



Australian Government
Australian Centre for
International Agricultural Research



Project Summary

Improving water use for dry season agriculture by marginal
and tenant farmers in the Eastern Gangetic Plains

**Addressing constraints of irrigated agriculture
by women and marginal farmers**



Project Introduction

The aim of the project was to improve the livelihood of marginal and tenant farmers in the Eastern Gangetic Plains, particularly women, through innovations in land and labour management and improved water use. These interventions supported increased dry season agricultural production in a region where cropping intensity is low. The project identified and tested a series of institutional and technical interventions, at a village scale, to increase dry season farming in the context of a highly stratified social structure.

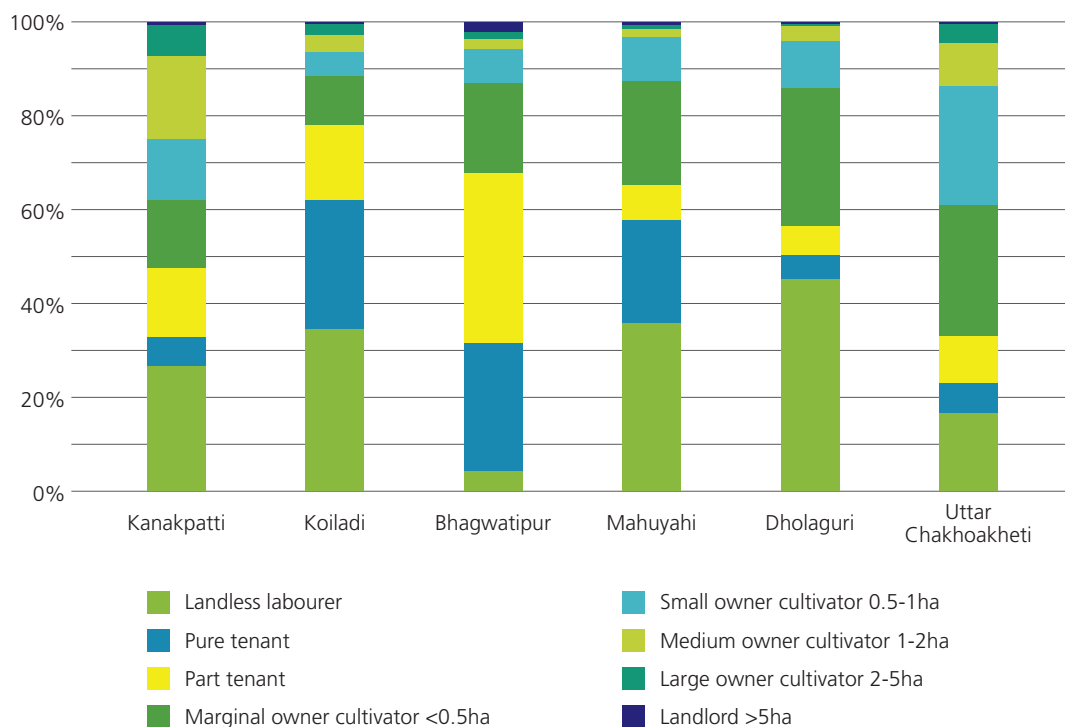
The project investigated opportunities for technical and socio-economic innovation across thirty-five sites in six villages in Nepal (Kanakpatti and Koiladi – Saptari district), Bihar (Mauahi and Bhagwatipur – Madhubani district), and West Bengal (Uttar Chakhoakheti and Dholaguri – Cooch Behar and Alipurduar districts) and six villages in North West Bangladesh districts (Rajshahi, Pabna, Bogra, Rangpur, Dinajpur, Thakurgaon). The sites all have a high percentage of landless, tenant and marginal farmers.

Key objectives were to develop a better understanding on:

- Approaches for the sustainable provision of dry season irrigation utilising both surface and groundwater, and energy efficient, affordable pumping technologies.
- Institutional innovations appropriate to marginal and tenant farmers, including women to strengthen livelihoods and build resilience.

Consideration was also given to how ground and surface irrigation interventions in Bangladesh can inform research for development interventions in Nepal and India.

Project reports can be accessed at the project website <https://dsi4mtf.usq.edu.au/>



Landless, tenant and marginal farmers dominate the agricultural landscape in study sites.

Background

The Eastern Gangetic Plains is one of the most densely populated, poverty-stricken belts in South Asia. Poor access to irrigation water in the dry season, limited investment capacity and limited access to agricultural knowledge flows, combined with entrenched social structures of class and caste, have for decades impeded the sustainable intensification of agriculture. In spite of chronic food insecurity amongst a majority of rural households, large areas of land remain fallow during the dry months

Access to year-round water for irrigation would substantially increase the productivity of agriculture, improving incomes and food security. However, past interventions have failed to address technical constraints, and the institutional barriers faced by marginal (those owning less than 0.5ha) and tenant farmers, who form the vast majority of the farming population.



Woman represented 60% of the farmers across study sites

With regards to technical barriers, dry season agriculture depends upon access to water reserves stored during the monsoon—namely groundwater resources, and surface storage such as ponds. Groundwater resources across this region are extensive but under-utilised in India and Nepal, with only a fraction of the cultivable area under irrigation of dry season crops, resulting in limited crop diversification, food insecurity and poor nutrition. Constraints include limited rural electrification and severe power shortages, which have made farmers in Bihar and Nepal dependent upon more expensive diesel pumps. Technical barriers to irrigation also include inefficient pumps, poorly maintained ponds and limited technical expertise in irrigation scheduling and the operation of water efficient irrigation distribution systems.

