Australian Government

Australian Centre for International Agricultural Research

Final report

Project full title	**Transforming irrigation in southern Africa (TISA)**
project ID	LWR/2016/137
date published	21/02/2024
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approved by	Dr Neil Lazarow, Research Program Manager, Water
final report number	FR2024-004
ISBN	978-1-922983-85-5
published by	ACIAR GPO Box 1571 Canberra ACT 2601 Australia

Contents

1 Executive summary

This is the final report for the second phase (2017-23) of the *Transforming irrigation in southern Africa* (TISA) project that sought to improve the sustainability and profitability of small holder irrigated agriculture. We researched how to scale out and up successful interventions using simple to use water monitoring tools and Agricultural Innovation Platforms (AIPs) at the irrigation scheme scale to larger number of schemes and scales of governance, by building the capacity of farmers, government, and private sector organisations.

Achievements

Table 1. *Summary of achievements*.

Key outputs	Progress
i. Established capacity to use AIPs to innovate in at least five districts and 32 new irrigation schemes and publish guidelines on how to scale up and out the benefits from AIPs to other places with minimum investment.	Very good progress with the establishment of twelve district AIPs, see activity 1.1, working with forty one smallholder irrigation schemes comprising over fifteen thousand farmers, see Appendix 10.7 for details.'
ii. Published ways of using simple soil and water monitoring tools to benefit irrigators on a large scale, by identifying enhanced practices from irrigation patterns.	A range of guides are available on the VIA web site, https://via.farm/how-to-guides/
iii. Documented processes to better represent women, the young and tail end farmers in decision-making, and aid their access to land, water and new technology.	Good progress, see activity 2.4.
iv. End users of key national government agencies and multilateral irrigation funders know how to apply project techniques.	Moderate progress, see activity 3.1 and 3.2, and section 3.4.

A subset of the research data collected above was used for monitoring and evaluation of the project's performance. Table 2 outlines the outcomes against project performance indicators are:

Table 2. *Outcome against project performance indicators*.

Objectives and indicators	Outcomes
Objective 1 – AIPs and simple tools	
Number of AIPs implemented.	12 district level AIPs have been established (see activity 1.1; target was 5), engaging 41 schemes (target was 38). The formation of resource intensive new scheme level AIPs was not a priority - only one was formed, see activity 1.3.
Number of farmers using tools	930 sets of sensors have been installed, with 754 farmers (includes some from phase I) on the VIA site, and farmers

Objectives and indicators	Outcomes
	trained in their use. See Annex 10.2 “TISA project - Tracking key indicators”.
Number of farmers buying tools	Developing the business model to fund tool production, operations and maintenance is now the responsibility of our sister project, VIA. However, TISA team in Tanzania have worked to get VAT removed from tool imports and jointly with VIA, are establishing a VIA business.
Number of key farmers demonstrating capacity to innovate and adapt the tools	This is being reported on in the three country special issue papers that are currently being finalised.
Number of trained AIP facilitators in governments and NGOs.	276 government officers have been trained. See Appendix 10.2 ‘TISA project - Tracking key indicators.
Number of low-cost means to out scale AIP benefits identified at scheme scale.	Scaling out from existing AIPs has occurred in all countries. See activity 1.4, and Appendix 10.7.
Number of low-cost means to out scale AIP benefits identified for higher scales of governance.	National level innovation meetings were held early on in Tanzania, and Zimbabwe but COVID-19 restricted that progress, however national agencies are being engaged in all countries, see activity 3.2.
Number of irrigation funding partnerships.	Many strategic partnerships have been explored in all three countries and internationally, in Mozambique the tools have been adopted by a couple of externally funded projects, however overall progress has been limited see activity 1.9.
Number of methods identified for using Chameleon and associated data to improve irrigation management at scheme, district and national scales.	In Mozambique they are using the data in national database of irrigation schemes. In Zimbabwe, a collaboration with AGRITEX is deploying tools across Matabeleland North Province as a national pilot. Tanzanian engagement is across two district governments.
Number of government agency staff able to map farm plots.	Good progress: Mozambique with seventeen staff trained and guidelines developed, Tanzania fourteen extension officers, ten at scheme level and four at district level, and Zimbabwe nineteen extension officers were trained to map schemes. A journal paper has been submitted for review.
Number of scheme maps produced.	Thirteen schemes have been mapped across the three countries, see activity 1.8.
‘How we’ guide to better irrigation practices.	Guide published in English and translated into Portuguese and Swahili. The next step is to share the guide further with other stakeholders/ See activity 2.4.
Number of videos, including in national languages.	Videos have been produced in all countries. The project team produced one in Mozambique, one in Zimbabwe on focusing on the tools, and ACIAR have produced videos of the project in Tanzania and have supported the “Good Cooks” production in Mozambique, see 10.1. The production of other videos stalled due to COVID-19 travel restrictions.
Objective 2 – Equity	
Number of means of reducing inequity in irrigation schemes identified.	Inequity was explored in several ways and reported on, see activity 2.3. There have been significant reductions in inequity as a result of project interventions.
Research consolidation and COVID-19 analysis (V3[1])	Surveys and analysis completed in all countries, see activity 2.5, 6.3 and 7.3.2.
Scoping study (V3)	Report completed and presented in ACIAR in March 22, see activity 2.4.
Modelling approach to demonstrate water savings and climate smartness. (V4)	Modelling and data compilation have been completed and are being reported, see activity 2.6.

[1] *V3 = ACIAR Variation 3, and V4 = ACIAR Variation 4.*

Objectives and indicators	Outcomes
Climate smart irrigation efficiency demonstrated through case studies and analysis. (V4)	Climate case studies presented at UN COP 27, and papers have been produced, see activity 2.6.
Objective 3 – Policy	
Number of academic publications, including in national languages.	Since start of TISA, 41 journal articles, and book chapters have been published and a further six articles are under review, and further eight being drafted; details are contained in Annex 10.1 and 10.6. The two *International Journal of Water Resources Development* special issues continue to be well received; with papers in both special issues have had 163,928 views and 546 CrossRef citations an Altmetric of 295, see Annex 10.5.
Number of popular policy briefs, including in national languages.	Six case studies and policy briefs have been developed and been disseminated widely, see activity 3.1 and 10.1.
Scaling TISA research through FANRPAN activities.	Scaling of TISA research through CAADP reporting (V3) activities is ongoing with the holding of regional online meetings with regional online meeting held. Additionally scaling of policy lessons and reform options through virtual dialogues has taken place. Activities are being planned for the scaling of climate change adaptation benefits (V4) to take place in the FY. See activity 3.1.
Number of instances where government institutions at the basin, provincial, national and/or regional scales adopt and mainstream interventions and policy lessons from the project.	The partnerships with national agencies in Mozambique and Zimbabwe, and two district governments in Tanzania have resulted in changes in policies and practices.
Number of project lessons for policy reform presented at the most relevant and influential multilateral forums for irrigation in Africa.	Project lessons have been presented to many audiences, including 65 meetings and conferences at both national and international levels, see section 3.4 and appendix 10.6.2 ‘Communication and dissemination activities.

What impacts has the project had or is it likely to have in the future?

The TISA project won the Gold Award in the Ecosystem Development category of the 2022 European Foundation for Management Development[2] (EFMD) Excellence in Practice Award. The award is recognition of the successful learning and development approach implemented through TISA’s two main interventions: AIPS and soil moisture monitoring tools.

Effective AIP leadership is crucial to ensure sustainability of AIP activities. Ideally, leadership should be a mix of farmers who are leaders in the scheme and farmers who are not leaders in the scheme. AIP leaders who are also scheme leaders are more active, and feedback and spread of learning was faster. The introduction of the tools and farmers field books has initiated a sustained process of farmer to farmer learning resulting in ongoing experimentation with frequency and duration of irrigation and the introduction of new crops and varieties. Over time the reliance on the tools decline as farmers gain confidence in their new irrigation management regime

TISA’s interventions show that small-scale irrigation policies and development projects should consider multi-stakeholder processes to support the introduction of new

[2] https://www.efmdglobal.org/awards/eip-excellence-in-practice-award/

technologies and, more broadly, find solutions to productivity and profitability constraints. These processes can improve farmers' livelihoods and effectively transform small-scale irrigation systems in the regions of eastern and southern Africa. Ensuring multi-stakeholder processes have a multi-generational focus will support intergenerational renewal and scheme sustainability.

TISA's scaling dimensions, strategies and mechanisms utilised to scale agricultural innovations were effective in five key areas i) expanding the geographical and institutional coverage of the innovations ii) embedding innovations into the culture of institutions and communities iii) changing policy, behaviour and practices iv) delivering impacts at the right scale v) contributing to the enhancement of irrigation development at different levels.

There is a need for a mix of scaling dimensions to scale innovations to the appropriate level and scaling strategies to allow those engaged in scaling endeavours to adapt the scaling process to align with specific contextual differences. Once the AIPs at small geopolitical scales are successful, then representatives from new areas can be invited to gain some experience prior to establishing the new AIP. Scaling AIPs at a greater geopolitical scale is costly but the benefits can outweigh the operational cost of the AIPs. However, AIPs extended to more than one district do not perform well due to long distances, greater operational costs, and different contexts (by-laws, production focus, stakeholders, and different approaches to address issues).

Scaling mechanisms facilitate the acquisition of information and evidence required to make decisions around adoption of innovations at different levels. During the TISA project, the agricultural innovations have contributed to increased adaptive capacity and resilience to shocks within the domains of field, household, community and markets. We also postulate that investing in a mix of hardware, software and orgware innovations and creating spaces for them to be embedded into institutions at different levels results in the scaling impacts being sustained with limited intervention from external entities.

Once institutional and technical interventions are successfully introduced in one location and farmers and stakeholders understand their benefits, it is possible to out-scale them with considerably less external input and at considerably lower cost. Learnings, and associated behavioural changes and improved outcomes, from the interventions takes place much faster when interventions are introduced by fellow farmers from schemes where the interventions have already successfully taken place. The rate of change is also accelerated by upscaling an AIP to the regional level where it can cover schemes facing similar production and market challenges. This allows the transfer of solutions to other schemes at a much faster pace and at much lower cost.

The changes reported provide evidence that participatory multi-stakeholder scheme planning processes combined with a technological intervention have had significant, direct equity impacts. Importantly, there were positive impacts beyond those most immediately included in the interventions. It is likely that TISA's stimulation of economic improvements has also stimulated equity changes, rather than vice versa.

Our research highlights the importance of intervening more broadly than the scheme. There are poor opportunities for young people limited land access. Households' livelihood strategies integrate irrigation, livestock, dryland and home agricultural production, as well

as non-farm activities. Hence, profitable and more sustainable irrigation schemes should function to stimulate the broader local economy around schemes.

What future actions might be required?

Governments and developmental partners need to invest in transforming dysfunctional irrigation schemes to achieve the CAADP/Malabo targets. Development should follow from evidence-based irrigation policies, to ensure smallholder schemes are profitable, equitable and self-sustaining. Possible policy actions include reforming land tenure, supporting farmer organisations, and developing market links for small holder farmer. For schemes to succeed, irrigation associations need to be autonomous and to have clear roles and responsibilities.

Policy approaches for small-scale irrigation schemes should incorporate multi-generational land access and scheme decision-making to support intergenerational renewal and scheme sustainability. Consideration could be given to setting aside areas for new entrant farming, including for small groups of young farmers. There is also a need to initiate dialogue with other relevant policy sectors to identify a pathway to address the complex and sensitive rural development question of how to support adequately and appropriately those who might wish to exit farming and relinquish their scheme plots (elderly farmers, for example).

The projects' researchers have recognised that there is an opportunity to work further with the schemes that have reached a certain stage of development, and to expand small-scale irrigation scheme interventions to include the broader local economy. Participatory planning and innovation forums with multi-stakeholder representation have proved valuable for scheme development. Extended representation and focus in these planning processes could be part of policies for problem solving and planning for a scheme and its surrounds. Strategic plans at this scale can be used to focus locally-appropriate investment and effort across other scales: ministries, policy and development agencies.

Conclusions

Irrigation schemes are complex systems, but many are stuck in dysfunctional states. The TISA project demonstrates that addressing the root causes through a range of co-designed interventions that tighten and increase connectivity within the constellation of actors, and improve the flow of information. By aligning objectives and strengthening incentive frameworks we generated feedback mechanisms that enhanced self-organization and increased efficiency. Highlights of our research conclude that:

- Engaging diverse actors in AIPs improves identifying problems, their root causes and the efficient design of social and institutional innovations.
- Technologies like Chameleons and Wetting Front Detectors facilitate local experimentation, individual learning by doing, and learning from others in structured and informal conversations. Most farmers reduced irrigation amounts and frequency through peer-to-peer learning.
- Farmers respond to incentives, and gross margin analysis prompted many farmers to change production enterprises, growing more lucrative crops.

- Government decision-makers also learned and changed scheme rules and policies as to when water is provided and what crops may be grown.
- More profitable and sustainable irrigation can significantly reduce inequity among farmers by improving the livelihoods of women, youth and the poorest.
- Scaling partners are crucial to make transformational change possible over large areas. Once the project (, for example, in Zimbabwe) illustrated proof of concept in one or two schemes, high-level decision-makers used this evidence to scale the process to many more schemes.

The TISA project demonstrates key options for the sustainable intensification of agriculture that the world needs to feed a growing population more sustainable and equitably.

2 Background

The nature of this final report

This final report is long befitting a decade long research for development project that sought to catalyse change in irrigated agriculture in three nations and across Southern Africa. In relevant sections there are contributions from each of the three country teams plus FANRPAN to ensure that there is an African 'voice from the field'. Most report sections conclude with a frank summary. Those who wish to see key, quantitative indicators of project performance should begin in the table in section 10.2. Most of this report constitutes a qualitative analysis of project performance and impacts. For more quantitative research outputs, readers are invited to access the large number of peer reviewed academic papers published from this project.

Background

Across Africa, governments and donors are investing in a massive expansion of irrigated agriculture, assuming that this will reduce poverty for smallholder farmers, stimulate the economy and increase food security. Yet existing smallholder irrigation schemes on the continent have largely failed to significantly reduce farmer poverty, use the land and water sustainably or maintain the irrigation infrastructure. There is a complex array of reasons for this, ranging from farmers' limited skills, and weak markets to dysfunctional institutions (Stirzaker and Pittock, 2014; Bjornlund et al., 2016). Stirzaker and Pittock, 2014; Bjornlund et al., 2016). Climate change is exacerbating the challenges for agriculture. On 23 September 2023, the Australian Minister for Foreign Affairs and Trade told the UN General Assembly that: "Already, African agricultural productivity has dropped by a third."[3]

Outputs from the TISA 1 research project (FSC/2013/006; 2013-2017) extensively reviewed previous irrigation research and development projects and was used to develop a theory of change for this TISA 2[4] research phase.

The TISA 1 research at six irrigation schemes provided simple tools for water management to farmers, to enable them to learn more efficient agronomic practices. It facilitated discussion among key stakeholders using the AIPs[5] process to identify barriers and opportunities, and to develop solutions for more profitable farming.

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[3] https://www.foreignminister.gov.au/minister/penny-wong/speech/national-statement-united-nations-general-assembly

[4] Both TISA and TISA 2 are used in this report referring to LWR/2016/137. TISA 2 is used when differentiating research activities from the previous project TISA 1 – FSC/2013/006

[5] An AIP, agricultural innovation platform, is a forum established to foster interaction among a group of relevant stakeholders around a shared agricultural interest. The stakeholders perform different but play complementary roles in the development, dissemination, and adoption of knowledge for socioeconomic benefit. AIPs seek to harness innovations related to technology processes, institutional and social-organisational arrangements. To promote these innovations, partnerships along and beyond agricultural value chains must be fostered to bring on board actors with a special mix of skills (Makini et al., 2013:2–3).

An independent review of TISA 1 (de Lange and Ogutu, 2016) found that, in its first three years, the project had significant success, giving farmers the knowledge and confidence to source better quality and cheaper farm inputs, reduce application of water, better use fertiliser, reduce labour and develop markets that are more profitable. This led to reduced conflicts over water, more effective local institutions[6] and improved management of the irrigation schemes. The TISA 2 project has built on this research base.

Project justification

African governments have ambitious plans to expand irrigated agriculture (Sullivan and Pittock, 2014). The sub-Saharan Africa region, through the African Union's Comprehensive Africa Agriculture Development Program, prioritises increased agricultural production by seeking an investment of 10% of national budgets to increase agricultural production by 6%, year on year. In 2015, the African Union Heads of State and Governments committed to ending hunger by 2025, including by facilitating irrigation.

Lower-cost interventions are essential to achieve some of the desired policy outcomes in irrigation given that expansionist infrastructure agendas are seriously limited by affordability. The budgets to rollout the proposed innovations for greater productivity of existing irrigation schemes explored in this research at a national scale are a fraction of new build projects, and therefore are more affordable in an African context.

The challenge that remains is how to turn concept and strategy into practical action. At the national level, several countries have developed policies and begun implementing better irrigation practices. Our research project has been demand-led from the government partner agencies in the participating countries, each of which has relevant strategies and priorities:

Mozambique – In this largely agriculture-based economy, improving irrigation is a national development priority as indicated in the following initiatives:

- Within the National Agriculture Investment Plan 2022–2030, rice irrigation development is one of four priorities. The country has three million hectares of potential irrigation land, of which 181,000 ha has irrigation infrastructure but just 90,000 ha is currently irrigated.
- The Investment Plan for the Agricultural Sector and National Irrigation Program includes 3-, 10- and 25-year plans for developing irrigation and linking to markets. The private sector is expected to be the major investor in irrigation.
- The PROIRRI Sustainable Irrigation Development Project supported by the World Bank focuses on research for better use of water. By understanding and providing water availability information in the development of 3,000 hectares of new irrigation schemes (and partnering with this project).

[6] Institutions are defined here as the formal rules (e.g., government regulations) and informal or customary rules (e.g., types or work performed by men versus women) within a society. Organizations such as government agencies or irrigators' associations may develop and implement many institutions.

- Agricultural development corridors have been designated across the country covering the Maputo, Limpopo, Beira, Zambezi Valley, Pemba-Lichinga and Nacala corridors. The aim is to transform subsistence farmers into smallholders supplying big food purchasers.

Tanzania – Irrigation development is seen as a key approach to achieving agricultural growth and food security. As such, it is part of several key strategies:

- The Agricultural Sector Development Programme (2015-25) is investing more than US $155 million to enable the country to attain one million hectares of irrigated land.
- The Southern Agriculture Growth Corridor public–private partnership to transform agriculture (irrigation schemes participating in the proposed research project are in the corridor) has partnerships with more than 50 suppliers, producers, processors/traders, and enablers, including Monsanto, DuPont, Syngenta, Unilever, General Mills and SAB Miller.

