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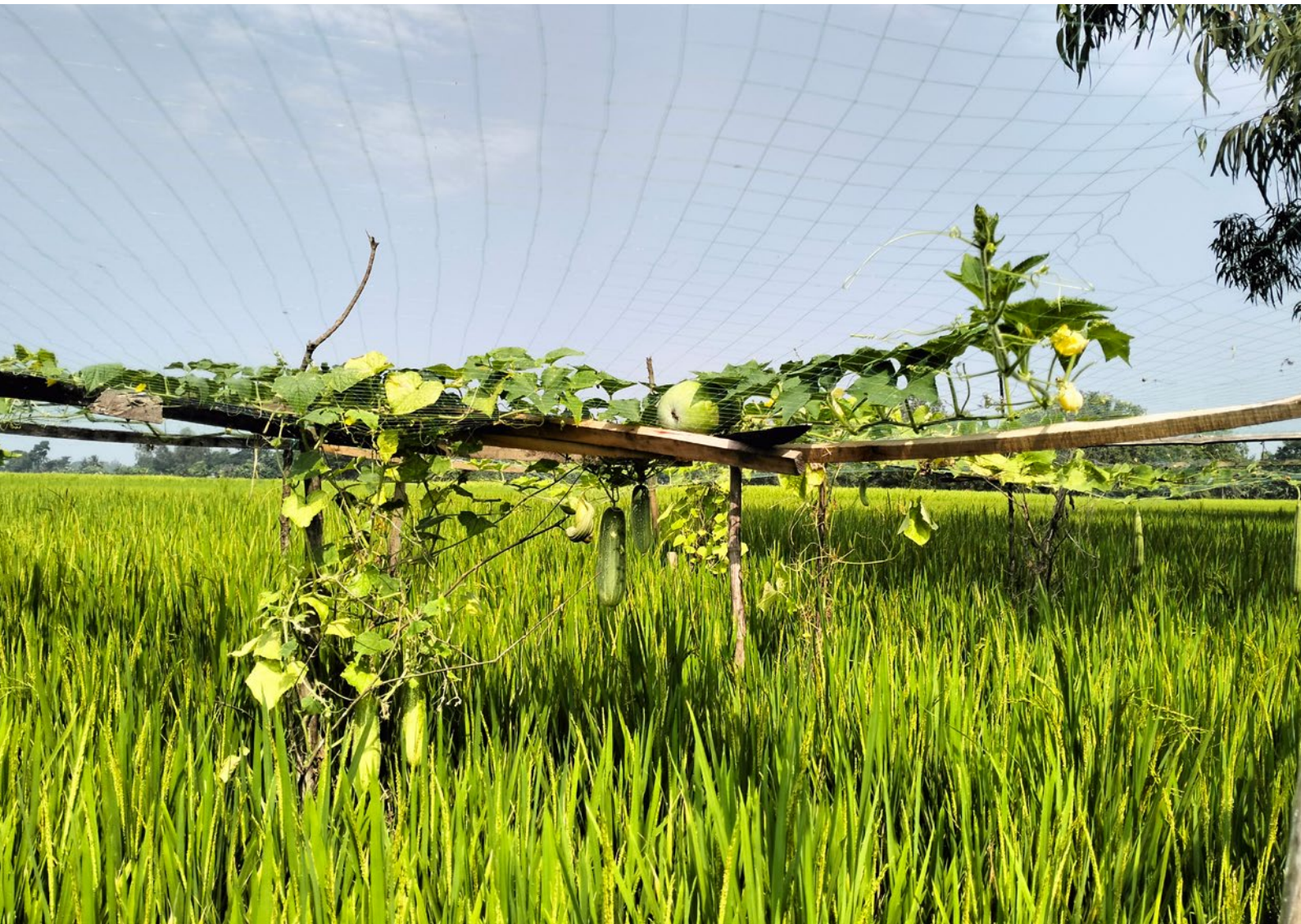
Growing Australia's impact internationally: Cropping system intensification in the salt-affected coastal zone of the Ganges Delta

Impact story | Tahlia Jones, Samantha Stone Jovicich, Kate Langford, Mark Glover and Mohammed Mainuddin

July 2025



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A woman farmer looking at her watermelon field, Dacope, Khulna, Bangladesh

Impact Story

Challenge

The coastal zone of the Ganges Delta in Bangladesh and West-Bengal, India, is disadvantaged by food insecurity, environmental vulnerability, and limited livelihood opportunities. The region is exposed to tidal floods, storm surges, tropical cyclones, riverbank erosion, and salinity intrusion (Akter et al., 2019)[1]. Traditionally, smallholder farmers in this salt-affected area produce low-yielding local rice varieties under rainfed conditions in the Kharif (wet) season. In the Rabi (dry) season, most agricultural land remains uncultivated due to prolonged waterlogging, high soil salinity, and a lack of freshwater for irrigation.

Poverty alleviation and food security are a priority for the governments of Bangladesh and India. Over 60 million live in the coastal zones of the Ganges Delta (nearly 40 million in Bangladesh and 23 million in West Bengal India), with 90% reliant on agriculture for their livelihoods (Rahman et al., 2022)[2]. Hence, innovative and transformative research development to improve smallholder farmers' cultivation of salt-affected fallow lands during the Rabi season is key to navigating the growing complexities and challenges along this coastal region.

CSIRO and partners' response

CSIRO has been collaborating with Bangladeshi and Indian organisations on water and food security since the mid-1990s, with funding from the Australian Government, including the Australian Centre for International Agricultural Research (ACIAR) and the Department of Foreign Affairs and Trade (DFAT). With funding from ACIAR, CSIRO led a scoping study in 2011 that resulted in Phase 1 (2015-2020) of the project *Cropping systems intensification in the salt-affected coastal zone of Bangladesh and West Bengal, India*. The project aimed to sustainably increase cropping intensity and productivity in the coastal zones of Bangladesh and West Bengal particularly during the Rabi (dry) season through integrated soil, water and crop management. The project was led by CSIRO in partnership with five research organisations in Bangladesh, four in India, and Murdoch University in Australia (see Appendix 1 for full list of partners). In the first phase of this work, multidisciplinary teams carried out research on crop adaptation and soil and water management strategies for increasing crop yields in the Kharif season and cultivation in the Rabi season across a variety of locations. The project subsequently received additional funding for a Phase 2 (2021-2026) from the Government of Bangladesh (AU$1.25 million) for in-country project partner research organisations to scale-out the farming practices, and from ACIAR (AU$3.25 million) for CSIRO to further assess options for increasing cropping intensity and diversity, and livelihood opportunities. During this second phase, the team also explored and refined suitable climate-smart agriculture options; out-scaling of fit-for-purpose and profitable technologies through experimentation and demonstration in the wider region; integration of extensive on-farm mapping through remote sensing analysis; development of resilient farming strategies through vulnerability and climate risk assessment; and socio-economic modelling and analysis.

1 Akter, R., Asik, T. Z., Sakib, M., et al (2019). The Dominant Climate Change Event for Salinity Intrusion in the GBM Delta. Climate, 7(5), 69. https://doi.org/10.3390/cli7050069

2 Rahman, M. M., A. Haque, R. J. Nicholls, et al (2022). Sustainability of the coastal zone of the Ganges-Brahmaputra-Meghna delta under climatic and anthropogenic stresses. Science of The Total Environment 829: 154547.

Key outcomes

CSIRO's and partners' 10 years of cropping intensification research in the Ganges Delta led to significant science and technology innovations and outcomes for farmers, local research organisations and the agrifood system in the southern coastal zone of the Ganges River in Bangladesh and India. These are summarised in the table below, followed by further details.