These technical barriers to improved irrigation and water management are matched by acute socio-economic and institutional constraints. The marginal and tenant farmer majority cannot afford investment in pump sets or tubewells, and this is made worse by monopolistic pump rental markets, which further drive up the costs. Furthermore, even if cheaper pumping and distribution technologies can reduce operating costs, tenant farmers who constitute a significant proportion of farmers, have limited incentives to invest due to tenure insecurity, while small and fragmented holdings make investments unfeasible. Agrarian stress has driven many young men into the migrant labour market, paving the way for the feminisation of agriculture. The women who increasingly manage the land experience a high workload, while facing further constraints to accessing irrigation due to entrenched gender relations and limited access to resources.

This project has piloted an integrated approach which simultaneously addresses technical and socio-institutional constraints to improved year-round cropping intensity.

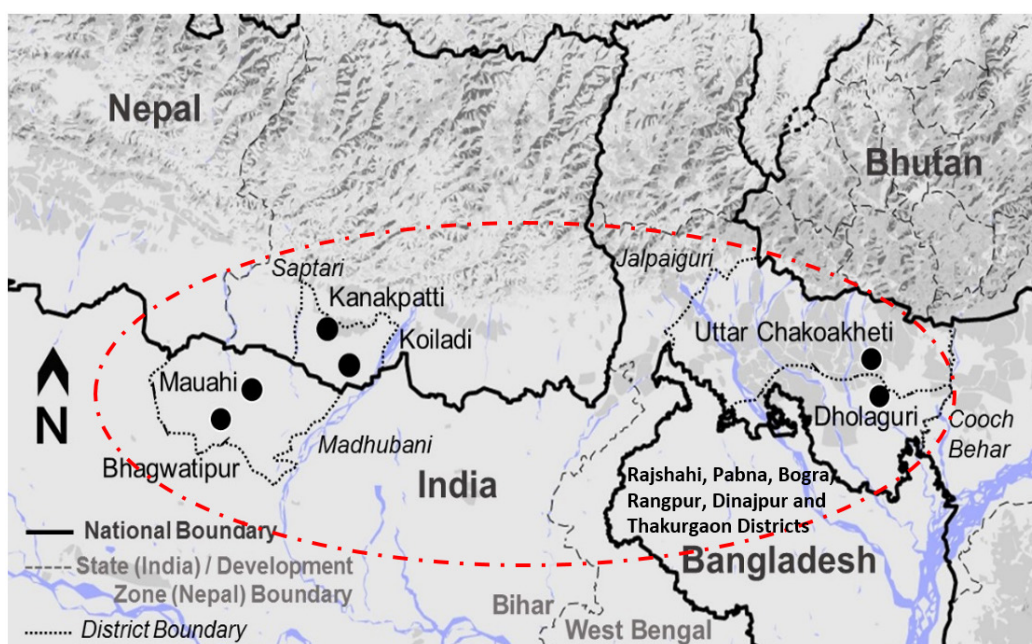
Activities Pursued

Following an extensive technical baseline analysis, involving hydrological and technology assessment, a large scale farm census and in depth qualitative research on the social and cultural character of the agrarian system, this participatory action research project identified and piloted a series of institutional and technical interventions across thirty-five sites and six villages in Nepal (Saptari), Bihar (Madhubani), and West Bengal (Cooch Behar) and six villages in North West Bangladesh.

The project successfully introduced a range of improved irrigation systems and management practices, assisted farmers to migrate from predominantly single season rice based cropping systems to multi crop systems, including vegetables, with cropping intensity increasing from 100% to more than 200% in most sites.

Technologies piloted included drip irrigation, solar pumping, alternative wetting and drying, irrigation scheduling as well as low technology systems, such as improved surface irrigation and water conveyance through poly-pipes. A central intervention in the India

and Nepal sites was the establishment of twenty farmer collectives, through which the new technologies were introduced. These entailed groups of between 4 and 10 households together engaging in different levels of cooperative production, pooling land, capital and labour. The collectives surpassed expectations in their capacity to provide marginal and tenant farmers with economies of scale, while enhancing their bargaining power. They also encouraged the efficient use labour, saving time at a time of crippling labour shortages, while addressing the challenge of small scattered plots to make the piloted irrigation technologies more feasible. The collectives made possible the introduction of appropriate high value crops and cost effective irrigation systems, which improved yield and incomes for marginal and tenant farmers.



Locality map

Key Achievements

Irrigation and cropping systems in India and Nepal

- A village scale assessment of available surface and ground water resources, as well as irrigation systems and strategies was undertaken and a baseline survey was administered which included irrigation and agricultural production information. The analysis found that traditional cropping systems comprised of kharif rice, with limited winter cropping of wheat, maize, mustard, potato or jute depending on region. There was little reliance on irrigation by marginal farmers and traditional irrigation systems were based on flood irrigation of paddy fields with low application efficiency, and high pumping costs.
- Groundwater is readily accessible using centrifugal pumps, with depths to the water table seldom exceeding 7m below surface. Groundwater quality is generally good, however reports from surrounding areas suggest potential for iron, fluoride and arsenic contamination. Village ponds are small, offer limited potential for irrigation, and are generally dry in summer due to evaporation and seepage losses. They are usually reserved for more profitable fish production and domestic purposes.
- Irrigation systems and technology usage was evaluated through field and system measurements and farmer discussions. Detailed pilot study sites were established to develop and test irrigation improvement approaches. A range of interactive tools and smart phone Apps were developed to assist in field level data collection and irrigation assessment. Irrigation system performance was assessed at selected sites. This included pump performance tests, conveyance loss assessment, irrigation application uniformity, and plot water balance assessments.
- A range of methods to assist in irrigation scheduling were considered. These include visual assessment of the plant or soil, soil sampling for volumetric soil moisture assessment, soil moisture monitoring with a range of hardware tools, mini evaporation pans and water balance assessment (e.g. FAO 56).
- The project piloted a wide range of more technically advanced systems (drip irrigation, solar pumping) and processes (irrigation scheduling). While these supported increased productivity, low-tech solutions, such as improved surface irrigation and water conveyance through poly-pipe, had the greatest impact, while being more feasible to upscale.



