical constraints such as soil and weed dynamics, and a better understanding of the context for water and energy resources management. The growing challenges of climate change, and the need to promote gender equality by empowering women and girls are themes that were integrated in activities across the program.

2.2 Phase 2 program framework

In Phase 2, ACIAR SDIP moved to a program approach managed by ACIAR, with 18 projects of various sizes (Table 2), and working with a range of commissioned organisations from independent consultants to local research and development agencies, and international research organisations. Extending the time for SRFSI allowed learning from Phase 1 activities, and to maintain a connection to field locations. The ACIAR SDIP program was implemented through 4 interacting components of work that contributed to the target outcomes and overall program goal, as shown in Table 1 and Figure 3. Importantly, a dedicated team was resourced to provide support for integration and synthesis. This meant that project activities and outputs were coordinated and communicated for maximum benefit to the end user from farmer to policy level.

The flexible structure of the program allowed ACIAR to build a program that addressed issues where ACIAR projects could 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 was 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. More information on the planning and objectives for Phase 2 can be found in the implementation framework (ACIAR 2018a).

The program framework (Figure 3) shows how individual project activities and their outputs fed into the program's objectives, often with multiple areas of influence; and how these objectives in turn overlapped to create synergies within program outputs that contributed to key themes, including groundwater, institutions, gender, climate and the food-energy-water nexus. Importantly, the objectives both inform and are informed by individual projects. The projects used cross-cutting research approaches including:

- working at multiple scales and locations
- multi-stakeholder engagement
- capacity building, with the ultimate aim of scaling.

The 4 major components of the program contributed in the following ways:

1. **Foresight framing.** These activities helped to frame the food system from the future, and provided an overarching method for synthesis and dialogue. The intention was to improve collaboration between key regional partners to strengthen understanding of longer-term food system changes and the implications for food, water and energy security; and identify transformational opportunities, particularly in the context of gender and climate change.
2. **Effective institutions.** These activities focused on the space between planning and technology implementation to identify effective institutional arrangements to support food systems. The aim was to create a more conducive, enabling environment for sustainable food systems by building capacity within district, state and national agencies in the Eastern Gangetic Plains to identify and promote institutions that foster successful intensification, integrated decision-making and inclusiveness in agriculture.
3. **Better field–policy links.** These activities capitalised on existing work in Phase 1 to improve the understanding of scaling approaches that link field and policy levels. Linking macro and micro understanding of different elements of the food system was a key output. The aim was to optimise the learning from scaling field-scale activities and local engagement to promote two-way flows of information.
4. **An improved knowledge base.** These activities built the technical and socioeconomic knowledge base with respect to sustainable food systems and practices, including the role of women and men and the impact of climate change, knowledge sharing mechanisms, better understanding of the resource base and interactions, and the major drivers of food systems. These filled critical knowledge gaps to support the development of an enabling environment, and to allow better decision-making.

Table 2 List of projects in ACIAR SDIP Phase 2

Component	Project	Commissioned organisation
Foresight framing	Foresight for sustainable food systems in the Eastern Gangetic Plains (WAC/2018/168; WAC/2019/136; WAC/2020/158)	International Food Policy Research Institute
Effective institutions	Institutions to support intensification, integrated decision making and inclusiveness in agriculture in the East Gangetic Plain (LWR/2018/104)	University of South Australia
	Sustainable Agricultural Mechanisation in the Eastern Gangetic Plains: Facilitating change through institutional innovation (WAC/2018/220) "Roadmaps"	CIMMYT
Better field–policy links	Sustainable and Resilient Farming Systems Intensification – Variation 4 & 5 Learning from scaling (CSE/2011/077)	CIMMYT
	Understanding the gendered implications of changing weed dynamics in farming systems intensification in the Eastern Gangetic Plains (WAC/2018/221)	CIMMYT
	Pilot project on commercialisation of the Virtual Multi-Crop Planter in Bangladesh (LWR/2018/111)	Murdoch University
	Value chain and policy interventions to accelerate adoption of zero tillage in rice-wheat farming systems across the Indo-Gangetic Plains (CSE/2017/101)	University of Adelaide
Improved knowledge base – context for development	Understanding women's role in agriculture in the Eastern Gangetic Plains: The macro and micro connections	South Asia Consortium for Interdisciplinary Water Resources Studies
	Political economy analysis of cross border agricultural trade in Bangladesh, India and Nepal	The Asia Foundation

continued

Table 2 *continued*

Component	Project	Commissioned organisation
Improved knowledge base – sustainable resource use and interactions	Regional scale water impacts (WAC/2019/104)	CSIRO
	Unravelling the WEF nexus in WB, India. Does increased access to groundwater irrigation through electricity reforms affect equity and sustainability outcomes? (WAC/2019/151)	International Water Management Institute
	Role of groundwater in agrarian change in West Bengal and Bangladesh: A comparative analysis	International Water Management Institute
	Quantifying crop yield gaps across the Indo-Gangetic Plains from new perspectives – production, farmer profit and sustainability of water use (WAC/2018/169)	CSIRO
	Aquifer characterisation, artificial recharge and reuse of suddenly available water in south Bihar (WAC/2018/211)	Nalanda University
	Identifying Eastern Gangetic Plains Soil Constraints (CROP/2018/210)	University of Queensland
Improved knowledge base – knowledge sharing mechanisms	Farmers' Hubs as a vehicle to deliver solutions and services to farming communities (CROP/2020/202)	CSIRO
	Pilot study on knowledge transfer mechanism for effective agriculture extension services in Nepal	Centre for Green Economic Development Nepal

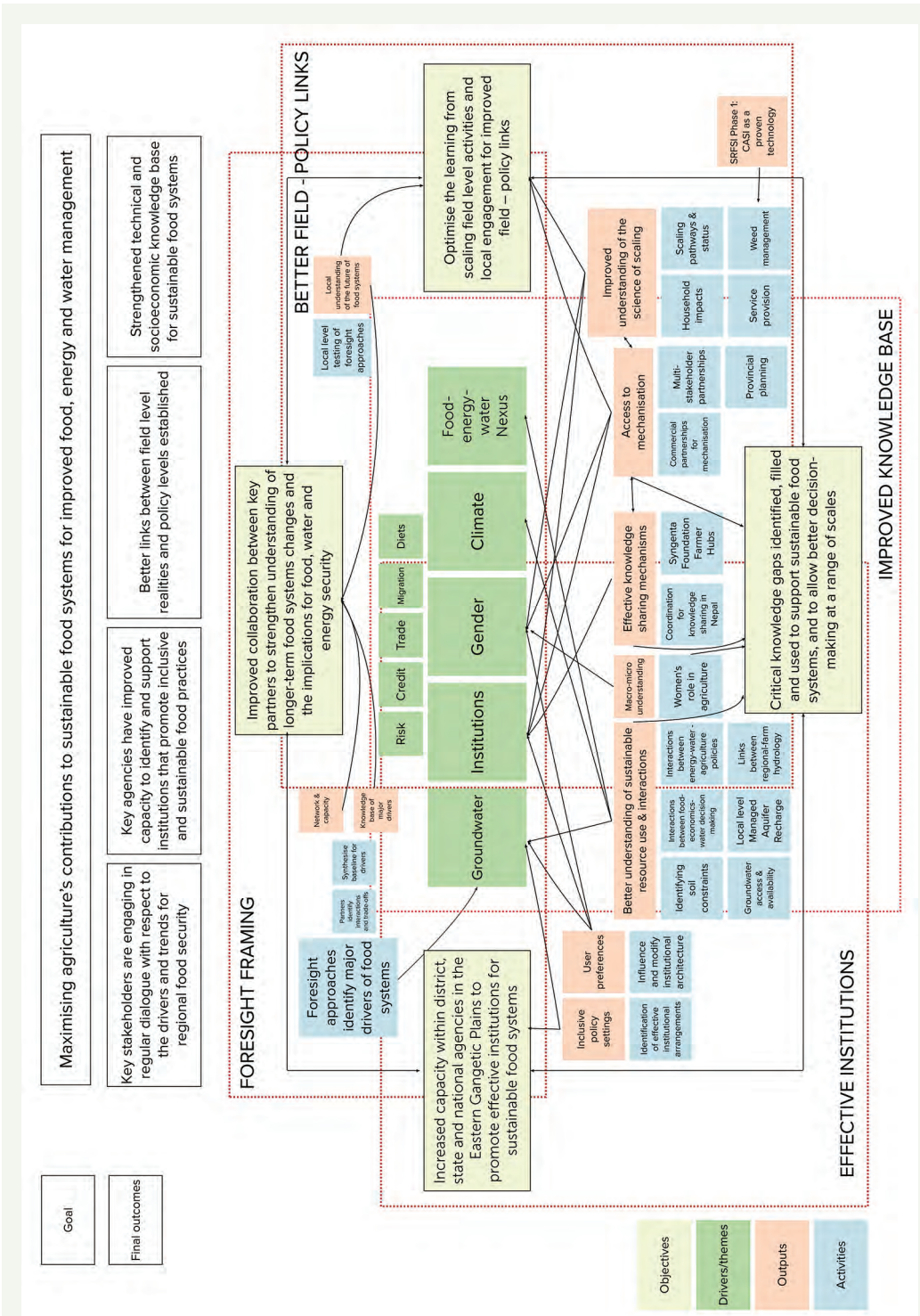


Figure 3 ACIAR SDIP Phase 2 research framework

2.3 Reflections on the program approach

When moving into Phase 2 in 2016, there was a push from DFAT to use a more flexible program design, building on what had been achieved in SDIP Phase 1 (SRFSI), but not replicating this approach. Consequently, the ACIAR component of SDIP undertook a lengthy planning phase during 2016–17, which saw 2 different strategies developed, with the first one superseded by a more flexible program design developed at the end of 2017. A new team came on board in late-2017, having to operationalise this strategy quickly, as the program was already 2 years behind schedule.

2.3.1 Transitioning from a project to program approach

Transitioning between the phases presented both opportunities and challenges. The opportunities included enhanced flexibility. This meant the program had the ability to work at different scales and could bring in new partners to expand the ACIAR network in South Asia. It allowed work on a more diverse set of research questions. These benefits are further outlined in **Chapter 8**.

However, the delay in starting Phase 2 had implications for the operation of the program, and these did create some challenges. With effectively half the time to implement Phase 2 (2 years instead of 4), there was not a lot of time for reflection while in operations mode. Project teams were under time pressure, and so linking activities between projects that might have been possible (and budgeted fully) with the full time of the phase was not realistic, as the management team tried to reduce additional burdens for teams. The transition of SRFSI between phases also became reactive rather than planned from the start, which potentially altered decisions taken.

2.3.2 Managing delays in timelines

The delay in design and implementation of SDIP Phase 2 ultimately meant that we had to commission projects that could be started quickly, and that could address complex issues in relatively short timeframes. Additionally, we had to work within the ACIAR commissioning processes. This was managed by using trusted partners we knew could deliver, although there were still opportunities to work with some new partners, particularly in the foresight activities. We developed most projects as small research activities and short contracts. This suited both the process side and the need to constrain research questions because of the compressed time. Phase 2 relied heavily on SRFSI for the field-level links. We also lobbied for more time and funds from DFAT in 2020, and were successful. Continued staggered extensions to SDIP Phase 2 (from August 2020 to December 2020, then to June 2021, then to September 2021) meant we were able to continue to deliver results at project and program levels. However, it would have been much more useful to have known we had the additional year (and funds) and been able to plan accordingly.

2.3.3 Prioritisation, project and partner selection processes

Prioritisation of projects to be funded and selection of partners in Phase 2 was driven by the framing of the wider portfolio, as well as the reality of working within a constrained timeframe (initially 2 years, eventually extended to 3). First, projects and research questions needed to fit within the broader scope of the food-energy-water nexus framing within the wider SDIP, as well as the climate and gender themes.