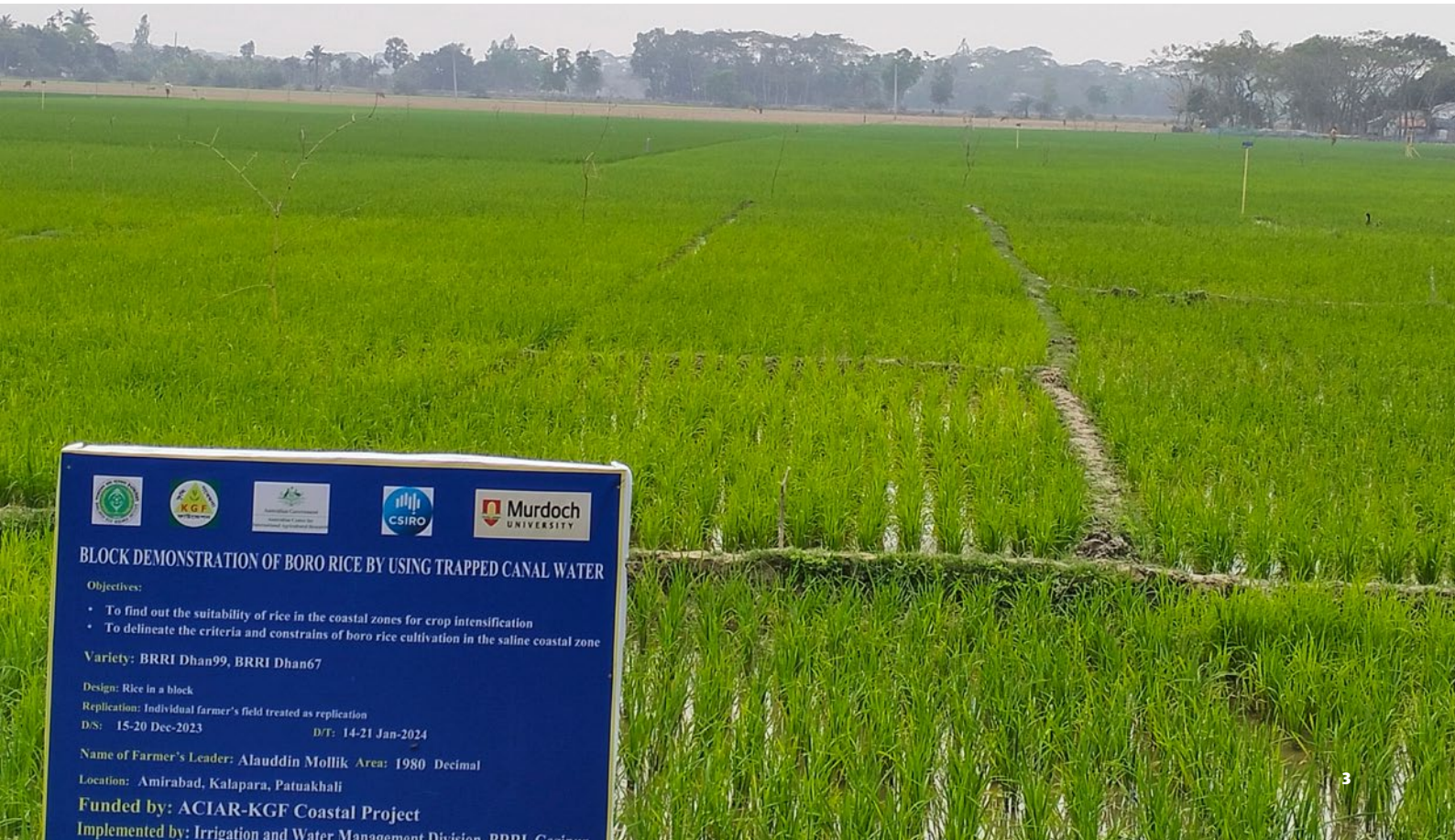
Improved understanding of soil, water and salt dynamics and coastal region characteristics	The project filled key knowledge gaps in soil, water and salt dynamics and balance, leading to improved understanding of groundwater and salinity interactions; and the impacts of climate change, existing farm practices, and cyclone-induced inundation. The project also improved multiscale understanding of the characteristics of the Ganges River coastal zone. Filling these knowledge gaps has been critical for the development soil, water and crop management strategies to improve crop intensity and productivity, and provided the foundational knowledge for the project to further test and demonstrate climate-smart, profitable cropping technologies in a wider region of the Ganges Delta.
Co-development and co-piloting of innovative farm management strategies	The project co-developed and co-piloted with farmers a range of farm management strategies. These included soil, water and crop management strategies for increasing yields in the Kharif (wet) season and capacity to grow crops in the Rabi (dry) season, across a variety of locations. This led to the development of a breakthrough innovative cropping technology – zero-tillage potato cultivation. The project also worked with farmers to improve storage of crops and linkages to markets.
Capacity building of smallholder farmers, including women, and in-country project partners and scientists	The project strengthened the technical and science expertise and capabilities of smallholder farmers, scientists, and research organisations in the region. This is strengthening Bangladesh's and West Bengal's capacity to achieve greater future water and food security in the Ganges Delta.
Strengthened smallholder farmer cooperation and coordination	The project initiated and facilitated greater cooperation and coordination among smallholder farmers involved in the projects in water resource management and sluice gate operations. Community-based water storing and management is critical for irrigation of Rabi season crops and improving cropping intensification in the Ganges Delta.
Increased investments from in-country government partners	The Government of Bangladesh invested a further AU$1.125m in local research organisations to build upon and extend the project's findings in sunflower, dry season rice and water and soil salinity management. This was complemented by special budget funding from the Bangladesh Government, leading to significant investment in scaling the project's technologies and providing farmers with free seeds, fertilisers, and advanced technologies. These substantial government investments have been crucial to increasing crop cultivation in the Ganges Delta, particularly during the Rabi season.
Increase in cultivation of fallow land, crop productivity, and profits for smallholder farmers	Within and beyond project sites, there has been a significant increase in previously fallow land currently under cultivation (~70% increase) during the Rabi season, with greater intensification and diversity of crops planted. That has resulted in increases in crop yields and profits and consequently socio-economic and livelihood benefits for smallholder farmers, including women farmers.
Out-scaling of climate-smart, profitable cropping technologies	The project's successful demonstration of climate-smart, profitable integrated soil, water, and cropping strategies and cropping technologies has led to additional investments for further exchange of knowledge, demonstration, and scaling out technologies in the Ganges Delta, the Pacific and other regions. This includes further testing of zero-tillage potato cultivation by an international organisation (International Potato Centre) across a wider region in Asia, and in Latin America and Africa.
Significant high-level government engagement, media attention, and awards	The project has received significant interest and engagement from high-level government officials from Bangladesh, India and Australia. It also has garnered extensive coverage in a wide array of electronic and print media in Bangladesh, India and beyond; and won prestigious CSIRO awards.

Improved understanding of soil, water and salt dynamics, and coastal region characteristics. Prior to the project, there was limited understanding of soil, water and salt dynamics and balance in the coastal zone of the Ganges River – knowledge that is critical for the development of farm management strategies to improve crop productivity and livelihood benefits. The project increased understanding of salinization processes, surface water, groundwater and salinity interactions; and impacts of climate change, farm management strategies, and cyclone-induced flood inundation on the salt and water balances of smallholders' polders (large areas of land that are enclosed by man-made earth embankments to protect against seawater flooding), and ways of recovering polders following a flood inundation event. Filling these knowledge gaps allowed for more accurate assessments of the impact of crop, soil, water, and salt management strategies on crop yields, the environment in polders, and other salt-affected areas.

Additionally, the project enhanced understanding of the characteristics of the Ganges River's coastal environment. This was achieved via the development of a tool using Data-Cube and Google Earth Engine (GEE) and a web-based modelling platform using APSIM which generated a multiscale visualisation of the region. By producing a series of maps and management guidelines for mitigating risks of untimely and unexpected events (e.g., untimely rainfall, extreme climate events, market failure), the project provided farmers with critical information for improving crop productivity and increasing cropping intensity. This regional characterisation information was also instrumental for the project to extend demonstration of profitable cropping technologies in the wider Ganges Delta region.

Co-development and co-piloting of innovative farm management strategies. Building on the science, and through extensive piloting and assessments with farmers across a variety of locations, the project led to the development of a comprehensive set of farm management strategies to increase crop yields in the Kharif season, enable crops to be grown in the Rabi season, and improve linkages to markets. These included: management of soil, plant, water-logging and salinity interactions at the farm scale; selection of suitable and early maturing rice varieties for pre-monsoon, monsoon and Rabi seasons; growing of vegetables in water-logged rice fields in the monsoon season; early establishment of different Rabi season crops using different techniques such as zero tillage, relay cropping, dibbling, and mulching; development of technology for, and optimum use of, irrigation; forecasting crop production considering complex saline coastal environment and climate change; selection of suitable cropping patterns, development of market linkages and value chains and their potential for socio-economic benefits; and community-based water storing and management. Combined, these innovative farm management strategies are critical to increasing agricultural productivity and rural livelihoods in the coastal zones of Bangladesh and Eastern India.