Ponds offer limited potential for irrigation but support fish farming



Crop diversification increased cropping intensities from below 110% to over 200% in most sites. Profit margin from new cropping systems ranged between 20% and 60%

- The interventions we piloted supported an increase in cropping intensities from less than 110% to more than 200% in most sites. Intensification and diversification resulted in improved production, water use efficiency, profitability and household nutrition.
- Profit margins from the new cropping systems typically ranged between 20% and 60%. There was however large variability, between sites and seasons, driven by the complex mix of crops, seasonal productivity and market price. Seasonal cropping and input costs depend on the cropping system and varied depending on the need for labour, agri-inputs and machinery.
- Profitability is not the only benefit for these communities. Improved nutrition, and stable income and food sources are key benefits from diversified farming practices. Cropping decisions are often about labour, cultural preferences, risk aversion, market limitations, input costs and local consumption needs.

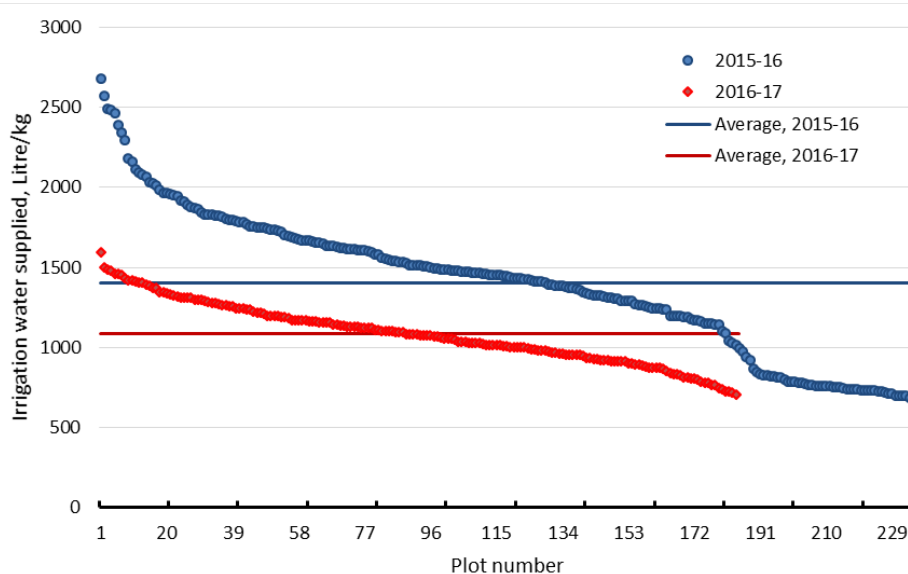
- Demonstration trials showed that vegetable crops require careful management and are sensitive to untimely rainfall, inadequate irrigation during critical crop stages, pest and disease and volatile market prices. Vegetables are not part of traditional commercial farming systems and the research suggested that capacity development, training and agronomic support is required to improve farmers' skills in crop selection, planning, agronomy, pest and disease management and marketing.
- Local irrigation had no significant impact on ground water levels, which recovered during monsoon rains. Impact of large expansion into irrigated crops on groundwater requires further research.
- It was found that the cost of some technologies is prohibitive for small-scale farmers, even when they are part of a group, better access to subsidies is needed. Skills development and technical support is crucial to sustain technologies such as solar pumps and drip irrigation and is not always available locally.
- While the payback on group owned solar pumps is less than 3 years, when compared with diesel pumping costs, the initial capital cost is too high for marginal farmers. Solar pumps need to be integrated with efficient irrigation systems producing high value crops, and need maximum utilisation to justify the capital outlay.



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Irrigation and cropping systems in Bangladesh