Projects on the role of women in agriculture broadened the knowledge base and identified macro and micro links. The portfolio of work on groundwater helped

deepen understanding of the context for the food-energy-water nexus beyond the farm scale. This set of projects involved partners with known expertise and experience in the region to capitalise on their previous research outputs. Projects had discrete research questions that could be completed in a short timeframe.

In the foresight projects, the commissioned organisation was a trusted partner with the capacity to look at the 'big picture', and an interest in working with an evolving activity. Specific topics within these projects were determined through expert consultation. Small research tasks were intentionally given to regional experts to build on existing capacity and widen the network of stakeholders.

Several of the projects that addressed constraints to sustainable intensification were identified as priorities in the Technical Review of SRFSI in March 2018, recognising that with longer-term implementation of conservation agriculture there are often emerging, secondary constraints. Partners were existing SRFSI partners with specific, subject-related expertise and capacity to deliver within a shorter timeframe.

The focus on scaling mechanisation was appropriate, given the work in Phase 1 on conservation agriculture, and the intention to enable scaling. These projects capitalised on existing drivers and opportunities, for example, the role zero till can play in addressing stubble burning and hence air pollution; and existing machinery networks looking to commercialise.

A set of work on improved knowledge-sharing mechanisms was tied to the foresight work in Nepal – to address issues with changed governance approaches as a key driver of food systems in Nepal, and as an identified local need for coordination mechanisms between different levels of government. This also capitalised on existing partnerships and opportunities identified through ACIAR networks.

2.3.4 Steering committee

The role of the steering committee was to guide the work of the program by informing of national priorities and responding to higher-level research results. The committee advised on the program's integration with regional policy, dialogue processes and other research efforts, and commented on specific proposals.

The committee consisted of a mix of eminent representatives of the wider agricultural system, including members of national planning commissions, regional partner organisations, academia, research, development, and the private sector. The members were intentionally recruited to represent expertise that spanned the program priorities including food and agriculture, gender, water, energy and nutrition; a spread of nationalities across the target countries; and with a gender balance (see Appendix 2 for details).

Practically, the committee members contributed their time gratis to meet twice in a year, within the participating countries. The meetings were intentionally aligned with project activities, particularly foresight meetings, and with out-scaling activities. The committee guided the development of relevant and responsive studies emanating from policy, analytical and synthesis studies within the program.

3 Framing food systems using a 'foresight' approach

The foresight component contributed to Objective 1: *Improve collaboration between key partners to strengthen understanding of longer-term food systems changes and the implications for food, water and energy*. Changes in the agricultural production system, such as those demonstrated by the SRFSI project, need to be understood within a wider context of long-term changes in food systems, in particular economic transformation, a changing climate, altered consumption patterns, trade, and issues of nutrition. Foresight approaches provide a way of framing the food system.

Sustainable food systems are those that promote production and consumption of safe and healthy food without compromising the environment. They consider sustainability, health and economic issues from the integration of consumption, distribution and production.

Food systems foresight aims to help to provide a long-range perspective on key drivers and trends in regional and local food systems and the implications for water and energy use. Foresight is a process to bring greater social and political awareness of these issues, and to drive change by engaging key stakeholders and exploring alternative future scenarios and transformation pathways.

In terms of foresight for agriculture, the work has explored how the sector is unfolding, what the key pressures are, and what it may look like in the future under business as usual and other scenarios. This can help to identify preferred transformation pathways for the future of small-scale farming.

3.1 Approach

Working with international, regional, national and local partners to test foresight approaches to understanding the food system at different scales in the Eastern Gangetic Plains, the framework at Figure 4 has been applied within ACIAR SDIP. It follows these steps:

1. Engaging with relevant actors, and identifying the purpose and motivation for foresight.
2. Understanding the system of analysis.
3. Identifying drivers, trends and uncertainties.
4. Exploring visions and scenarios.
5. Influencing change.

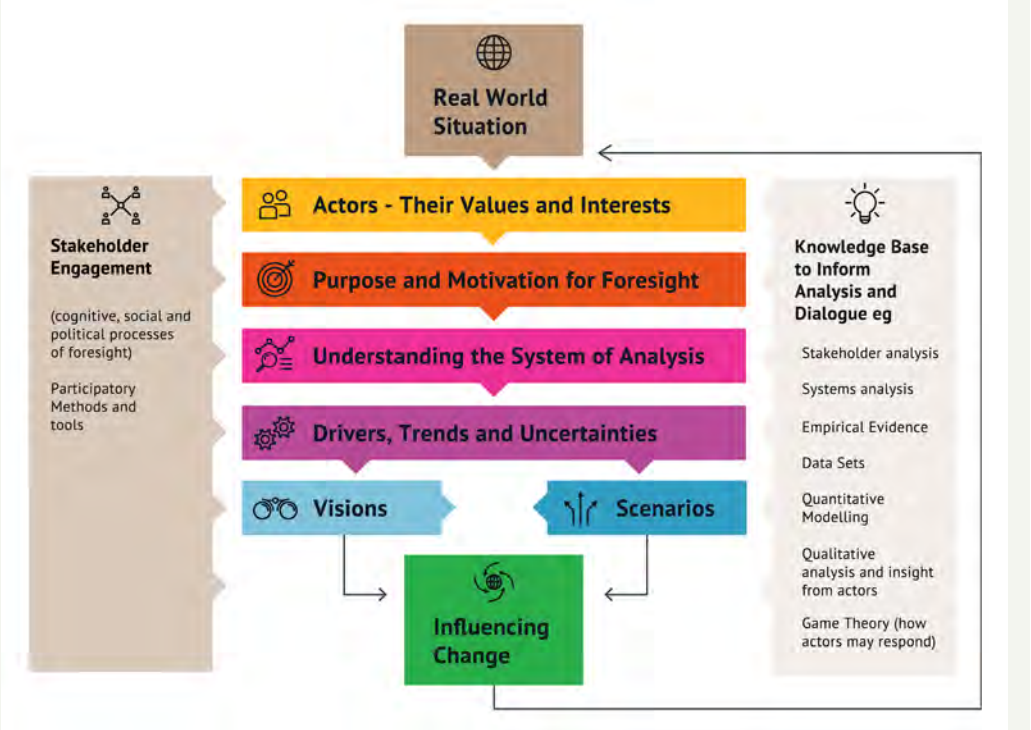


Figure 4 Foresight Framework (Woodhill and Hasnain 2019)

3.1.1 Engaging with relevant actors and identifying motivation

The first stage of the foresight work was to engage with relevant actors. A group of researchers, farmer leaders, and policymakers, who were interested in foresight and scenario-building exercises for a more sustainable food system, was convened (ACIAR 2018b). From the outset, participants noted that foresight work should be linked to the wider food system and include bigger donors, the private sector and the people who are making the decisions.

Over a series of workshops in 2018–19, more than 200 researchers, planners, policymakers, entrepreneurs, and civil society members came together for planning, learning and information sharing. These workshops helped build and strengthen a core group interested in undertaking foresight for food exercises in the region. The workshops also helped generate new ideas, gain new perspectives, and disseminate research findings.

We organised training and capacity building of regional actors to develop a shared understanding of what foresight for food means, and how to carry out foresight and scenario-building exercises. A participatory learning workshop was held in February 2019, with 47 participants (ACIAR 2019). It was designed as a series of training presentations and participatory exercises in methods for foresight and scenario analysis, using real-world examples based on the 4 focus geographic regions of ACIAR SDIP: Bihar, West Bengal, Nepal (Terai) and Bangladesh. Tools practised included developing rich pictures, systems diagrams, causal loop diagrams, participatory scenario development, and considering

the relevance and application of models for foresight analysis. Throughout the workshop, participants worked in regional groups to define a set of foresight activities that could be undertaken at the local level to inform and improve the future of food systems in different parts of the Eastern Gangetic Plains.

Economic transformation in Bangladesh, India and Nepal offers new opportunities and challenges for smallholder farmers in the region. Some of these opportunities and challenges are predictable and already apparent while many others are not. Whether leveraging the opportunities offered by rapid economic transformation or addressing the new challenges created by it, both require foresight and a systems-oriented approach to research and policymaking.

3.1.2 Understanding the system of analysis: building the evidence base

To commence the foresight process, country-level presentations were given by local partners to show the current situation for food systems, and to identify key drivers of change. This was followed by a session where mind maps were developed at country or province levels (Nepal), considering the key elements of the food system and the links between them. Interestingly, these drivers of change played out differently when they were prioritised in the different locations. Following this meeting, key deliverables were assigned to foresight partners, including:

- preparation of food systems mapping for India, Nepal and Bangladesh
- a series of status briefs
- the need for a centralised repository for regional data and reports related to understanding food systems in the region.

Through a series of workshops, participants explored country-level food systems to show the current situation, and to identify key drivers of change. Food systems status reports were produced for each country (for example, Subedi et al. 2020). The key drivers of change in the food system, and the links between them, were identified for each country (province in Nepal) through mind mapping and group discussion. Most of the existing food system mapping exercises focus on nutritional and health outcomes. Our analysis used a food-energy-water nexus lens to understand the food system in the Eastern Gangetic Plains and focused more on sustainable environmental and resource management aspects. The role of women in the region's food systems and the implications for them if the food system follows different trajectories of change was a core concern for all our analytical work and the workshops we organised in this small research activity.

Once a priority list had been agreed as outputs from the first workshops, a set of short status reports was developed as background material to support a better understanding of food systems in the Eastern Gangetic Plains. These highlighted the key facts, trends and patterns, and gaps in our understanding of the dynamics of these parts of the food system, and are summarised in **Chapter 3.1.4**. As well as the status reports, research papers were prepared on:

- food trade in Eastern Gangetic Plains countries
- comparing Indian diets with the EAT-Lancet reference diets
- demand elasticities of different food items in rural and urban India
- farmers' responses to food policies and weather shocks.

It is recognised that there is a wealth of information related to food systems in the Eastern Gangetic Plains, but it is scattered and exists at various scales. A key output of this project has been to synthesise and collate relevant information, hosted at aciarsdip.com/food-systems-in-the-egp.

3.1.3 Visions and scenarios

The foresight work intentionally explored visions at different levels and from different stakeholders. It aligned the work with the priorities of the state/provincial and national governments in the Eastern Gangetic Plains, and their ongoing activities for preparing a future vision for the agriculture and food sector and in realising this vision. Foresight activities were also undertaken at the local level, recognising that there are many opportunities and challenges unique to each location, and that there are few levers of change at the global or regional level. The agency for change in the food system is at subnational levels, as highlighted by participants in early foresight meetings (ACIAR 2018b).

In a comprehensive training workshop in February 2019, partners worked through the stages of a foresight process, applying tools and processes to the food system in their respective countries and local settings (ACIAR 2019). At the end of the training workshop, they had identified specific research questions that would be undertaken to explore foresight at the local level, with the intention of understanding and influencing change in local food systems. These exercises aimed to strengthen local capacities for scenario-based foresight exercises through training, mentoring and supporting a learning-by-doing approach. They also helped connect the big picture context with work at the local and regional level where change can happen.

Mechanisms to coordinate agricultural development in Nepal

In Nepal, foresight approaches were used as a policy dialogue tool to understand the implementation of agricultural development at a range of local levels: community, municipal and provincial. Participants collated and validated secondary data on different aspects of the food system in Province 2, with farmers – including women and near landless farmers – and other stakeholders in different parts of the province. These activities used a food systems framework and scenario-building approach. The team also held a stakeholder dialogue to discuss their findings, ultimately agreeing to jointly set up a large frontline agriculture enterprise demonstration in 3 municipalities. This brought together provincial, research, extension and federal Department of Agriculture actors to act as a coordinating mechanism, which was previously identified as a gap.