Demonstration of dry season Boro rice at Kalapara, Patuakhali, Bangladesh



Capacity building of smallholder farmers, including women, and in-country project partners and scientists. The project enhanced Bangladeshi and West Bengali farmers' capacity to increase cropping productivity and livelihood benefits. Over approximately 10 years (2016-25), a total of 17,383 farmers in the Ganges Delta region received formal and informal training in the field, including in cultivation of new crops or varieties, agronomic and water management, zero-tillage cultivation of crops, growing vegetables in water-logged rice, storing rainwater in the canals and ponds for use during the Rabi season, and improved marketing of the produce. Over this time period, training activities expanded from two polders in Bangladesh and one island in West Bengal to eight polders and six islands, respectively. Of farmers taking part in these activities, approximately 29% were women, with over 2100 women receiving training in improved farm and collective water management practices. This led to the formation of a women's group that is teaching water management and crop cultivation techniques to women in other communities in the region.

The project also strengthened the technical and science expertise of research partners in Bangladesh and Eastern India through a range of formal trainings. This included training in project monitoring, evaluation and pathways to impacts; advanced statistical analysis and data management; use of electromagnetic surveys and associated geo-spatial modelling, Unlocking Potential: Earth Observation (EO), cloud computing, data analytics, and data cube technology; crop production modelling using APSIM Framework; use of ADOPT and Value-Ag tools for socio-economic and adoption analysis; and writing of peer-reviewed journal papers.

Bangladeshi and Indian scientists from project partner organisations were also supported to pursue further graduate studies. This included 6 Bangladeshi scientists involved with the project receiving a John Allwright Fellowship (JAF) to pursue their PhD in Australia; 4 of whom have since completed their studies. Another 10 scientists received and completed in-country PhD fellowship through co-funding from KGF (Krishi Gobeshona Foundation) in Bangladesh. There were also 6 PhD fellows from India; 3 of whom have since completed their fellowships. In addition, 22 Master's students from both India and Bangladesh worked on their thesis as part of the project. All PhD fellows and Master's students received supervisory support for their research and several of the trainings mentioned above.

Additionally, in-country scientists were supported to attend conferences and spend time working with CSIRO scientists. This included 15 scientists from Bangladesh and India who received funding to attend conferences in Australia (such as TropAg in Brisbane), and 17 scientists to attend the ACIAR salinity symposium in Vietnam in 2024. An additional 3 PhD fellows spent 6 weeks working with CSIRO scientists in 2018, 2023, and 2024. Bangladeshi and Indian scientists also spent time with the project team at CSIRO sites in Canberra and Brisbane as Visiting Scientists. This included 3 scientists (2 from India and 1 from Bangladesh) who each spent 2 weeks at different times (2022, 2023) and, more recently (2025), an Indian scientist who spent 6 weeks collaborating with CSIRO scientists in Brisbane on APSIM modelling. A further 2 scientists from Bangladesh are scheduled to work as Visiting Fellow at Murdoch University for 8 weeks starting from 28 July 2025.

This extensive capacity building of farmers and scientists from in-country research organisations is strengthening Bangladesh's and West Bengal's capacity to further progress their goals of achieving greater water and food security. The region's leading research organisations are now less dependent on external science expertise and better equipped to train farmers and shape agrifood policy.

Strengthened smallholder farmer cooperation and coordination. The project initiated and facilitated community-led water management and water storing which are critical for irrigation of Rabi season crops. Farmers involved in the projects are now working more closely together to manage water resources and sluice gate operations, enabling farmers to grow crops such as rice in the dry season.

Increased investments from in-country government partners. The project's achievements led the Government of Bangladesh to further invest in the work. This included funding (AU$425K, July 2018-June 2021) for local research organisations to extend R&D on production, dissemination and postharvest technology development of sunflower for saline lands in the coastal region. A further AU$700K (July 2020-June 2023) was invested to investigate increasing cropping intensity of Rabi rice in the coastal Barishal and Khulna regions through water resource and soil salinity management. The Government of Bangladesh also allocated special budget funding in 2020-2021 to scale-out the project's technologies in the wider Ganges Delta region and to provide farmers with free seeds, fertilisers, and advanced technologies. In Eastern India, the West Bengal Government has incorporated zero-tillage potato cultivation into the Department of Agriculture's core programs, promoting it for wider adoption and scaling out. These substantial cross-government investments have been crucial to increasing crop cultivation in the Ganges Delta, particularly during the Rabi season.

Increase in cultivation of fallow land, crop productivity, and profits for smallholder farmers. As a result of the project, cropping intensity has increased significantly in the salt-affected coastal zone of the Ganges Delta during the Rabi season. Remote sensing analysis with imagery from 2023 revealed an ~70% increase in Rabi season cropping activity in areas previously identified as fallow land. In areas beyond the study site, there was an increase of ~10%. In these cultivated lands both cropping intensity and diversity increased with farmers growing high-yielding varieties of Kharif and Rabi rice, and new Rabi crops, including garlic, watermelon, and sunflower.

These cropping improvements have led to significant benefits for farmers, including women. The project increased women farmers' access to new agricultural technologies and associated advisory services. Through their involvement in growing new rice varieties and vegetables in both lowland rice fields and in homesteads, women increased their knowledge, skills, confidence, and ability to make farm management decisions. Women are expected to fully control the cash benefit from some of these crops in the absence of their partners, particularly in West Bengal. A comprehensive survey in Bangladesh showed that 80% of women have more freedom to spend their earned money. This offers expanded opportunities for education, employment, and social participation, contributing to the overall empowerment and well-being of women in the region.

Out-scaling of climate-smart, profitable cropping technologies. The project's integrated soil, water and crop management strategies and technologies have been further promoted and demonstrated in the coastal zone of Bangladesh and Eastern India and beyond. Funding (AU$450K; April 2022 to June 2025) secured by a DFAT-CSIRO Sci-Tech4Climate Partnership extended the demonstration of selected technologies to other areas of the Ganges Delta and helped establish linkages and knowledge exchange with countries in the Pacific (Fiji and Samoa) facing similar challenges in coastal regions with respect to water and food security. Recently, one of the project's most innovative technologies – zero-tillage potato cultivation – has been chosen by the International Potato Centre (CIP) for testing across a wider region in Asia (Bangladesh, India, and Vietnam) and water scarce regions in Latin America (Peru) and Africa (Malawi and Kenya).

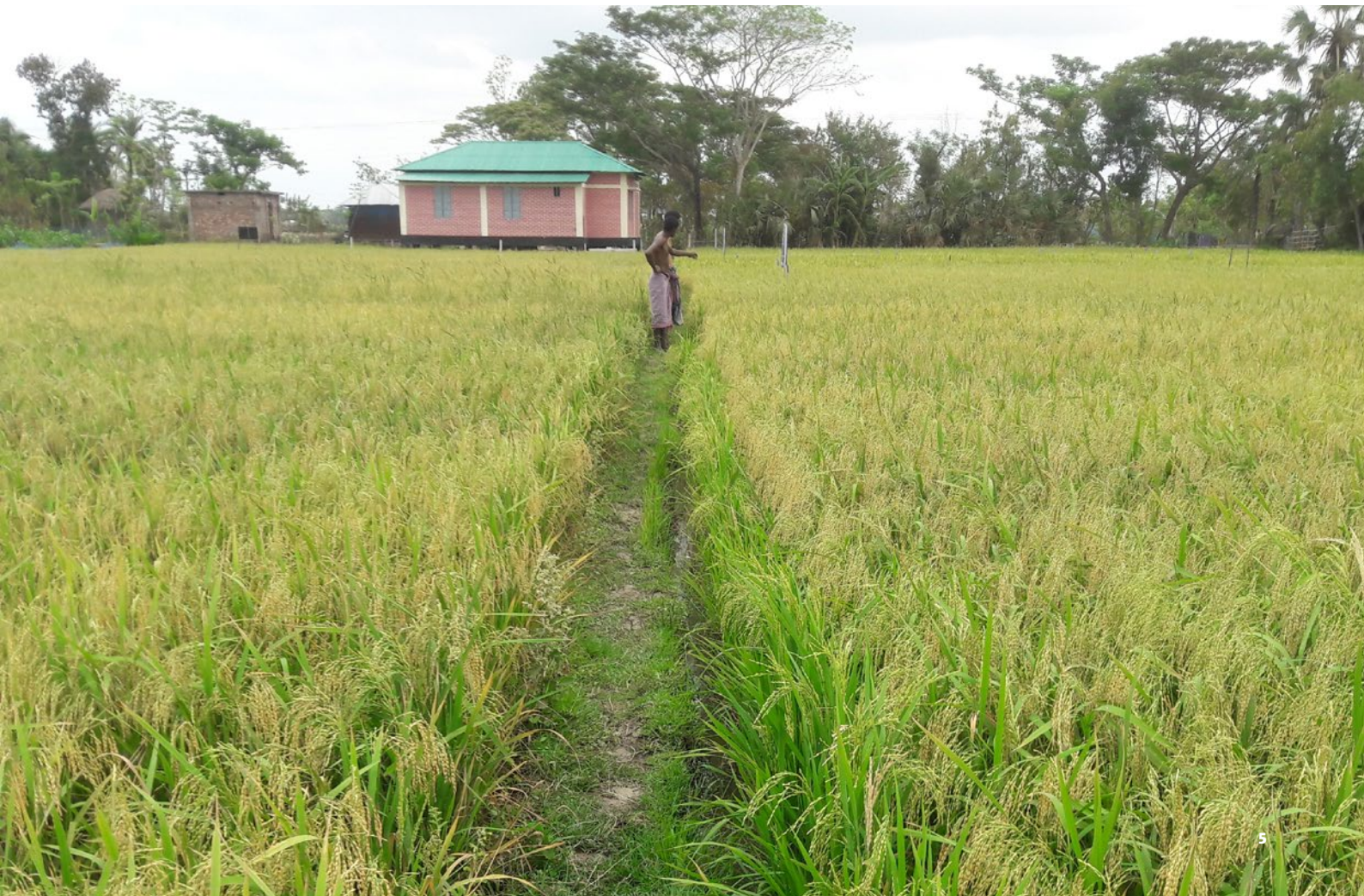
Significant high-level government engagement, media attention, and awards. The project received significant interest and engagement from government officials (see Appendix 3). This included numerous visits in 2020-2025 to project field sites by high-level officials from the Ministry of Agriculture of both Bangladesh and West Bengal, and Australian government officials and funding agencies.