- The study provided an assessment of productivity, economic cost and benefit, and irrigation water use of irrigated agriculture in northwest Bangladesh. This was done through intensive monitoring of groundwater irrigation by shallow and deep tubewells in seven selected locations. In addition, the project demonstrated and provided training efficient irrigation practices such as alternate wetting and drying (AWD), use of polythene pipe for irrigation water delivery, effective water management in the field, and introduction of recent high yielding varieties of rice to increase productivity.
- Drivers for change in cropping systems in Bangladesh have included availability of irrigation, and advances in research, extension and government support. Recent maize expansion is driven by market demand, availability of water, better profits and a shift from subsistence to commercial farming. Potato is the most profitable crop but initial investment and risk is very high. Maize has similar initial investment as rice but much higher profit.
- In some areas, irrigation of Boro rice has resulted in lower groundwater tables, resulting in greater water stress in the dry season. Adaptation to water shortages has been through deployment of electric deep tubewells, which have halved the cost of irrigating rice, and doubled profits. In some areas, drawdown of groundwater levels has limited access to groundwater by centrifugal pumps and hand pumps.
- Percolation rate from the rice fields was shown to be on average 3 mm/day. Percolation recharges the aquifer during the irrigation season. Water saving measures, such as AWD resulted in less pumping costs and had economic and environmental benefits, but do not save groundwater. Alternative wetting and drying was shown to reduce irrigation water supply by about 14-18% in Boro rice cultivation.
- Use of polythene pipe for irrigation water distribution was found effective in minimizing conveyance loss of irrigation water. This saved about 20-25% irrigation conveyance water and reduced irrigation time by 25%.
- Total cost, gross benefit and gross income significantly differ among locations based on types of pumps used for irrigation, and varieties of rice and transplanting dates. Cost of irrigation is high being typically 35% of the total production cost of rice, but is also affected by different water pricing models.
- Farmers are generally efficient in applying water to the crops, especially shallow tubewell operators. Deep tubewell sites have greater oversupply since water price and pumping costs are lower. Water saving measures, such as alternative wetting and drying and piped distribution, have improved irrigation efficiency and have been driven mainly by need to reduce pumping costs.
- Water use efficiency by farmers is generally much better than believed and impacts on groundwater are not as severe as expected. Nevertheless there is need to better understand the impacts on groundwater of expanding dry season agriculture, and different crop selections, as well as multiple water sources, not fully dependent on groundwater.



Irrigation supplied to produce one kg rice was well below the general perception of 3,000-5,000 litres per kg

Collective farming and institutional innovations for marginal farmers in India and Nepal

- The baseline analysis pointed to acute socio-economic, structural and institutional constraints to agricultural production by marginal farmers, whereby access to technology is constrained by unequal distribution of resources and exploitative landlord-tenant relations. A significant portion of the land is under tenancy, particularly in Nepal and Bihar, with rates rising to more than 60% in some villages. An ageing farmer population, migration and feminization of agriculture has impacted labour availability. Further patterns of agrarian stress include the limited availability, price and quality of various production inputs, particularly seeds and fertilisers. This has a direct impact on productivity and profitability, not to mention external stresses such as climate change. Price fluctuations, lack of favourable marketing infrastructure, and inadequate and less organized marketing mechanisms hinder the potential to reap benefits from agriculture intensification.
- Women have limited capacity to influence decisions in the households, are powerless to change gendered norms for access to water, and can be easily overcharged in markets for inputs, crops and groundwater. Typically men purchase inputs, negotiate with traders, plough and arrange irrigation pumps while women conduct time intensive but low value tasks like weeding and harvesting, and do this alongside domestic chores. After male out-migration, women's decision making power sometimes increases, yet they suffer a crippling work burden as they have to take on formerly 'male' tasks, facing numerous cultural barriers in the process. Women from better off households can hire in labour to offset these constraints. Gender training provides a platform for better understanding of gender norms roles and relations and helps promote enthusiasm, self-esteem and promote change.
- The study found that drought and untimely rain is the most severe shock encountered by farmers and responses included supplemental irrigation, changing the cropping pattern, following improved crop production practices, and selling livestock or land. Key determinants of household vulnerability include farm size, household age, marital status, main occupation and access to credit.
- While policies exist to support agriculture and water management and build resilience, marginal farmers are not well equipped to follow procedures and access subsidies and support services. Constraints are particularly high for women whose husbands are often working overseas or in urban areas. They often experience isolation and limited access to social networks, while lacking documentation (e.g. land ownership certificates) required to access certain agricultural services.
- The lack of a progressive large farmer class has meant there is limited exposure to new irrigation and farming systems.
- A central socio-economic intervention was the establishment of farmer collectives. Building upon a model proposed by Agarwal (2010), the collectives entail small groups of 4-10 farmers who farm a contiguous plot of land, and engage in different types of cooperation in land preparation, production and marketing. The highest levels of cooperation piloted entailed the pooling of labour, costs and sharing of output.
- Different levels and types of cooperation evolved, based on the land ownership structure, and local experience with running groups over time. The greatest benefits are derived when labour, profits and outputs are shared. This helps overcome peak labour shortages and supports a pooling of knowledge, although coordinating labour can create challenges.
- The collectives benefitted from much more efficient irrigation, as farmers no longer needed to compete for pump sets, even the groups not pooling labour, costs and profits. Certain crops are more amenable to collective farming than others, due to cultural practices and intensity of labour use. Flexibility is required in developing appropriate collective models.



Models for collective farming have evolved to suit local needs



Ethical community engagement is a prerequisite to facilitate maximum adoption.