Understanding farmers' perceptions on agrarian change in West Bengal

In West Bengal, foresight contributed to expanding our understanding of the impacts of CASI for sustainable and equitable rural livelihoods. It explored how local communities foresaw agrarian change taking place, and the different strategies being used, or planned to use, to cope with these changes. In a comprehensive survey, farmers reported on technical, environmental and socioeconomic changes they were experiencing and that they believed would be important in the future, and strategies to cope with these changes. The general expectation is that women's participation in agriculture is shifting to a more significant role, while engagement of youth is declining. Youth decline is attributed to employment opportunities and low wage rates in agriculture, particularly for people with higher levels of education. CASI offers the potential for engagement of the rural youth

in service provision for agriculture, which is a welcome alternative income stream. Mechanisms for aggregating farmers will play a vital role in agricultural development in the future.

Three important issues were identified as important in the future, including market fluctuations, the labour availability crisis, and how to attract rural youth into agriculture. At the same time, farmers were concerned about soil and climate with the present strategy and future goals. Strategies used to cope with market fluctuation include seeking price verification before selling produce, and trying to understand the demand of the market before starting the season, however, farmers do not have any information support for this except information from fellow farmers. The labour crisis remains the major obstacle in timely sowing and harvesting of crops, and they anticipate this will become more serious in the future. Strategies to combat the future labour crisis include mechanisation, which is needed alongside proper training. Self-employment by providing business and crop diversification based on market demand were also potential options. It was recognised that a strategy of mechanisation and self-employment are linked to the involvement of youth, as a third key challenge to be addressed. Three major driving forces to bring youth back to agriculture were seen as increasing profitability through advanced technology, mechanisation, and appropriate youth training.

More in-depth study is required to understand the behaviour of the farmers undergoing agrarian changes and the strategies they think are best suited for them to combat the changes to stop driving development in a backward direction. From this study, it seems inevitable that mechanisation will be the major driving force in the future, however the communities are still not prepared with adequate capacity. A capacity-building process is needed to support proper mechanisation for conserving the soil, environmental health and maintaining sustainable development in the community.

How transitioning to diversified food systems impacts nutrition in Bangladesh

In Bangladesh, the impacts of transitioning to a diversified farming system on household nutrition were explored using 3 waves of nationally representative Bangladesh Integrated Household Survey data (BIHS 2011–12, 2015 and 2018) and a panel data model using fixed effect regression. High value agricultural diversification (crop, fish and livestock production) at the household level is the basis for a diversified food system. Analysis incorporated the links between price volatility, agricultural diversification and dietary diversification. Diversifying agricultural production has a statistically significant and positive impact on dietary diversity of both households and their individuals, especially on women and children. Moreover, women's empowerment and commercialisation of farm households also have a strong association in improving the dietary status, food and nutritional security. Participation in the market is helping farming households to become more commercially oriented, and has a significant effect on both agricultural diversification and dietary diversification. Participation in non-farm activities was also found to have a significant impact on dietary diversity, but not more than agricultural diversification. Diversification varies among regions, and policy interventions are needed to support the process as a way of improving nutrition status and women's empowerment.

Pathways towards healthy diets in India

The EAT-Lancet Commission developed and recommends a planetary health diet that promotes human health and sustains the health of the environment – achievable by improved production practices that transform food production into sustainable high-productivity systems and by reducing food losses and wastes.

The IMPACT model was used to assess potential pathways to make healthy diets more affordable in India. Importantly, the comparisons are not only for the current 2020 diet but also for alternative future diets by 2050 in light of the increasing influence of climate change on the supply of food; scarcity and unsustainable exploitation of land and water resources; and distortionary policies in agriculture.

Although moving nearer to the EAT-Lancet diet, the projected 2050 diet is still far removed from an Indian version of a planetary health diet. The general prescription of the EAT-Lancet Report of doubling the consumption of plant-sourced foods such as fruits, vegetables, legumes and nuts, and at least 50% reduction in the consumption of animal-sourced foods such as red meat and added sugars, does not serve well for the Indian diet, since the projected Indian diet is already high in fruits and vegetables and low in animal-sourced foods. Considering climate change, the shifts of future Indian diets are to come from a different direction.

As preconditions to a meaningful planetary health diet, policies that promote market inefficiencies and unsustainable production systems, such as subsidies on electricity that promote unsustainable exploitation of groundwater resources, and restricted trade, are addressed first before deliberately shifting towards an EAT-Lancet diet version for India.

A **sustainability policy scenario** provides for sustainable exploitation of groundwater resources and institutes a liberalised food trade. It is projected to further increase per capita consumption and push the resulting diet away from the reference EAT-Lancet diet, while providing positive welfare effects to society compared to net welfare losses in the absence of sustainability and efficiency policies. A deliberate effort to develop an Indian version of a planetary health diet would then be developed to complement the recommendations of the EAT-Lancet Commission.

The EAT-Lancet Commission advocates for supply-side transformations to sustainable food production systems to support the EAT-Lancet diet, including improved food production practices and the reduction of food losses and wastes along the food supply chains. **A demand-side policy scenario** focuses on changing consumer tastes and preferences, and enhances purchasing power by repurposing agricultural subsidies to increase productivity, profitability and income. The demand policies move the projected Indian diet closer to a version of a planetary health diet that closely tracks the EAT-Lancet diet and provides net welfare gains to society – with high gains for consumers while minimising losses to producers.

A **comprehensive policy scenario** that combines the sustainability scenario with a demand-shift scenario aims to maximise the gains from both policy scenarios. This further simulates the development of a planetary health diet version for India that not only promotes human and environmental health, but also optimises economic gains and welfare benefits to society.

From all these simulations, diets resulting from the demand policy and comprehensive policy are close candidates for an Indian planetary health diet – consumption levels

are within the ranges of the EAT-Lancet diet; exceed 2,000 kilocalories per person per day; are highest in land and water savings; and have positive gains to society. The major difference between these 2 policies is who bears the costs, and who enjoys the benefits most, in moving towards the EAT-Lancet diet. The demand policy favours the producers, with lower welfare loss annually, while the comprehensive policy favours the consumers, with welfare benefits of USD144 billion versus USD61 billion per annum. If, however, the winners (consumers) can compensate the losers (producers), in terms of welfare gains, the better choice is the comprehensive policy diet.

3.1.4 Influencing change

A multifaceted approach to influencing change has been undertaken in the foresight work. First, participants in the various meetings and workshops were intentionally targeted from a range of disciplines, sectors, organisations and stages of career development. This provided rich discussion and understanding of the key issues influencing food systems, and connected to a wide network of actors.

Local-level work has been included, recognising that there are many opportunities and challenges that are unique to each location, and there are fewer levers of change at the global or regional level. This is a way of connecting ground-level realities and priorities with the wider context of change in the Eastern Gangetic Plains.

For example, at a workshop in July 2019 in Kathmandu, elected leaders, senior officials from provincial and federal governments, participants from the Nepal Agricultural Research Council, leading think tanks and international organisations joined to discuss ways to capitalise on opportunities created by the federalisation of Nepal to build sustainable, inclusive and safe food systems for the country. Participants from across sectors focused on the role of credible knowledge and its extension to women and men farmers to build a sustainable food system. Participants called upon researchers to help build a shared understanding of the challenge before Nepal and facilitate greater coordination across the 3 levels of government – local, provincial and federal – for sustainable intensification of agriculture. These priorities have subsequently been incorporated into a small research activity that is looking at ways to coordinate knowledge exchange in 2 locations of Province 2.

The final stage of work under this program will produce a regional report on foresight for food systems in the Eastern Gangetic Plains region. It will synthesise the big picture analysis and the inputs from local-level participatory foresight exercises to share the findings with the policymakers, entrepreneurs and other stakeholders from the region, and connect the work done on foresight for food under SDIP with similar work by other national and international organisations. Planning and envisioning how food systems cope with big expected and unexpected shocks (black swan events) is an important part of foresight for food exercises. The project will also use the COVID-19 experience to explore the impact of a major disruption in the food system.

The foresight component is linked to a wider global initiative, Foresight4Food (foresight4food.net), being developed by a group of international organisations, research institutions, business networks and funders. It seeks to improve foresight and scenario analysis for the global food system, including strengthening the links between science and forums for dialogue.

3.1.5 Summary lessons

Foresight processes can create an opportunity for learning by bringing together different views and a breadth of intellectual enquiry that can contribute to the bigger picture of challenges in the region. Integration and synthesis of existing information, coupled with scenario planning, can enhance the knowledge–policy interface.

The foresight work has contributed to the ACIAR SDIP Phase 2 goals of developing a better understanding of the drivers and constraints that affect development of a sustainable food system in South Asia to ultimately create a more effective enabling environment.

The participatory research process in this project and its outputs will help ACIAR engage with policymakers and the private sector in the Eastern Gangetic Plains region in broader discussions about future directions, especially in the context of the food-energy-water nexus. The high-level policy forum on sustainable food systems for the Eastern Gangetic Plains region will offer an excellent opportunity for public diplomacy in the region and create greater visibility for the Australian Government's efforts to support agricultural research and policymaking in the region.

4 Food systems in the Eastern Gangetic Plains

Part of the work of ACIAR SDIP has been to explore the context for and links between farming and food systems in the Eastern Gangetic Plains to understand the various factors that influence agricultural development, from farm to country levels. This chapter is drawn from the work of multiple projects within ACIAR SDIP and provides a comprehensive snapshot of food systems in the region.

4.1 Agricultural systems

Agricultural systems in the Eastern Gangetic Plains are dominated by a single rain-fed rice crop in the kharif (monsoon) season, although it is possible for 2 kharif crops to be produced (that is, kharif 1 and 2). The rain-fed kharif crop(s) are followed by a crop in the rabi (dry, winter) season when farmers have access to irrigation or residual soil moisture. The main cropping systems differ by location but are traditionally rice–rice and rice–wheat, with rice–maize a relatively new system in most areas. The kharif crop is central to household food security in a region where most farming households operate at subsistence level.

Rabi (winter) crops in the study areas include wheat, maize, mustard, pulses (lentil, mung bean), jute and leafy vegetables depending on the location and water availability. In Bangladesh, tobacco, potato and mustard are other important crops in the rabi season, while rice, maize, jute, vegetables and pulses are grown in kharif. In Bihar, vegetables and potato are planted in the rabi season, with rice, vegetables, maize, mung bean and jute in kharif. In West Bengal, mustard, potato, summer rice, maize, pulses and tobacco are planted in the rabi season, with rice, jute, maize and vegetable in kharif. In Nepal, wheat, maize, lentils, vegetables and potato are planted in the rabi season, with rice, maize, mung bean and vegetables in kharif.

Cropping intensity is highly variable across the Eastern Gangetic Plains, ranging from 180 to 247% at the district level. This is coupled with low productivity and limited diversification due to a range of interacting factors, including limited market access; sparse agricultural knowledge and service networks; and inadequate development of water resources (whether due to physical infrastructure or economic barriers to pumping). Mechanisation is similarly limited to mostly diesel irrigation pumps, and 2- and 4-wheel tractors for farm operations. There is therefore significant scope to improve the sustainable productivity of these systems using appropriate technology and institutional settings, such as the CASI systems tested in the SRFSI project.

CASI can improve productivity and profitability in the kharif season through the use of improved seed of appropriate varieties, mechanised crop establishment techniques for

rice (mechanical transplanting and drill seeding), elimination of the traditional puddling operation, and better irrigation and fertiliser management. The rabi season is where CASI approaches can potentially have the biggest impact in terms of water savings and increased profitability, and where opportunities for diversification are ecologically more feasible and more likely to be accepted by local communities.