Most recently, the achievements in West Bengal were prominently featured in the *Australia-India Roadmap* launched by the Australian Prime Minister on 25 February 2025.

The project also received extensive coverage in both electronic and print media in Bangladesh and India (Appendix 3), and more widely including a feature story and podcast in the Earth Island Journal that was subsequently shared by Scientific American, The World from PRX, The Africa Report, Nikkei Asia, among other global outlets.

The significance of the project's achievements is also attested by awards won, including CSIRO Land and Water's *Effective Communication of Science Award* in 2021 and Agriculture and Food RU's Impact Award in 2024.

Demonstration of dry season Boro rice in Dacope, Khulna, Bangladesh



How the outcomes were achieved

The project's achievements are the result of a combination of factors. This includes the diversity of capabilities that CSIRO and Bangladeshi, Indian and Australian partners brought to the project; the range of collaborations and networks that were built, supported and strengthened; the quality and relevance of the science that underpinned the work; and the way the teams delivered and scaled the soil, crop, and water management strategies and cropping innovations. These are further discussed below.

Capabilities

Interdisciplinary, multidisciplinary and transdisciplinary capability: CSIRO brought to the project a range of capabilities, including expertise in the fields of land use characterization using remote sensing in DataCube and Google Earth Engine, hydrology, electromagnetic soil survey, crop production modelling using APSIM, agronomy, irrigation and water management, whole-farm economic modelling (IAT/CLEM), agrifood value chains and systems, adoption prediction (ADOPT) and impact analysis (Value-Ag); and value-chain analysis, climate adaptation, and integrated risk assessments. The project team involved 60+ scientists from different divisions and disciplines, as well as farmers. This resulted in a truly inter-, multi- and transdisciplinary team working on all aspects of soil, water, salinity, and crop management in collaboration with farmers in their fields.

Deep knowledge of local culture and language: In addition to scientific capability, the project's CSIRO lead (Dr Mohammed Mainuddin) had personal and professional connections to Bangladesh. His deep understanding of Bangladeshi culture and institutional dynamics in-country, his ability to speak fluent Bengali, and extensive experience in co-developing and co-delivering research projects in the region enabled him to act as a key broker between CSIRO and partners in co-designing an agile and collaborative project.

Extending capabilities of researchers: Several CSIRO scientists who had not previously worked in international projects were offered the opportunity to lead project sub-teams. This helped build their capabilities in cross-cultural and multidisciplinary collaboration and in supervision of in-country PhD and Master's students. These latter scientists' capabilities were also extended, through their direct involvement in project activities and exposure to cross-disciplinary and on-farm applied research. Several of these graduates now hold significant leadership positions within various research institutions in a variety of science disciplines.

Responsiveness and connectedness

In-country scoping phase: In 2010, ACIAR set the coastal zones of Bangladesh and Eastern India as priorities for investment to lift agricultural productivity and improve rural livelihoods by increasing cropping intensification. CSIRO, in collaboration with in-country partners, used this opportunity to carry out a scoping study focused on identifying gaps in current understanding and opportunities for future agricultural research investment by ACIAR in the Ganges Delta. This initial scoping study helped CSIRO and local partners build a strong foundation for the subsequent two phases of the project. Spending time in-country during this early phase was instrumental for developing contextual understanding of the issues and research and development needs. It also was critical in building trust among the project team members, local institutions and farmers.

Cross-institutional, multi-stakeholder project team: The project team included diverse key groups from the region (universities, government institutions and non-government organisations and farmers – see Appendix 1). This improved the sharing, analysis and integration of local knowledge, context and pathways to work towards outcomes.

Cross-project collaborations and synergies: CSIRO encouraged collaboration with other projects in the region to capitalise on synergies, improve efficiencies and enhance opportunities for greater impact. The project team collaborated with other ACIAR-funded projects such as *Incorporating salt-tolerant wheat and pulses into smallholder farming systems in southern Bangladesh (led by University of Western Australia), Promoting socially inclusive and sustainable agricultural intensification in West Bengal and Bangladesh* (led by CSIRO), *Nutrient management for diversified cropping* (led by Murdoch University), and *Transforming smallholder food systems in the Eastern Gangetic Plain* (led by the University of Adelaide). Connections were also made with a project in Pakistan on *Improving salinity and agricultural water management in the Indus Basin of Pakistan* and a project in Vietnam on *Crop diversification challenges in the changing environment of the Mekong Delta*. These cross-project and cross-sectoral collaborations strengthened networks of scientists working on improving understanding of the coastal ecosystem and agricultural development and adoption in other Asian large river deltas.

The project team also partnered with DFAT's SciTech4Climate Indo-Pacific Climate-Smart Agriculture Initiative. This enabled CSIRO researchers to leverage previous investments and outcomes in Bangladesh, India and the Pacific, build on findings emerging from the Ganges Delta Cropping Intensification project, and integrate knowledge, technologies and systems developed with partners in those regions. This helped the team facilitate an Indo-Pacific knowledge exchange for impact in salt affected coastal lands of Bangladesh, West Bengal, Fiji and Samoa.

Multi-scale engagement across the agrifood system: Throughout Phases 1 and 2, the project team's engagement with a range of groups was key to achieving outcomes in the Ganges Delta. In addition to working in partnership with in-country agricultural and water management research and extension organisations, project activities

were designed, piloted and further refined with the close involvement of smallholder farmers. The project also engaged early-on and regularly with key decision-makers, including policy makers, from both the Indian and Bangladesh governments via field visits and high-level workshops held in Dhaka and Kolkata (see Appendix 3 for further details). This raised the visibility of the project and its achievements, leading to further government funding being invested in local organisations to sustain and build on the impacts of the project.

Science excellence and research and technology offerings

Building on existing science and creating new science: The project built upon the scientific findings from the scoping study and Phase 1, advancing understanding and modelling of the crop systems and hydrology of the Ganges Delta. A key innovation was the development of a novel salt and water balance model – believed to be the first of its kind – which, when supplemented with a detailed model of surface water, groundwater, and salinity interactions - enabled a comprehensive assessment of farm (polder) management strategies. The team also introduced a 3D electromagnetic (EM) soil survey in the coastal zone to map salt distribution both within the soil profile and across the landscape. A GIS-based procedure was developed that integrated experimental data with the EM survey results, further enhancing understanding of crop-soil interactions in saline environments. Additionally, the team expanded APSIM modelling to improve understanding of soil-water-plant-salinity interactions in the crop rootzone in complex saline coastal environments.