Zimbabwe – The key priorities for the government are food security and nutrition. Irrigation is addressed in two key policies:

- The Accelerated Irrigation Rehabilitation and Development Plan (2021-2025) (https://sdgs.un.org/partnerships/zimbabwe-accelerated-irrigation-rehabilitation-and-development) that seeks to develop the irrigation area to 400 000 hectares by 2025. The Plan includes rehabilitation and modernisation of 45 000 hectares of existing irrigation; development of 204 000 hectares of new irrigation infrastructure; and rehabilitation of 26 000 hectares of communal irrigation on 450 irrigation schemes.
- Within the Comprehensive Agriculture Policy Framework (2012–2032) and the Food and Nutrition Security Policy, the Ministry of Agriculture, Fisheries, Water and Rural Development has drafted an irrigation policy for consideration by parliament.

While the focus in this project has been on smallholder irrigation scheme which provided a practical organisational boundary for the research, AIPs were similarly organised involving independent irrigators on a locality basis. Independent irrigators have over the last decade gained increasing importance across Africa and internationally due to the combined area that they cover, their intrinsic business orientation, and their self-starting entrepreneurial character. This group encompasses a greater irrigated area than government schemes in countries like Ghana, Nigeria, and South Africa, among others. Thus, this research on public schemes is also relevant to a wider and increasingly important grouping comprising all smallholder irrigators.

Many bilateral, multilateral, and foundation donors are interested in supporting agricultural development such as irrigation in sub-Saharan Africa, including the World Bank Group, African Development Bank Group, International Fund for Agricultural Development, European Union, Islamic Development Bank, United States Agency for International Development and Gates Foundation. We assessed major irrigation project funders in

southern Africa and agreed to a partnership with the World Bank Group in Mozambique. We used the Food, Agriculture, Natural Resources and Policy Analysis Network's (FANRPAN) connections to engage the African Development Bank.

Research questions

The research questions flowing from the previous research and new objectives to learn about up and out scaling and equity within irrigation schemes were as follows:

a) **Irrigation innovation platforms**.

- How should innovation platforms be scaled up through formation and implementation at district level and through national innovation systems[7]
- What are the mechanisms by which the common solutions from an innovation platform at an irrigation scheme can be scaled out to include adjacent schemes?
- What are the indicators that can be used to determine when a new innovation platform is needed rather than expanding an existing one for low input spill over?
- What are the capacity requirements and needs for an AIP at different scales (scheme, district and national)?

b) **Technical interventions**.

- How can the data from simple tools across multiple irrigation schemes enhance farmer's learning, and enable prioritisation of government interventions and identification of better irrigation practices?
- How can the simple tools and internet platform be better used by farmers and enhance irrigation development programs of government and other development partners?

c) **Equity.**

- How can the AIPs and simple tools be used to identify and reduce inequity for women, youth and tail-end farmers while improving the profitability and sustainability of smallholder irrigation schemes?

d) **Policy**.

- What policy changes based on use of the AIPs and simple tools will improve the livelihoods of irrigators and help smallholder irrigation schemes become more profitable and self-sustaining and environmentally sustainable?

[7] National agricultural innovation system is the phrase used to describe the institutions that exist or can be established to enhance national policies, such as Zimbabwe's multi-stakeholder national Agriculture Working Group. These are not defined as innovation platforms because in most cases they are ongoing organisations.

e) COVID-19

- How did the capacities that irrigation communities built from the project enable them to adapt to shocks from the COVID-19 pandemic?

f) Climate smart

- How “climate smart” are the irrigation improvements (institutional, technical, and non-technical) promoted by the project research for the irrigation communities?

3 Objectives

The project aimed to improve farmer livelihoods, equity, and community management in smallholder irrigation schemes in southern Africa.
Consequently, the objectives were to:

1) Determine how the package of AIPs and simple tools for water and land management can best be scaled out and up;
2) Identify what institutions lead to inequity among farmers in water supply and financial benefit from irrigation schemes, and how this inequity can be reduced;
3) Develop irrigation policy options for governments and multilateral agencies so that smallholder schemes can be more profitable, equitable and self-sustaining.

Activities for each objective

Objective 1. Determine how the package of AIPs and simple tools for water and land management can best be scaled out and up.

- Activity 1.1: Scale up using district-scale AIPs.
- Activity 1.2: Sorting irrigation schemes within a district.
- Activity 1.3: Scale out by establishing new scheme–level AIPs in new localities.
- Activity 1.4: Scale out from existing scheme-level AIPs.
- Activity 1.5: Assess the effectiveness of and interactions between different methods of out scaling and up scaling as outlined in activities 1.1 and 1.4.
- Activity 1.6: Develop approaches to disseminate soil and water monitoring tools to farmers.
- Activity 1.7: Explore how to use large datasets of soil and water monitoring data to identify priority places for interventions and better agronomic practices to improve irrigation.
- Activity 1.8: Collaborative mapping of irrigation schemes.
- Activity 1.9: Engage major irrigation donors and other funders and stakeholders to accelerate innovation.

Objective 2. Identify what institutions lead to inequity among farmers in water supply and financial benefit from irrigation schemes, and how this inequity can be reduced?

- Activity 2.1: Assessment of and approaches to equity in water access by farmers, especially those at canal tail ends.
- Activity 2.2: Resources, livelihood, equity, and market data collection.
- Activity 2.3: Assessing equity between farmers within irrigation schemes and effects on scheme productivity and viability.
- Activity 2.4: Develop ‘How we’ guide.
- Activity 2.5 Research consolidation and COVID-19 analysis in extension phase
- Activity 2.6 To evaluate and extend climate change adaptation benefits.

Objective 3. Develop irrigation policy options for governments and multilateral agencies so that smallholder schemes can be more profitable, equitable and self-sustaining.

- Activity 3.1: Assess and document lessons and policy reform options from scheme- and district-level AIPs.
- Activity 3.2: Form or add to national-scale innovation systems.

4 Methodology

The research was conducted in Mozambique, Tanzania, and Zimbabwe. Each country has very different biophysical and socioeconomic characteristics. Within each, the focus was on the following areas, Maputo, Manica, and Gaza provinces (Mozambique), Iringa and Mbeya regions (Tanzania) and Midlands, Matabeleland North and South provinces (Zimbabwe). This considered biophysical variation in crops, soils, irrigation systems, water sources and availability. The research involved varied socio-economic settings and focused upon smallholder irrigation farmers drawing on surface water resources (groundwater use is very limited in these countries). The research activities aimed to ensure that the project did no harm and seized opportunities to positively transform the lives of women and men.

The project involved three cohorts of irrigation schemes to compare 'before, during and after' interventions, and among each other, to discern the efficacy of the simple tools and AIPs from this project, namely the:

a) Original six schemes intensively engaged since 2013;

b) An additional 35 schemes were engaged, less intensively through district AIPs, with new schemes engaged in 2017, 2018 and 2019; and

c) Schemes in the irrigation programs of partner international donors, who were little engaged by project researchers.

This overarching methodological approach enabled activities to test research questions.

Research strategy

In TISA 1 (FSC/2013/006), research was undertaken with intensive engagement of project staff, demonstrating the benefits of multiple interventions to strengthen farmer learning, problem-solving skills, and market development. In particular, the social and economic value of the AIP process, the use of simple tools, and scheme mapping was demonstrated at individual irrigation schemes (action categorised as "agriculture innovation delivery partnerships" by Dorai et al. (2015)).

In this TISA 2 project, we worked 'one step back', through farmer groups and district-scale agencies. It involved finding out how to achieve change from local to district and national scales, based on demonstrated models at individual irrigation schemes. The strategy for scaling up and out is shown in Figure 1 and elaborated in the text below.

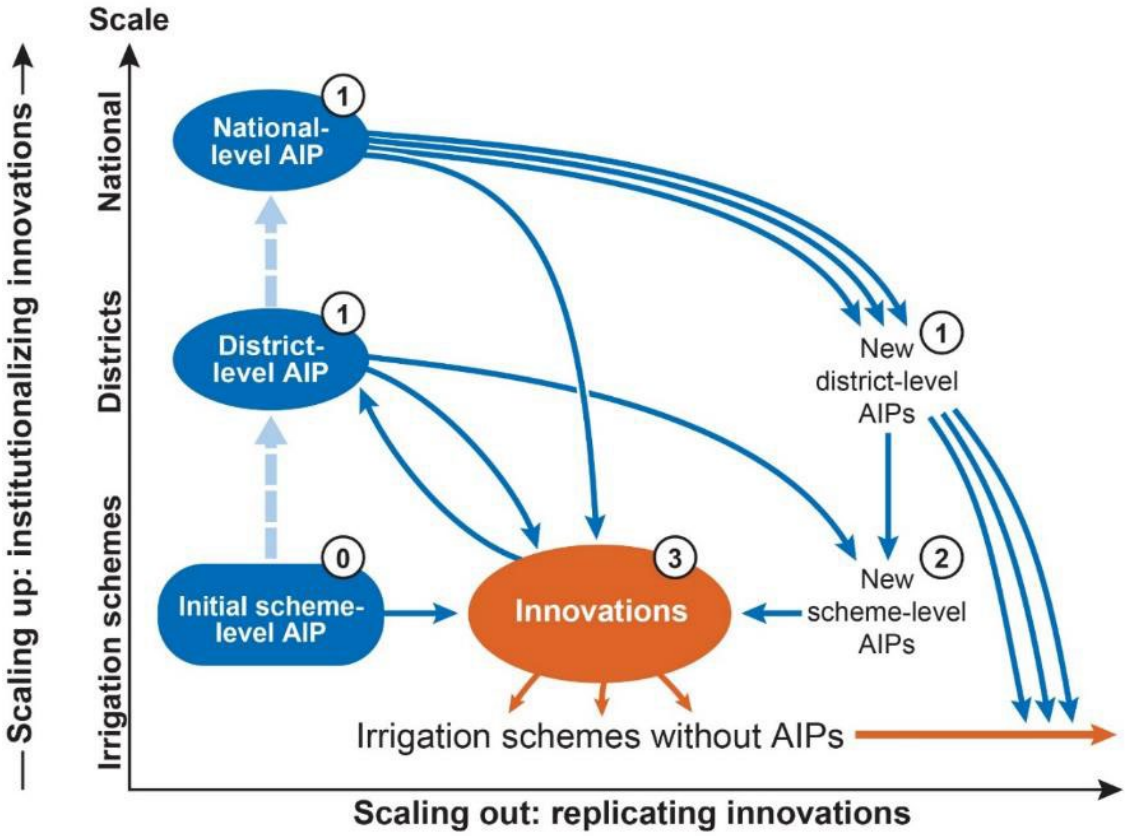


Figure 1: Strategy for scaling innovation up and out in the project, from irrigation scheme to national scales.

The project assessed the circumstances under which each of three scaling processes (#1–3, elaborated in the text below) is most effective in increasing impacts from agricultural innovation platforms (AIPs), based on the initial irrigation scheme AIPs from TISA 1 (process #0).

Scaling process 1. Scale up to enable innovation at greater geopolitical scales.

District-scale AIPs were established in twelve places (more than our target of five) and compared to identify the most effective combinations of participating stakeholders needed to foster innovation across smallholder irrigation schemes in each jurisdiction. By working at the district scale, a critical mass of knowledge, skills and experience was established; providing the capacity for ongoing improvement after the project ends.

National-scale innovation systems were engaged. Three national case studies were compared to identify different combinations of participating stakeholders and institutions that can foster innovation across smallholder irrigation schemes in each nation; in particular, how project innovations can be effectively transferred to new districts. This tested Dorai et al.'s (2015) "national agri-food systems innovative partnerships" where avenues for innovative farm practice to enable policy are proposed to positively impact on food systems to systemically address complex problems.

Scaling processes 2 & 3. Scale out to new irrigation schemes.

Led by ICRISAT and ANU, our African national research and government partners expanded project engagement from the current six irrigation schemes to a further 35 schemes (Table 3). In each of the first three years of the project, 10 to 12 more irrigation schemes were engaged in the project. By the fourth year this resulted in 41 schemes (more than our target of 38 schemes) at different stages of change, enabling lessons from earlier schemes to be transferred to later-starting schemes, and building self-reinforcing networks among farming, business and government stakeholders at the district scale.

Table 3: Irrigation schemes that were involved in the project.

Summary	Country	TISA 1	TISA 2	Total
Number of schemes	Mozambique	2	10	12
	Tanzania	2	8	10
	Zimbabwe	2	17	19
	Sub-total	6	35	41
Scheme size ha	Mozambique	56	1,077	1,133
	Tanzania	1,133	5,012	5,909
	Zimbabwe	58	669	789
	Sub-total	1,247	6,758	7,831
Number of farmers	Mozambique	65	985	1,072
	Tanzania	2,018	11,975	12,655
	Zimbabwe	287	1,560	1,872
	Sub-total	2,370	14,520	15,599

Two distinct processes for scaling out were compared, to identify cost-effective ways of promoting innovation. First, where new irrigation schemes have different issues that that require different stakeholders to progress, we assessed how new AIPs can be established most effectively (Figure 1, process #2). Second, from existing schemes, we assessed the efficacy of extending the innovation solutions to other irrigation schemes in geographic proximity that have similar challenges (e.g., accessing certified farm inputs at a reasonable price) (Figure 1, process #3). Our hypothesis is that extending innovations from existing AIPs would achieve impact with lower investment required compared to establishing new AIPs. Consequently, a key research question is what are the conditions under which a new AIP is required as opposed to extending innovations from existing AIPs for low input spill over?

More effective use of technical interventions

The research further examined how technical interventions used in TISA 1 could accelerate the uptake of innovations by farmers and government agencies. How can the aggregated data be better used by irrigator's associations and government agencies to improve irrigation scheme performance? Distribution by CSIRO of the simple tools via our African partners were to be expanded to reach more farmers, and a more self-supporting business model was established. Through the district-scale AIPs, we worked with farmers and government partners to use the aggregated data to identify under- and well-performing irrigation plots and schemes, to identify priority places for intervention and how to enhance agronomic practices to maximise crop yields.

The farm plot mapping technique developed at two irrigation schemes in TISA 1 by Ardhi University in Tanzania was refined and extended to other schemes. The effects of this mapping and sharing of farm boundaries on reducing conflicts among farmers, improving fee collection, strengthening irrigators' associations, and enhancing governance were assessed. Ardhi University staff worked with our partners in Mozambique and Zimbabwe to transfer the skills required.

Objective 1 – Determine how the package of AIPs and simple tools for water and land management can best be scaled out and up.

Activity 1.1: Scale up using district-scale AIPs.

District-scale AIPs were established in twelve (initial target five) districts (see Appendix 10.7) as a first step in scaling up (Figure 1, process #1). These are Boane, Magude, Moama and Manica districts in Mozambique, Iringa – rice, Iringa – vegetables, and Mbarali districts in Tanzania and Insiza/Filabusi, Lupane, Bingam Bubi, and Hwange districts in Zimbabwe.

The district AIPs were to be formed by drawing on the KARI-ACIAR innovation platforms manual (Makini et al., 2013) and revised methods from TISA 1 (van Rooyen et al., 2017). The initial "How we" guide from TISA 1 was used and tested with the new district AIPs. In the first year we identified the key district stakeholders (starting with our government partners) influencing irrigation and invite them to an initial AIP meeting for a visioning exercise and identification of key barriers and opportunities for enhanced irrigation. Other key value chain stakeholders who were engaged included businesses such as input suppliers or markets for the crops, to promote mutually beneficial market-oriented partnerships with the farmers. These included Cheetah Developments in Tanzania and the Bulawayo Projects Centre in Zimbabwe.

These case studies were compared to draw lessons for successful district-scale AIPs. Data was collected through researcher observation of institutions, annual AIP reports and focal group discussions. Following Swaans et al. (2013) data was collected and analysed on the innovation platform processes (establishment, functioning and maintenance), outputs (products/deliverables generated) and outcomes (knowledge and behavioural changes of platform members). The development of markets beyond the AIP members were monitored by partner companies using data on sales of agricultural inputs and outputs, and on the development of further processing of agricultural products. Progress was judged against three key indicators of self-sufficiency and growth in the agricultural economy, namely: a) district participants developing a working plan that prioritises interventions, b) AIP members appropriately engaging irrigations schemes to take up innovations independently of the project researchers, and c) input and output markets increasing interaction with the targeted irrigation schemes. Comparing the indicators for the district AIPs enabled deeper analysis of the institutional factors that aid successful scaling up.

Activity 1.2: Sorting irrigation schemes within a district.

Each of the 35 new irrigation schemes in the districts were analysed to identify whether they could engage via the six existing scheme-level AIPs or if a new local AIP was

required. We selected a minimum of 32 new irrigation schemes as an ambitious target (more than five-fold increase in schemes compared to the earlier project) to test the conditions under which scaling innovations out and up may occur (but subsequently engaged 35 new schemes). This number of schemes is beyond the capacities of project researchers to directly service and so required the project team to engage the district scale organisations to undertake the necessary extension activities for innovation. Through each district scale AIP, irrigation schemes in that district were assessed to compare the commodities grown and the input and output markets to assess whether the key non-farmer stakeholders are the same or differed from those for an existing AIP.

The irrigation schemes were then divided into two main categories. First were those schemes who have similar agricultural systems, markets, and stakeholders as those in existing scheme-level AIPs, where the same stakeholders can be engaged to extend to these additional places and provide similar solutions to problems as already used in the existing AIP (Activity 1.4 below). The second category were those schemes where there are different agricultural systems, markets, and stakeholders, where new stakeholders need to be engaged to develop solutions to problems through a new scheme level AIP (Activity 1.3 below). We hypothesized that more schemes would be similar (Figure 1, process #3) and that fewer would be significantly different and require new AIPs (Figure 1, process #2).

The key research questions were a) whether this approach to categorise schemes for different levels of engagement works, and b) whether schemes were consistently correctly categorised. This was assessed by collecting data through observation of institutions, annual AIP reports and focal group discussions in irrigation schemes. The key indicators that this categorisation approach worked with came from evidence of innovations being adopted in the schemes, of strengthening of irrigators associations and of changes in the input and output markets. The number of irrigation schemes where less or no change is evident indicated the extent to which there are problems with the approach versus categorisation of individual schemes. The institutional factors supporting or hindering change may then be assessed. This was documented in the Activity 2.4 “How we” guide.

As with other data collection for research in objective 1, senior project research staff constantly questioned and tested information recorded to seek: i) recording of the same events in the same way by government, NGO, farmer, and business participants, and ii) collecting contextual data, particularly given the diversity of scheme histories, agricultural practices, irrigation technologies and condition. This was essential to ensure that generalisations beyond the study schemes could be drawn.

Activity 1.3: Scale out by establishing new scheme–level AIPs in new localities.

Where there were, significantly different agricultural and market systems involving different stakeholders to existing AIPs (Figure 1, process #2) new AIPs were formed. These were based on the KARI-ACIAR innovation platforms manual (Makini et al., 2013) as revised in TISA 1 (van Rooyen et al., 2017). In years 1 to 3, we worked with the district-scale AIPs to identify and train AIP champions and facilitators needed to establish new AIPs in those schemes where this is required, as well as key farmers and extension offices on use of the simple tools (activity 1.6). For these schemes, the key stakeholders

influencing each scheme were identified. We invited them to initial AIP meetings for a visioning exercise and to identify key barriers and opportunities for enhanced irrigation.