Considering the entire cropping system, as opposed to each singular crop, is vital from a food-energy-water perspective, as there are residual effects (both positive and negative) from changes made in one season on subsequent crops. For example, minimising or eliminating tillage and maintaining crop residue as per CASI principles builds soil carbon and improves soil structure, which improves water holding capacity of soil; fertiliser applied on a rabi maize crop often has a positive effect on the yield of the subsequent rice crop; and planting pulses and legumes provides nitrogen for a following crop. From a food-energy-water perspective, the biggest benefits from wide-scale implementation of CASI are likely to be through:

- improved water use efficiency for rabi rice
- the replacement of rabi rice with a lower water use and higher productivity crop like maize
- expansion of rabi crop production through improved access and management of irrigation
- the ability to intensify with a third crop in between kharif and rabi seasons.

All of these options improve water and energy efficiency at the farm level, while at the same time improving system productivity and profitability. More details are available in Jackson et al. (2018).

4.2 Socioeconomic settings

The socioeconomic make-up of the Eastern Gangetic Plains is complex, with a range of agroecological systems, livelihood strategies, farm sizes and tenure types, and access to technologies and institutions. The historical co-evolution of farming systems and agrarian socioeconomic structures has differentiated states and nations out of what was originally one Bengali region. Famine and food insecurity, which have featured for centuries in the Eastern Gangetic Plains region, have shaped the contours of Eastern Gangetic Plains' modern jurisdictions and are deeply ingrained on the psyche of farmers and policymakers. Food security is entangled with caste and tribal identities and their relative socioeconomic status within (rapidly eroding) strict social hierarchies. Regional differences are exacerbated by competition for energy, water resources, investment and market access. The Eastern Gangetic Plains jurisdictions are in varying degrees of transition from feudal, agrarian socioeconomic structures, and of integration into the global economy.

The region, in which some 450 million people live, features the world's highest concentration of rural poverty, which is interwoven with the social structures of class, caste and gender. The Eastern Gangetic Plains remains strongly dependent on agriculture, and landholding size is small even by South Asian standards. Average land size is just 0.6 ha, and this is often both highly fragmented and tightly held. Property rights are poorly defined in most parts of the region, including laws related to share cropping. Most farmers are classified as marginal or subsistence-level farmers. The major share of household income comes from cereal production (rice and wheat), and income tends to

be spent on food and farming. Access to markets is variable, with physical proximity to market sites ranging from 5 to 60 km from the household. Some locations are linked to national markets via private sector initiatives, and in these locations, farmers benefit greatly from these links. While the biophysical landscape is similar in terms of the extensive lowland alluvial plains, there are notable differences, for example in soil quality, which impact productivity. Importantly from an intensification angle, access to irrigation is highly variable.

Credit availability is a longstanding issue within the Eastern Gangetic Plains. Although there are financial institutions in all areas under the study, the ability of a farmer to access credit is highly variable. Due to limited public services in the Eastern Gangetic Plains, most farmers depend almost entirely on the private sector to secure agricultural inputs and access markets for their farm produce. The Eastern Gangetic Plains is a difficult environment for more formal medium- and large-scale businesses – profitability is generally low, with farmers having small input requirements, low purchasing power and small marketable surplus. Generalised infrastructure is poor, the region has low rates of urbanisation, and it is distant from major urban markets and ports. Poor connectivity (roads, power, credit, markets) increases inefficiency and decreases profitability. The cost of doing business in the Eastern Gangetic Plains is thus high for the private sector, which is dominated by small, informal and unorganised local businesses with limited reach among consumers, limited capital, and little value-adding capacity.

Widespread male circular and overseas labour migration is a common strategy to diversify household income. Such change inevitably alters gender relations, as farming women who are left behind are forced to take over the everyday decision-making that incrementally loosens patriarchal social structures. Although the 'feminisation' of agriculture is not universal in the Eastern Gangetic Plains, it is a notable trend in some parts, with the average incidence of female headed households ranging from 13 to 19%. Feminisation in Nepal and Bangladesh is consistent with expected trends, but defeminisation appears to be occurring in Bihar and West Bengal. This could be related to several factors, including higher levels of unemployment, lack of jobs and increased remittances. Within the household, women reported spending 50 to 60% of their time on household activities, with the remainder engaged in farming, livestock and leisure activities. Throughout the region, population growth is high, and there is a large youth population.

The information in this section is taken from Brown et al. (2020) and Jackson et al. (2018), where work undertaken in Phase 1 of the SRFSI project was synthesised.

4.3 Geopolitical economy

The Eastern Gangetic Plains countries of Bangladesh, India and Nepal all have overarching agricultural development strategies which aim to improve the incomes of smallholder farmers, improve profitability, and achieve sustainable resource use. Agriculture employs 38% of the total population in Bangladesh, 41% in India, and 65% in Nepal, while its contribution to the gross domestic product (GDP) of the 3 countries is only 13%, 16% and 24%, respectively. The income gap between those engaged in the farming and the non-farming sector has increased rapidly in South Asia. Most farmers in the Eastern Gangetic Plains cannot earn a living income from their small and shrinking landholdings if they rely on growing food grains only. Nor can grain agriculture

gainfully employ the rapidly growing numbers of working-age people. Various strategies have been developed to address these problems.

4.3.1 Bangladesh

Bangladesh emerged as a nation in the early 1970s as a result of a war of independence from west Pakistan and was immediately plunged into famine. Market liberalisation policies under structural adjustment settings throughout the 1980s helped the new nation to kickstart a Green Revolution in the 1990s that achieved national food grain self-sufficiency by 1995. Agriculture is a central subject in Bangladesh, with policy formulation and funding to provinces disbursed by the central government. It remains one of the most important sectors of the Bangladeshi economy, contributing 13% to the national GDP in 2019, although remittances from international labour migrants are just as significant. Trade liberalisation and a focus on infrastructure, for example the Jamuna bridge connecting the north to the south, helped agriculture to thrive and grow with cheaper water pumps and machinery. There is significant donor funding to this sector which has influenced the Government of Bangladesh's policies towards agriculture. A focus on achieving national food security, and significant and regular climate shocks, brought about protecting farmers and agriculture over the last 2 decades through state interventions like subsidies (Islam 2014). Currently, about 45.1% of the labour force is engaged in agriculture, but significant seasonal labourer scarcity and increasing labour wages have led to increasing production costs.

The Bangladesh Agriculture Development Strategy, developed as a part of the eighth Five Year Plan (2020–2025), describes the major strategies for agriculture as being diversification of agricultural production with high value crops, strengthening supply channels, and ensuring credit for smallholder farmers. It is critical that smallholders aggregate to form links with domestic and international markets. There is a need for institutional innovations and research which is inclusive and responsive to enable smallholders to increase their incomes while maintaining resource sustainability, particularly in terms of water resources.

4.3.2 India: Bihar and West Bengal

The key strategy which guides agricultural development and research for India is the policy of *Doubling Farmers Income by 2022* (NITI Aayog; equivalent of the Policy Commission). The need for transformational change in food systems is to meet the challenges of sustaining food and nutrition security, adaptation and mitigation of climate change, and sustainable use of critical resources such as water, energy and land. A new vision for agriculture is required, with a focus on production efficiency and employment generation, climate change adaptation and sustainability. Suitable policy interventions, regulations and reforms are needed to support the new vision. It is likely that they would include a shift in emphasis from food security to nutrition and health security; and from input-intensive to knowledge-intensive systems (Ramesh Chand (NITI Aayog), Personal Communication 2020).

Agriculture is a state subject in India. The Central Government makes policies and provides 40 to 60% of funds, which are matched by the states in what can be called cooperative federalism. Several large policies like the Rashtriya Krishi Vikas Yojana scheme, National Food Security Mission, and Bringing Green Revolution to East India can be modified by the states into programs which suit their constituent farmers' requirements.

Subsidies on fertiliser, electricity, Minimum Support Price and insurance use a major chunk of the central budget leaving very little for investments in irrigation, processing and storage (Bathla and Hussain 2021). A major change in the way the government relates to farmers is underway in India. Nearly 50% of the Government of India's agriculture budget is spent on an income support program where landowners receive a direct cash transfer of INR6,000 per year irrespective of their holding size. State and central governments are also switching to cash transfer of other subsidies, but not fertilisers or energy yet. The income support program has not replaced the existing subsidies, it has instead become yet another subsidy. Economists favour cash transfers but only if they replace the existing distortionary subsidies. The increase in total agricultural subsidy is crowding out public investments in research and development, infrastructure, and other forms of capital formation in agriculture. On the positive side, the system to ensure a smooth transfer of cash to millions of landholders has created a platform to promote digital agriculture in India and may even be used to promote e-commerce in rural regions.

The terms of trade for farmers in India have worsened in recent years (Himanshu 2019). This is true for all of India but even more so for Bihar and West Bengal, because most of the farmers in these 2 states do not benefit from high electricity subsidies and assured output prices – the Minimum Support Price scheme – unlike their neighbours in the states of Odisha, Chhattisgarh, and much of the north-west.

4.3.3 Nepal

There have been years of political instability in Nepal at the federal level, with frequent changes in ruling coalitions and prime ministers. This instability has hampered cohesive long-term planning and implementation of supporting policies, which is important for developing sustainable food systems. The second major issue is the change in the structure of governance in recent years, from a centralised system to a federal one with a three-tier governance structure. There is a lot of confusion about how different units will coordinate vertically (local–provincial–federal) and horizontally (between provinces). Coordination is essential for the management of shared resources such as water, and agricultural market systems. There is also a lack of clarity on how to reconfigure the agricultural knowledge and extension system. Added to this is the challenge of low state capacity (Dahal et al. 2020).

A further major challenge for Nepal is that its government(s) have fewer degrees of freedom when devising agricultural policies because of the long, open border with India that provides unfair competition for input and output markets. Inputs are expensive in Nepal compared to India and productivity is low, but Nepali farmers must compete with their heavily subsidised and more productive Indian neighbours in the output markets. Input markets are similarly influenced. For example, Nepal cannot subsidise all the urea its farmers need or use because of limited budgetary resources. Nor can it do away with subsidies; when the Government of Nepal abolished fertiliser subsidies for more than a decade under an Asian Development Bank program, it did not work. Nepal's fertiliser companies cannot compete with the cheaper urea smuggled in from India in large quantities. This unfair competition limits Nepali farmers' incentives for intensification of farming, especially of staples like rice and wheat that India grows in large quantities. As a result, Nepal's imports of rice and wheat are rising rapidly.

4.4 Major drivers of food systems

The status reports on major trends of the food system of the Eastern Gangetic Plains encourage a better understanding of the current status, future challenges, research and knowledge gaps. These reports form part of the Foresight for Food Systems work in the Eastern Gangetic Plains (see **Chapter 5**), which is a project laying the groundwork for an open, scientifically informed and participatory foresight for food exercise. The reports have been summarised to highlight the important trends in the Eastern Gangetic Plains, which in turn are impacting its food systems. These trends are acting collectively to shape and effect the food systems in the region. The foresight status brief reports can be accessed online at aciarsdip.com/food-systems-in-the-egp.

4.4.1 Water

The major features that influence agricultural water use in the Eastern Gangetic Plains are:

1. Alluvial deep plains with rich reserves of groundwater fed by ephemeral to seasonal, and sometimes perennial, streams and rivers of the river Ganga.
2. Near to absent systems of reliable surface water irrigation.
3. High dependence on irrigation through groundwater for basic livelihoods.
4. Problems with accessibility for many households due to socioeconomic factors.

Energy irrigation nexus

States of India in the Eastern Gangetic Plains have rich and stable groundwater endowments. Though physically abundant, groundwater is economically scarce (see **Chapters 4.3.3** and **7.1**). The high cost of irrigation makes farmers under-irrigate their crops resulting in low yields, low cropping intensities, high vulnerability to droughts and terminal heat, and lower profit margins. Groundwater irrigation is expensive in the region because it has been dependent almost entirely on diesel pumps. Diesel is more expensive than grid electricity, and diesel pump-sets are significantly less energy efficient. The majority of farmers rely on pump rental markets for irrigating their crops. Irrigation with rented pumps is significantly more expensive because rental markets are not competitive. The high cost of access to irrigation disproportionately affects marginal and Scheduled Caste farmers. Although there have been policy changes to reduce barriers to electricity connections for irrigation, these systems are also being manipulated for capital gain at the expense of the smallholder farmer. The full report is by Kishore (2019).