Other scientific advancements included the integration of different models in a gridded APSIM Framework, Earth Analytics Science and Innovation Platform; policy informing risk modelling frameworks; and Comparative Impact Scorecards. This required large-scale socioeconomic surveys, large-scale EM survey and linking of this survey data with satellite-based remote sensing information and data acquired using aerial drone, and analysis of the GCM data for future change in climate.

These scientific achievements, and underpinning model assessments, were instrumental in demonstrating farm management strategies aimed at increasing crop productivity, cropping intensity and profitability.

Co-produced knowledge, strategies and technologies: The development of improved soil, water and crop management strategies and associated technologies was informed not solely by the science (mentioned above) but also by the new knowledge that was created through sustained collaborations and interactions among the multi-stakeholder project team. Importantly, farmers' local knowledge and experiences was integrated throughout the project.

Delivery and scaling approach

Co-delivery and co-learning approach: All the cropping experiments and demonstrations were done in farmers' field and farmers oversaw the activities, with scientists working closely with them. Farmers played a vital role in trialling and piloting various components of the research including growing Rabi crops, including ones not previously grown in the region; using advanced machinery; incorporating different cultivation practices; treating seeds; and applying lime and rock phosphate in the field. This co-delivery approach, which was underpinned by continuous learning and adapting of the research, was important in ensuring that farm management strategies and technologies were relevant and effective, and for building the capacity of farmers to further adapt and adopt them.

Engaging directly with farmers, including women farmers: The scale of participation from farmers in the region was essential to trialling various components of the research and soil, water and crop management strategies and technologies. Over the course of the project (2016-2025), the number of farmers who were directly involved with the project team grew from 384 (12% female) to 4,751 (36% female). The project team also engaged directly with women farmers to create solutions that supported women's needs and resourcefulness.

Extensive and tailored communication and dissemination of knowledge, strategies, and learnings: Significant effort was made to ensure the projects' key findings, outputs, and learnings were shared more widely and made accessible to other farmers, local extension officials, the broader community, and to policy makers and scientists in-country (see Appendix 2). This was done through a range of outreach mechanisms, including focus group discussions, community gatherings, and visits to field sites.

The team also used creative approaches to raise awareness and share project findings with farmers. The team partnered with the NGO partner Shushilan to produce a 20-minute song and dance performance showcasing the project's technologies. Starting in 2022, this show was performed annually at different project sites at the start of the Rabi season when farmers were relatively free. Each live show drew 200-300 people, with approximately 10 live shows performed per year, complemented by screenings of recorded performances in some areas.

In addition, over 50 newspaper articles were published, and 12 radio and television segments involving local researchers were produced. Eleven 25-minute episodes showcasing project achievements were aired on major national TV channels in Bangladesh and India.

This extensive and wide-reaching dissemination approach helped popularise the technologies among farmers and attract attention from policy makers.

Looking back: Key reflections and lessons learned

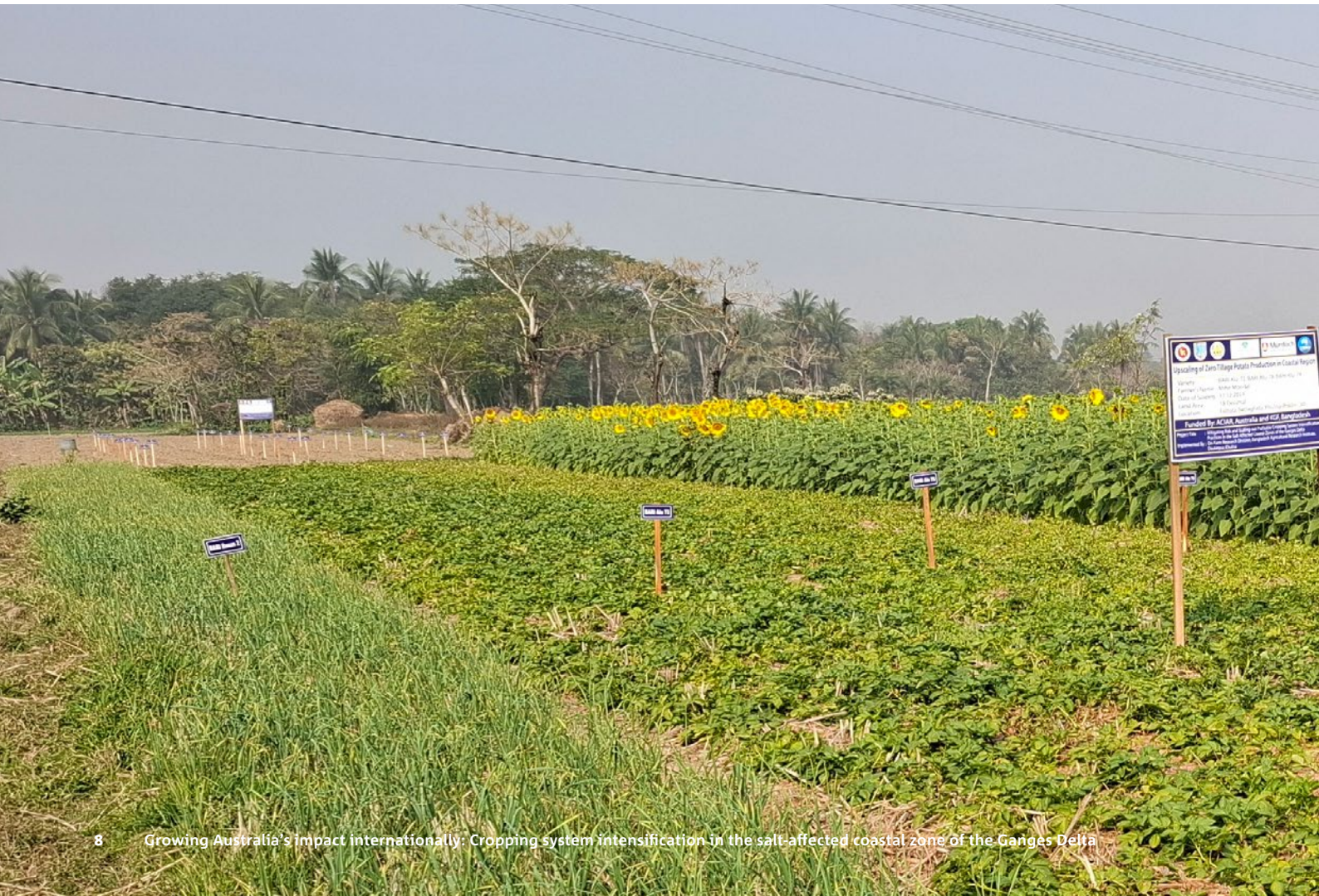
Cross-disciplinary, multi-stakeholder collaboration and diversity are vital and challenging. Bringing together researchers with different expertise and farmers is essential when trying to solve complex and evolving problems. In this project, cross-disciplinary collaboration successfully challenged the traditionally independent and siloed workstyle of Bangladesh and Indian researchers, and improved communication and cohesion amongst project team members. The co-delivery and co-learning approach with farmers was vital. While initially it was hard to find farmers to set up experiments with new crops or cropping methods, after seeing the success of experiments and demonstrations over the years, farmers came forward to practice new technologies, requesting training, seeds and other inputs. Organising a Farmers Field Day at the end of each season to showcase achievements was very helpful.

Changing mindsets is complex but possible. Traditional farming mindsets are difficult to alter without evidence of positive outcomes. It is also complicated by the need to build the capacity and confidence of farmers to independently own and shape their adoption of technologies and techniques. Dr Mainuddin explained how "One way of convincing farmers is not by speaking, but showing the benefit through demonstration sites... Once they see the benefits, they are easily convinced, and they share their learning".

Developing local trust transforms outcomes. The development of relationships that are founded on mutual trust assists in locally led and supported change. This project emphasised the importance of having project team members who could communicate in the local language and understand cultural contexts. Connectedness to, and valuing of, culture fosters co-implementation efforts.

Transboundary awareness scales the applicability of research rapidly. Awareness of other innovation efforts, particularly in nearby regions, was important for expanding crop intensification efforts beyond the project. Sharing project findings and identifying opportunities to adapt and implement them in other contexts was essential.