Annual AIP reports included data from the simple tool use and farmer workbooks, records from extension staff as well as agricultural input suppliers and output businesses, observation of innovations adopted, institutional changes, and focal group discussions in irrigation schemes. Key research questions included: a) Where was it, if possible, to establish effective scheme AIPs with fewer resources than other schemes, and why? b) Do some AIPs perform better than others, or where is there scale out from existing scheme AIPs, and if so, why?

Activity 1.4: **Scale out from existing scheme-level AIPs.**

Where irrigation schemes in Activity 1.2 are categorised as having similar agricultural and market systems involving the same stakeholders to existing AIPs (Figure 1, process #3) then the six currently functioning AIPs were used to research out scaling to them. Different approaches to this out scaling were tried to test the most effective combination of actors (e.g., leading farmers, businesses, government agencies) as well as the key factors (e.g., social institutions, distance, communication mechanisms) for extending the AIPs.

The process of out scaling was monitored using simple tool use and farmer workbooks, records from extension staff as well as agricultural input suppliers and output businesses, observation of innovations adopted, institutional changes, and focal group discussions in irrigation schemes (see 2.3) to determine the effectiveness of this process and the key success factors in out scaling innovations from existing AIPs. The original AIP scheme and new schemes were monitored to see if and why the new schemes benefit in the same way or differently to the original scheme.

Activity 1.5: **Assess the effectiveness of and interactions between different methods of out scaling and up scaling as outlined in activities 1.1 and 1.4**.

With local officials, from among the 35 new irrigation schemes and the twelve district level AIPs (Table 3) we compared the differences between the different approaches and the interactions between them (Figure 1, processes #1-3). We determined the outcomes from the different approaches and the costs of the different approaches.

Qualitative social analysis (Ritchie and Lewis 2003) was used to collect data as described in activities 1.1 – 1.4 and 2.3. The data was analysed as described in activity 2.4.

Cost–benefit and gross margin analyses (following Mupaso et al., 2014) were used to assess the extent to which the expansion of AIPs or extension of AIP solutions, and the use of water monitoring tools (Activity 1.6), improves the financial performance of irrigation schemes and household livelihoods and agricultural markets.

Economic cost benefit analyses were undertaken for the different AIP approaches to compare the cost of introducing AIPs and tools versus the benefits.

We also assessed the relative contributions of the four proposed impact pathways for agricultural research for development: (1) market linkages, (2) social capital, (3) institutional changes or (4) innovation capacity (Maru et al., 2018).

Activity 1.6: **Develop approaches to disseminate soil and water monitoring tools to farmers**.

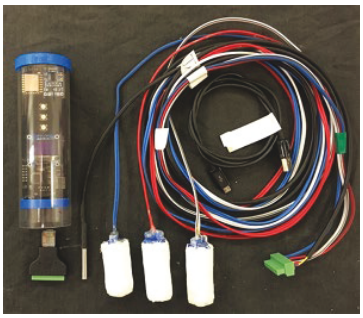
This work was conducted in partnership with Virtual Irrigation Academy (LWR/2014/085) which is developing the business supply chain for the tools. Two approaches were undertaken in this project. The first studied the value proposition of the tools to the individual farmer and mechanisms to make them affordable. We deliberately budgeted only enough funds for 800 sets of tools. Thus, the research approaches to co-payments by farmers and scheme level irrigation associations to access tools, which was essential for developing a business model to sustain these interventions post-project. We worked with district AIP partners to ensure that they have the capacity to train farmers on use of the simple tools in the new irrigation schemes. We explored ways in which leading farmers from the six existing AIPs could be supported to travel to the new irrigation schemes to assist farmers there to use the tools.

The second approach was to secure investment from major stakeholders to deploy the simple tools. A co-investment prospectus was to be developed for the partners who will be needed to take the tools to scale, including government agencies, the private sector and non-government organisations (NGOs). This was to detail both private and public benefits to justify why certain aspects require investment or subsidy. We were then to develop co-investment partnerships to enable the provision of tools and the associated learning environment to 1,700 farmers. In each country we believed that there were reasons why major government organisations and businesses would subsidize deployment of simple tools by farmers to use water more productively, including to improve sustainability of investments in new irrigation schemers by multi-lateral donors (Mozambique), enhance water supplies for hydropower generation (Tanzania) and for downstream mining (Zimbabwe). Using these two approaches, we expected to build the business cases for affordable commercial access to the simple tools.

Simple tools (see table 4) were used for water and soil monitoring based on the methods developed in TISA 1 (Stirzaker et al., 2017). Co-production of knowledge by farmers, extension staff and researchers were used to understand how well the tools and learning system work and how we can measure changes in knowledge (Armitage et al., 2011).

Experiential learning was documented based on feedback received from peer observations, focal group discussions and farmer workbooks (that are needed to supplement the automatic data collection with additional information, such as on rainfall and crop yields) (Garvin 1993; Kolb 2014). We then sought to understand how best to translate knowledge from experiential learning using the tools into action (Cash et al., 2003), and the value of the tools as boundary objects (Clark et al., 2016).

Table 4: Soil monitoring tools used in the learning systems.

	The Chameleon reader shows the water stress that plants are experiencing at four depths in the soil. The data are displayed as coloured lights (blue = wet, green = moist and red = dry). The Chameleon helps farmers to see how deep roots are extracting water, how deep irrigation water penetrates, and the optimal time and duration of irrigation. The reader is Wi-Fi enabled and can hotspot off a phone and deliver the data to the website using the unique ID chip in every sensor array. The data is then collated and displayed in real time to give the 'Chameleon water pattern'. Phone apps are used to collect, store, display and share data so participants can learn together in real time. The Chameleon is an ACIAR-funded tool in early rollout and is being tested in farmer fields. It is available on https://viashop.csiro.au/
	The FullStop Wetting Front Detector is buried in the soil and pops up an indicator when it captures a sample of infiltrating water from irrigation inside the funnel. This water can then be extracted for measurement of salt and nitrate. The FullStop Wetting Front Detector is a CSIRO-developed tool that is commercially available.
	Nitrate colour test strips are used to show farmers the nitrogen status of their soil and help minimise leaching of expensive nutrients. These are commercially available.

The Chameleon simplifies complex soil water content data to patterns, so a range of participants can quickly assimilate a large amount of information. Figure 2 gives the example below) from a maize crop in Tanzania.

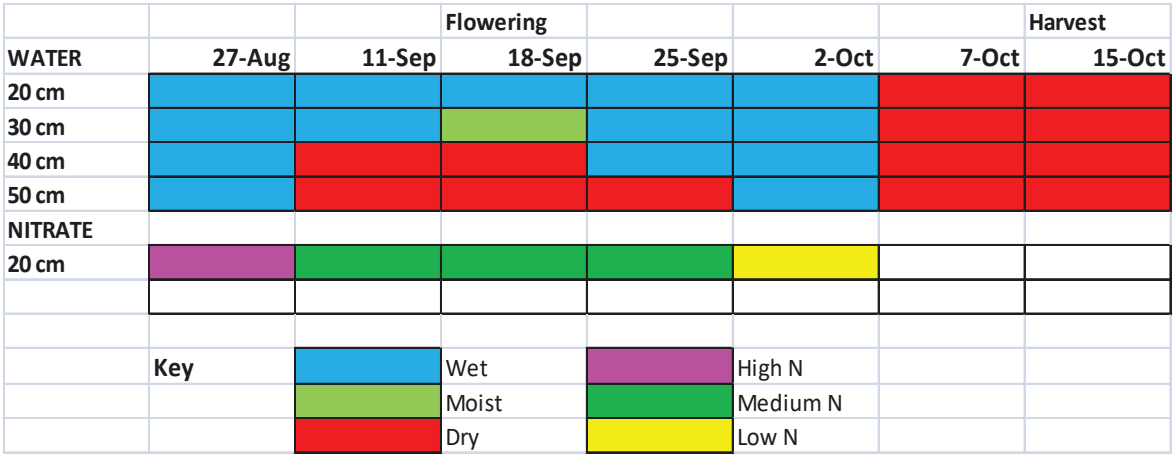


Figure 2: An example of colour patterns from the Chameleon and nitrate from a Wetting Front Detectors.

Since the 2019 mid-term review, the roles of the LWR/2016/137 and WAC/2018/162 Virtual Irrigation Academy projects have been redefined, but the outputs remain unchanged. For the extension phase CSIRO choose to opt out of active engagement in TISA project activities, but continued to provide support through VIA workshops, tools, and website; and the LWR/2016/137 team partners continued to upload data to the VIA website. The VIA project became the lead for several activities originally envisaged as being undertaken in TISA 2.

Activity 1.7: **Explore how to use large datasets of soil and water monitoring data to identify priority places for interventions and better agronomic practices to improve irrigation.**

Field data on moisture patterns, fertility and yield was to be collected and aggregated through the Virtual Irrigation Academy (LWR/2014/085) website as well as farmer workbooks maintained by farmers having the simple tools.

Data was to be used to estimate key factors such as water consumption, water use efficiency and yields at scheme scale and within parts of schemes (spatial variability). This was then to be used in combination with data from farmer workbooks on yields and other factors to identify better agronomic practices within and across schemes.

Researchers worked with district-scale AIPs, water managers, extension officers and irrigator associations to assess how data on soil fertility, water use and crop yields can be used to help prioritise strategic interventions to enhance irrigation productivity across schemes in a district. At one level, this was documented in the Activity 2.4 “How we” guide.

In practice, this activity proved to be unrealistic for several reasons. Farmers were only motivated to apply the immediately available data (e.g., colours indicating soil moisture levels) rather than also supply additional data to enable and use the more elaborate secondary analyses. The complexity of the actions needed to upload data to the cloud and then receive analyses back mitigated against these more sophisticated secondary analyses. Limited access to smart phones in many communities was also a factor. Further, over time, we found that farmers who significantly changed their agronomic practices based on primary tool data then used the tools less and less frequently over time.

Activity 1.8: **Collaborative mapping of irrigation schemes**.

The boundaries of individual plots, with sizes, name of plot holder and mobile phone number, were mapped at each irrigation scheme. Mapping used the participatory process developed in project FSC/2003/006, was undertaken in the field with farmers and irrigation agencies. The boundaries were drawn by agreement between neighbouring farmers. Where desired by farmers, government officials were invited to the scheme to issue land occupancy certificates and identity documents.

The use of the maps was explained to and discussed with irrigation associations to enhance their management activities. Data was collected on resulting changes to farmers,

scheme, and institutions from mapping, including issuance of occupancy certificates, farmer's access to finance, as well as fee collection by irrigation associations.

A land use element was explored in each country to promote secure, short-term, local leasing of unused plots by non-farming plot holders. Locally developed pro-forma lease agreements were signed by the farmers, the irrigation scheme committee, traditional authority (if appropriate) and appropriate government representatives. The contractual binding power comes from social sanction, rather than the courts. This can have a catalytic effect in promotion of a business farming orientation as it facilitates increased farm sizes, with positive implications for economy of scale and enables a move from part-time to full time farming.

Mapping also sought to raise issues of equity in terms of whether women cultivators or men are recognised as title holders, or if there is joint titling.

Activity 1.9: **Engage major irrigation donors and other funders and stakeholders to accelerate innovation.**

This activity aimed to engage donors in discussion about investment in irrigation institutions and capacity building to improve the returns on infrastructure investment and increase the sustainability of irrigation projects. It was also about engaging with water, energy and mining companies in Tanzania and Zimbabwe who wish to access more water from river systems where there is major irrigation usage. In these situations, there is the potential for farmers to gain financial or other benefits from engaging in water marketing with these entities.

Major funders were identified through a grey literature review of irrigation investment in Africa. Possible partners were selected through a process of defining key attributes that may make them receptive to investing in capacity building around irrigation.

The shortlisted funders were approached individually to discuss the training/capacity building component of their programs and the project experiences of AIPs and simple tools and their benefits in irrigation. The project was then to pilot the AIPs and tools jointly with amenable donors.

Discussions were to be held with private water management, mining, and energy companies regarding opportunities for water trading with irrigation schemes via investment in irrigation schemes for increased efficiency and/or establishing water markets.

Joint evaluation of irrigation scheme performance with and without the project approaches was to be used to engage donors in a dialogue on their wider adoption of project interventions.

Objective 2 – Identify what institutions lead to inequity among farmers in water supply and financial benefit from irrigation schemes, and how this inequity can be reduced?

Activity 2.1: **Assessment of and approaches to equity in water access by farmers, especially those at canal tail-ends.**

TISA 1 found that on average, around a quarter of plots at the tail end of canals were not receiving water reliably enough to irrigate. The plot holders were trapped in poverty and forced to work as labourers for farmers who could access water adequately (Manero 2016). Experiences from TISA 1 were that provision of soil and water monitoring tools (Activity 1.6), and infrastructure improvement provides a 'circuit breaker' in reducing demand at the head end and improving supply to the tail end plot holders.

Discussions were held with farmers, water user associations, water agencies and other stakeholders regarding the distribution of water in each scheme and analyse how equitable it is and the effects upon those who receive the least. The use of the soil and water monitoring tools (Activity 1.6) were discussed as an approach to understanding this issue of inequitable water distribution and as an approach to making the problem more visible and quantifiable.

Scheme irrigation associations were supported to agree on new water sharing rules to codify reliable water supply to all plots and especially those at the tail end of canals. Examples of water scheduling systems from successful schemes were shared with new irrigation associations.

Data was collected on the spatial variability of water supply over time, individual farmer incomes, payment of water fees, functioning of water user associations, irrigation system maintenance and social harmony. The data was to be analysed for changes in water availability and use and changes in equity; also, if and how improving reliability of water supply to plots at the tail end of canals enhances the functions of irrigation institutions, for instance, through increasing water fees paid to irrigation associations.

Activity 2.2: **Resources, livelihood, equity, and market data collection.**

Data was collected at each of the 41 schemes before, during and after research engagement to enable assessment of changes in resource use, livelihoods, equity, and local markets as a result of the project's interventions. For each other activity, in this section the data to be collected and the method for analysis is stated. Here, that data collection is repeated together as a whole, to state in one place how the different data elements were collected for analysis.

As data collection is very expensive and many irrigation schemes were involved in the project, a strategic approach was taken focussing on the key qualitative and quantitative data needed to identify any perverse impacts, further opportunities, positive changes and resulting research findings. The indicators chosen were revised based on the results from quantitative surveys from TISA 1.

The TISA 1 survey identified a standard set of around 20 of the most informative indicators of the state of resource use, livelihoods, and agricultural productivity. These indicators were winnowed down through analysis of the 2017 survey. The survey of these six irrigation schemes was undertaken in 2021-22 to provide eight years of quantitative, time-series data for in depth analysis. This extensive, quantitative data on the six schemes was used to validate and interpret the more limited quantitative and qualitative data collected on the new irrigation schemes.

In going back to these six original irrigation schemes to validate the survey results in late 2017, we invited farmer representatives from new schemes to attend. For the new schemes, we discussed with the farmer representatives whether they perceived similar or different circumstances in their communities. Meetings were then held with the farmers in each of the new irrigation schemes to discuss a) the desired future state for their irrigation community, b) whether the issues identified in the original schemes were valid or different, and c) what indicators might be used to measure progress towards their desired state. Data was collected on the standard set of indicators supplemented by additional locally specific indicators. Data was collected on gender, age, and location on the canals on adoption of technologies and participation in decision making to assess equity.

Data on the indicators for the new schemes was collected before, during and after research engagement in a range of ways intended to facilitate insights at minimum cost. Meetings with the farming community and government agencies were used to collect some basic data on aspects such as demographics. Community members were asked to collect some basic data, for example, on the gross margin analyses that they undertake as part of project activities. Farmers using new generation simple tools were uploading some soil, water, and crop data automatically to the VIA website https://via.farm/. The farmer workbooks used in TISA 1 were provided to farmers to manually collect additional data on rainfall, watering frequency, crop yields and other pertinent data needed for the key indices. This data collection was linked to the irrigation scheme map (Activity 1.8). Research staff recorded observations of innovations adopted and institutional changes on irrigation schemes. Focus groups were held with farmers before and after each cropping season to track progress (Ritchie and Lewis 2003). These were recorded and transcribed for qualitative analysis. Local government partner extension officers were asked to collect some data. We shall also seek data from input suppliers and output markets to assess changes in agronomic practices, crops grown prices paid and productivity.

Data at the new schemes was collected at two scales, at the scheme scale and at the household scale. The research on livelihoods and equity was based on the livelihood's framework of Ellis (2000) that focusses at the household scale on assets, mediating processes, and activities. Sampling methods included focus groups with women and men, and targeted household surveys. The sample sizes, approach, and level of detail in the livelihoods data collection were developed following review of the March – April 2017 end of project survey for TISA 1, which were used to focus research and indicators used in this new project.

This data was used to assess the efficacy of scaling AIP innovations up and out in Activities 1.1 to 1.5, and 1.9, the impacts of adoption of technologies in Activities 1.6 to 1.8 and impacts on equity in Activity 2.4.

***Activity 2.3*: Assessing equity between farmers within irrigation schemes and effects on scheme productivity and viability.**

This activity was to identify and better understand the institutions and any other key factors that create gender, age or other inequity related to irrigation productivity and income generation, such as access to new technology, water distribution and participation in decision making at household and scheme scales and the effects different levels of inequity have on scheme productivity and viability.

A range of data, qualitative and quantitative (as described above) were used to understand the extent of inequity within the schemes and the factors associated with it, building on the research in TISA 1 by Manero (2016). The analysis focused on access to natural resources, economic wellbeing, agency in decision-making and the role of social capital in promoting equity (Quisimbing, 2010 and Doss and Meinzen-Dick, 2015). Building on work in TISA 1, three groups of potentially disadvantaged people were the focus of this research, namely women, youth, and plot holders on the tail end of canals. Demographic, plot holding, access to technology and participation in decision-making data was collected for each scheme for these groups.

These results were then discussed in relevant AIPs and irrigator associations to enable them to identify options to improve equity. We shall track changes over the course of the project. The effects of change in equity within a scheme were analysed regarding the benefits or otherwise to all farmers of changes to equity, benefits or otherwise at a scheme level of changes in equity on scheme viability and productivity for instance better infrastructure maintenance and water user association functioning and whether there were any changes in social harmony.

***Activity 2.4:* Develop 'How we' guide.**

An output that started development in TISA I was the 'how we' guide of knowledge for better irrigation scheme management generated through the interventions at six schemes. The guide provided practical advice to farming leaders, community organizations and government officers on interventions for sustainable and profitable irrigation. It was used to assist facilitators on how to ensure equitable gender and age distribution, and how to engage women and the young in the AIP process. It also helped ensure that public investments in repairing existing smallholder irrigation schemes or building new projects were not wasted.

Working with key stakeholders including farmers, businesses and extension staff, this guide was tested in this project. The guide was translated into at least two key languages, Swahili and Portuguese.