Groundwater quality

Groundwater contamination is rife. The widespread presence of arsenic, and other emerging contaminants such as fluoride, iron, manganese, chromium and uranium are threatening the status quo of irrigation and livelihoods. Diarrhoea and viral contamination are also widespread due to poor sanitation and hygiene combined with a high dependence on drinking from shallow groundwater sources contaminated by toilet pits.

The majority of groundwater usage in rural areas of the Eastern Gangetic Plains region is for irrigation and is a primary cause of the geogenic water contaminants crises related both to arsenic and salinity. This combination is estimated to affect 60% of the area in the Indo-Gangetic Plains (MacDonald et al. 2016). The mechanisms by which geogenic contaminants are released into aquifers are quite closely related to the manner in which groundwater is used through tubewells. Groundwater

pumping can increase arsenic levels due to over pumping over clay layers releasing arsenic from deeper aquifers. Water table fluctuations from summer to monsoon are also responsible for arsenic release. Fluoride contamination is also seen with increased groundwater exploitation through tubewells but is dependent upon the type of geology in the region. High iron concentrations in the groundwater are locale dependent. Pesticides, herbicides, the use of agricultural chemicals and industrial chromium are also contributing to groundwater contamination.

Alarm over contaminants such as arsenic in rice or contaminants in the food chain could significantly affect the region's agricultural economy. Investigations are required to determine whether better control over irrigation could reduce the problem of contaminants. Testing this needs a strong convergence across sectors and policy support. The highly sensitive linkage between groundwater-based livelihoods and contamination also means that policies need a balance between minimising impacts to livelihoods while reducing public health risks. The full report is by Sen et al. (2019).

4.4.2 Climate change

There is a clear consensus across the literature that the impact of projected climate change on agricultural productivity in the Eastern Gangetic Plains will be overwhelmingly negative and crop yields (especially grains) are likely to fall. This could have potentially serious repercussions for the maintenance of food security and millions of rural livelihoods. The most critical threat in the short to medium term will be the increase in year-on-year climate variability, including changes to the frequency and intensity of extreme weather events (particularly heat extremes, droughts and intense rainfall events). In the longer term, the expected changes to mean temperatures and seasonal water availability are likely to make existing cropping regimes unviable and may necessitate a move out of agriculture for millions of people, especially if warming exceeds 2.5 to 3°C. The full report is by Dawson (2019).

4.4.3 Food trade in South Asia

There is significant informal, undocumented trade across the 1,751 km open border between India and Nepal and the 4,097 km porous Bangladesh–India border. However, reliable estimates of the volume and the value of the informal food trade are not available. Food exports of Bangladesh, India and Nepal grew rapidly in the early 2000s and have stagnated or declined in recent years. Food imports of all 3 countries are however growing rapidly at a compound annual growth rate of more than 10%. India runs a trade surplus in food trade, while Bangladesh and Nepal have rapidly growing trade deficits which have increased 5 to 6 times in real terms over the last 15 years. India is a large exporter of rice, animals and animal products, while fish and fish products are the main exports of Bangladesh. Nepal's main food exports are now coffee, tea and spices. Palm oil is the largest import of Bangladesh and India, while in recent years, cereals (rice and wheat) have become the largest imports of Nepal.

The formal food trade in Bangladesh, India and Nepal is much smaller than the neighbouring Association of Southeast Asian Nations (ASEAN) countries (Ajmani et al. 2019). Both food exports and imports of the 3 countries are small relative to their agricultural GDP. The food trade is not only small in value, but also highly vulnerable to domestic and international price shocks, weather events and swings in international relations. Both tariff and non-tariff barriers

in Bangladesh, India and Nepal have led to their low trade openness. The policy quest for self-sufficiency in the production of rice and wheat (and other food items like pulses and sugar), even at the cost of resource depletion, is partly responsible for low values of food imports. Poorly developed value-chains, weak infrastructure, and low food safety standards limit export potential. Ad hoc export bans to protect consumers from episodes of spikes in food prices are also responsible for underdeveloped food exports in Bangladesh, India and Nepal. Greater trade openness in South Asia can benefit both farmers and consumers and help agriculture in the region become more environmentally sustainable by permitting production to take place in regions most suited to it. Farmers benefit from trade through specialisation, increase in efficiency, technology transfer and knowledge spillover, while the consumers get access to a larger variety of better quality food items available at more affordable prices (Ajmani et al. 2019).

The trade of rice

The trade of rice across the political boundaries of South Asia is centuries old, and while the formal institutions that support and mediate this trade have transformed with the emergence of the modern state, the essential practices that undergird them retain a familiar shape. Relationships between the farmer and aggregator of rice, the cycles of informal capital that dictate production and the political importance of the grain in stability of the state are as central to the politics of rice in the region today as they were in the 17th century. India is the largest producer, consumer and exporter of rice in the region. The social complexities of India's rice markets are equally important because of its position as the largest rice exporter in the world, reaching around 140 countries each year. Trade volume drivers are sudden and significant fluctuations in volumes from year to year are common. These are caused by climate-related events such as floods or droughts, short-term fluctuations in currency values or political disturbances that lead to changes in import tariffs in Bangladesh or Nepal, the 2 net importers in the region. Rice trade policy in South Asia should be seen as a safety valve for domestic markets, serving as an instrument to stabilise domestic prices. However, fears of scarcity lead to the erection of export barriers, just as spikes in wholesale prices facilitate imports. Trade plays a crucial function in cushioning the price volatility induced by increasingly unpredictable weather, particularly precipitation, in the region. Untimely bursts of rain or multi-year dry spells that disrupt paddy output in the region and beyond are balanced by large surpluses in India. This adaptive aspect places a renewed emphasis on developing smoother systems for trade, particularly at the borders where several forms of distortions tend to undercut the desired predictability and efficiency in trade practice.

Just as trade has the potential to fill supply gaps and stabilise consumer prices across in import markets, it can also in theory have a positive impact on farm incomes by reducing glut and expanding markets. It was found, however, that sub-regional trade between India, Bangladesh and Nepal does not produce such an impact. There are 2 main reasons for this counterintuitive reality. First, all intermediary marketing functions between onsite collection of produce at the farms and delivery of consignments across the border are, in effect, run by businesses functioning in competitive landscapes, where capital accumulated can yield exponentially higher growth. These intermediaries, such as the aggregators of paddy, have entrenched financial and social relationships with farmers that allow them to extract favourable terms of purchase and employ

capital in profitable informal banking ventures to farmers. This mechanism prevents a fair share of the marketing revenue from reaching the farmer. Second, the millers of Indian rice, who themselves often operate as aggregators, both usurp windfall profits and absorb hits on the margin without either of these effects reaching the farms in full measure. For exports to play a significant role in increasing farmer incomes, a new type of regulatory thinking that recognises the incentives and vulnerabilities of each layer of intermediation before acting upon them is required. For more details see Pillai and Prasai (2018).

ASEAN, SAARC and China in the food system

ASEAN and South Asian Association for Regional Cooperation (SAARC) are 2 of the largest trading blocks in Asia, with a combined population of 2.4 billion (2016). Openness in food trade is desirable as it allows access to larger markets, creates opportunities for specialisation in production, and creates gains from economies of scale, technology transfers, and knowledge spillover. An assessment of trade between and within SAARC and ASEAN countries and China reported that most country pairs under-export. Overall, wherever there is under-exporting in food products, SAARC countries tend to be under-exporting to a greater degree than ASEAN countries.

A country may over-trade with its potential partners due to its weak economic fundamentals which determine trade. Relatively weak economic characteristics such as domestic infrastructure and an unfavourable investment climate may predict a lower trade level, resulting in countries over-exporting. Over-exporting may highlight the importance of focusing on policies that enhance the trade potential of the country. Where countries are under-trading, exports could be increased by focusing on their competitive commodities with high export potential in foreign markets. Tariff levels on food products are much higher in South Asian countries relative to ASEAN countries, making access to South Asian markets more difficult.

The high level of informal trade within this region provides indirect evidence of the significant trade potential between the countries. It is estimated that informal trade among South Asian countries is 50% of their trade. Factors which prompt informal trade include higher tariffs, stringent non-tariff measures, distorted domestic policies, and non-economic and institutional factors. Another unobservable factor is trust. Lack of trust between the countries can severely affect their bilateral trade flows. Trust between South Asian economies is described as fragile because of their complicated history, conflicts, and size asymmetry, which prevent them from reaping the full economic benefits of geographical proximity and complementary resource endowments. A full report is by Ajmani et al. (2020).

Embedded resources

In considering the food-energy-water nexus, food exports also contain embedded water and energy (Pillai and Prasai 2018). Rather than focus on exports, policies to regulate the amount of embedded water in rice exports must begin with decentralised technology, systems and incentives that reduce the water intensity of rice production in general. The theoretical appeal of virtual water export curtailment through ‘sustainable’ input pricing also crumbles when one begins to imagine the political backlash in a country where the core of politics is still the farm. Any change in input prices, subsidies, and access to free water either thins margins further or impacts the output.

Improved trade facilitation matters. The domestic production, processing and pricing of rice in the sub-region have tentacles in difficult domains of public policy where change is often difficult to drive. In this landscape, resolving some of the most nagging problems of cross-border trade actually appears more achievable. Problems such as lack of port-level infrastructure or inadequate digitisation of procedures and approvals or a lack of mutual recognition agreements can be resolved with additional allocations of budget, a couple of rounds of staff training and a few administrative changes. Although more difficult to implement, bilaterally negotiated, stable import tariffs (particularly in the case of India–Bangladesh trade) would go a long way in making demand signals for exporters and millers more reliable. Slight improvements in internal governance and accountability standards of border agencies can begin to undercut a thriving world of syndicates and cartels that operate cross-border trade and transit services. The net effect of these trade facilitation measures has the theoretical potential to impact consumer prices directly and significantly.

4.4.4 Credit

Credit plays a vital role in agricultural development. It enables farmers to undertake new investments and adopt improved technologies. In the Eastern Gangetic Plains, farm households borrow money for agriculture as well as to meet basic household needs. Access to credit enhances the risk-bearing ability of farmers and acts as a catalyst to break the cycle of poverty in rural areas. Realising the importance of credit in promoting agricultural growth and development, agricultural credit policies within the Eastern Gangetic Plains have sought to expand the outreach of institutional credit by replacing traditional money lenders with formal institutions such as cooperatives, commercial banks, and rural development banks.

The experience of farmers in the region, the majority of whom are smallholders, suggests that the extent of financial inclusion varies greatly and only a small proportion of agricultural households are able to access institutional credit, with poor families lacking collateral or guarantors often excluded. Deliberate delays in the disbursement of loans, long paperwork, demand for bribes and opaque procedures are common problems farmers face when borrowing money from banks. The relationship between land size and access to formal credit is positive. Agricultural households with better resources find their access to formal credit systems relatively easier compared to households with fewer resources. Non-institutional sources of credit tend to charge exorbitantly high interest rates and are frequently considered exploitative. The full report is by Kumar and Saroj (2020).

4.4.5 Migration

Throughout the Eastern Gangetic Plains, labour out-migration (generally male) to better remunerated urban labour markets is an important livelihood strategy for the rural poor. It provides supplemental income which is pivotal to agricultural household security. This circular and seasonal migration pattern tends to entrench subsistence agriculture, as the additional income is generally spent on consumer goods, health care and schooling, rather than investment. Remittances from international migrants contribute significantly to national economies. Male out-migration results in farm labour shortages, increasing the cost of employing

labourers, and the demand for labour-saving farm machinery. Significant seasonal agricultural labourer scarcity and increasing wages have led to rising production costs and food prices. Male migration has also undermined the functioning of many irrigation management institutions, and persisting limitations on women's engagement has failed to counterbalance these changes (Brown et al. 2020). The impacts of the COVID-19 crisis on migration are being explored and will be reported separately.