- All the collectives have helped farmers collectively work on much larger contiguous plots, and benefit from associated economies of scale in machine use, input application and irrigation. It has also increased farmers' bargaining power with landlords – enabling them to obtain better rental terms and undermine the landlord's ability to extract additional 'rents' through labour contributions. The collectives have also supported better organisation for claiming state subsidies and other resources.
- Ethical community engagement, which implies that knowledge production is inclusive, and respects the wisdom and perspective of communities, was found to be a foundation for successful engagement, communication and capacity development, and a prerequisite to facilitate maximum adoption.
- Value chain mapping identified limited value addition and processing activities at farm level and poor access to credit and subsidies. Local institutions, such as collectives could play a key role in improving access to inputs, government support and strengthening marketing through linkages with traders and better market information in the future.
- Increased scaling is required to maximize impact. Different typologies of scaling exist. While scaling out and up facilitate physical and spatial spread, scaling deep offers the cultural glue to keep the impacts intact and internalized.
- It was found that institutional structures should be strengthened at a local level, through identifying ways for the collectives to team together as a community based organisation or federation to better access services and share high cost investments. The improved sustainability of collective farmer groups will also require stronger local institutions and better linkages with markets and service providers. This will require a greater scale of production, which again points to the need for larger scale institutional structures.
- The government has a key role in creating the conditions for long term sustainability and out-scaling, through incentivizing the adoption of a collective approach by increasing awareness of the benefits to collectives, allocation of budget to support local establishment and making it easier to access subsidies. Governments can also support access to land and tenure security and provide trainings on collectives' management and agro-economic skills and empower lead collective farmers to act as a knowledge hub to wider communities. There is a critical need for further orientation and support and strengthened linkages with service providers.
- The small scale of interventions makes commercial service support a challenge. There is limited ability to negotiate prices or discounts on inputs. Scaling farming operations, strengthening supply chain linkages, better market prices and improved linkages with agencies and government support has been limited and should be a key focus in future work.

Impacts

Scientific Impacts

The project has confirmed its main underlying premise: that the combination of innovative social interventions, such as the formation of farmer collectives as a vehicle for innovation, coupled with judicious introduction of appropriate tried and tested biophysical interventions (high value crops, cost effective irrigation) can improve the livelihood of marginal and tenant farmers in the Eastern Gangetic Plains. This is a major achievement, which has important development implications and makes this project highly relevant to food security and poverty alleviation in the EGP.

Interdisciplinary and multi-partner research knowledge and skills:

The project successfully integrated the scientific skill sets of researchers in social sciences, irrigation and water management, and community engagement. This resulted in successful implementation of interdisciplinary and cross-institutional research across a diverse project team including science focussed government agencies, socially focussed NGO's and diverse academic researchers.



Improving market linkages for marginal farmers is critical to farmer sustainability

Viability for marginal farmers engaging in dry season agricultural production:

An improved understanding has been gained on the livelihoods of marginal farmers using dry season agricultural production systems, and the interventions needed to make this possible.

Trials in West Bengal have shown the positive impact of liming on jute yields. Anjali, a short duration paddy variety, has been shown to be a good gap crop prior to planting other Rabi crops. Zero tillage technology in wheat, maize and mustard has also shown advantages over conventional tillage with productivity and resource-use-efficiency and profitability improvements.

Improved knowledge of crop diversification, through Rabi and winter vegetable cultivation, has increased crop intensity and profitability, with better understanding of crop rotation options and agronomic practices. The project has piloted protected housing for cultivation of high value out of season crops in West Bengal, yielding significant profits. Improved water management practices, including reduced furrow length irrigation of potato, water conveyance through plastic pipe, and timing of irrigation have been demonstrated, and understanding of opportunities and constraints of solar pumping systems and drip irrigation systems has increased.

Successes from the formation of collectives of marginal farmers has led to better understanding of the potential for these approaches in addressing labour scarcity, weak bargaining power and poor economies of scale for farmers who wish to intensify. These models are now being adopted in neighbouring communities.

Bangladesh water efficiency results:

In Bangladesh, results from detailed plot scale trials informed broader scale modelling initiatives being conducted in other projects. Findings in Bangladesh have illustrated that water use efficiency by farmers is much better than widely believed and impacts on groundwater are not as bad as expected, offering learnings for other parts of South Asia.



Community monitoring of water resources and app-based data collection tools improved accuracy and timeliness of data collection and information transfer

Participatory monitoring of water resources and irrigation systems:

The introduction of appropriate mobile phone-based data collection tools, complemented by a concerted effort in training and capacity building of partners, has improved the accuracy and timeliness of data collection, specifically around irrigation system performance and water resource monitoring. With further refinement, there are opportunities to promote these tools for wider use.

Ethical community engagement:

Ethical community engagement processes evolved as the project matured. Early research into community engagement perspectives, processes and practices, became a precursor to these approaches, which have been a foundation for other projects including ACIAR funded Socially Inclusive Agricultural Intensification project.

Gender training:

The project developed a better understanding of how changing gender relations affect women's access to water and land resources by examining women's empowerment and their perceptions on being a farmer, within the feminization of agriculture in the Eastern Gangetic Plains. Through this, a gender training approach was developed and piloted with farmer groups. This culminated in development of a training manual and associated training film the basis of which has been used across a number of other projects.



Capacity impacts

Confidence knowledge and skills change

There has been significant capacity development of farmers, driven through group meetings, training events and continuous onsite technical support and social mobilisation. Farmers participated in exposure field visits and farmer exchange visits oriented around technical and institutional capacity building, which resulted in substantial change in confidence, knowledge and skills.

The capacity of project partners has strengthened, particularly in the delivery of research for development projects with a social-biophysical interface. The interface between technical and social aspects of research was a challenge but most partners significantly advanced their capacity in this area.

Improved confidence of women, marginal and tenant farmers has been documented in numerous case studies, while adoption of dry season cropping and collective farming has been impressive. At some sites, farmers have demonstrated a greater confidence to take on risk and are investing in expanded production based on learnings from demonstration sites

Individual practice change

Farmers have adopted new agricultural, water and technological management practices and migrated from predominantly rice based cropping systems to multi crop systems (including vegetables) with cropping intensity increasing from around 100% to over 200% in most sites.



Exposure visits and knowledge exchange between regions increased confidence, knowledge and skills.