***Activity 2.5* Research consolidation and COVID-19 analysis in extension phase**

LWR/2016/137 involved a challenging research transition from intensive interventions at irrigation schemes to more institutionally complex work at district, provincial and national governance scales. We ended up being a year behind with data collection due to slow delivery of tools, droughts and floods, and the impact of the COVID 19. During the extension was proposed to enable completion of data collection, analysis and publication,

the transfer of this research into development projects as well as the development of a research proposal. Six research outputs were planned, namely assessment of: i) methods for out-scaling adoption; ii) socio-economic change resulting from project interventions; iii) changes to the economics of operations and maintenance of the irrigation infrastructure; iv) methods of participatory mapping and resulting benefits; v) irrigation community adaptation to the COVID19 shocks; and vi) undertaking a scoping study to develop a research proposal that would assess how farming systems for small scale farmers and their communities could be transformed into more inclusive (integration, productive, secure and nutritious) circular food systems, leaving more value and jobs in local communities for improved food security, nutrition, health and education in sub-Saharan Africa.

Activity 2.6. To evaluate and extend climate change adaptation benefits.

Building on previous TISA project work and data, this research was conducted in existing TISA irrigation schemes in Tanzania, Mozambique and Zimbabwe.

The three target nations have between 63% and 68% of their populations living in rural areas, the majority of which live in poverty. Further, the three countries are subject to high rainfall stochasticity that is anticipated to be exacerbated by climate change.

This research involved:

1) Assessing water savings and climate smartness through modelling.

A modelling approach was developed (led by ICRISAT) to measure and test climate smartness (i.e., increased productivity, enhanced resilience, and reduced GHG emissions) of the project activities achieved by the TISA two-pronged approach of monitoring tools and AIPs, particularly the quantification of the (i) reductions in water use, (ii) reductions in the amount of nutrients leached and (iii) associated mechanism of increased yields. It also supported modelling farmers changing behaviour driven by improved understanding of water and nutrients dynamics and improved market and knowledge linkages. Data was already available, collected during the lifetime of the research and was used to develop and calibrate the model(s). Some of the data had been collected under different climatic conditions, so were able to examine to what extent good yields (income & livelihoods) could be maintained with reduced rainfall. To be able to develop and test robust models, some new data was collected.

Two main levels of modelling were developed, one at plot level to evaluate plot level water savings and nutrient dynamics, and the other at landscape level, evaluating the landscape or sub-catchment scale dynamics and impacts. The Agricultural Production Systems sIMulator (APSIM) linked with existing regional climate model (RCMs) was used.

Results from the modelling (currently being written up for publication) show that the use of soil monitoring tools leads to improved water productivity (WP) of irrigated agriculture, which is critical to improve water management under climate variability and predicted climate change. Improvement of crop production, alongside a reduction in total irrigation water applied, means that irrigators have greater adaptive capacity to future water shortages. The modelling results show that production losses will be lower as climate

change makes water availability more volatile. Improved WP is critical by enhancing the adaptive capacity of irrigation systems, helping the process of transitioning existing unproductive systems to more productive systems, which in turn could justify investments in increasing the area under irrigation.

The water productivity benefits of the TISA interventions have been independently confirmed through GIS research that shows that under the right circumstances it is possible to produce more crops with less water (Wellington et al. 2023).

2) Assessing climate smart irrigation efficiency through case studies and analysis.

To assess further climate smart irrigation resulting from TISA activities, case studies were conducted. These studies and existing TISA evidence were then analysed and linked to food systems. The following case studies were undertaken:

- Case studies with schemes who have extended food production with limited water supplies (in drought): Mkoba, Tshongokwe and 25 de Setembro.
- Case studies with schemes who have increased command areas, including at Kiwere and Magozi.
- Case studies with schemes along rivers with upstream-downstream interactions between schemes (Kiwere & Magozi), and schemes from dedicated reservoirs, namely Silalatshani and Tshongokwe.
- Case studies extrapolated to provincial and national irrigation systems.

The case studies were assessed in the context of the ‘irrigation efficiency matrix’ (IEM) which is a conceptual framework that maps and contains irrigation efficiency as a technically and hydro-socially mediated performance measure and boundary object (Lankford et al., 2020). The framework includes:

- Five scales from local to national: sub-field, field; farm and tertiary irrigation unit; irrigation system; basin, aquifer, multiple irrigation systems; and global, national, sectors and firms.
- Ten discursive dimensions: goals; people; time; motives; science; losses; allocation; technology; context; and research.

These dimensions ‘underpin agricultural production, water control, management, consumption, and allocation, that link through to global water and food challenges including the UN’s Sustainable Development Goals’ (Lankford et al., 2020). The IEM is outlined in Figure 3. Using the framework will likely have implications for the study countries regarding the debate over irrigation efficiency investments.

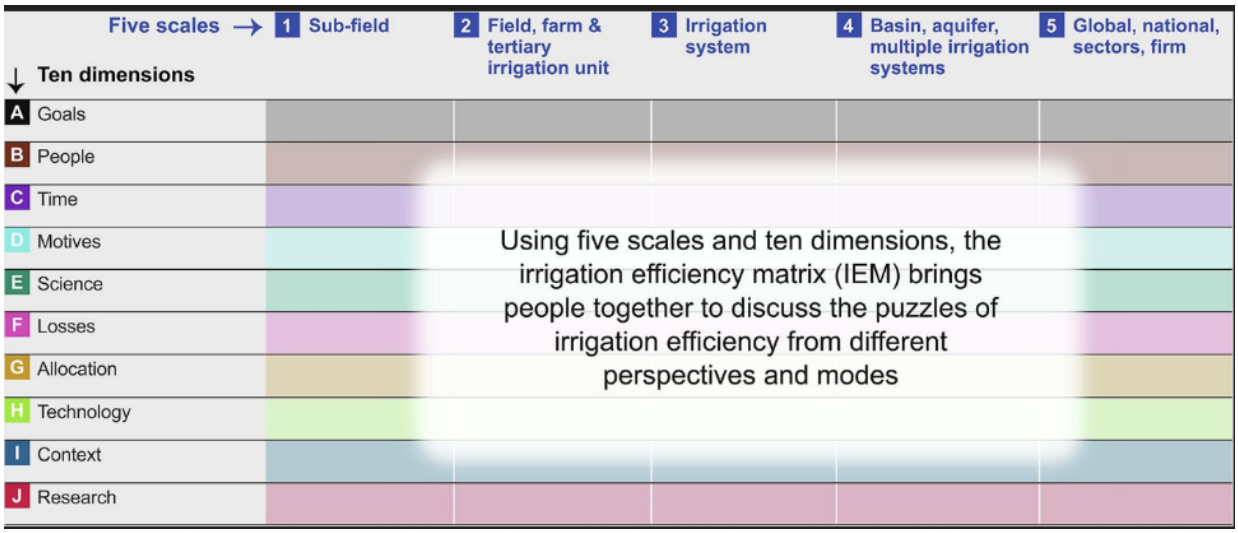


Figure 3: Irrigation efficiency matrix from Lankford et al., 2020

Objective 3 – Develop irrigation policy options for governments and multilateral agencies so that smallholder schemes can be more profitable, equitable and self-sustaining.

***Activity 3.1:* Assess and document lessons and policy reform options from scheme- and district-level AIPs.**

This activity was to synthesise, document and communicate lessons and policy reform options from this research for national and multi-national governance institutions. The policy lessons and reform options will be developed applying the 'three lenses' of evidence-based policy (science, practice and political feasibility) (Head, 2008) and comparative public policy analysis (Rose, 2005). We drew on recent research in this field to elaborate on the insights that may be added from this project for sustainable intensification and research for agricultural development in an irrigation sector context. The lessons and reforms were documented in policy briefs and through academic publications (see section 4.1 below). Often the 'reform' required is more effective implementation of existing national policies at sub-national scales. Several key national reforms have been suggested from the earlier project by Mwamakamba et al. (2017).

The FANRPAN team drew on TISA/VIA research findings to inform the Comprehensive Africa Agriculture Development Programme (CAADP) reporting formats at relevant levels. During the extension period, the focus was on disseminating evidence generated and recommended policy options and mobilizing resources towards scaling-out and -up of TISA interventions in the respective project countries as well as the Southern African Development Community (SADC) region and the continent.

Promoting climate smart irrigation agriculture in the region

FANRPAN organised a regional climate smart agriculture dialogue for Southern Africa in March 2023 at the University of Pretoria. The dialogue engaged other regional water management organisations such as International Water Resources Association (IWRA) and the International Water Management Institute (IWMI). TISA research findings were

presented to key stakeholders in Southern Africa, the FANRPAN regional network and other international stakeholders, including at the November 2022 UN Framework Convention on Climate Change Conference of Parties.

Activity 3.2: **Form or add to national-scale innovation systems.**

Based on key government agencies to enhance national policies and programs. We communicated lessons and desired policy reforms from scheme- and district-level AIPs into national innovation systems.

National innovation systems were engaged in Mozambique and Zimbabwe in order to share findings from the project's research and explore opportunities for wider adoption by government and other organisations. We promoted adoption of project findings to members of the multi-stakeholder Agricultural Working Group in Zimbabwe. In Mozambique we worked with our partner, the National Institute for Irrigation, to use project research findings to inform implementation of the National Irrigation Program. In Tanzania, a symposium in July 2017 with the National Irrigation Commission in Tanzania was undertaken to assist this agency to achieve its objectives through evidence-based policy.

Organisations involved.

In Australia,

- The Australian National University (ANU) led the research work in the areas of effective water governance institutions, understanding the value of water and trade-offs across water users, between water users and the environment, innovation platforms and policy.
- CSIRO Land and Water led the biophysical agriculture and water productivity and learning components of this project. They decided not to be directly involved in the research from December 2021.
- The University of South Australia led the socioeconomic analysis and water economics research.

In Africa,

- In Mozambique, the National Irrigation Institute is the government agency responsible for the development and management of irrigation in the country led the research.
- In Tanzania, the national Ardhi University is specialising in land and natural resource planning. They led the Tanzania research. Ardhi University is closely linked to government programs.
- In Zimbabwe, International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) is a leading agricultural research organisation and a centre of excellence on AIPs. They led the Zimbabwe research in collaboration with national institutions. Additionally, they undertook key capacity building and mentoring of the AIP facilitators Tanzania and Mozambique, supported by ANU.

- Based in South Africa, Food, Agriculture and Natural Resources Policy Analysis Network (FANRPAN) is constituted by member national governments across Africa. They are an expert-based, non-governmental organisation that is endorsed by and has access to regional institutions. They contributed expertise in food security, poverty reduction and gender equity implications of agricultural policies.

5 Achievements against activities and outputs/milestones

We have a lengthy list of activities, outputs and milestones, in the interest of space, we scored each out of 10 with 10 being complete, and 0 not conducted. A separate 55 page table of activities is available.

0.0 Getting started.

No.	Activity	Outputs / milestones	Due date of output/ milestone,	Comment	Progress
0.01	Initiation of the contract process (ACIAR and ANU), approval from ANU management to start the project while the contract is in process, if necessary.	Signed contract between ANU and ACIAR	Yr1, -m1	Complete	10
0.02	Initiate contract process with ANU and CSIRO.	Signed contract between ANU and CSIRO	Yr1, -m1	Complete	10
0.03	Initiate contract process with ANU and UniSA.	Signed contract between ANU and UniSA	Yr1, -m1	Complete	10
0.04	Initiate contract process with ANU and ICRISAT.	Signed contract between ANU and ICRISAT	Yr1, -m1	Complete	10
0.05	Initiate contract process with ANU and FANRPAN – including country partners Ardhi and INIR.	Signed contract between ANU and FANRPAN	Yr1, -m1	Complete	10
0.06	Initiate contract process with ANU and EC.	Signed contract between ANU and EC	Yr1, -m3	Complete	10
0.07	Discuss with partners and develop agenda for the inception workshop to be held in Tanzania. Agenda to include discussion on site selection, impact pathways, monitoring indicators and evaluation plan, procedure to work together, internal communication, and stakeholder engagement and communication. *JP, RS, HB, EC, PM, AvR, MM, SN*	Agenda of the inception workshop, including list of participants, finalised and circulated.	Yr1, m1	Complete	10
0.08	Draft plans for stakeholder communication, impact pathways, and project monitoring and evaluation *JP, EC, RS, HB, PM, AvR, MM, SN*	Draft plans ready for discussion at Tanzanian inception workshop.	Yr1, m1	Complete	8
0.09	Organise inception workshop 16-20 July 2017	A report of the inception workshop.	Yr1, m3	Complete	10
	JP, PR, MM	Draft stakeholder communication plan, impact		Complete	10

No.	Activity	Outputs / milestones	Due date of output/ milestone,	Comment	Progress
		pathways report, and monitoring and evaluation plan.			
0.1	Finalise the communication plan, and monitoring indicators and evaluation plan after cross-correlating (or discussing) with similar plans of sister projects	Inception report, inclusive of plans, decided at inception workshop.	By December 2017	Complete	8

0.2 Management Activities

No.	Activity	Outputs / milestones	Due date of output/ milestone,	Comment	Progress
0.21	Annual research team meeting to review progress against plans and indicators, share lessons, build capacity and identify plans for the next year.	Meeting report provided to RPM	Annually in June to July	Complete	10
0.22	Annual reporting	Annual report provided to RPM	Annually in June - July	Complete	10
0.23	Mid-year reporting	Report provided	January each year	Complete	10
0.24	Midterm review preparation	Prepare agenda, field visits, stakeholder visits	Approximately 2 years after project start	Complete	10
0.25	Final review preparation	Prepare agenda, field visits, stakeholder visits	Approximately 6 months before end of project	Underway	7
0.26	Prepare a comprehensive report integrating the outputs of all activities of each objective.	Mid-term report	For mid-term review	Complete	10
0.27	Financial acquittals and invoices	Financial acquittals and invoices provided in ACIAR format and in timely manner	6-monthly	Complete	10
0.28	Apply the project gender and equity guidelines (Appendix B) to ensure that the project does no harm and seizes opportunities to positively transform the lives of women and men.	Team receives gender training at inception workshop	Training – July 2017	Not undertaken as each teams received training through their own organisations.	0
	Project team will receive gender awareness training and hold discussions on the guidelines, and these will be revised for application in this project.	Project gender guidelines reviewed and published	Guidelines published by August 2017	Complete	10

No.	Activity	Outputs / milestones	Due date of output/ milestone,	Comment	Progress
		Report on application of gender guidelines in project activities and revision of guidelines as necessary	Report by June 2018 and annually	Complete	10

Objective 1.0 - Determine how the package of AIPs and simple tools for water and land management can best be scaled out and up.

No.	Activity	Outputs / milestones	Due date of output/ milestone,	Comment	Progress
1.1	**Scale up using district-scale AIPs**	**District AIPs** - At least five district AIPs established.	Established district AIPs by June 2018.	AIPs complete.	10
	Lead: Countries	**Reports / minutes of AIP meetings** recorded for analysis.	Report / minutes. after each AIP meeting	Completed.	10
		Report annually on progress of each district AIP in TISA report to ACIAR.	Annual reporting on AIPs in TISA report to ACIAR.	Completed.	10
1.2	**Sorting irrigation schemes within a district.** Lead: Countries	**A table** of irrigation schemes divided into those who can be served by an existing scheme-level AIP and those, which need a new AIP, stating the key reasons.	Table by Dec 2017.	Table completed.	10
1.3	**Scale out by establishing new scheme–level AIPs in new localities.**	**New AIPs formed.** Identified through activity 1.2.	**New AIPs** formed in years 1-3.	Completed, numbers determined by activity 1.2.	10
	Lead: Countries	**Report annually** on progress of each AIP in TISA report to ACIAR.	**Annual reporting** on AIPs in TISA reported to ACIAR	Complete, only one new scheme AIP formed.	10
1.4	**Scale out from existing scheme-level AIPs**	**Irrigation schemes** added to existing scheme-level AIP.	**Additional irrigation schemes** engaged in years 1-3. Numbers determined through activity 1.2.	Completed, numbers determined by activity 1.2.	10
	Lead: Countries	**Annual reporting** on the AIPs summarised in annexes 2.	**Annual reporting** on AIPs in TISA report.	Complete	10
1.5	**Assess the effectiveness of and interactions between different methods of scaling out and up as outlined in activities 1.1 and 1.4**	**Draft report of results and learning** from activities 1.1-1.4, with best bet approach to lower cost and increase impact when out and up scaling AIPs and tools.	**Draft report** by June 2020.	Underway not completed.	7

No.	Activity	Outputs / milestones	Due date of output/ milestone,	Comment	Progress
	Lead: Countries		**Policy briefs a**nd at least one academic paper by 2021.	Underway not completed.	7
1.6	**Develop approaches to disseminate soil and water monitoring tools to farmers**. Lead: RS and JP	**Tools**: At least 2,100 sensor arrays deployed.	**Tools**. Sensors deployed. Update Annex 1.	Not complete. Tools. 937 sensors deployed, 754 farmers on the VIA website. Many sensors have had to be replaced.	5
		At least 2,100 farmers using water monitoring tools across the schemes.	**Tool service and repair**.	Complete. VIA team completed a short-written guide by VIA for field staff.	10
		Model for scaling tools: Work on business systems, co-investment and resulting research will now be undertaken by the VIA 2 project.	**Tool masterclasses.**	Complete. Tools 'masterclasses' run by VIA staff / consultants held in each TISA country twice. Classes run in Zimbabwe and Tanzania. The COVID delayed class in Mozambique will be held in July this year.	10
			Accreditation survey.	Not undertaken by VIA.	0
			Handover of tool support to VIA at end of TISA.	TISA was extended and now concludes at the same time as the VIA project in 2023. VIA Farm provides tools commercially and advice. TISA 2. In Tanzania, working with CSIRO a sustainable tools business is being established, called KIKI. In Zimbabwe, remaining tools will be handed over to the Department of Irrigation.	10
1.7	**Explore how to use large datasets of soil and water monitoring data to identify priority places for interventions and better agronomic practices to improve irrigation.** Lead: RS - VIA 2	**Brief** on proposed methods for the analysis of the datasets produced by VIA. Analysis of best practices collated and reported.	**Data upload reports.**	This activity suffered from farmer's limited interest in using the Wi-Fi function of the tools. The activity was a responsibility of CSIRO/VIA from 2019. CSIRO have developed some methods for using large datasets.	2

No.	Activity	Outputs / milestones	Due date of output/ milestone,	Comment	Progress
		Country workshops: TISA will support two VIA 2 workshops to research means for downloading and communication of useful VIA platform analytics, at the sub-national scale for application by end users.	**VIA analytics synthesis workshops.**	Complete. VIA analytics synthesis workshops held twice.	7
			Research papers.	Complete; contributed to relevant research papers.	10
			Ongoing coordination.	Complete. Coordination meetings conducted when needed.	10
1.8	**Collaborative mapping of irrigation schemes.**	**Mapping method documented** and **training provided** where required.	**Mapping method fully documented,** and **training provided** by December 2020.	Complete.	10
		Infrastructure and plots (both used and unused) mapped in participating irrigation schemes and maps provided to relevant local and national authorities.	**Infrastructure and plots mapped** June 2018, 2019, and 2020.	Complete. Twenty-six schemes have been mapped, six in Mozambique, six in Tanzania and fifteen in Zimbabwe.	10
		Report annually on mapping activities, including how many occupancy certificates (this is specific to Tanzania) were issued and where the maps reside.	**Annual reporting** on mapping in TISA report to ACIAR	Complete	10
		Publications: A policy brief and an academic paper published.	**Academic publication** by June 2021.	Draft paper being finalised, led by Tanzania, including inputs from Mozambique and Zimbabwe.	8
1.9	**Engage major irrigation donors and other funders and stakeholders to accelerate innovation.** Lead: JP	**Report** on irrigation funders in Africa and their approaches to capacity building.	**Irrigation funding report** by December 2017.	Complete.	10
		Discussions held with two donors (proposed with the World Bank in Mozambique and the African Development Bank).	**Donor discussions** by June 2018.	Extensive discussions were held with multi- and bi- lateral donors in all three countries in 2017-19, but this did not result in uptake. Issues included donors' limited irrigation focus, loyalty to existing implementors and methods, and	8

No.	Activity	Outputs / milestones	Due date of output/ milestone,	Comment	Progress
				challenges working through national agencies.	
		Report on interactions with donors, piloting of AIPs and tools and moves by donors to take up project techniques**.**	**Donor interaction report** by June 2019.	Complete.	10
		Report on the possibilities for and approaches to private sector water, mining and energy companies investing in irrigation infrastructure for water saving and/or water trading with irrigation farmers.	**Donor approaches report** by June 2021.	Complete.	10
		Model proposals. TISA to prepare draft/model proposal/s that convincingly argue the case for inclusion of VIA + AIP in irrigation revitalisation/rehabilitation programmes.	**Water trading report**	Complete. Published see appendix 10.2.	10
			Initial assessment of tradeable water.	Complete. Published see appendix 10.2.	10
			Report on the possibilities for investing in water efficiency and /or water trading.	Complete. Published see appendix 10.2.	10
			Model proposal/s	Completed, more than five proposals have been developed and some submitted.	10

Objective 2.0 - Identify what institutions lead to inequity among farmers in water supply and financial benefit from irrigation schemes, and how this inequity can be reduced.