4.4.6 Gender relations

Widespread male migration inevitably alters gender relations, as the decision-making by women left behind incrementally loosens patriarchal social structures. The increasing participation of women challenges social norms, which could initiate lasting changes in the gender relations observed historically. However, in the last decade, due to an increase of unemployment among men in both rural and urban areas, male migrants have been returning seasonally as cultivators, leading to a decline in the share of women cultivators. In Nepal, where out-migration tends to be by young couples rather than by men alone, the burden of increased farm labour falls on older women. As women have historically been required to work agriculturally in Nepal, out-migration is less likely to change social norms despite the farm workload increasing for women.

Women's labour force participation in rural India has been consistently low over the past 3 decades. Women's work is determined by both supply and demand factors in rural India. On the supply side, it is affected by sociocultural norms that reward housework and child rearing. Working outside the house is considered a social stigma or a low-status activity. As a result, only the poorest women engage in wage work out of necessity and once family incomes increase, they withdraw from the workforce. On the demand side, factors like gender discrimination in hiring, gender wage gaps, unsafe environment, unsuitable transport/commute, and lack of jobs can result in low female labour force participation. For more information refer to **Chapter 7.2** and the full report by Joshi et al. (2019).

Spatial and temporal pluralities exist with respect to gender and work in agriculture across the Eastern Gangetic Plains. The context is derived from the generally accepted view that feminisation of agriculture is typical of most developing countries which primarily stem from male-selective out-migration. The agricultural labour forces of Nepal and Bangladesh reveal positive feminisation trends, but a consistent defeminisation that cannot be fully explained has been observed in India (Bihar and West Bengal). A defeminisation process linked with higher levels of unemployment is indicative of distress and is suggestive of displacement from jobs or lack of jobs that women can take up along with care work. Women's burden of extra domestic work like collection of water, fuel and fodder has increased over time, with the degradation and privatisation of common property resources. The full report is by Sen, Mondal and Raj 2019).

4.4.7 Diet and nutrition

Poor diets are a big reason for persistently high levels of hidden hunger in the Eastern Gangetic Plains. Overall, while there are broad similarities in diets across the region it is important to note that there are significant differences in consumption patterns across different income groups. There can also be large intra-household differences in diets of men and women, boys and girls in South Asia, with girls and women having poorer quality diets.

Among whole grains, consumption of coarse cereals is low. Eastern Gangetic Plains is relatively poor even by the South Asian standards and cereal consumption is high in poor households worldwide. High subsidies on rice and wheat through the public distribution system in India and active management of rice prices in Bangladesh and Nepal at low levels have also contributed to high share of rice and wheat calories in the diets in the region. Consumption of all protein is also significantly low in the Eastern Gangetic Plains. The region under-produces pulses, the most common vegetarian source protein in diets here. Calories from fruits are significantly more expensive than the cereal calories as are calories from processed foods, resulting in their low consumption.

The region has a low consumption of added fats. In addition, most of the fat comes from palm oil, which is high in unhealthy saturated fats and low in healthy polyunsaturated fats. Palm oil is the largest food import of both India and Bangladesh and the second largest of Nepal. It is cheaper than other vegetable oils, and cheap imported palm oil from east Asia crowds out the production and consumption of oils in the Eastern Gangetic Plains. The full report is by Choudhary and Kishore (2019).

5 Effective institutions to support sustainable food systems

The work on institutions has both conceptual and practical elements. The ultimate aim was to use the conceptual outputs to strengthen and inform on-ground work.

5.1 Identifying effective institutional arrangements for intensification

The 'Institutions to support intensification, integrated decision making and inclusiveness in agriculture in the East Gangetic Plains' (LWR/2018/104) project, managed by the University of South Australia, has identified institutional arrangements that foster (and constrain) intensification, integration and inclusiveness. It focuses on 3 areas:

- The institutions for transferring knowledge to farm households.
- The institutions and activities related to risk mitigation by rural households.
- Those institutions and practices related to water property rights.

This is based on the final report by Crase (2021).

A review of CASI and related development work by Joshi et al. (2017) suggested that there were major opportunities to enhance adoption of alternative farming practices in the Eastern Gangetic Plains through improved institutional settings. But questions remained about what were the 'best' policy/delivery combinations, and whether experts could be engaged to critically review the extant approaches and look for better solutions. In addition, could the 'best' solutions from experts align with those most acceptable to farmers and thus generate win-win outcomes? The purpose of this project was to tackle these questions head-on, but to do so in a way that encouraged the policy communities to be directly engaged. This approach hinged on the interaction with policy communities to generate primary data that could then be transposed to compare with the views of farm households.

To make the overall task manageable, the ambition was to build a set of insights from the 3 related domains, as outlined above.

These 3 strands of research were also overlapped with an interest in the impacts of institutional design on inclusion, especially for women and tenant farmers. The overall aim of this project was to develop capacity within district, state and national agencies in the Eastern Gangetic Plains to identify and consistently promote institutions that foster the '3 Is' (Intensification, Integrated decision-making, and Inclusion).

The project had planned to assemble sets of primary data that would both inform policymaking communities and engage them in a discourse about the current settings. This data would reveal policy/delivery institutional combinations that were most effective and also provide

farmer insights into the perceived merits of different combinations. The primary data collection of experts in the policy communities was completed, and analysis consistently highlighted the important role of increased access to inputs as the preferred means of raising and stabilising farm incomes across the region. In addition, there was strong support for the use of private sector institutions to deliver on this goal, rather than government.

A Delphi study was completed to extract knowledge from experts of existing institutions that impact rural households' wellbeing and their key characteristics. Delphi is a structured means of engaging with experts to gather information and ultimately reach consensus. Delphi is usually conducted over several rounds with information provided by experts interrogated by investigators and then put back to experts for validation. These have shaped a best-worst scaling survey, which allows a measure of institutional effectiveness to be generated. To match the outputs from experts, the project planned to conduct a similar best-worst scaling survey with farmers to understand how well expert and farmer preferences match.

The onset of COVID-19 and the related uncertainty resulted in the main farmer survey instrument being deemed unfeasible in the current environment, regardless of the significant investment in its development. The project team thus sought to develop an alternative methodology, which resulted in analysis of several secondary data sources to meet the other objectives of the project, along with a reduced primary survey focused on specific topics.

Overall, the findings from the numerous studies support these views:

- Knowledge transfer to farmers, especially on new technologies, offers promise on multiple fronts. However, its benefits are not universally accessible because of the delivery apparatus, with women particularly disadvantaged but (ironically) having much to gain from better transfer mechanisms (like mobile phones).
- Water access in the region is intimately tied to energy and the incentives for using energy differently. Leveraging diverse preferences around pumping technologies offers promise for further developing groundwater markets and widening the water access.
- Policies that are seemingly focused on risk reduction are producing perverse impacts and require a rethink in terms of how they are rolled out. Additional international support around broadening better governance and financing systems can have important benefits in agriculture.

The project has made significant progress by shaping new thinking among the local policy communities about policy and delivery institutions. Leveraging this beyond virtual dialogue would deepen and widen this influence. In addition, the innovative primary data collection from farm households is poised for deployment and, if ultimately sanctioned, will deliver important low-cost, high-quality data to sharpen future dialogue.

Across the expert communities that span the Eastern Gangetic Plains, policies focused on increasing access to inputs are seen as having the greatest prospect of increasing and stabilising farmer incomes. These policies are best supported by actions that involve greater use of the

private sector. There is some support for policies that increase access to modern technologies but the delivery mechanisms for these policies are not clear-cut.

Continued strengthening of governance at the state level in West Bengal should be a priority if private investment is to be stimulated. The delivery of irrigation as an input is of itself not a panacea, and a range of accompanying factors need strengthening. Careful attention needs to be paid to the linkages between energy reforms and their impacts on groundwater markets as these can have perverse impacts for the poor. The differences in preferences of some farming groups are material, and policies that favour the preferences of some better-off groups can reinforce inequalities or even make them worse. Overall, the work reinforces the important role of access to inputs and the capacity of the private sector to deliver better outcomes, provided governments take care to avoid establishing perverse incentives.

Subsidies for inputs, like fertiliser, have limited impacts on production and incomes. They are also distortionary and unless well targeted will likely benefit larger, richer farmers disproportionately. Shifting to income transfers as a policy approach has some merits at first sight but the detail of delivery again matters. Unless comprehensive transfer systems are in place that cover all the community there is risk that more transfers will simply accrue to landholders. International funders of agricultural development research might consider broadening their focus to go beyond the farm to achieve better poverty-reducing outcomes. The adoption of new techniques might on average lead to higher farm incomes. Greater attention to the stability of those incomes and the risks of new production techniques is required.

Technology can increase incomes and make them more stable. Focusing on how technologies can specifically address the needs of less advantaged groups can lead to even greater welfare gains than simply looking to increase universal access. Policy communities have made substantial progress in recognising the benefits of greater empowerment of women, but this needs to be matched by efforts to measure and monitor change in the status of women over time. Care also needs to be taken when reviewing data on empowerment – there may be some instances where aggregate improvements in empowerment disguise the welfare impacts on some women.

5.2 Implementing processes for improving institutional effectiveness

Other projects are demonstrating practical approaches to improving institutional effectiveness and building capacity, focusing on multi-stakeholder coordination. The Roadmaps project (Brown, Chaudhary, et al. 2021) is working to facilitate the development and implementation of 'participatory roadmaps' to create an enabling environment for sustainable agricultural mechanisation 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 and drafted roadmaps. Project partners have implemented field-level interventions, undertaken 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, 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 the needs of different stakeholders to be communicated. The project has conducted 42 semi-structured interviews with Nepali agricultural service providers to understand their business decisions and the viability and perspectives on providing CASI services, and an additional 26 service provider interviews were conducted in India and Bangladesh to enable comparison.

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. An exposure visit to Satish Satmile Club, West Bengal was facilitated by CIMMYT to explore their experiences and learn of different business modalities and new learnings related to agricultural mechanisation which can be successfully adopted in Province 1. 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. As well, the project developed a Nepali language booklet on how to use a Zero-Till Multicrop Planter. The booklet was displayed and distributed among the participants from the Roadmaps working group of both the provinces. 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 such as the establishment of demonstration sites, and training sessions. Work has resulted in new working relationships, wider sensitisation to potential mechanisation options relevant to Province 1 and 2, and a set of extension activities co-funded by key change making organisations and individuals.


স্ট্রিপ চাষ পদ্ধতির মাধ্যমে ভুট্টা উৎপাদন
Maize Cultivation by Strip Tillage (CASI) Technology
শস্য বিন্যাস: আমন ধান-ভুট্টা
কৃষকের নাম: মো: বাবলু, লেবু, বাদল, তোফাজ্জল, তৌহিদুল, তৌফিকুর
স্থানের নাম: মন্ডলাবাড়ী, বড়দরগাহ্, পীরগঞ্জ, রংপুর
জমির পরিমাণ: ১৫ একর
বীজ বপনের তারিখ: ২৫/১২/১৮-১০/০১/১৯ জাতের নাম: ৯৮১, ৯৮৭, এলিট, এনকে-৪০
আরডিআরএস বাংলাদেশ
RDRS Bangladesh
CIMMYT

6 Better field–policy links for scaling

In the context of the multiple challenges facing the food system in the Eastern Gangetic Plains, solutions are needed that can address them at a range of levels, including at the farming system level. ACIAR SDIP has worked from the basis of conservation agriculture based sustainable intensification (CASI) as an appropriate technology to address challenges in the farming system, as evidenced by the work from SDIP Phase 1. Phase 2 has explored the context for scaling CASI in the wider food system. Key lessons demonstrated from this work include:

- Effective field–policy links can result in convergence with government programs.
- The need to promote and work with multi-stakeholder arrangements for out-scaling.
- Groups continue to provide opportunities that are not possible for most individual smallholders to capitalise on.