Farmers have adopted new irrigation management practices, through the introduction of new technologies such as solar pumping or sprinkler / drip systems, and through improved water management practices, using ridge and furrow irrigation, lay flat piping for better water distribution, and controlled water application, made possible by the collective approach to cultivation and operation of a contiguous plot. Farmers have expanded their knowledge of agronomic practices such as seed treatment and fertiliser placement, use of herbicide, composting, mulching, raised bed cultivation and tray nursery cultivation.

Farmers have themselves participated in irrigation system assessments resulting in a better understanding of the need for regular maintenance and monitoring. While traditionally, irrigation is considered a man's responsibility, women have started operating irrigation systems at intervention sites. For example, women are using sunflower solar pumps, drip irrigation kits, and are applying fertigation to crops through their drip irrigation systems. Women are also starting to take responsibility for farming decisions and operations, highlighting the importance of gender inclusive technologies.

Dry season agriculture has expanded into surrounding fields in the village. In some sites farmers have contributing to infrastructure maintenance costs,

however since profits are still relatively low, surplus funds are often used for other household expenses. There is therefore some risk in sustainability of infrastructure such as solar and drip irrigation after project completion. It is likely though that increased scale and profitability over time will improve long term sustainability. There is need for ongoing training and support and better linkages to local institutions and service providers to ensure this.

While gradually improving profitability and productivity is widely observed as farmers' skills develop and technical problems are resolved, where losses have occurred these have primarily been due to crop failure due pests and disease, unseasonal weather and market failure. However, farmers are willing to continue to work to overcome these setbacks.

Institutional and group practice change

In most of the sites, farmers now have a greater capacity to work collectively at a range of levels, from the stage of input procurement up to marketing. Farmers have learned about and participated in a range of collective farming models, which have evolved organically over the last three years and have been documented to better understand their trajectory. In some cases there was reluctance in the early stages for collective farming



Irrigation and pump performance monitoring improved understanding of system repairs and maintenance

systems under intensive dry season vegetable crops until confidence and trust has developed amongst the 20 groups.

Resource owners and landlords who have often shown little interest in tenant practices other than extracting rent, have seen value in collective farming systems and mutual trust has developed between both sides. As expected, in some instances, there have been problems in the relationship with tenants, generally a result of local disputes on access to land, tubewells and ponds, often associated with caste divisions.

Collective (group) practice change has been significant and generally positive. However, institutional practice change, through policy or government extension programs, is not widely evident. Local out scaling through neighbour farmer interest is occurring and there are some examples of agencies and departments upscaling and out scaling soil water management practices but these are localized. Sustainability of these groups will require stronger local institutions and better linkages with markets and service providers. This will require a greater scale of production. Food security,



Local collective farmer institutions can play an effective role in agriculture and need to be out-scaled.

livelihood and production/profitability has improved for most farmer groups following project interventions.

There have been significant benefits to women farmers who comprise 60% of the farmers in the Nepal and India sites, however in some cases established woman leaders have benefited over other woman farmers. Unequal power relationships still occur in some mixed woman/men groups with negative effects in particular on women's labour burden.

Dry season crops have improved productivity and profitability however there has been increased risk through higher value specialized crops. Agronomic practices and market prices have been critical. Collective farming has been a challenging concept for many of the communities, especially at labour intensive times for critical crops (e.g. vegetables).

Policy implications

While project impact is largely localized, it has started to interface with local agencies and departments who are now supporting the farmer groups. This includes provision of subsidies and support for inputs (e.g. seed and fertiliser) based on the registration of collectives as well as installation of new tubewells and pumps as part of existing government programs. Registration of farmers with the relevant government department is often a prerequisite for support. This generally requires land ownership or tenancy certificates, which many do not have. Marginal farmers can bypass these restrictions by registration for programmes as a group, a potentially transformative change for landless tenants and women without land in their name.

A key policy message has been the transformative role of local collective farmer institutions for effective water management in the Eastern Gangetic Plains – particularly at a time when most new technologies are disseminated through better off 'leader farmers' who are expected to spread ideas to their poorer counterparts. This project reverses this model by using the marginal and tenant farmers as the entry point for new systems, with the contiguous plots and group model of dissemination making up for scale limitations. A policy note was developed and is available on the project website (<https://dsi4mtf.usq.edu.au/publications-resources/>). The brief outlines the conditions for out-scaling the model and the role of government through incentives for collective farming, expanding access to land and tenure security, and facilitating linkages with the non-governmental sector who can provide support services for marginal farmer collectives.

Community impacts

Economic impacts

Within the project groups and pilot sites, there has been demonstrated increase in income from new cropping systems and irrigation practices, and increased food security. This is a considerable contrast with the pre-project situation, when farmers were engaged in subsistence oriented paddy cultivation with limited winter wheat farming. Economic benefits will likely continue to increase as farmers become more familiar with new agronomic practices and irrigation practices. Nevertheless, farmers have an additional source of cash, and this is particularly valuable for women who are most active in the groups. Poor market access, oversupply and low prices have occasionally affected farmers. Crop selection has evolved as a result of these experiences, and even when crops are not sold they bring nutritional benefits for households when consumed.

For example in Madhubani cropping intensity has increased from 110% to >200%, with yields up to 50% higher than in past. There is further scope to increase cropping intensity and profitability especially through better market access and higher market price. Farmers are making better crop choice decisions based on recent

experiences on income, market demand and pest and disease impacts. Farmers are recognising the potential for furrow, drip and sprinkler irrigation to meet crop water requirement with less water than used when flood irrigating bays.