No.	Activity	Outputs / milestones	Due date of output/ milestone,	Comment	Progress
2.1	~~**Re-allocation of un-used irrigation plots to women and youth.**~~ COMBINED with 1.8				
2.1	**Assessment of and approaches to equity in water access by farmers,**	**Farmers field book** (FFB): data on total duration of irrigation during each season of head end, middle and tail end users, and total discharge into	FFB	Complete.	10

No.	Activity	Outputs / milestones	Due date of output/ milestone,	Comment	Progress
	especially those at canal tail end.	the field during this period. Extrapolation of this data to larger scale to assess total water saved.			
	Lead: Each country	**Using AIP meeting template** to assess the impact of the changing irrigation regime on scheme allocation practices. End of project survey to assess farmers perception of changes in the perception of equitable water supply	AIP template.	Complete.	10
			End of project surveys.	Complete.	10
			Synthesis paper by end of May 2022.	Complete. It was distributed to country governments prior to COP in Egypt. Synthesis papers currently being expanded into journal articles for forthcoming third SI.	10
2.2	**Resources, livelihood, equity, and market data collection.** Quantitative and qualitative data will be collected from all schemes that can be used to assess resource use, livelihoods and equity, and market access.	**Livelihood strategies** will be assessed based on 2.3 as well as end of project survey (EOPS) and draw on previous publications.	**Livelihood strategies and market access publications**	Complete.	10
	Lead: UniSA	**Equity will be** assessed as part of 2.3.			
		Market access will be assessed based on EOPS, AIP templates, FFB and focus groups with farmers during last six month of project.	**Synthesis paper** by end of May 2022.	See above 2.1	
2.3	**Assessing equity between farmers within irrigation schemes and effects on scheme productivity and viability**.	**Paper on income distribution** and changes over time. How have these changes impacted on the three disadvantaged groups? Based on Baseline, end of phase I and end of TISA 2 surveys.	**Income distribution and youth paper** by end of May 2022.	**Income distribution**: Statistical analysis has been completed analysing the data by gender, age and location within the scheme. Equity paper is in preparation for the SI.	8
	Lead: UniSA	**Paper(s) on youth** and their role within irrigation schemes and their livelihood strategies. Based on Karen Parry's fieldwork, farmers field books and end of project survey		Complete	10

No.	Activity	Outputs / milestones	Due date of output/ milestone,	Comment	Progress
		Synthesis paper on equity issues and how these have developed over the life of TISA 2 and I. Also, an assessment of how these have influenced overall scheme productivity. An assessment of the institutions that have created inequities and steps taken by or lessons learned from TISA to overcome them. Based on previous TISA publications, All three surveys and Farmers Field books	**Synthesis paper**, income distribution and youth paper by end of May 2022.	See above 2.1	
2.4	**Develop 'How we' guide.**	**'How we' guide** developed under TISA 1 will be tested with end users (farmers, community leaders, water managers and government officers). We will consider whether to revise the guide, and/or add supplementary material, and/or break into separate briefs.	**'How we' guide tested in** year 1, 2 and 3.	The 'How we' guide has not been updated as it was judged as serving the intended purpose and a low priority to revise during the COVID years. Complete. On ResearchGate, there have been 2,194 'reads' and four citations of the guide.	
	Lead: ANU	**Frontline staff:** We will enhance collaboration opportunities among frontline staff to jointly undertake and share practices e.g., around participatory mapping. Their lessons may be used to refine the 'How we' guide.		Complete	10
	Support: Countries	**Guide published** in at least three key languages.	**Guide published** in English and translated versions.	Guide published in English and translated into Portuguese and Swahili. The next step is to share the guide further with other stakeholders.	8
		Other media based on user needs developed and published, short videos shared in Access Agriculture.	**Videos** published by June 2021.	Complete. Videos of project presentation on ANU web site. ACIAR video of the project in Tanzania released in 2021. Mozambique video 2023	8
2.5	**Research consolidation and COVID-19 analysis in extension phase**	Research outputs, assessment of:	By Apr 2023		
	Lead: ANU	i) methods for out-scaling adoption;		Analysis complete and being reported in country papers for	8

No.	Activity	Outputs / milestones	Due date of output/ milestone,	Comment	Progress
				the special issue. An independent overview paper has been submitted by Xolile Ncube for the SI. A further overview paper in under consideration.	
		ii) socio-economic change resulting from project interventions;		Analysis complete and being reported in country papers for the special issue.	8
		iii) changes to the economics of operations and maintenance of the irrigation infrastructure;		Analysis complete and being reported in country papers for the special issue.	8
		iv) methods of participatory mapping and resulting benefits;		See above 1.8.	10
		v) irrigation community adaptation to the COVID19 shocks;		Analysis complete and being reported in country papers for the special issue.	8
		vi) Conducting a scoping study to develop a research proposal. (V3)		Completed	10
2.6	**Research to evaluate and extend climate change adaptation benefits (V4)**	Research outputs:	**Draft reports** by Dec 2022.		
	Lead: ANU	i) Modelling approach to demonstrate water savings and climate smartness.	**Final reports submitted for review** by May 23	Modelling being led by ICRISAT is advanced and a paper is in preparation.	7
	Support: Countries	ii) Climate smart irrigation efficiency demonstrated through case studies and analysis.		Complete	10

Objective 3.0 - Develop irrigation policy options for governments and multilateral agencies so that smallholder schemes can be more profitable, equitable and self-sustaining.

No.	Activity	Outputs / milestones	Due date of output/ milestone,	Comment	Progress
3.1	**Assess and document lessons and**	**Policy lessons and reform options** included in the 'how we' guide (see.2.5) published on better practices emerging	**Policy lessons and reform options** included in 'How we'	Communicated through FANRPAN briefs and dialogues in regional institutions. Complete.	10

	policy reform options from scheme- and district-level AIPs	from our AIP, soil and water research for irrigation scheme managers and farmers.	guide by June 2021. FANRPAN to lead with ANU support.		
	Lead: FANRPAN / ANU	**Publication.** Academic publications, policy briefs and videos in national languages.	**Publications.** Briefs on climate change adaptation benefits published and disseminated widely. (V4)	Briefs have been published; dissemination will be ongoing to project end.	8
		CAADP reporting: design processes for data from TISA/VIA farmer achievements to feed into the CAADP reporting formats at relevant levels; write up and disseminate this process as one of the "stakeholder messages" in the Guide; Investigate possible linkages and opportunities emanating from other high-level policy instruments, e.g., African Union – Comprehensive Agriculture Strategy. (V3)	**CAADP reporting and policy briefs (V3)** on key policy reforms and the report on the national innovations systems.	Complete: Regional online meetings have held.	10
		Virtual dialogues: "Building Resilient and Sustainable Food Systems in Africa: Mobilizing African Voices and Building Momentum for the UN Food Systems Summit, and CAADP/Malabo BR performance & the importance TISA interventions; and two policy briefs (V3)		Complete. Several meetings held including Forging Effective Partnerships to deliver Sustainable Agriculture and Food Systems, 21 July 2021; and Catalysing Action to Transform Africa's Food Systems, Policy Dialogue, 28 -30 September 2021	10
		Climate change adaptation benefits: research findings will be promoted to regional decision makers and presented in a regional climate smart agriculture conference in South Africa. (V4)	**Climate change adaptation benefits.** (V4)	Complete Provided input to pre-feasibility study for a programme for integrated development and adaptation to climate change in the Zambezi watercourse July 2021. Case studies developed from each of the three countries shared at UNFCCC COP27 Nov 22.	10
			Briefs on climate change adaptation benefits.	Complete. Two policy briefs have been developed from the proceeding of the CSA regional policy dialogue.	10
			Regional climate smart agriculture conference, by April 2023	Complete. Regional climate smart agriculture policy dialogue (13-15 March 2023) was held and hosted at University of Pretoria, Future Africa Campus.	10

				UNFCCC COP27 Official FANRPAN Side Event was held Monday,14 November 2022.	10
				FANRPAN and the Common Market for East and Southern Africa (COMESA) in partnership with Global Roundtable for Sustainable Beef (GRSB) organized an official UN Climate Change Conference (COP26) side-event: Towards Resilient, Sustainable, Transformed African Agriculture and Food Systems. The TISA project was presented as an example of initiatives building resilience of smallholder farmers in Africa.	10
				FANRPAN presented the TISA project at the ACIAR Side Event at the Australian Pavilion during UNFCCC COP27.	10
3.2	**Form or add to national-scale innovation systems**.	**National innovation systems** At least three national innovation systems supported.	Three **innovation systems** supported by June 2019.	Complete. Engaged with national level innovation systems in all three countries. Changes in government practice and policies being seen.	10
	Lead: Countries	**Report** on approaches to support the systems.	**Report** on approaches used by 2019.	Complete. Meeting reports available	10
			Policy briefs by June 2019.		
		Publications Findings published in a brief and an academic paper.	**Academic publication** by June 2021. Planned but results so far are limited.	Included in country and innovation scaling papers for upcoming SI. A further scaling paper is being considered.	8

6 Key results and discussion

Results and discussion based on our six project research topics and their respective questions:

6.1 Irrigation innovation platforms.

We conducted research into four questions:

i. How should innovation platforms be scaled up through formation and implementation at district level and through national innovation systems?[8]

ii. What are the mechanisms by which the common solutions from an innovation platform at an irrigation scheme can be scaled out to include adjacent schemes?

iii. What are the indicators that can be used to determine when a new innovation platform is needed rather than expanding an existing one for low input spill over?

iv. What are the capacity requirements and needs for an AIP at different scales (scheme, district and national)?

In the following sections we share experiences and examples of how we addressed those questions.

i) How should innovation platforms be scaled up through formation and implementation at district level and through national innovation systems?

Each country formed district AIPs, with a total of twelve being formed, four in Mozambique, three in Tanzania and five in Zimbabwe, and national level AIPs in Zimbabwe and Tanzania. The examples provided how these AIPs were scaled.

Tanzania. This research demonstrated that district AIPs become most effective if established by identifying common issues or productivity barriers among the scheme level AIPs. During the first session of the district AIP, stakeholders working on different aspects of the agricultural value chains were involved, together with the farmers. Some of the actors represented national level agencies or organisations but were designated to the district, region, or zone. During the session, solutions to the identified common issues were proposed and relevant stakeholders were identified. Facilitators were identified and trained, mostly being District Agricultural Officers as well as project officers from development organisations supporting the agriculture sector at district, regional and national level. The project team conducted a training of AIP facilitators in August 2020 for 20 participants representing district agriculture officers, farmers, officers from NGOs and private companies involved in marketing of agricultural produce. Two district AIPs

[8] National agricultural innovation system is the phrase used to describe the institutions that exist or can be established to enhance national policies, such as Zimbabwe's multi-stakeholder national Agriculture Working Group. These are not defined as innovation platforms because in most cases they are ongoing organisations.

were formed, one for rice producers and the other for vegetable producers. One scheme level AIP was established in a third district, Mbarali, at the Igomelo scheme.

In Tanzania, the national level AIP involved two different attempts to build on existing sector platforms to bring together stakeholders through policy. The dialogue was used to discuss and inform decision makers on relevant research results for policy decisions. These proved difficult to sustain as government agencies focussed on new irrigation projects rather than maximising production from existing schemes.

Zimbabwe. It has been critical to identify who the core district-level stakeholders should be in the AIPs, as well as building the capacity of a central actor to coordinate and facilitate the AIP meetings. As the project spread to each of the district in Matabeleland North Province, AIP inception meetings were organized in each district, engaging farmers and identifying core stakeholders to constitute the district AIPs. The inception meeting identified broad areas of interest, and additional relevant actors for subsequent, more focused AIPs. A total of four new district-level AIPs (Binga, Bubi, Hwange and Lupane) were formed. The setting up of district AIPs involved financial outlay, and this was observed to be a major bottleneck for frequent district-level AIP meetings.

Following years of inactivity, the national-level Irrigation Working Group was reactivated. Due to the visibility of TISA district-level AIPs, where senior government officials had been invited to participate, ICRISAT was invited to participate in the working group. Participants in the working group included donors, development agencies, academia, and others. Through this platform, TISA innovations were presented to a broader audience. The absence of intermediate institutions that link district-level AIP to national-level platforms limits the scaling of solutions to the national level.

Mozambique. Four district AIPs were formed in Boane, Magude, Moamba and Manica / Vanduzi Districts. The first two were built up from scheme AIPs. We found that these AIPs were most effective when a critical mass of knowledge, skills and experience was established during different stakeholders' engagements. The engagements provided the capacity to foster innovation at scheme and district level.

The communication, knowledge sharing and learning, were key to driving the behaviour change among the farmers (pictured below). These changes occurred very quickly, especially among farmers who were initially reluctant to engage in dialogues to solve the problems they faced in the schemes. This enabled the joint design of strategic and practical models to effect access and distribution of quality agricultural inputs and services not only across TISA schemes (25 de Setembro, Manguiza, Mafuiane and Bloco I) but also to the surrounding schemes which had the same problems accessing quality agricultural inputs.

Discussion between farmers' associations and TECAP (agricultural service and input provider) enabled farmers to benefit from locally accessible quality agricultural inputs and services purchased through TECAP's mobile store.

ii) What are the mechanisms by which the common solutions from an innovation platform at an irrigation scheme can be scaled out to include adjacent schemes?

Tanzania. Through the AIP process, we first conducted analysis of barriers to irrigation productivity in the TISA 2 schemes. The farmer groups from the schemes developed their visions and action plans to address the identified barriers. Existing schemes were paired with new schemes based on the similarity of crops produced. The paired schemes developed joint action plans to address agreed common productivity barriers.

Further AIP meetings focused on assessing progress on implementation of the agreed action plans, sharing of experiences on how some of the challenges were addressed, new information, technologies, and innovations for improving productivity and profitability. To improve the effectiveness of out-scaling the solutions, it was important to select leaders of the expanded AIPs from amongst the farmers.

Support from the Iringa District Council has been critical as research learnings were shared via the regular meeting of extension officers within the Council. Additionally, the extension officer at Kiwere during the early stages of the project was moved to another scheme and took the learnings with him.

Other mechanisms applied in the AIP processes, including farmer learning visits to other schemes, establishing farmer managed demonstrations plots and farmer to farmer trainings. The AIP processes also extended invitations to leaders of nearby schemes to attend in

workshops and linked with value chain stakeholders such as financial institutions, crop buyers and input suppliers.

Zimbabwe. AIP meetings were convened at district level to be inclusive of several schemes within the districts, making it easier to scale innovations from one scheme to the other. Farmer-farmer extension was also very important, resulting in the scaling out of the use of the tools to monitor soil moisture and nutrients within new schemes occurred faster than in the first TISA phase. Between 2017 and 2021, our end of project survey indicated that 96% of farmers in the new schemes changed their irrigation practices based on the use of the tools. The social networks that developed among farmers between the different schemes became strong assets, which enabled the spread of solutions emerging from scheme-level activities to nearby schemes.

Putting the public agricultural extension system AGRITEX, at the core of convening and facilitating the AIPs has also proven to be more sustainable and will allow solutions from an innovation platform at one scheme to be scaled to other schemes. Though the initial AIPs were convened by ICRISAT, AGRITEX has taken a leading role in facilitating and convening these. Through the extension officers' interactions within the districts the spread of innovation to other irrigation schemes within the district was observed. During the AIP meetings, there were discussions on pertinent issues affecting the irrigation schemes within the district. The visioning exercise was used to identify opportunities to reach a desired state, and to identify issues constraining the schemes in the districts from reaching their desired state. Stakeholders holding back the process are identified and the facilitator then separately approaches them to try to convince them to change their behaviour.

Mozambique. The introduction or familiarization with the concept of AIPs was fundamental for the scaling out of common solutions within adjacent schemes. This ensured a collective understanding developed of these solutions among the stakeholders, about their roles, objectives, importance, and procedures for follow-up. Thus, the collaborative nature of the platform safeguarded it from being defined just by the interests of any restricted groups.

The district AIPs, enabled key farmers to share their knowledge on the management of water and fertilizers in the production system, based on their experiences with the tools. Farmers from other schemes were then able to also understand the importance of managing water and fertilizers in the production system to increase yield.

The same key value chain stakeholders (e.g., important input suppliers, buyers for the crops, and extension service providers) who were engaged in a district-scale AIP were invited to establish new AIPs using the common solutions from an original innovation platform to benefit new schemes. For example, using the same approach, TECAP representatives discussed with different farmers associations the main opportunities to facilitate access to agricultural inputs in their schemes, resulting in an expansion of access to quality inputs to an extensive community of farmers located around the target irrigation schemes.

iii) What are the indicators that can be used to determine when a new innovation platform is needed rather than expanding an existing one for low input spill over?