Project flexibility helps manage unforeseen challenges. Despite the many successes of this project, complications did arise, including an increase in rats and birds in polders as new crops were grown in the Rabi season, and an oversupply of particular produce, such as watermelon, in smaller markets. Building designated time into the project logic and designs to accommodate and problem solve, mitigated the ongoing risk of not adequately planning how to address challenges as they arose.



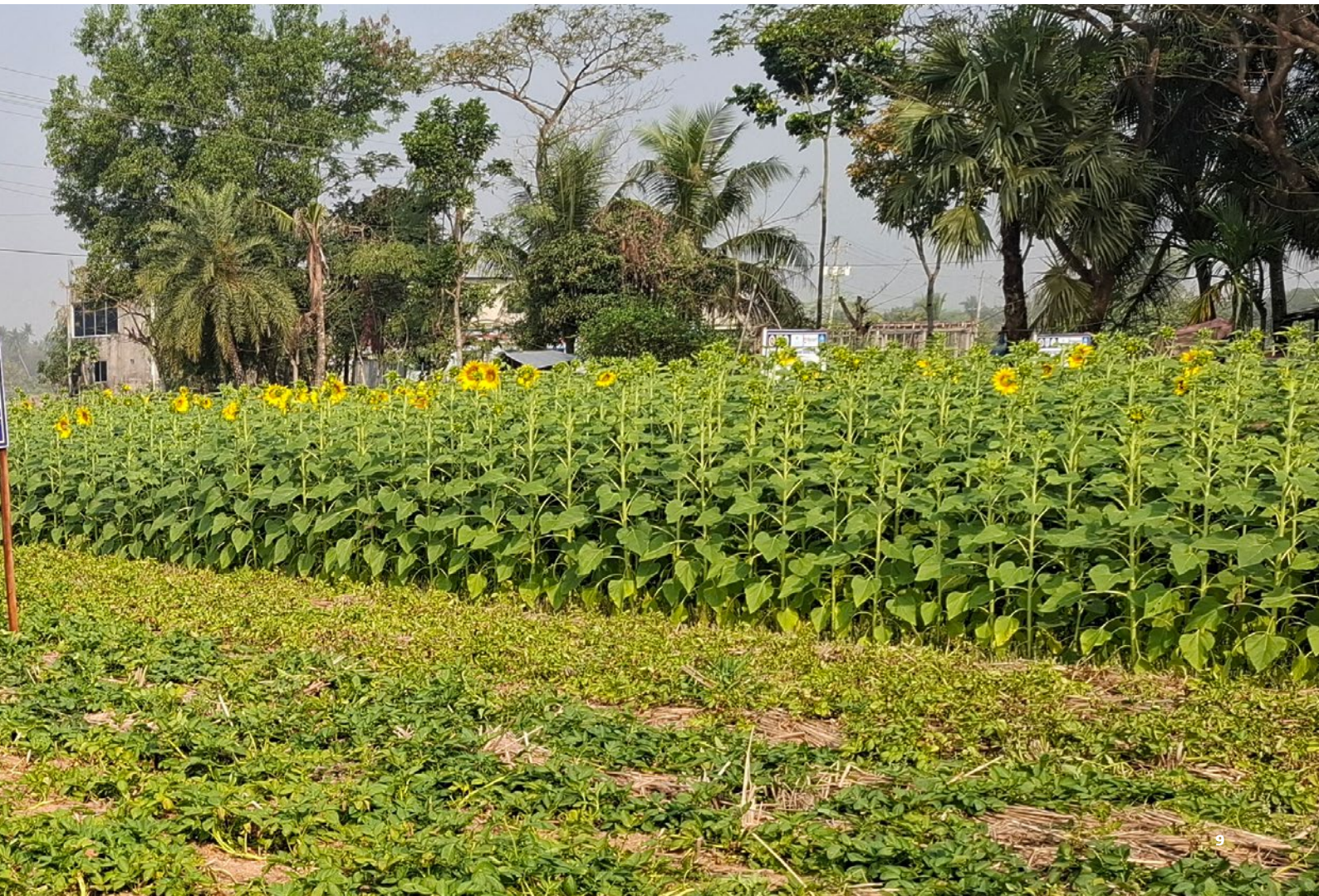
Looking forwards: where to next

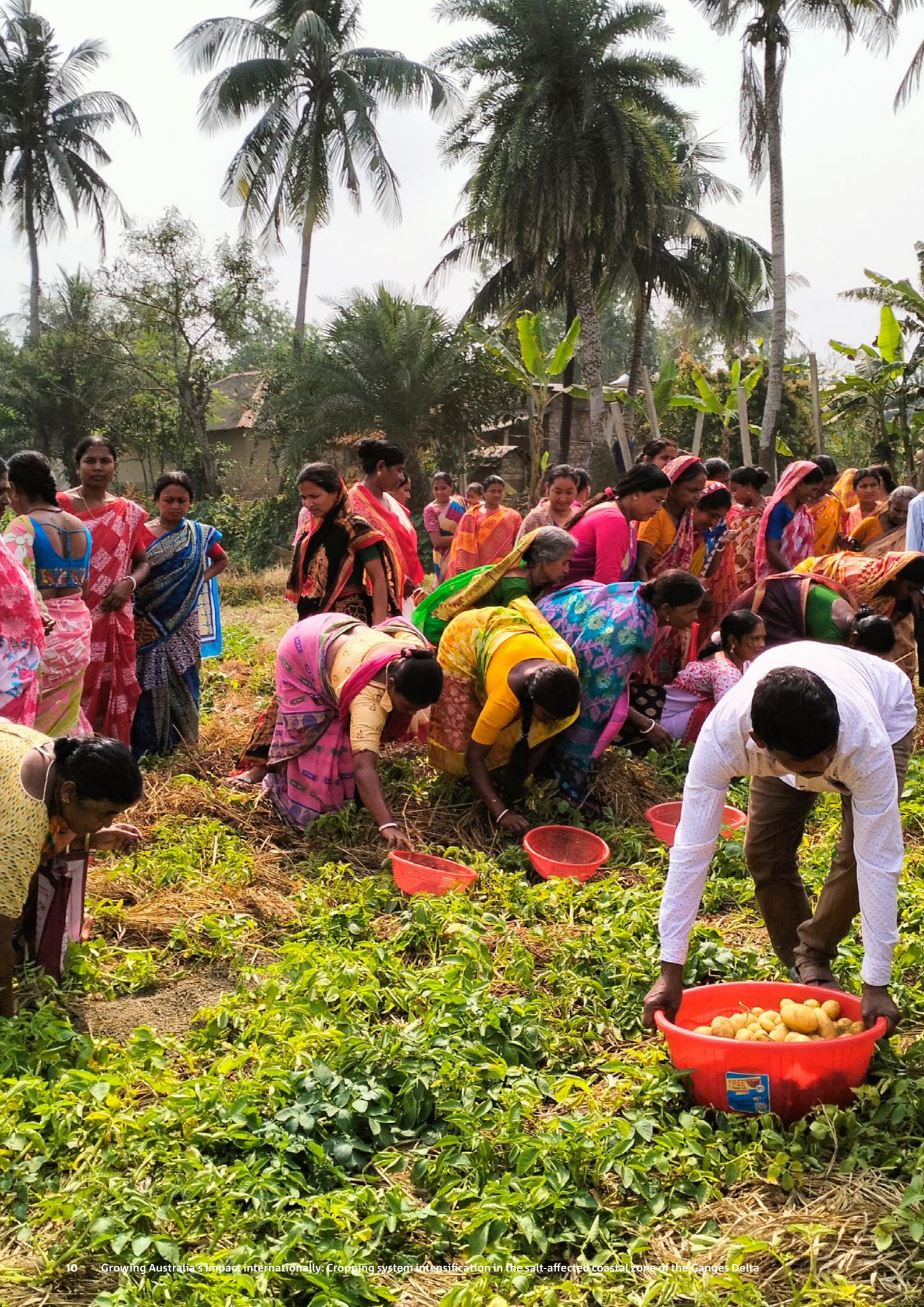
The project has been extended until June 2026, with the focus now shifting to assess if there are opportunities to diversify future research to consider integrated farming, such as improving livestock and fisheries practices for more sustainable and profitable livelihoods. The team is working on a scoping study proposal for ACIAR that is considering the health impacts of drinking water shortages and salinity particularly on women in the region. Researchers will also further assess how to equip farmers to better manage marketplace dynamics; respond to supply and demand fluctuations, such as preparing seed storage capabilities; and navigate increasingly destructive environmental and weather conditions in order to test the intercropping capacity of the region.