In Bangladesh, farmers have demonstrated greater awareness of the importance of water resources management and an interest in water saving irrigation practices. Farmers are adopting improved agronomic practices including use of younger seedlings, improved varieties, application of balanced fertilisers, biological control of insects, and water saving irrigation techniques such as alternative wetting and drying and polythene pipe water conveyance.

In Saptari farmers now have savings and credit facilities through the collectives, with interest earned on savings and loans used primarily for agricultural inputs and household activities. Farmers are now negotiating with market actors and landlords and are generating increased profits. The farmers are showing greater confidence and skill in the operation of irrigation technologies and closer linkages with ward representatives have developed.

In West Bengal economic impacts are already evident at most sites at both individual and community level with farmers adopting collective farming practices. Farmers are more aware of the importance of profitability and not just productivity and their market intelligence has improved. The best mechanism for profit sharing amongst the collective group members is still evolving. Introduction of furrow and basin methods of irrigation has resulted in saving of irrigation water, and techniques like zero tillage, mechanized paddy transplanting, and better water management have led to reduced cost of cultivation and higher profit – interventions which have been made possible by the land consolidation brought about by collective formation. Local institutions such as collective groups and farmers club have evolved and there are now better relationships between tenant, poor and rich farmers. Neighbouring farmers are also coming forward to trial new crops under collective arrangements. The project is promoting environmentally sustainable agriculture and farmers are using organic compost fertilisers and vermi-compost. The economic impact is increasing slowly and farmers are gaining knowledge on crop selection and maximizing financial benefit. Even with crop failure farmers are remaining confident and learning from failure to implement new approaches.



Crop diversification, increased cropping intensity and productivity helped lift profitability



Improved irrigation management was demonstrated using flexible piping for water conveyance, furrow irrigation and in some cases drip irrigation systems with resultant water savings.

Social impacts

There has been strong evidence that through collectives, the confidence of farmers has increased and their ability to negotiate with landlords has been strengthened. Farmers have begun mobilizing access to government services, including provision of irrigation infrastructure through government programs and access to subsidised production inputs such as seed and fertiliser – through accessing resources as a group. For example in Saptari, three farmer groups pooled efforts to access subsidies for seed and fertiliser which are only offered to cooperatives with a minimum of 20 members. Links between government agencies and farmer groups have been strengthened through a number of coordination meetings, stakeholder meetings and associated field visits. Collectives are evolving with a new group even forming in response to a landlord at Koiladi discontinuing a lease. A significant achievement was the establishment of four new collectives, largely on the initiation of the farmers themselves, who had observed the successes of the other groups.

In many instances while larger farmers have access to information and benefits of government schemes, marginal farmers do not. Through group mobilization and support, marginal farmers are increasingly becoming part of the dialogue with the government and stakeholders. This represents a significant achievement.

The project has opened up opportunities to undermine entrenched caste relations. In villages such as Mahuyahi where divisions were rigid and landlords rarely leased land to Dalits, a group from that community are now leasing land, and the women who lead this group are now making key decisions in crop choice and management. They were even been able to join forces with the youth groups to negotiate a reduced rent.

In West Bengal the promotion of collective farming approaches has had a significant social impact in Uttar Chakoakheti, home to Adivasi communities which had previously had limited engagement in agriculture aside from rainfed rice cultivation. The collective models in West Bengal are unique, whereby farmers have voluntarily provided their land to the collective. This appears to have built trust and empathy between the farmers. The land-poor women members who have taken part in the groups have benefitted from enhanced knowledge and experience, although some challenges remain. Across sites, Marginalized communities are coming forward to establish their voice and actively participate in meetings and farming activities. Some cultural barriers remain, such as women being reticent to sell their product to the local market. The empowered local institutions are establishing social capital and networks.

Collectives are also spreading knowledge and raising political awareness beyond the immediate group. For example, in Uttar Chakoakheti, a predominantly Adivasi (tribal) village, the farmer group members were instrumental in encouraging other villagers to apply for Scheduled Tribe status, as well as make a collective application for government installed tubewells, and even land ownership certificates.

Environmental impacts

In a number of sites, particularly Kanakpatti, farming has commenced on land which had been fallow and neglected for a decade. Land fertility is being improved and better nutrient management and agronomic practices are being introduced, which will improve soil nutrition and weed control. These improved management practices are starting to be adopted by farmers adjacent to pilot sites. Farmers are learning that land will be more productive over a longer period



Collective planning approaches were key to facilitating trust and create depth in scaling

when using correct application of especially organic fertilisers and judicious use of water. There is greater understanding of the role of pulses in increasing soil nutrition. Environmentally friendly Integrated Pest Management techniques have also been used to control pest and insects.

Better irrigation practices and systems that are more efficient have been introduced, limiting water waste and unnecessary extractions from groundwater. In many sites, where the cropping system has been dominated by monsoon rice production, sustainable rice intensification has been demonstrated in which alternate wetting and drying has resulted in a saving of water, and repeated tillage operations needed for puddling have been avoided. Less water demanding pulses and oil seeds have also been introduced.

The major environmental impact has been crop diversification. In many parts, the traditional rice-wheat cropping system has been replaced with new crops such as moong bean, okra, lentil, cabbage, cauliflower, cucumber and brinjal. This assists in building of soil health and management of some pests and diseases, which were prevalent in the rice-wheat cropping systems.

Farmers are irrigating more effectively using improved irrigation practices. Solar pump systems have been introduced and efficient water management techniques are being practised. Efficient irrigation methods are being promoted reducing exploitation of ground water resources.