6.1 Scaling sustainable farming systems

The Sustainable and Resilient Farming Systems Intensification (SRFSI) project was implemented through SDIP Phases 1 and 2 (see Figure 2), and was a major part of the program's budget. The project had 3 distinct stages, each with its own methodology. The initial stage of the project was primarily focused on CASI **proof of concept** to ensure that CASI should be scaled. SDIP Phase 2 incorporated the second and third stages of the project, which focused on CASI **capacity development** to build institutional knowledge and momentum for scaling, and the **science of scaling** to provide inputs on how to scale and institutionalise CASI. The SRFSI Final Report (Brown 2021) contains details of work undertaken and results for stages 2 and 3; these are summarised in the subsequent sections.

6.1.1 Proof of concept of CASI for the Eastern Gangetic Plains

The farming systems improvements tested in ACIAR SDIP are based on CASI, which is a broader form of conservation agriculture that incorporates agronomic, socioeconomic 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 conservation agriculture principles of minimising soil disturbance, ensuring soil cover and diversification through rotations – and include improved varieties, better irrigation practices and improved crop management techniques. Results from more than 400 participatory multi-year field trials demonstrated that CASI practices improved productivity (3–6%) and profitability (17–41%) while reducing input related emissions (6–12%), water (11%), energy inputs (6–11%) and labour requirements (40%) in rice–wheat, rice–maize and rice–lentil systems in the Eastern Gangetic Plains (Gathala et al. 2021; Gathala et al. 2020; Islam et al. 2019).

Gross margins were found to increase by an average of 25% (Gathala et al. 2021). Based on socioeconomic 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 AUD222 per ha, with males experiencing a higher value of production by AUD190 per ha and females an even higher value of production by AUD538 per ha compared to their non-CASI counterparts. Also, the net income for CASI farmers overall was significantly higher by AUD115 per ha. Female CASI farmers had a higher net income by AUD509 per ha compared to their non-CASI counterparts.

The work in SDIP Phase 2 has helped up to 113,000 farm households adopt more productive, sustainable and inclusive farming techniques that improve profitability, address labour constraints, and reduce the emissions footprint of food production systems in the Eastern Gangetic Plains with the potential for significant impact if widely adopted.

6.1.2 The science of scaling CASI systems

Given the length of time and resources devoted to the SRFSI project, there was an opportunity in the final stage to focus on understanding the key lessons on how to scale and institutionalise CASI in the Eastern Gangetic Plains, as well as further confirming the impacts for users. This was undertaken through 4 work streams:

1. **Adoption and impact learnings.** This explored the suitability of CASI though adopter experiences and estimating the extent of current process towards CASI scaling. This also explored decision-making processes of non-users to suggest suitable development activities to increase the success of scaling efforts. A large quantitative impact survey and in-depth qualitative explorations were undertaken to understand what worked where and why.
2. **Institutionalisation of CASI capacity development.** This explored gaps in capacity development and established strategies that can address these gaps.
3. **Policy and convergence activities.** The status of convergence and next steps for sustained enabling environments were explored through various evaluations. This culminated in location-based scaling reports that provide a pathway for handover and next steps to policymakers and key actors.
4. **Creation of scaling and legacy products.** This included academic publications, novel training materials and promotional materials. An online repository (https://srfsi.cimmyt.org/) was developed as a knowledge hub for conservation agriculture in South Asia, targeted at a range of different stakeholders, including materials suitable for farmers, extension agents, researchers and policymakers.

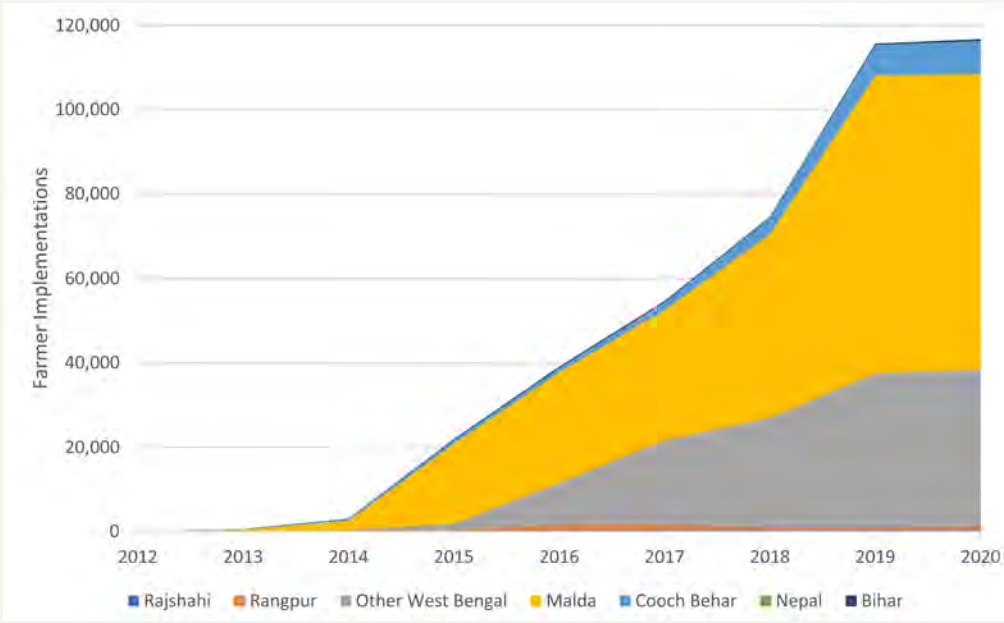
Impacts

In addition to the proof of concept in Stage 1 described above, later surveys and assessments confirmed yield changes for farmers using CASI, with 80% of people experiencing yield increases in both kharif and rabi seasons. Savings in time and money for farm households who use CASI enabled multiple flow-on effects, including enabling diversification of farming systems through crop and livestock pathways as well as other income generating activities; addressing common livelihood challenges; and fulfilment of both self and family's expectations which led to increased resilience, livelihood outcomes and overall life satisfaction.

Unlike in other locations, for example Sub-Saharan Africa, CASI does not increase female burden, and provides opportunities to increase agency and empowerment. For example, CASI enables time saving through herbicide use, reducing the time spent weeding for both men and women household members (see **Chapter 7.4.2**). These multiple impacts have been confirmed through both quantitative and qualitative assessments.

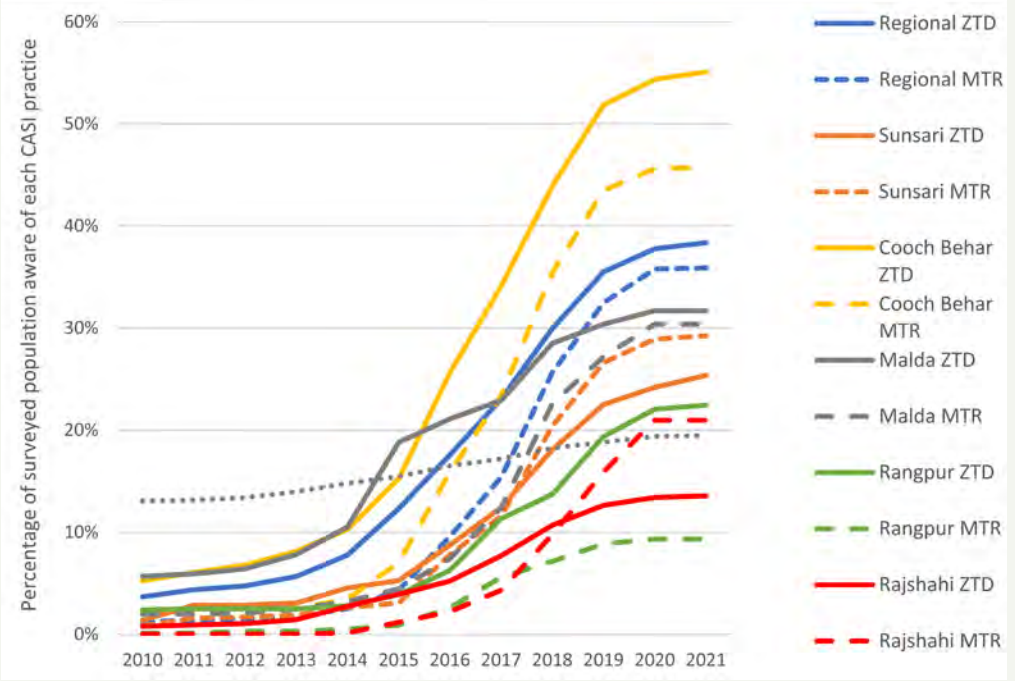
The current status of CASI use

SRFSI partner implementing organisations have been estimating uptake of CASI across their jurisdictions since 2012, with varying uptake across the region. In total, at least 424,686 CASI farmer implementations have occurred since the inception of SRFSI, with an annual peak of at least 116,434 CASI farmer implementations during 2020 (see Figure 5). This has primarily been achieved in rabi season, accounting for 85% of CASI farmer implementations. Surface seeding was responsible for 87% of farmer uptake of CASI in 2020. West Bengal dominated with 99% of farmer adoption in 2020 across the region. Adoption rates alone cannot provide a full understanding of the types of adoption dynamics occurring in communities. To explore this, 2 different approaches were employed using the 2021 quantitative impact survey. Assessing a population in terms of both awareness and use of CASI technology to understand the extent of exposure and use over time is a useful tool. Figure 6 highlights the rates of awareness for each of the CASI technologies by location. In all locations there is an obvious increase in awareness, particularly between 2016 and 2020.



Note: Farmer implementation refers to the decision of a farmer to use a CASI planting practice in any given season. It is framed this way because data has been collected on a seasonal basis and hence some farmers may be double counted if they apply CASI practices in both rabi and kharif seasons, if reported on an annual basis.

Figure 5 Partner estimates of the extent of uptake of various CASI practices by farmers across the Eastern Gangetic Plains (presented by location)



Note: ZTD = zero till drill; MTR = mechanical transplanting of rice

Figure 6 Awareness rates for each investigated technology from 2010 to 2021 by location

Adoption is often considered as either a yes or no response, which does not allow for a deeper understanding of the processes contributing to use and non-use. A Stepwise Process of Mechanisation framework (Brown et al. 2021) was developed to understand the different stages of CASI uptake at regional and location specific levels. At a regional level, most farmers are still unaware of CASI technology, however in most original SRFSI locations, there is increased awareness and higher rates of both supported and unsupported use which indicates project success in targeted locations. Non-SRFSI (or 'control') communities tend to have more limited adoption and awareness rates. Counter to this, it also highlights there is still a need to work on wider convergence initiatives to ensure that benefits are also experienced in non-SRFSI communities.