Expanding existing innovation platforms was conducted in all three countries, but new innovation platforms were formed based on a range of indicators including schemes growing different crops or having different supply networks. Examples include:

Mozambique. Each stakeholder's potential to contribute to solving the value chain challenges was identified in the AIP. This allowed the AIP facilitators to map the scope of interventions and roles for each stakeholder. Thus, when it was necessary to involve new stakeholders to develop new solutions for problems that could not be solved by the same actors, then there was a need for a new innovation platform.

Tanzania. The indicators of the need for new AIPs included: different type of crops produced; e.g., vegetables versus rice; productivity barriers or challenges that are distinct between the existing and new schemes; distant physical locations between schemes; and divergent priorities in addressing barriers in scheme action plans.

Zimbabwe. At the core of AIP are small-scale irrigators who face several challenges across technical and institutional spheres. The AIP setup in Zimbabwe comprises a core group of stakeholders that include farmers and other district-level stakeholders such as the public extension leadership and others with permanent presence and interests in facilitating a conducive policy environment for farmers to thrive. The AIPs identified a specific challenge that needed to be addressed and invited relevant actors to an issue specific meeting. Once the challenge was addressed, those stakeholders invited to those task specific platforms ceased participation and a new set of actors were invited to address a different challenge. The institutions making up the core of the AIP did not disband after a solution was identified, but incorporated new members as required for the new challenge. Through this setup, a new innovation platform with unchanged core actors arises whenever new issues arise that may include co-opting other relevant stakeholders.

Additionally, in Zimbabwe, ICRISAT was invited by the Government of Zimbabwe to work with schemes in the province of Matabeleland North, an area not covered in the first research phase. ICRISAT with AGRITEX formed four new district AIPs which were based around scheme locations, schemes experiencing similar issues and growing similar crops.

iv) What are the capacity requirements and needs for an AIP at different scales (scheme, district and national)?

Zimbabwe. At the scheme level and district level, the facilitation skills of the facilitator of the AIP are critical to ensure inputs from all stakeholders are heard, interrogated, assessed and either adopted or not in a transparent manner, which ensures the interest of stakeholders is sustained until solutions are found. Facilitators of the AIP thus will require capacity building in facilitation skills. Other areas key to successfully implementing AIP will include leadership, report writing, and organizational and coordination skills. Leadership skills are critical for relationship building, with actors from within and outside the scheme, conflict management, negotiations, agility, and adaptability.

Tanzania. Facilitation skills at all stages of the AIP process as well as the available resources. As financial resources are needed to enable stakeholders, and facilitators to participate in meetings which are organized in one location, access stationary, meals and accommodation during the workshops. Financial resources are also needed for when AIP leaders engage with stakeholders who have been identified to address barriers or challenges in the action plans.

Mozambique. At the different AIP scales established in Mozambique, it was essential that the platform participants understood the concept and objectives of the AIP by building the participants capacity. The facilitator played a crucial role in building the farmers' understanding to help overcome their initial tendency to think that the platform would safeguard only their interests and helped them understand the objective of ensuring a mutual benefit between the stakeholders.

The project team from INIR, ended up assuming the coordinating role and had to adopt the mindset of a facilitator, becoming a “government facilitator” who brought together the relevant stakeholders and oversaw the process. It was paramount that INIR assumed this position, because of its capacity to understand and continue the facilitation process beyond the project, so establishing a sustainable system.

Key findings from this research are that:

a) AIPs can be scaled up successfully to the district scale to maximise benefits for more farmers more quickly and at lower costs, and build community capacities to identify and find solutions to their problems and opportunities;

b) District AIPs still require bespoke processes that incur costs and require skilled facilitators;

c) Contrary to earlier AIP research (Makini et al. 2013), an independent facilitator is not required provided there are community leaders or government officers who have the capacity to adopt ‘the mindset of a facilitator’;

d) Further, we show that there are considerable advantages in having trained government staff facilitate district AIPs as this: i) embeds the innovation process in organisations with a mandate and resources to enable change, and ii) builds a critical mass to implement innovations as trained staff are promoted or move.

6.2 Technical interventions.

Research was conducted to address the following questions:

i. How can the data from simple tools across multiple irrigation schemes enhance farmer’s learning, and enable prioritisation of government interventions and identification of better irrigation practices? And,

ii. How can the simple tools and internet platform be better used by farmers and enhance irrigation development programs of government and other development partners?

iii. Mapping of irrigation schemes.

i) The approach adopted in all countries with the simple tools was on farmer-centred learning, and the following section includes examples of how the data from the simple tools was used including changing behaviour of individual farmers, farmers to farmer training within and between schemes. Additionally, examples of the data being used at national policy level.

Mozambique. The adoption of a farmer-centred learning approach in the dissemination of the tools enabled the farmers to quickly assimilate a large amount of information, identify and adopt better agronomic practices, both within and across schemes. The results of the end-of-project household survey in the TISA 2 schemes indicated that 76% of the farmers learned enough from working with the Chameleon sensors and the WFDs to have confidence in maintaining their new irrigation regimes if there were no more access to the information from the tools. In 25 de Setembro the survey also indicated evidence of farmer-to-farmer learning with 64% of farmers changing their practices because of observing and talking to their neighbours when only a minority of farmers had tools in their plots.

Additionally, the data generated from the use of the tools provided evidence for policy advice on the necessary reforms to transform small-scale irrigation into a more profitable and sustainable sector. The data was used to identify those who had the best agronomic practices. These project findings were used to enhance irrigation productivity across schemes in a district and was essential to achieve the government targets on agricultural development, including:

- Informing the structure of the work plan of the Irrigator Support Department (DAR), instituted at INIR (March 22, 2022).
- Incorporating the water and nutrient monitoring tools in the activities of other INIR projects. for example, the FASIMO (CultiAF, farmer-led irrigation) and more recently the IRRIGA (World Bank funded scheme development) projects.

Tanzania. The simplicity of the colour patterns from the Chameleon and nitrate test strips helped understanding among farmers and contributed reduced irrigation frequency, reduced use of fertilizer and better management of fertilizers in the soils while maintaining or increasing their yields. The representation of complex processes and data into simple colour patterns has significantly enhance farmers learning. The impacts demonstrated by our research on the use of soil water Chameleon and Wetting Front Detectors highlight how important it is for governments to integrate simple technologies that farmers can use to monitor water and nutrients. Farmers that use the tools in Tanzania have been training farmers without tools, from both within their schemes and from other schemes, and the results have seen much faster adoption of improved agronomic practices.

The results from the use of simple tools were presented to national policy dialogues and discussed by stakeholders to enable them to prioritize the simple technologies in their interventions. The National Irrigation Commission in 2021 included the Chameleon sensors and WFDs in their communication materials promoting soil water and nutrient monitoring technologies.

Zimbabwe. Data from the use of the smart water management tools is very vital as there is rising concern about the need to build resilience to climate change and protect the investments made in the irrigation sector. In Zimbabwe, there is evidence of ongoing and sustained changes in irrigation practices due to learning from the monitoring tools and associated AIP interventions. Data from end of project survey indicates that the most changed irrigation practice was the reduction in frequency of irrigation events. Farmers lengthened the period between irrigation events, reduced the number of siphons used per irrigation event, and the duration of the event. This reduced the amount of water used, saved time, and reduced fertilizer leaching. By reducing the frequency and duration of irrigation events, the time that farmers were spending irrigating their plots was diverted to other uses such as enhanced crop management or off-farm income generating activities that helps the TISA farmers cope better with shocks, which is important for farmers as well as the government of Zimbabwe. Another example would relate to the reduction in irrigation at Silalatshani which was associated with improved crop yield and therefore a large improvement in water productivity (crop yield relative to water applied). This has led to improved food and nutrition security amongst the irrigators.

In Zimbabwe, one of the key issues raised by the Director of Irrigation is the need to come up with evidence of how climate smart the tools are. The data from the tools, end of project survey report (inclusive of the modelling paper), as well as the case study that seeks to elicit how the TISA schemes coped with the COVID-19 shock, will help answer that question. Once we have the evidence on the climate smartness of the tools, we will be able to share with policy makers, and the tools could eventually be rolled out country wide. Sharing of personal experiences by farmers of how the tools have benefited them within and across schemes has the potential to increase demand for information, which can accelerate the scaling out of the tools to other schemes.

ii) This following section is focused on how the simple tools and how the VIA internet platform could be better used by farmers to enhance irrigation development programs.

Mozambique. Government officers helped to upload Chameleon data at many irrigation schemes in Mozambique. The combination of the use of tools and the internet platforms, helped estimate key factors: water consumption, water use efficiency and yields at scheme and within parts of the schemes (spatial variability), which were important to identify better agronomic practices within and across schemes.

The VIA platform has played a significant role in sharing the collected data across irrigation schemes and helping government irrigation development programs. Those responsible for the management of irrigation systems (water managers, extension officers and the irrigators association itself) can also have access through the internet platforms to crucial information to help them in the decision-making process and prioritise strategic interventions to enhance irrigation productivity across schemes in a district as they can compare the performance of different irrigation schemes (if for example, farmers are using more or less water).

Then through workshops and meetings, the positive impacts of the tools and platform have been showcased to partner institutions interested in irrigation and been used to identify intervention priorities in their programs various institutions and projects. For instance, the PROIRRI project has acquired sets of tools, set to be deployed in early 2024 in irrigation

schemes in Manica and Zambézia provinces. The tools will also be used for monitoring and evaluating the performance of the investments in irrigation.

Another notable advantage of these tools is their potential to cut down on travel costs to irrigation schemes. Given the limited government budget for such visits, these tools offer a cost-effective alternative. Moreover, these tools align well with INIR's mission of improving water use and ensuring the sustainability of irrigation schemes. They enable us to make more informed decisions and support our goals effectively.

Tanzania. Data from soil and water tools were uploaded onto the VIA farm website. Currently, farmers get access on the soil water and nutrient patterns for their irrigated plots through the scheme extension officers smart phones as well as through a print out of their irrigation pattern at the end of season workshops. As the number of farmers with access to smart phones and mobile social platforms such as WhatsApp increases, it may be important to link the internet platform with the mobile social platforms to improve access to information. This requires regular training for both the farmers and extension officers about the functionalities of the tools and the platform.

Zimbabwe. Under a regime of changing climate, irrigation cannot continue with a business as usual approach since it is affected by the increasing frequency of droughts. Adapting smallholder irrigation and other forms of agricultural water management to climate change is a priority for their livelihood security. The tools can guide farmers on how much water to use and when to irrigate. We have found that there is a significant reduction in irrigation events. Not over irrigating will also lead to better nutrient retention at the root level, improving crop productivity. From these benefits, the Government of Zimbabwe has requested widespread use of the tools across the country.

Key findings from this research on tools are that:

a. The soil monitoring tools, even when only installed in a minority of farmers' plots, resulted in rapid changes in agronomic practices by the majority (68% average across the three countries[9]) of farmers. These include significant reductions in water application and better nutrient management. A cascading series of positive benefits ensued, including increased crop yields, less water use, a reduction in conflict, and labour savings enabling time to be invested in other activities;

b. There were ongoing challenges with few farmers purchasing tools (even though that would be profitable), trade and bureaucratic barriers to importation, and limited systems for repairing and replacing tools. Hopefully the new VIA Farm business will overcome these barriers;

c. Despite the positive reports from the country teams above, farmers were focussed on the immediate data from reading the Chameleon and nitrate strip colours. Farmers had

[9] *Of those farmers that changed irrigation practices in 2013-17, we found that in TISA 2, 78% in Zimbabwe, 48% Tanzania and 77% in Mozambique continued to learn and make agronomic changes. (Bjornlund et al, forthcoming paper)*

limited interest in using the Wi-Fi function of the tools and only did so with involvement of extension staff. Further, there is evidence that after farmers change their agronomic practices, that their use of the tools declines in frequency or stops;

d. As the country reports imply, the Wi-Fi enabled big data collection from the tools found most use with national agencies and donors for irrigation schemes for ensuring that the very expensive irrigation infrastructure was being managed to achieve its objectives at little cost. Even so, we found that it has taken 10 years to get a modest level of deployment in two countries from donors and national agencies (and less uptake in a third).

iii) Mapping the schemes.

Farmers, project officers and other key stakeholders participated in informal mapping teams to map thirteen smallholder irrigation schemes in Tanzania, Mozambique, and Zimbabwe. While the purpose of conducting participatory mapping differed between the countries, most identified barriers were similar, and others were scheme-specific. The mapping process translated problems generally known by stakeholders into problems which were publicly known and shared, creating a common responsibility for resolution. Hence, problems identified at both the scheme and plot levels led to immediate responses by the farmers, irrigator organizations, and government departments, boosting farmer agency and confidence, and renewing their sense of scheme and plot ownership. It is important that irrigation agencies prioritise participatory processes and the use of informal networks to improve farmers' understanding of their resource and management challenges and to build their sense of ownership and responsibility for effective management of irrigation schemes (for more see Mdemu et al, 2023).

Tanzania. The mapping process was an outcome the AIP and has enabled some significant benefits including:

- Infrastructure issues. Addressing the large volumes of irrigation water lost through leaking unlined canals was seen as priority, though it was recognised it was long-term issue to address with the support of the government. In the short-term, clarity of ownership and inventory led to improved community cleaning of the canals.

- Poor or limited farm access roads are contributing to conflicts and crop damage. This is being addressed through sequencing of machinery to avoid crop damage, and voluntary land allocation for improved access.

- Multiple uses of information generated. A mapping database was developed which has been used for fairer and more effective farmer fee collection by the irrigator associations, boosting funds for operations and maintenance. It has also been used to help secure loans to buy inputs for over 800 farmers. Further it has been used to facilitate farmers' access to Certificates of Customary Right of Occupancy (CCRO) that recognize their tenure.

Mozambique. The mapping process was used as an entry point in Mozambique to start discussions with 'new' schemes and as well building trust with the farmers, it helped to clarify:

- Farm plot boundaries. The process encouraged farmers to pay more attention to the boundaries and size of their plots, reduce conflicts and helped to identify boundaries more clearly from encroaching settlement.
- Access roads. During the process, farmers realized they needed to expand some paths to facilitate movement within the scheme, so some farm access roads were widened to allow vehicle circulation. The participatory mapping team has proposed rehabilitation of the roads by local municipal authorities and the national road administration.
- Marginal cropping areas. Problems with flooding and the drainage system caused inundation of farming plots and soil salinization were identified in Bloco I. INIR and SDAE, worked together with other organizations to finance infrastructure repairs. Unfarmed areas were identified in schemes enabling discussions on reallocating the plots to increase production.

Zimbabwe.

- Boundary conflicts between blocks within the irrigation scheme was a priority issue to resolve. The use of resources in the reserved areas located on the boundary between the blocks was contested. Reserved areas are set aside for future development. Increasing awareness of these areas has helped to reduce conflicts.
- Canal cracks, water leakages and blockages were identified. Irrigation block committees held meetings to identify solutions and address each issue, including immediate actions to clear canal blockages and pathways to facilitate the water flow.
- Scheme engagement and salinization. The active involvement of irrigators and their leaders in the participatory mapping exercise created a sense of scheme and plot ownership at both Silalatshani and Mkoba schemes. This led to greater willingness to pay fees and participate in scheme and plot maintenance. Mapping helped to manage the increasing salinization in the lower Silalatshani scheme plots, especially in the Nonoka and Phelandaba blocks. Solutions adopted included farmers in low-lying areas regularly applying lime and reinforcing the importance of farmers in the upper plots using improved water and fertilizer management regimes.

The key finding from this research is that participatory mapping of irrigation schemes has a catalytic role in improving scheme governance and operations. Farmers and government officers mapping schemes together built trust in the resulting data (e.g., plot size used to calculate water fees), and clarified ownership and responsibilities for maintenance. It enabled irrigation organisations to raise fees for operations and maintenance and reallocate unused plots. Defining plot holders was vital for government agencies to issue identity documents that were needed for microfinancing.

6.3 Equity.

Research was conducted to address the following question:

How can the AIPs and simple tools be used to identify and reduce inequity for women, youth and tail-end farmers while improving the profitability and sustainability of smallholder irrigation schemes?

The primary equity focus of the project was to ensure inclusion in the key interventions, which does not mean direct inclusion of all disadvantaged groups. In responding to the research question, we first provide examples from each country of how inequities have improved directly through key interventions. Note that there is a feminisation of agriculture in Mozambique and Zimbabwe, so that enhancing agricultural profitability in irrigation schemes in these countries primarily improves the livelihoods of women. After these examples, we respond to the equity objective concerning identifying institutions that lead to inequity among farmers and summarise some of the changes in equity that have spread across the community as a result of the interventions.

Tanzania. The AIP process involved mapping of the existing situations and the identification and analysis of challenges. Issues of inequity and distribution of benefits were considered when the action plans were developed, with some resulting activities focusing on disadvantaged groups including women, youth and tail end users.

The colour patterns generated from the soil and nutrient monitoring tools in TISA1 demonstrated that farmers in the upstream and middle section of the schemes over-irrigated while those at the tail end received inadequate irrigation water. This inequity in supply meant approximately a quarter of plots at the tail end of canals were not receiving water reliably enough to irrigate. The plot holders were trapped in poverty and forced to work as labourers for other farmers who could access water adequately (Manero 2016). The continued use of the tools in TISA 2 contributed to a saving of irrigation water and the time of those engaged to irrigate the farm. The saved water became available to tail-end farmers. Time saved allowed women and youth more time for better management of farm plots and engagement in other livelihood activities to improve household income.

Mozambique. The AIP helped to map the conflicting relationships between farmers (men, women and youth) over irrigation resources and brought stakeholders together to effectively address the specific issues. The participatory approach used in the project enabled women and youth to be fully included in decision-making process in the irrigation scheme. This enhanced their control over irrigation scheme resources and other benefits, including assets, knowledge and finances. The AIP through the collaborative mapping process helped to reduce conflicts and increase the level of certainty about land access in the schemes. The mapping identified new irrigable lands, allowing 13 young people (8 women and 5 men) in 25 Setembro scheme to start farming. They were connected to an experienced farmer as a mentor for knowledge sharing. These young farmers also had the opportunity to attract microfinance to buy a pump to bring water to the highest points of their fields.

Key research findings on equity:

Our research has increased understanding of the constraints that give rise to exclusion, such as deeply held social norms about decision-making, and women's time constraints and whether interventions exacerbate their burden. Significant income inequalities were found to exist on

small-scale irrigation schemes between those with agricultural-only and diversified incomes (Manero, 2017). In addition to those that might have lower relative incomes, Parry's PhD research in TISA 2 on young people on Silalatshani has added nuance to 'who' maybe more vulnerable to exclusion, including single mothers, orphans and households with a child household head.