Improved agronomic practices are also resulting in more targeted chemical inputs of fertiliser and pest and disease control. In many sites environment friendly technologies to control insect pests such as lure traps are being used. Soil quality is being improved through reduced tillage and use of organic composts. Fertigation of vegetable crops is practiced at sites in Madhubani and Saptari which should reduce leaching of fertilisers to the groundwater and secondary salinization of the soils. Farmers are being informed about proper nutrient management. Organic fertilisers, especially vermicompost, cow dung, compost fertilisers etc are increasingly used in production.

Environmental benefits have included transition from diesel pumps to solar pumps. With the introduction of solar pumping systems, there has been reduction in the consumption of diesel at some sites resulting in reduction in the greenhouse gas emissions.

Resource conservation technologies are being promoted to ensure sustainable crop production with less environmental impact. Previously with limited access to groundwater many areas were mono-cropped. With the development of adequate irrigation infrastructure there has been a shift from traditional rice-based cropping system to multi-crop systems with greater crop diversity in the villages.

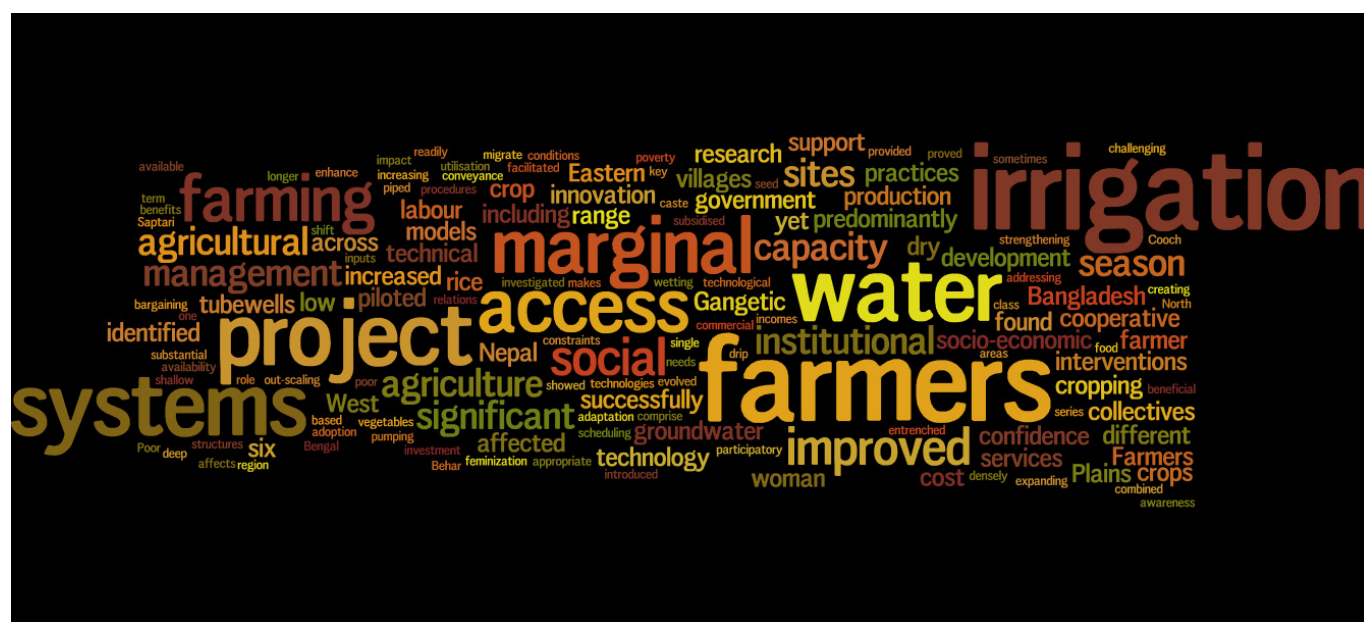
Recommendations

Further research is required to facilitate scaling, social inclusiveness and resilience of cooperatives to withstand future climatic, hydrological, social and economic stresses.

There is a need to address these risks by strengthening climate-smart agricultural and water management practices, improving understandings of the impact of scaling on regional water resources, and identifying opportunities to strengthen institutional structures and supply chains, more fully integrating cooperatives with market development opportunities in the Eastern Gangetic Plains.

Further research should consider three key aspects.

1. How climate-smart irrigation and water management practices for marginal farmers can be extended and scaled into government and agency implementation programs and initiatives to improve irrigation productivity.
2. Institutional structures, policy frameworks and value chain interventions required to support the long-term sustainability of farmer collectives at a village level. These include new models of group formation, and the development of an institutional spine to bind groups together and support in the cultivation of forward and backward linkages for the collectives.
3. The regional hydrological impact of farm-scale water abstraction under different out-scaling and upscaling scenarios.



Further research is required to facilitate scaling, social inclusiveness and resilience of cooperatives and climate-smart irrigation practices.

Acknowledgements

We acknowledge the Australian Centre for International Agricultural Research (ACIAR) and Department of Foreign Affairs and Trade (DFAT) for their financial support of the project. This research received co-funding from the CGIAR programme for Water Land and Ecosystems whose contributions are gratefully acknowledged.

We acknowledge the participation of farmers and communities who we worked alongside over the five-year term. Farmers engaged actively with DSI4MTF researchers as project partners. Capacity development and learning was truly multidirectional.

Project organizations as recognized below and team contributions are gratefully appreciated.