Acknowledgements

This study is funded by the Australian Centre for International Agricultural Research (ACIAR) and the Krishi Gobeshona Foundation (KGF) of Bangladesh. We sincerely acknowledge the significant in-kind contributions from CSIRO, Murdoch University, and our collaborative partners in Bangladesh and India. The project team is also deeply grateful to the farmers who have been with us on this journey from the beginning. Their wholehearted collaboration has been instrumental in making this achievement possible.

Demonstration of dry season Rabi crops (garlic, zero-tillage potato, and sunflower) in Botiaghata, Khulna, Bangladesh





Appendix 1. Summary of projects delivering cropping systems intensification in the salt-affected coastal zone of the Ganges Delta

PROJECT NAME	SCOPING STUDY	CROPPING SYSTEMS INTENSIFICATION FOR COASTAL ZONE (CSI4CZ) PROJECT (PHASE 1)	CSI4CZ FOLLOW-ON PROJECT (PHASE 2)
CSIRO team (lead + team members)	Mohammed Mainuddin, Howard M Rawson, Perry L Poulton, Riasat Ali, Christian Roth	Mohammed Mainuddin, Mac Kirby, Don Gaydon, Mark Glover, Sreekanth Janardhanan, Yingying Yu	Mohammed Mainuddin, Don Gaydon, Jorge Pena-Arancibia, Fazlul Karim, Marta Monjardino, Mark Glover, Yingying Yu, Heidi Horan
Funders	Australian Centre for International Agricultural Research (ACIAR)	ACIAR, KGF	ACIAR, KGF Government of Bangladesh
Key partners		Bangladesh Bangladesh Rice Research Institute (BRRI) Bangladesh Agricultural Research Institute (BARI) Institute of Water Modelling (IWM) Khulna University Shushilan (NGO) India ICAR Central Soil Salinity Research Institute (CSSRI) Bidhan Chandra Krishi Viswavidyalaya (BCKV) Ramkrishna Mission Vivekananda Educational and Research Institute (RKMVERI) Tagore Society for Rural Development (TSRD) Australia Murdoch University CSIRO	Bangladesh Bangladesh Agricultural Research Council (BARC) BRRI BARI Shushilan (NGO) India CSSRI BCKV RKMVERI TSRD Australia Murdoch University CSIRO
Duration	2011-2013	2015-2020	2021-2026
Focus of project	Identifying gaps in current understanding and opportunities for future research investment	Crop adaptation, and soil and water management strategies to support yield increases in the Kharif season and successful cultivation in the Rabi season across a variety of locations	Mitigating risk and scaling-out profitable cropping system intensification practices (ACIAR-funded, CSIRO-led) Scaling-out of sunflower and dry season Boro rice cultivation (Government of Bangladesh funded; in-country partners-led)

Harvesting zero-tillage potato, Gosaba, South 24 Paganas, West Bengal, India

Appendix 2. The project mapped against the Theory of Change for CSIRO A&F Secure Food Systems Impact Area

IMPACTS

Agrifood systems in Australia and the region are environmentally and economically sustainable, resilient, nutritious and equitable

AGRIFOOD SYSTEM OUTCOMES

Agrifood systems in Australia and the region have the capacity to respond to a changing set of social, economic and environmental aspirations

In Australia and the region:

Policy & societal support and leadership for transitions towards secure & resilient agrifood systems	Collaborations, networks & organisations are established that are socially inclusive, systems-oriented, and have means and skills to support/ lead agrifood systems	Science/ research institutions embedded in, and valued as partners, in agrifood system collaborations and networks	Agrifood systems actors drive, in a collaborative and concerted manner, what is needed for transformation to a secure & resilient agrifood system	Agrifood system actors are equipped with, and use, relevant and appropriate knowledge, technologies & approaches to strengthen security & resilience of the agrifood system	Investments in appropriate agrifood system level interventions further increased and/ or expanded

CSIRO AND PARTNER OUTCOMES

Within direct sphere of influence (sub-set of agrifood system and key actors):

Medium to long term

Agrifood system actors establish or strengthen collaborations, networks & organisations	Agrifood system actors collaboratively determine what is needed for transformation to a secure & resilient agrifood system	CSIRO and partners' science-informed, system-oriented knowledge, tools & approaches are adopted and inform decisions, practices, policy, investment and incentives	Increased investment in appropriate agrifood system level interventions

CSIRO and partners:

Short term

Support and strengthen relationships and collaboration across sectors & across policy, research, industry, donors & community	Demonstrate system thinking in projects & practices	Raise awareness and enhance understanding of pathways and intervention options for strengthening security & resilience of agrifood systems	Build agrifood system actors' capability and capacity (multiple levels and two-way, including CSIRO's)	Collaborators (e.g., farmers and other agrifood system actors) take ownership and adapt science-informed, system-oriented knowledge, technologies and approaches

INNOVATION STRATEGIES

CSIRO builds relationships and connections with diverse agrifood system actors	CSIRO convenes & supports actors across the agrifood system to build an evidence-based, collaborative and holistic understanding of agrifood system challenges & potential future approaches	CSIRO & partners co-develop agrifood system technologies and knowledge products (including tools, data, information & processes) to catalyse & measure system performance	The science underpinning the agrifood system technologies and knowledge products is scientifically rigorous and important, context-appropriate, legitimate and positioned for use and impact	CSIRO & partners co-design & implement interventions that respond to agrifood system challenges using appropriate technologies & approaches	CSIRO & partners adopt most appropriate approaches to scaling interventions

CAPABILITIES

Domain expertise incl. production, environmental, social, economic, market & traceability, biosecurity, land management	Systems & innovation expertise & experience incl. innovation policy analysis, innovation brokering, systems theory & approaches, future visioning	Knowledge brokering skills incl. outreach & research translation, cross-cultural communication, IP sharing, capacity building	Project management & organisational skills incl. complex project/program/ portfolio management, measurement evaluation & learning

The ‘Cropping system intensification in the salt-affected coastal zone of the Ganges Delta’ project aligns with the A&F’s Secure Food Systems Impact Area (2025). It provides an example of how CSIRO, in collaboration with farmers and partners in Bangladesh and West Bengal, have achieved significant outcomes that are beginning to catalyse larger-scale changes in the agrifood system of the Ganges Delta region.

Appendix 3. High level engagements, media and awards

High level engagements

Bangladesh

- Bangladesh Minister of Agriculture visits (12 March 2020 and 9 May 2022)
- Two visits from the Secretary of the Bangladesh Minister of Agriculture (15 January 2023 and 25 November 2023)