The constraints that create exclusion are multi-dimensional, vary across activities, and are highly differentiated for women and young people. For example, single mothers and orphans may exhibit a multitude of constraints for a range of activities; whereas other young people that can progress economically may face constraints to engage in civic forums or leadership. Implicit within the multi-dimensional constraints is the notion of 'cost' to participate and whether the incentives to participate (e.g., support to access finance or knowledge to be gained) are sufficient to address the mix of barriers. Table 5 provides examples of social and institutional constraints for young people identified in Parry's research for a mix of activities.

Table 5. *Examples of constraints for young people to engage in key activities.*

Activity	Examples of multi-dimensional constraints
School education	Cost, distance, social & family norms that prioritise children, gender (e.g., challenges of menstrual management, early pregnancy that terminates schooling), parents' health, and quality & content of education. Poor schooling has flow-on effects for confidence, cognitive development, learning skills and future training or learning opportunities.
Irrigation farming	Access to plots: household membership (or not) of scheme, availability of plots, input costs (plot fees, leasing, fertiliser), household size, parents' characteristics (patriarchal or collaborative approaches to succession). Constraints on crop choice and, hence, value of production: knowledge about new varieties, who within the household has control over decisions, access to contract farming and inputs.
Water (scheme & river)	Cost, physicality of irrigation (deterrent for women), time, distance
Extension services	Limitations on sector that service support (i.e., irrigation or dryland), invitation style (scheme plot holders or elderly only, youth encouraged or not), delivery of training (location, timing, language, facilities)
Scheme decision-making	Scheme rules, inter-generational dynamics and respect for elders as leaders), patronage, willingness of young people to engage, busy-ness/time, knowledge & community standing
Starting a new business	Availability of or access to financial services or savings opportunities, business knowledge, risk management, collateral, family support, access to new ideas

Source: K. Parry, PhD research

In addition to the country examples of direct influence of the AIPs and monitoring tools on equity, our research also explored changes in equity across the community as indirect outcomes of the package of interventions: for women, youth and tail-end users. Household surveys of the irrigation communities were used to collect data on in 2013/14, 2016/17 and 2020/21 on area farmed, income, and participation in decision-making and disaggregated by

gender, age and plot location. The following points are a selection of positive equity findings, with a forthcoming paper in a special Issue of the *International Journal of Water Resources Development* reporting more fully on the outcomes:

- Households headed by unmarried females have been able to increase their farmed irrigated area alongside male-headed households, and on some schemes this increase is greater for the de jure households compared to male-headed. In some cases, these households retained a greater proportion of their irrigated area through COVID, when the average for other households reduced.

- There is also evidence that young farmers have increased their irrigated area alongside older farmers, and on some schemes the average proportional increase was greater compared to older farmers. In Silalatshani, the youngest farmers further increased their irrigated area through the COVID period.

- Tail-end farmers also increased their irrigated areas, though this was more marked on Silalatshani where head, middle and tail-end also maintained a greater proportion of their irrigated area through COVID.

- Economic wellbeing is complex to interpret as households have mixed income sources, varying numbers of contributors to household income, and COVID impacted households between data collection periods. However, there are some encouraging signs for greater equality: for example, households headed by unmarried females on Kiwere increased their farm and non-farm income when compared to male-headed households. Despite COVID, unmarried female-headed households on Silalatshani had a higher farm income post-COVID compared to the beginning of the project. On Magozi, where the scheme was impacted by flooding and COVID, unmarried female-headed households managed to achieve a marginally higher net income by the end of the project compared to male-headed households.

- In addition to the household surveys, data from irrigators' field books showed that female farmers on Kiwere increased their gross margins by 42% from 2015 to 2018, more than double the gross margin increases achieved by male farmers (Mdemu et al., 2020).

- On Kiwere, tail-end users' farm income was almost half that of head-end users, but by the end of the project tail-end users' farm income was greater than head-end users. Interestingly, their net income was higher or comparable in both periods. On Silalatshani, tail-end users' net income was comparable with head-end users at the beginning of the project and was greater at the end of the project. While gains have been made for tail-end users, the findings suggest that in some circumstances tail-end users are not necessarily disadvantaged in terms of income and find ways to compensate for a precarious water supply.

- Decision-making about crop production and cattle on the Tanzanian schemes has shifted from being more male-dominated to having more gender balance. There is also a shift to more gender balance in decision-making in Silalatshani, though this arises from some reduction in female-dominated approaches. Interestingly, the decision-making

index often showed a reversal of changes between the second two surveys, suggesting some impact from COVID on decision-making dynamics.

These positive equity outcomes lend support to the first part of the hypothesis that underpinned the equity research question: namely, that AIPs and simple tools [as an intervention package] can help reduce inequity for women, youth and tail-end farmers and improve the profitability and sustainability of smallholder irrigation schemes. It is less clear whether the equity changes have driven improved profitability or vice versa. The fact that TISA stimulated changes in irrigation practices, crop changes and income diversification in the early stages of the project, suggests that economic improvements have stimulated equity changes.

The equity changes are important findings and provide evidence to demonstrate that participatory scheme planning processes with multi-stakeholder representation (AIPs, mapping and so forth) in combination with a technological intervention can have equity impacts that extend beyond those most immediately engaged. Just like the learning from monitoring that spread across the community to households that did not have the tools, so too it appears equity outcomes have arisen and spread as the interventions have improved scheme productivity and profitability. The findings provide evidence that improving households' economic circumstances can act as an indirect intervention route to improving equality and equity even though the specific pathway may not be fully understood.

6.4 Policy.

Research was conducted to address the following question:

> *What policy changes based on use of the AIPs and simple tools will improve the livelihoods of irrigators and help smallholder irrigation schemes become more profitable and self-sustaining and environmentally sustainable?*

Our research found a wide range of policy lessons including the benefits from: removal of fixed water supply scheduling; the abandonment cropping calendars; expanded extension services and more mobile extension officers; training extension officers in crop livestock integration, intercropping etc.; as well as extension staff with some agricultural business qualifications.

Examples of policy changes to aid irrigation productivity and profitability include:

Tanzania. After several years of engagement from the team, Chameleon sensors and WFDs were exempted from VAT in Tanzania from 2022, which will incentivize importation and distribution of the tools by entrepreneurs in the country.

Using the AIPs and simple tools, we saw improvements in the farmers abilities to organize themselves and manage irrigation systems. This included improved policies within the irrigation management committees, including linking with financial institutions to access financial credit for farming which was based on the establishment of the plot and scheme mapping databases, and promoting and supporting farmers' access to user friendly technologies for efficient management of irrigation water.

The Economic and Social Research Foundation (ESRF) facilitated two TISA policy dialogues. The first one was conducted on 21st August 2019 and was organized by ESRF together with ARU and FANRPAN. The second Policy Dialogue was conducted on 3rd December 2020 and was organised by ESRF in collaboration with ARU. Both policy dialogues were held in Dodoma and attended by key stakeholders and representatives from the Government of Tanzania (GoT) (including NIRC, Mechanization and Irrigation Department of the Ministry of Agriculture and Tanzania Agriculture Research Institute (TARI)), Donor Community (DC), Private Sector (PS), and Non-State Actors (NSAs). These engagements led to NIRC (Ag. Managing Director, Economist, Planning Director, Director of Irrigation Research and Technology promotion) making a field visit to Lipuli and Igomelo schemes to learn from the farmers on soil water and nutrient monitoring tools. NIRC also invited TISA to participate and make presentation on simple irrigation technologies for smallholder farmers during a workshop for private sector engaged in irrigation on 13 August 2021. At the end of the workshop, the Chairman of the NIRC Board asked TISA to prepare a brochure on Chameleon Sensors and WFD for NIRC in Swahili. The brochure was to be included in the list of brochures by NIRC for distribution to stakeholders and NIRC uploaded the brochure on its website (https://www.nirc.go.tz/publications/brochures).

Zimbabwe. One of the most critical policies relates to changes in water management as a result of using the tools and the AIP process. In Zimbabwe, smallholder irrigation systems have been associated with inefficient and inflexible water scheduling, making it challenging to maximize yield and profit. Poor water management; low input use; relatively small irrigated plots; and complex group dynamics have been implicated in the low crop yields.

Zimbabwe's primary focus on production of staples at the expense of high-value crops has resulted in farmers' failure to make sufficient profits to pay for the schemes' maintenance and development demands. So, another critical policy change has allowed irrigators to focus on more profitable, high value crops and to have more flexibility in the cropping calendar. This has made it possible for the schemes to be self-sustaining and profitable.

Mozambique. Most irrigation schemes, no matter their size, are constructed and rehabilitated by the government. Because funding is limited for monitoring, it has been hard to check how well these irrigation systems are being used. Research findings have helped mainstream in to national programs. For example, the AIPs have helped uncover many challenges that farmers and these irrigation systems are facing, such as who is responsible for scheme infrastructure repair and how can it be done when farmers cannot afford even basic scheme repairs. To address this problem, INIR have supported the farmers to grow more profitable crops. There have also been talks about changing the regulations for water user's associations to redefine what farmers are responsible for, especially for newly constructed and rehabilitated schemes.

Drawing on the positive impact of TISA, INIR, has been helping farmers and businesses by supporting the removal of import taxes on irrigation equipment, including the tools.

FANRPAN. A policy brief developed titled "Transitioning Smallholder Irrigation Systems: Success Stories" was published and communicated with national governments in Africa. It explains the use of the AIPs and simple tools to improve the livelihoods of irrigators and help smallholder irrigation schemes become more profitable, self-sustaining, and environmentally sustainable. The key policy changes recommended were:

- Many existing small-scale irrigation schemes in the East and Southern Africa regions are dysfunctional; to transform agriculture there is a clear need to enhance investments in self-sustaining irrigation systems.
- Agricultural Innovation Platforms help develop social learning systems where knowledge generation and innovation are driven by the incentives of more profitable farming.
- Soil moisture and nutrient monitoring tools trigger a deep learning cycle for farmers and become a trusted reference point for irrigation decision-making.
- Learning, change and accountability spreads through meaningful farmer-to-farmer interactions, engagement with extension and governance stakeholders, and market players. This provides feed-back loops to further enhance farmers learning and behavioural change.

During TISA 1, particularly in Mozambique and Zimbabwe, governments made numerous policy changes that were informed by TISA (Mwamakamba et al., 2017). In the TISA2, project interventions at Silalatshani enabled production of a more diverse range of higher-value crops in place of mandated staple commodities. Based on this economic success at a scheme previously regarded as a ‘basket case’ by national authorities, the Ministry of Agriculture no longer requires adherence to a cropping calendar. Now, farmers are free to innovate and produce more profitable crops (van Rooyen et al., 2020).

Project interventions have also led to sub-national policy changes at the local to provincial scales (often by district governments), as illustrated at Silalatshani by the agreement on how to resolve the water debt owed to Zimbabwe National Water Authority (ZINWA). Our further hypothesis is that these local-to-provincial-scale governance innovations generate examples that may catalyse further national reforms.

To inform practice and provide policy options to key stakeholders across the African continent as well as globally, FANRPAN has convened and participated in multiple policy platforms. These disseminated evidence through policy related knowledge products on the importance of transforming irrigation schemes in Africa, see Appendix 10.4. These engagements have sought to inform policy development processes and practices on the ground, as well as mobilize resources (finances etc.) towards scaling TISA interventions up, out and deep. Most of the engagements have focused on the CAADP Framework and Africa's performance in the Biennial Review, those and other meetings are outlined in Appendix 10.6.1.

The following policy briefs were developed:

- "Smart Water Management Technologies",
- "Pathways for Irrigation Development in Zimbabwe",
- "Transitioning Smallholder Irrigation Systems: Success Stories",
- "Benefits of Transforming Smallholder Irrigation Schemes Towards Achieving the CAADP/Malabo Targets",

- "Investment Priorities for Transitioning to Climate-Resilient Farming Systems in Sub-Saharan Africa".

Each brief highlights pivotal aspects of irrigation transformations needed in Southern Africa. The policy briefs have been widely disseminated, reaching over three hundred and fifty primary stakeholders in the Southern African region across the seventeen FANRPAN national nodes.

Key research findings on policy: The TISA project has been able to catalyse key policy changes. District and provincial government leaders have enthusiastically supported the interventions facilitated by TISA. National scale policy changes have taken a decade to manifest in many instances. These policy changes have occurred where: a) TISA case studies have substantially improved the performance of previously failing irrigation schemes; b) national government agencies have been directly engaged and have had leaders willing to reform policies. Substantial engagement by TISA staff with decision makers has been required. The benefits from the tools have been a key entry point to engage national government agencies on more complex, institutional opportunities (yet barriers to importing tools are only just being overcome after nearly a decade of advocacy). Reform has been hindered where leadership in key national agencies has been in flux, and in one case, with a key government agency focussed on building new schemes at the expense of rehabilitation. More disappointing has been the lack of uptake of TISA interventions by bi- and multi- lateral donors, even though these measures at very low cost would greatly improve the performance of investments of hundreds of millions of dollars. Reasons for the lack of uptake include: a focus on building new infrastructure, long planning lead times and inflexible project plans, and loyalty to existing suppliers and systems even though they are far less effective.

6.5 COVID-19

Research was conducted to address the following question:

> *How did the capacities that irrigation communities built from the project enable them to adapt to shocks from the COVID-19 pandemic?*

Through our research we compared farming households from both TISA supported and none-TISA supported schemes. Our findings indicated those households in TISA supported schemes were more resilient to shocks. For example, they had better market connections, were growing higher value crops, had higher levels of trust between farmers and their irrigation management committees, and reduced conflict was seen within the schemes as there was increased willingness for collective action.

Zimbabwe. The COVID-19 pandemic impacted both TISA and non-TISA schemes, but the magnitude of the impact differed, being lower in TISA supported schemes. This implied that TISA interventions helped farmers cope better with the shock that COVID-19 pandemic caused, and this adaptive capacity may be transferable to perturbations arising from climate change.

Before the outbreak of COVID-19 in 2020, most farmers in TISA schemes were experiencing increased farm income, and the proportion of households experiencing food shortage had declined identified in the end of project survey. Compared to 2017, over 60% of farmers

reported increases in farm income and by 2019, about 10% of households reported experiencing food shortage compared to the baseline proportion of about 80%. COVID-19 reversed the gains realized from the benefits of the combination of tools and AIP in the schemes. However, compared with non-TISA schemes, it was observed that TISA schemes performed better. Since the first COVID-19 lockdown, 30% of households within the TISA scheme reported worsening food security compared with 48% within the non-TISA scheme.

The TISA project has demonstrated that technological and social interventions can have pervasive impacts on adaptations in farmers' fields, households, communities, and wider food markets. Generation of greater socio-economic benefit is being decoupled from increasing land utilisation and water consumption. Better water productivity and diversification of household income-generating activities has enhanced adaptive capacity, as demonstrated by improved food security. It has also improved participation in irrigation association meetings and willingness to pay for and contribute to scheme maintenance. These findings from Zimbabwe point to ways in which climate adaptation and resilience in agriculture in Africa can be greatly enhanced at modest costs with appropriate technologies (in this case, soil monitoring tools) and social capacity building processes.

Tanzania. The capacities that irrigation communities built from the project activities enabled them to adapt to shocks (particularly increased input prices and lack of market access) from the COVID-19 pandemic in several ways. As there were no lockdowns in Tanzania, the AIPs remained as the key vehicle for organising farmers together in and between schemes, which enabled them to gain access to financing from financial institutions for their farming inputs, access to output markets, and maintain and make minor repairs to the irrigation infrastructure. At the individual household levels, farmers' productivity and incomes improved over the project implementation period enabling them to increase household wellbeing, support the education of their children and afford cost for access to health services. Households also diversified non farming livelihood income sources by investing increased income from irrigation. All these contributed to their improved adaptive capacity to shocks from the COVID-19 pandemic as compared to non-TISA irrigation schemes in the project area.

Mozambique. Since the outbreak of COVID-19, farmers faced numerous challenges, particularly in acquiring input supplies. There was limited availability of inputs, and the prices were very high. Disadvantaged groups in the scheme, such as widowed farmers, female-headed households, and youth, were unable to afford these inputs, especially since they had to travel to Maputo City to acquire them. Through the AIP, a partnership with a local agricultural input supplier was established to provide the inputs directly to the scheme without additional costs.

TISA interventions in the schemes improved water management, crop productivity, market and community linkages. The access to resources and social capital improved household resilience and their capacity to adapt to external shocks, such as the COVID-19 pandemic compared to non-TISA schemes.

Key findings on COVID-19 responses: We found that the irrigation communities participating in TISA were more resilient to the shocks induced by the COVID-19 pandemic compared to similar communities who were not engaged. For example, greater food security was evident in TISA

communities in Zimbabwe. We ascribe this to the greater resources built up in TISA schemes and the higher social capital in these communities, including trust, problem solving skills and more effective local governance institutions. We consider COVID-19 to be a surrogate for the kinds of shocks anticipated from climate change, such as droughts and floods. Thus, the interventions facilitated by TISA greatly aid climate change adaptation.

6.6 Climate smart

Research was conducted to address the following question:

> *How "climate smart" are the irrigation improvements (institutional, technical, and non-technical) promoted by the project research for the irrigation communities?*

We used the following description of the climate smart agriculture as having three pillars, namely, (i) it seeks to increase productivity by sustainably intensifying agriculture; (ii) it seeks to enhanced resilience by adapting to climate change; and (iii) it seeks to reduce greenhouse gas emissions. Analysis of research surveys were conducted to assess, and some examples are presented below. Each country developed case studies (Appendix 10.4), which were shared with respective governments and at the UN Framework Convention on Climate Change COP 27 in November 2022.

Zimbabwe. The results from the end-of-project survey of 2021 of both TISA I and 2 schemes, indicated that there were considerable changes in irrigation practices due to irrigators learning from using the soil monitoring tools. About 80% of farmers had changed their irrigation practices by 2021 and in TISA I schemes 94% of farmers indicated that they were still practising changes they made before 2017. The irrigation improvements occasioned by using smart soil moisture and nutrient monitoring tools resulted in most of the irrigators reducing the frequency of irrigation from an average of seven days to fourteen days. As a result, water productivity (kgs/m3) increased from 0.20 to 1.28 in 2016/17 and was 0.98 in the 2020/21 season, improving agricultural productivity and enhancing resilience. This demonstrated that the benefits accruing from improved irrigation practices as a result of using the tools decoupled the need for increased water use to increase productivity, which is consistent with climate smartness where water stress within irrigation schemes due to low water levels in reservoirs has become a reality. As indicated earlier, the use of the tools led to a reduction in irrigation frequency. Farmers lengthened the period between irrigation events, reduced the number of siphons used per irrigation event, and the duration of the event. This reduction in irrigation frequency, saved time, and reduced fertilizer leaching due to over watering. By reducing the frequency and duration of irrigation events, the time that farmers saved was diverted to other uses such as enhanced crop management or off-farm income generating activities. These helped the TISA farmers cope better with shocks, an important aspect in enhancing climate change resilience. The AIP facilitated market linkages and as a result over 60% experienced increases in farm income, an indicator that the non-technical interventions also played a key role in enhancing the resilience of farmers in the scheme.