Pathways to use (and non-use)

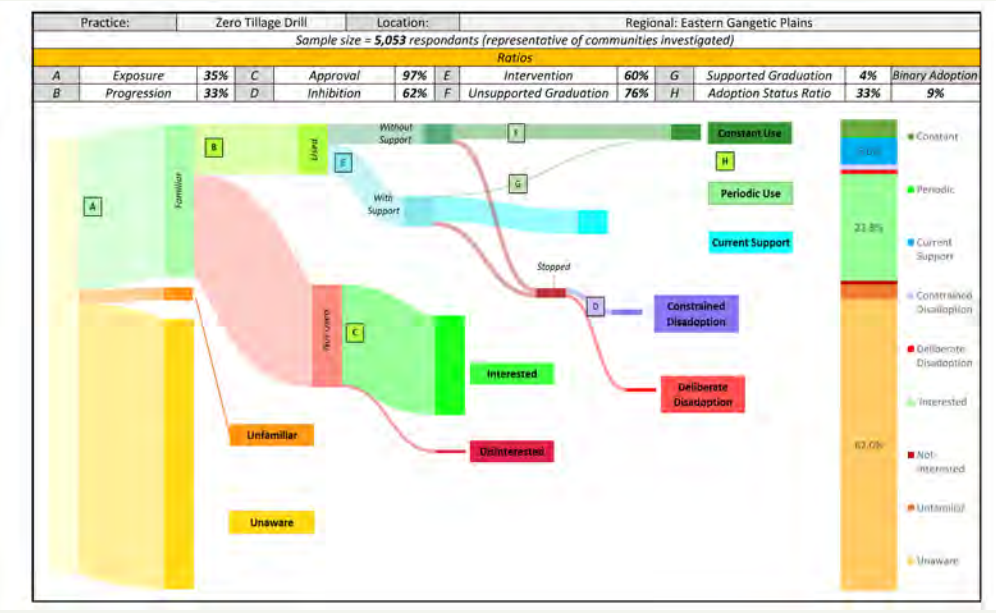
To create a deeper understanding of both current status as well as future sustainability and identify key constraints in the adoption process, a novel pathway analysis was developed based on the Stepwise Process of Mechanisation framework to further understand how users and non-users reached their current CASI situation. Figure 7 shows an example for the zero till drill across the Eastern Gangetic Plains. These are available for each location in detailed scaling reports to enable targeted use of resources to remove scaling barriers. Identified issues include:

- Information constraints leading to overall low exposure rates for all CASI practices ('Exposure Ratio').
- Limited progression to use once familiarity is obtained for all CASI practices ('Progression Ratio').

- High approval rates of non-users for all CASI practices ('Approval Ratio') paired with considerable rates of disadoption driven not by technological performance ('Inhibition rate'), meaning that there are issues in implementation of each CASI practice.
- Limited pathways to use that are without support via inputs for zero tillage (yet not for mechanical rice transplanter) suggesting the need for intervention to catalyse farmer uptake.
- High current support rates for zero tillage suggesting there may be future high disadoption rates.
- Limited graduation from support to constant unsupported use for the zero till drill, further suggesting implementation issues.

How CASI has been institutionalised

The SRFSI project based its scaling approach on building the capacity of large volumes of individuals in potential change making organisations in order for these organisations to adopt pro-CASI agendas that would support CASI scaling over the longer term. In the second stage of SRFSI, focus was placed on capacity development as the pathway to CASI institutionalisation. In terms of capacity development, more than 60,000 people received some form of training through the SRFSI project (with approximately 30% identifying as women), and the project was the primary source of training on CASI in the Eastern Gangetic Plains during this time. These trainings were across a broad range of potential stakeholders, including farmers, service providers, extension agents and policymakers. Additionally, support structures were established through innovation platforms that enabled co-learning and improvement of CASI. This was a substantial catalyst required to increase the knowledge base of communities, extension services and policymakers, and the basis for further establishment of enabling environments.



Note: Sample size = 5,053, representative of communities investigated

Figure 7 Pathway analysis for the zero till drill across the Eastern Gangetic Plains

This capacity development also led to substantial further investments of governments in CASI-related initiatives, particularly in West Bengal where state government funding has been allocated to demonstrations and a regional training centre, as well as policy changes that promote conservation agriculture machinery. The Centre of Excellence for Conservation Agriculture at Uttar Banga Krishi Viswavidyalaya (North Bengal Agricultural University) is intended to become a regional training centre for the entire Eastern Gangetic Plains.

Government and non-government organisation (NGO) schemes supporting CASI are also in place at various scales in Bihar, Nepal and Bangladesh. Both the agronomy and capacity development stages were integral to creating local ownership of CASI, with knowledge and capacity developed at multiple levels through constant collaboration with partners, both academic and non-academic. This has helped to institutionalise CASI in several project locations.

The enabling environment

Institutions that support CASI use, as well as favourable policy settings, can create an enabling environment for future use of CASI. At the local level, service providers have been promoted as the pathway for wide scale access to machinery, recognising that machine ownership is not financially viable (or sensible) for most smallholders. CASI service provision helps diversify incomes for machinery owners and lets farmers access required services.

The 2021 impact survey identified 82 organisations that have supported CASI machinery and practices (specifically use of the zero tillage drill, mechanical rice transplanter or surface seeding in Malda) in the past. Of these, 63 have supported the zero till drill, 67 have supported the mechanical rice transplanter and 12 have supported surface seeding in Malda. Twenty-nine per cent of identified actors are associated with SRFSI. Given that prior to the project there were almost no such organisations, this highlights a large change in the supporting networks for scaling CASI. A full analysis of the support networks for CASI scaling is available in location specific scaling reports.

Overall, the policy environment for CASI in the Eastern Gangetic Plains remains mostly directly unsupportive and indirectly mixed. While all locations have highlighted agrimechanisation in their policy platform, most locations do not have specific policies related to CASI and some have policies that are likely to limit CASI machinery uptake. The exception to this is West Bengal, where policies have been amended as a direct result of SRFSI project activities; all new custom hire centres must have CASI machinery as part of their package, and the recently inaugurated Centre of Excellence for Conservation Agriculture will provide state-funded training on CASI to farmers, service providers and agricultural extension agents.

6.2 Scaling mechanisation in the Eastern Gangetic Plains

6.2.1 Alternative mechanisation options: the Versatile Multi-crop Planter

Crop production in Bangladesh is becoming increasingly unattractive as a business proposition due to high production costs and its dependence on many labour-intensive manual operations. Widespread use of 2-wheel tractors (2WT) for land preparation and the recent development of small farm machineries provide a platform for implementing farm mechanisation, cost savings and the practice of conservation

agriculture. The use of the Versatile Multi-crop Planter (VMP), developed in a previous ACIAR project (LWR/2010/080) improves the efficiency of resource use (irrigation water, labour, fuel, seed, fertilisers), that in turn increases the profitability of crop cultivation for farmers and service providers.

The Pilot Project on Commercialisation of Small Holders' Conservation Agriculture-based Planters in Bangladesh aims to promote small-scale mechanisation of planting operations using conservation agriculture practices. The ACIAR project links medium-scale manufacturers, banks, farmers organisations, and small entrepreneurs (local service providers) as partners whose aim is to enable the business of mechanised planting, and create demand for the VMP to reach a scale where no further specific public funding is needed. New and prospective local service providers of VMP are being actively sought. The partnerships work together to help new local service providers secure loans for purchasing machinery (VMP and/or 2WT). The project will also conduct a desktop scoping study of the medium-term opportunities for a 4-wheel tractor conservation agriculture planting machine, and develop a prototype of this VMP.

Two business models are being tested to create sales of the VMP at a commercially viable scale. The first is a planting incentive model which ensures business can be maintained for the first season while the technology is still unfamiliar to both farmers and the local service providers (the new VMP owners get a one-off payment). The second scheme involves a tri-party investment model (a cost sharing arrangement between the local service providers/farmer, bank loan and project support, with agreed acreage to be planted within 2 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 (an international NGO) has been developed, which has helped expand the VMP use into the south-east regions of Bangladesh. They are currently working with 26,000 soybean farmers. Twenty units of VMP and 19 units of 2WT were purchased by farmers in this area during 2019–20, most taking advantage of a soft loan organised by Solidaridad Network Asia. The total benefit for soybean farmers was AUD547/ha relative to conventionally planted soybean, and they have obtained higher soybean grain yield by about 600 kg/ha in VMP planted plots.

This project is identifying policy-level bottlenecks and barriers to the adoption of conservation agriculture and mechanised planting (including gender impacts). It is also pilot testing 2 commercialisation models for scale out of the conservation agriculture-based planter (such as the VMP), which are needed at this critical juncture to advance the conservation agriculture-based mechanisation program for smallholders in Bangladesh.

6.2.2 Value chain and policy interventions to accelerate adoption of the Happy Seeder

A study on value chain and policy interventions to accelerate adoption of zero tillage in rice–wheat farming systems across the Indo-Gangetic Plains looked at the factors that were currently impeding uptake of zero tillage technology in the north-west, as well as making recommendations for the steps necessary to encourage its adoption and application in the north-east (Loch et al. 2018).

The current, traditional practices of rice–wheat farmers in north-west India includes both heavy soil tillage and concentrated seasonal burning of rice stubble prior to cultivating and sowing. The burn-off is recognised as causing significant air pollution and a measurable deterioration in air quality for cities such as New Delhi and the heavily populated regions of Punjab and Haryana. Soil health and quality are also negatively impacted by repeated tillage practices. These environmental impacts coupled with climate change, a reducing labour force and rising costs all contribute to the threat to the long-term sustainability of farmers in this region.

The Happy Seeder is a zero till drill developed specifically for the intensive rice–wheat cropping system of the western Indo-Gangetic Plains. It has proven capacity to directly sow wheat crops into standing rice stubble and has been commercially available for over a decade. The study identified a range of opportunities for accelerating the adoption of Happy Seeder/zero tillage. While a number of these opportunities have been identified in the past, there remains both a lack of awareness and availability of information relating to Happy Seeder/zero tillage technologies. Traditional farmer beliefs that crops can only be sown into well-tilled residue-free seed beds continue. In addition, the availability of Happy Seeder equipment remains a challenge, with poor sales and distribution networks, and very limited capacities in terms of machinery servicing, maintenance and operation. This combined lack of education and ongoing supply/support issues constitute major constraints to accelerating the adoption of the Happy Seeder/zero tillage seed drills in eastern India.

Based on the study's findings, a range of recommendations were developed and targeted to state governments to create enabling environments that support the accelerated adoption of zero tillage and Happy Seeder technologies:

1. Implement an awareness raising strategy incorporating digital media approaches that support the adoption of zero tillage/Happy Seeder technologies.
2. Expand the 'innovation platform' approach to other targeted regions to support the introduction and implementation of zero tillage/ Happy Seeder related technologies, facilitated through Krishi Vigyan Kendra agricultural extension centres and Farmer Producer Organisations.
3. Provide financial incentives to assist in improving the network of retail agents, service centres and farmer training schools (focusing on the maintenance and operation of equipment).
4. Establish a collaborative platform between multiple levels of government, responsible ministries and the manufacturing sector to help ensure that long-term relationships and the needs of the industry sector are clearly identified and supported to improve the development of effective zero tillage/ Happy Seeder seed drill supply chains.
5. Reorient mechanisms that currently provide direct subsidies for machinery purchase and devise alternative models of support directed towards a range of options.
6. Assemble a specific project team and support service comprising state governments, universities and international experts to provide a range of support services for the establishment of Custom Hiring Centres.

7. Maintain a Regional Collaborative Platform comprising representatives from the highest level of government for the Indo-Gangetic Plains region. Such a central platform would develop supportive government policy and the out-scaling of zero tillage/Happy Seeder technologies through sharing and dissemination of information, knowledge and training resources, on-farm validation of best management practices, and training and capacity building.

Priorities remain the increase in awareness of the Happy Seeder/zero tillage seed drills and changing farmer perceptions and acceptance of conservation agriculture techniques; notably removing misconceptions relating to the requirement to have a residue-free, well-tilled soil for successful crop establishment. A coordinated effort between governments, the university sector, manufacturing, finance and end-users is required to address the complexities of transitioning to conservation agriculture systems through information, extension, training, and technology exposure.

6.3 Summary

Work within a range of projects has demonstrated that strengthened field–policy links are important for scaling both by raising awareness of new technologies and through creating an enabling environment. Improving connections between stakeholders through mechanisms like groups, different models of service provision and capacity building are an important foundation. Success has been greatest in locations where field–policy links have been enhanced and stakeholder connections are strong. CASI has been demonstrated to enable diversification for crop, livestock and livelihood pathways, and this can build the foundation for future work on diversification for food systems' transformation.