India

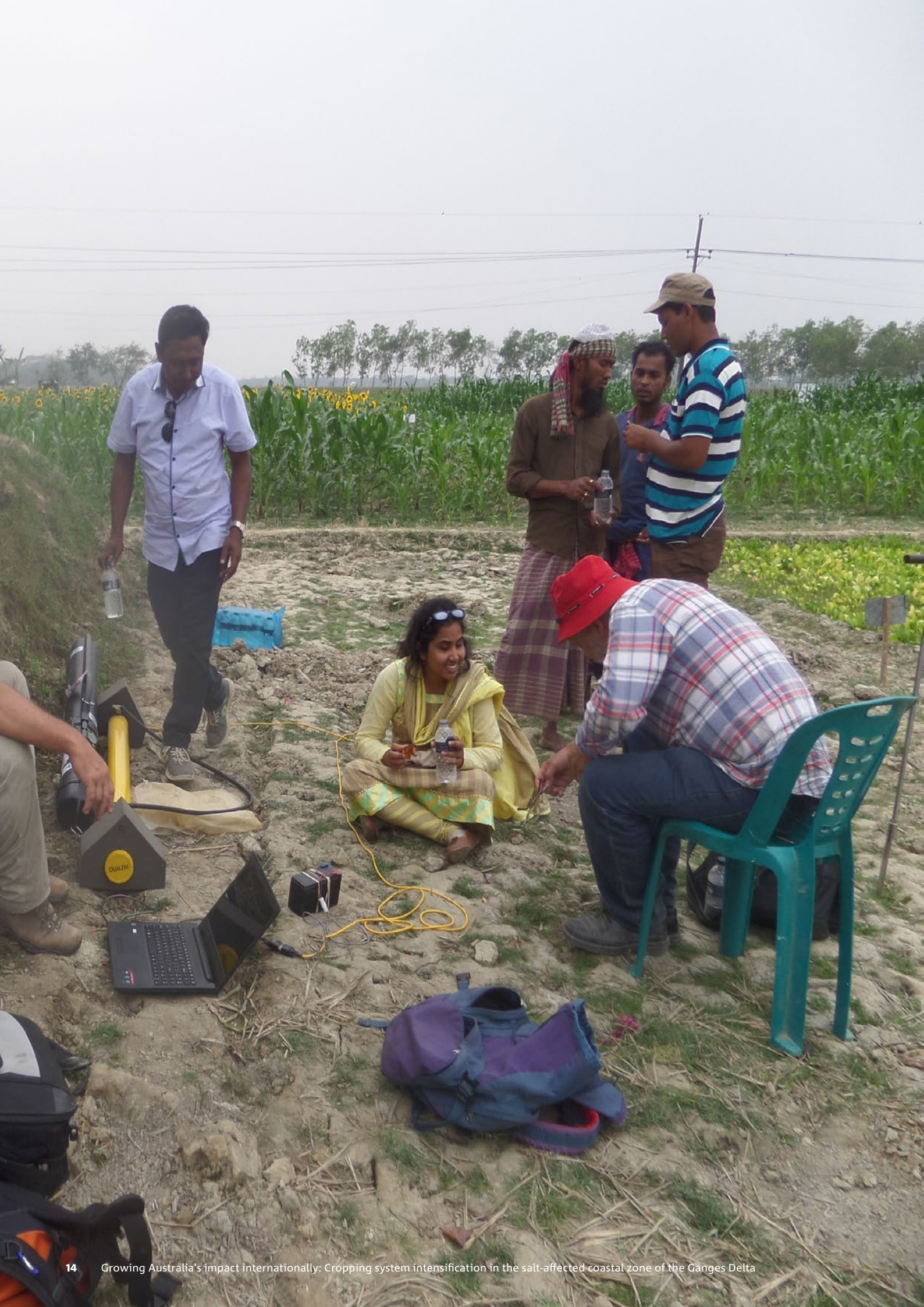
- Attendance of West Bengal Minister of Agriculture at project workshop (24 April 2017)
- Agriculture Advisor to the Chief Minister of West Bengal participation in project workshop (5 March 2020)
- Project Leader Mohammed Mainuddin met the Minister of Agriculture of Bangladesh on 30 October 2019 at the Minister’s Office to brief him about the work being done by CSIRO in Bangladesh

Australia

- Australian High Commission delegation led by Deputy High Commissioner from India, Ms. Sarah Storey, visited the fields in West Bengal (17-19 May 2022)
- ACIAR Commission visited project activities in Khulna region (14-15 February 2023)
- Australian Consul General based in Kolkata along with the Senior Research and Visits Officer visited the project activities in West Bengal (2-4 March 2025)

Media

- 11 episodes of TV program (about 25 min each, like Landline of ABC Channel Australia) were broadcasted in the national and private TV channels of Bangladesh and India. These episodes include interviews of Australian and local scientists. They are available in YouTube.
- Success stories were also covered as news items in regular news in the national and private TV channels.
- 50 reports have been published in the national and local newspapers of Bangladesh and West Bengal.
- ACIAR has prepared two videos (about 6 min each) on the project and circulated it in the social media. ACIAR also published several stories in the Partner magazine and in the web.



Appendix 4. Sources of information and additional resources

CSIRO and in-country partners produced 85 journal papers, four book chapters, and 50+ conference papers, in addition to numerous other outputs. Some of the key outputs are:

Journal papers

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10. Kohinoor, H., Uddin, M.S., Rahman, M.J., Mainuddin, M., Chowdhury, A.K., (2024). Stability Analysis for Seed Yield of Linseed (Linum Usitatissimum) Genotype in Saline Affected Soils of South-Western Coastal Region of Bangladesh. European Journal of Ecology, Biology and Agriculture, 1(5), 110-127. https://doi.org/10.59324/ejeba.2024.1(5).09
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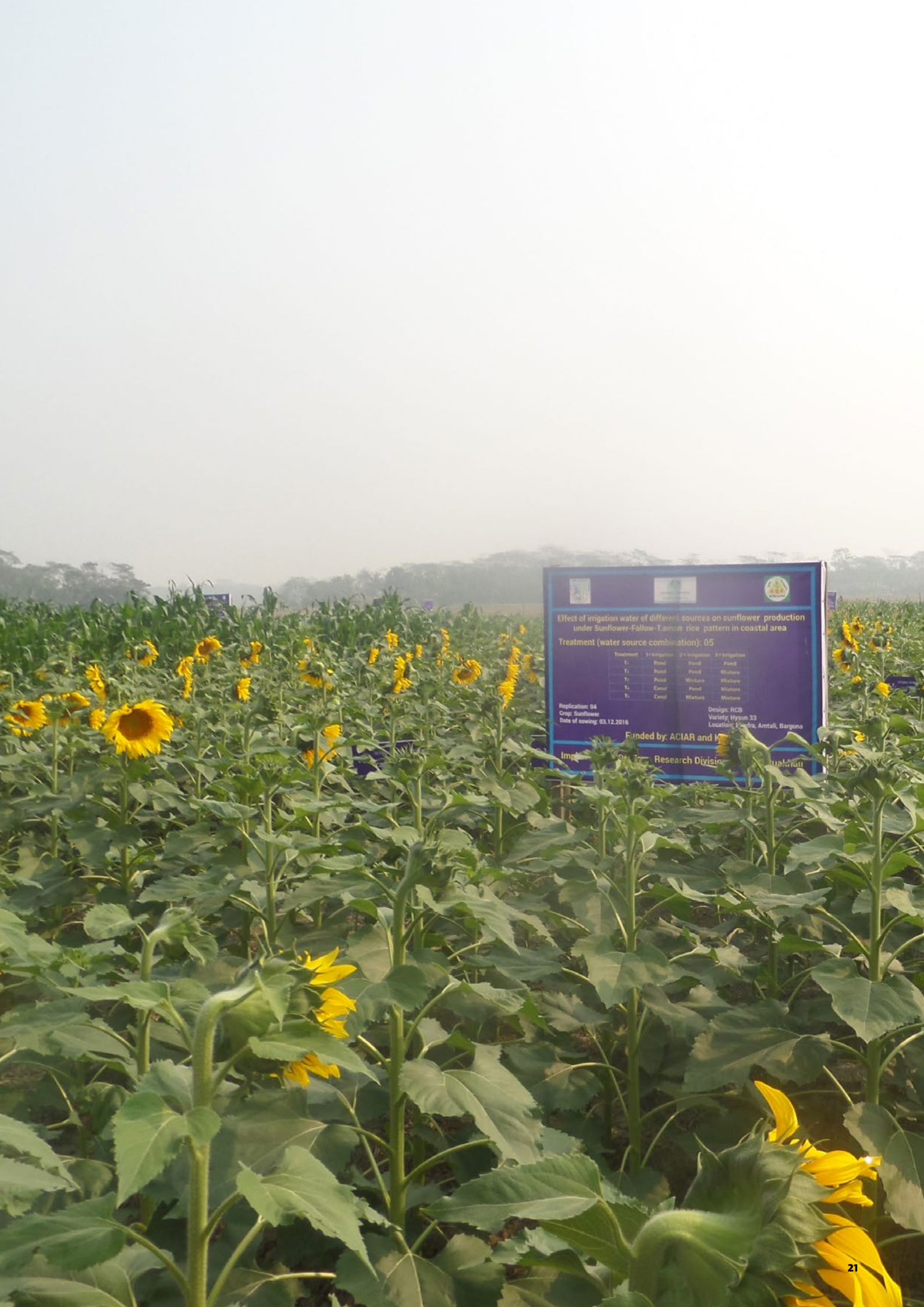
Other

- 50 articles in major newspapers
- 12 radio interviews and television broadcasts

Demonstration of sunflower cultivation at Amtali, Barguna, Bangladesh


Effect of irrigation water of different sources on sunflower production
under Sunflower-Fallow-T.aman rice pattern in coastal area
Treatment (water source combination): 05
Replication: 04
Crop: Sunflower
Date of sowing: 03.12.2016
Design: RCB
Variety: Hysun 33
Funded by: ACIAR and

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Contact us
1300 363 400
+61 3 9545 2176
csiro.au/contact
csiro.au

For further information
CSIRO Environment
Mohammed Mainuddin
Mohammed.Mainuddin@csiro.au

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