Mozambique. Due to the TISA interventions 64% of the tool using farmers from reported that they reduced their irrigation frequency from five days to nine days on average; and 93% reported that they reduced the duration of irrigation events, from 18 hours to 12 hours on

average. In addition, the farmers reported important benefits from using the tools, including saving water (82%), saving time (67.57%), saving labour (55.41%) and increased yields (50%). Accordingly, irrigation schemes now have more water to irrigate other portions of the scheme. This represents an important contribution to improving water resources management and farmers resilience to climate-related risks.

Tanzania. Surveys of farmers' experiences and observations and farmers' responses to COVID-19 pandemic at farm, household and community scales demonstrated that livelihoods, and therefore resilience to shocks, were improved. Improvement of the livelihoods and resilience resulted from greater productivity and profitability in the irrigation schemes. Both the reduction in water use and the amount of nutrients leached contributed to enhanced climate change resilience and reduced GHG emissions. Table 6 presents the results of our research in Tanzania on how COVID impacts the household/ farm / scheme were reduced, a surrogate for resilience to climate change impacts.

Table 6 *How did COVID impact your household/farm/scheme.* Selected responses to questions.

Topic questioned	Overall	Kiwere	Magozi	Non-TISA Schemes
How did COVID impact your household/farm/scheme?	n=200	n=100	n=100	n=100
Impacted it positively	11.5	23.0	0.0	0
No Impact	1.5	3.0	0.0	0
Minor negative impact	25.0	26.0	24.0	20.0
Moderate negative impact	40.5	28.0	53.0	49.0
Severe negative impact	21.5	20.0	23.0	31.0
What did it mean that a household member returned due to COVID (Multiple answers)	n=12	n=9	n=3	n=4
they brought the virus	0.0	0.0	0.0	0
increased household living cost	33.3	33.3	33.3	0
challenged our ability to provide sufficient food for the household	16.7	11.1	33.3	100.0
increased conflicts within the household	0.0	0.0	0.0	0
increased our available labour so we have increased our farming activities	41.7	55.6	0.0	0
Increased off-farm work income	8.3	0.0	33.3	0
How did the lockdowns affect you, and your farming operations (Multiple answers)?	n=437	n=218	n=219	n=100
Access to inputs	31.4	38.1	24.7	77.0
Access to output markets	35.0	29.4	40.6	98.0
Access to labour	3.9	6.0	1.8	3.0
Access to information	2.7	3.7	1.8	3.0
Access to financial institutions, banks, micro lenders, Mobile money	2.3	2.8	1.8	6.0
Reduced production and farm income	18.8	16.5	21.0	54.0
The fear of COVID contamination has reduced demand for some crops	5.7	3.7	7.8	8.0
How did COVID and the lockdowns affect your scheme (multiple answers)	n=307	n=136	n=171	n=86
Farmers unable to pay their water/membership fees	32.9	35.3	31.0	74.4
Maintenance jobs have not been carried out	13.4	14.0	12.9	20.9
Extension officers could not get to the scheme and help	32.2	28.7	35.1	44.2
Other stakeholder who provides advice could not come to the scheme	20.2	19.9	20.5	38.4
More land farmed as family members returned to the scheme	1.3	2.2	0.6	3.5

Topic questioned	Overall	Kiwere	Magozi	Non-TISA Schemes
The three biggest impacts of COVID on household	n=443	n=205	n=238	n=100
Household food security	10.6	9.3	11.8	26.0
Health of household members	2.5	4.4	0.8	5.0
Declining farm income	35.7	35.1	36.1	91.0
Declining off-farm income	15.8	16.6	15.1	45.0
Household conflicts	0.5	0.0	0.8	1.0
Decay of irrigation infrastructure	3.4	2.4	4.2	6.0
Children's education delayed	31.6	32.2	31.1	65.0
Farmers within this scheme have coped better with COVID than other members of the community				
Non-farmers	77.0	77.0	77.0	74.0
Dry-land farmers	66.5	69.0	64.0	67.0
Other	73.5	74.0	73.0	69.0
Think their scheme has managed the impact of COVID better than other schemes in the district	79.0	72.0	86.0	81.0

Key findings on climate smart impacts: As detailed above, we consider COVID-19 to be a surrogate for the kinds of shocks anticipated from climate change, such as droughts and floods. Thus, the interventions facilitated by TISA greatly aid climate change adaptation. In particular, the dramatic increases in water use efficiency seen in the participating TISA schemes enabled finite water supplies to be eked out longer, enabling more crops to be finished in the increasing numbers of dry seasons. Further, the increased profitability of farming, diversification of livelihoods and enhanced social institutions have improved the resilience of these communities to climate change impacts.

7 Impacts

Addressing the UN General Assembly on 23rd September 2023, Australian Minister for Foreign Affairs and Trade, Senator Wong, proudly said that "We are supporting improved food security in some of the most vulnerable communities in the world, including with irrigation technology that has improved crop yields and reduced water usage by 30% for farmers in countries including Malawi, Mozambique, South Africa, Tanzania and Zimbabwe."[10]The Transforming Irrigation in Southern Africa project was presented the 2022 Excellence in Practice Award for Ecosystem Development from the European Foundation for Management Development.[11]

7.1 Scientific impacts – now and in 5 years

Our project focused on impacts for: farmer learning, better understanding how to increase the effectiveness of innovation platforms, better ways of combining technical and institutional interventions and increasing equity. Our scientific publication and other communication outputs are summarised in section 7.4 below.

Noting some particularly significant scientific outputs, two *International Journal of Water Resources Development* (IJWRD) special issues have been published[12], as well as a range of other journal articles and conference papers, reporting the project findings from the use of the two synergistic interventions soil water monitoring tools and the AIPs.

Since start of TISA 2, 41 journal articles, and book chapters have been published and a further four articles are under review. The article published in the journal Nature, Beyond fertilizer for closing yield gaps in sub-Saharan Africa, has received an Altmetric Attention Score of 25, which is their high-level measure of the quality and quantity of online attention. Additionally, conference papers, web pages, videos and news articles have been presented or published; details are contained in Annex 10.1.

The 'How we guide' continues to be shared by the country teams and translation into Swahili and Portuguese have been finalised and will soon be distributed. On ResearchGate, there have been 2,194 'reads' and four citations of the guide.

The key scientific impacts of the TISA 2 project, as evidenced by the high read and citation rates for academic publications listed above, are:

a. Showing why so many small holder irrigation schemes are failing in Africa, namely because the schemes are not profitable when directed by governments to grow staple crops as opposed to enabling farmers to respond to markets and produce high value

[10] https://www.foreignminister.gov.au/minister/penny-wong/speech/national-statement-united-nations-general-assembly

[11] https://www.aciar.gov.au/media-search/news/water-research-africa-wins-european-development-award

[12] The papers in both special issues have had 163,928 views, 546 CrossRef citations and an Altmetric of 295; details are contained in Appendix 10.5.

commodities. Our research shows that when farmers are enabled to grow high value crops that irrigation schemes come close to being financially self-sustaining in operations and maintenance – a core test of sustainability;

b. Arguing that the agricultural research community has erred in its focus on yields and crop fertiliser rates rather than understanding irrigated agriculture as complex systems facing multiple barriers and requiring mixed interventions to succeed;

c. Demonstrating with soil monitoring tools that farmers can undertake autonomous learning and use water more efficiently at the field scale, unleashing a cascade of economic and social benefits;

d. Showing that participatory mapping of irrigation schemes has a positive, catalytic effect in building trust, clarifying roles, raising user fees, providing ownership/tenure clarity, improving infrastructure management and enabling access to finance;

e. Demonstrating that enabling farmers to experiment and learn themselves drives innovation. In particular it enables productive, demand driven extension rather than ineffectual ‘top down’ extension;

f. Facilitating social learning is a most effective way of out-scaling innovation and change within schemes and can also be used across schemes;

g. Challenging previous understanding (Makini et al. 2013) of Agricultural Innovation Platforms by showing that low cost, effective innovation is possible at the district scale and with AIPs that are convened by government officials and local stakeholders with a ‘facilitation mindset’;

h. Showing that the multiple simultaneous technological and social interventions (in our case, the tools and AIPs) facilitated by TISA enables communities to become more resilient by using water more efficiently, diversifying local economies, increasing wealth and social capital. This reduced impacts of the COVID-19 pandemic on participating irrigation communities suggesting an increased ability to adapt to climate change as well;

i. Demonstrating how small holder irrigation schemes can be managed to improve the agency and livelihoods of women and young people, and reduce poverty;

j. Showing that it is possible to scale up these complex interventions for more profitable and sustainable irrigation at regional and national scales, but it takes successful case studies, a long time (around a decade) and engagement of government leaders.

k. Demonstrating that multi-stakeholder forums can enable schemes to develop plans with locally-appropriate interventions that can harness and focus community and external resources to improve scheme functionality and livelihoods.

There are a number of key research outputs being submitted or in peer review at the time of writing that will further enhance the scientific impacts of TISA.

7.2 Capacity impacts – now and in 5 years

During this scaling phase of research, the project team implemented fewer on ground activities. To enable this, capacity building of stakeholders was required at multiple levels to assist with the up and out scaling of activities. At least 2,350 people have attended a variety of capacity building events, see Appendix 10.2.

Partner district and national government agency staff

To date, 276 government staff have participated in formal TISA training events. Additionally, many informal interactions have occurred.

In Zimbabwe, Masterclass trainings produced trainers of others with the public sector extension system. Through this capacity building, a critical mass of knowledgeable local extension officers is now available in country to scale out of the innovation beyond both the geographic areas of the project and life of the project. The capacity building workshops attracted senior managers from the Ministry of Agriculture's Department of Irrigation. Building capacity of staff from the Department of Irrigation, in addition to demonstrating evidence of the benefits of the simple-to-use, was key in also scaling up the uptake of the technology. Further, the Department of Irrigation research unit, the Zimbabwe Irrigation Technology Centre (ZITC), were provided with the tools, and they then validated their performance in the context of the smallholder irrigation. The Government of Zimbabwe, through the Department of Irrigation, has embraced the technology and indicated plans to acquire the tools to support improved water use efficiency in smallholder irrigation farming across the country.

In Mozambique, to build sustainability, during training sessions, 168 key extension officers from district level governments were trained, along with farmers on the soil moisture monitoring tools. INIR has mandated use of the tools in three large scale irrigation development programs beyond TISA.

In Tanzania, the team have conducted formal trainings for 44 district government staff and NIRC staff on the use of the tools and establishment and management of innovation platforms.

Farmers

Since the start of TISA 2, 754 TISA farmers have participated on the VIA platform, 924 farmers have participated in training events, and 1,100 farmers have used farmer field books for water and crop management and gross margin analysis. The training events around the use of field books and gross margin analysis was extended to farmers without the tools. The training activities have included: record keeping, financial management such as managing inputs loans, use of soil and water monitoring tools, management of farm field books, AIP facilitation, and VIA tools master classes.

In Mozambique, one example was the TISA team facilitated theory and practice-based water monitoring tool training with 77 men and women from 4 schemes on the 12thOctober 2021. Farmers who have mastered the use of the tools led this, which, in addition to explaining the functionalities of the use of the tools to the other farmers in the schemes, was testimony to the

impacts they verified during the use of the instruments. This is important evidence of the expansion of new skills and knowledge driven by the farmers themselves that resulted in a more sustainable use of water in the irrigation schemes.

Household survey results indicate that 75.5% of the scheme farmers' who had access to tools, affirmed that they have learnt enough from using them, and have increased confidence in maintaining the new irrigation regime. Additionally, between 67.6% and 81.8% of these farmers stated that the most important benefits from using the tools have been the water saved and labour time saved.

In Tanzania, one example was through the AIP process at the Igomelo scheme, farmers have visited other schemes to offer training and experiences, but they also received in their scheme men and women from nearby schemes. During training visits, farmers were able to learn about the collection of organisation and maintenance fees, infrastructure managements, good agronomic practices, and use of soil and water monitoring tools. Through the ongoing AIP support, the scheme leaders have become more innovative and confident about the issues they want to pursue in the AIPs as well as when facing their respective value chain stakeholders.

In Zimbabwe, training farmers to enhance water use efficiency in irrigation schemes has been an ongoing activity. Evidence from the end of project survey shows that participating in these training had positive impact on the viability of the irrigation schemes. In Silalatshani, almost 80% of the farmers that participated in gross margin trainings indicated that it had made a positive impact on their household income. During the TISA 2 phase, seventeen additional irrigation schemes were engaged involving 1,600 farmers. Results from the end-of-project survey indicated that 96% of the farmers had changed their irrigation practices since the tools were first introduced in 2017. Fifty-five percent of these farmers indicated that they had learned enough and would not revert to their old irrigation practices regardless of whether they had tools.

It is the changes in practices by farmers that have encouraged district, provincial and national government agencies to apply the TISA interventions more broadly within their jurisdictions.

Research partners

Research partners have developed their capacity to manage multi-disciplinary research projects that integrate different disciplines, including social sciences, natural sciences, soil sciences and agronomy. In addition, the teams and academic scholars have continued to benefit from collaborative work including significant capacity building in survey design, implementation, and analysis and to prepare peer-reviewed academic papers of international standing, see section 7.4, appendices 10.1, 10.5 and 10.6. For example, Prof Bjornlund has collaborated with members of the country teams to develop three case studies for the UN COP 27 conference and three journal articles: one on participatory mapping (Tanzania, Mozambique, and Zimbabwe), one on scheme operation and maintenance costs (Tanzania and Mozambique) and one based on scheme input costs (Tanzania). Currently work is underway on finalising country specific papers for the third special issue. A number of African and Australian scholars have completed or are undertaking research degrees working on TISA, see table 7. Graduates are now contributing to sustainable agricultural development.

Table 7: Summary of TISA related training activities

Who	Proposed training focus	Progress
African academic institutions	Graduate and Postgraduate degrees. Working with African universities, the project will support masters' students.	Engagement of masters students in African universities has proven more difficult than anticipated due to cost and limited, suitable courses. Nevertheless, there have been some progress engaging African students. Mr Thabani Dube, due to COVID-19 issues, postponed his PhD. He is now in the process of recommencing it on out-scaling models in Zimbabwe. Ms Charity Mapira, MSc completed at Lupane State University, Zimbabwe. She investigated the efficacy of using the tools for improved productivity at Tshongokwe irrigation scheme in Matabeleland North. Mr Emmanuel Kimaro in Tanzania completed his masters program through the University of Dar es Salaam. Mr Michael Assefa has enrolled in a PhD studying agricultural economics at the University of Fort Hare, Alice, Eastern Cape, South Africa Mr Aristarick Mkenda was mentored by UniSA to write a journal article on the Pangani Basin, Tanzania, which is now published. See appendix 10.1
Australian and other academic institutions	Postgraduate degrees linked to project research	Ms Felicidade Jorge is enrolled in a PhD at Bonn University on 'Do Agricultural Innovation Platforms and soil moisture and nutrient monitoring tools improve the production and livelihood of smallholder irrigators in Mozambique? Dr Karen Parry PhD. Karen completed her PhD on 'Young people's livelihoods on small-scale irrigation schemes in Zimbabwe'. She is currently completing four thematic chapters on engagement in the local economy and the macro, community and household and individual influences on livelihoods. Implications for policy, agricultural research-for-development and future research will be drawn from these chapters. Dr Fentahun Addis Abebe PhD. Completed his PhD on farmer willingness to pay for tools. Dr Michael Wellington. Michael completed his PhD on examining changes in water use efficiency and crop production following irrigation scheme interventions. Ms Xolile Ncube has started her PhD on 'Approaches to scaling of innovations initiated by Agricultural Innovation Platforms (AIPs) for sustainable smallholder irrigation schemes in Zimbabwe.'

7.3 Community impacts – now and in 5 years

In all the irrigation schemes the outputs of the two pronged approach of AIP process and simple tools have led to remarkable community impacts. This approach has instilled skills and experience, creating confidence among farmers that they can effect change leading to iterative, self-reinforcing reforms. Indicative of this impact is the renewed collection of water fees by

irrigation associations in all three countries, leading to communal efforts to repair and improve infrastructure, activities beyond the TISA project activities. This is illustrated in the following examples.

In Zimbabwe, the use of the tools in some schemes, such as Lukosi and Hauke has improved the availability of water for other water users within the community. Anecdotal reports indicate that conflicts that took place between irrigators and other community members before the use of tools have reduced due to prolonged supply of water in the dams resulting from the reduced use by irrigators. At the Tshongokwe scheme, despite water supply challenges, the ability of the farmers to produce crops through prudent and efficient water management practices has allowed them to secure better markets and benefit the community.

Additionally, AGRITEX and the Department of Irrigation have aided the scaling up the technologies. Engagement with development programs within the project districts and beyond has contributed to scaling out of the tools. An example is the work of the Zimbabwe Resilience Building Fund (ZRBF) funded projects; SIZIMELE in Matabeleland North and Enhancing Community Resilience and Inclusive Market Systems (ECRIMS) in the Midlands Province that have benefitted communities in several parts of Zimbabwe.

In Tanzania, the increases in income from farming have enabled more people in the community to benefit. For example, young people who ride motorcycles generate income by transporting farmers' produce to market, carrying farmers to and from the scheme and transportation of farm inputs to the scheme. Farmers are using available labour in the society, even people who do not own plots in scheme get income to support their families. Farmers in nearby schemes such as Luganga (near to Kiwere) and sharing same agriculture extension officer during the first phase of the project were able to adopt good farming practices based on implemented interventions in the project schemes. Several local NGOs and development organisation, input supply companies were attracted to establish demonstration farmers field plots in the project schemes because of TISA interventions. The district councils and National Irrigation Commission highly valued the use of scheme maps produced through the research.

In Mozambique, through project facilitated activities, farmers in several schemes are now benefitting from visits by agricultural input suppliers' mobile shops. The farmers are now able to buy inputs at the same price as in the city with no added travel cost. Further, they can buy certified inputs which are leading to increased production and profitability. These results will also benefit an extensive community of farmers located around the target irrigation schemes who also had problems accessing certified seeds and fertilisers.

The community impacts from TISA are substantial, self-reinforcing and are scaling out.

7.3.1 Economic impacts

The initial research phase in TISA I documents several positive economic impacts. For TISA 2, during the scaling phase, these beneficial economic impacts have continued and fall broadly into the following categories, policy reform, improved land tenure, greater access to finance, more efficient resource use, and better market access. Some examples of economic impacts include:

***Policy reform, improved land tenure, and greater access to finance*:** In Tanzania, banks have changed their policy and reduced the interest rates applied to agricultural loans from 16% to 9%. From our research, the linkages established between farmers and financial institutions through the AIP process, and the clarity of land tenure from participatory mapping, have been particularly beneficial. Financial institutions have recognized farmers plot details (boundary, size, ownership) from scheme mapping database as a requirement for provision of loans. It has enabled 411 male and 204 female farmers from irrigation schemes to access loans from the CRDB Bank for purchase of seeds and fertiliser. The loan access has expanded to other schemes as a result of increasing farmers' confidence, and their ability to network with financial services providers and other stakeholders through the AIP process.

In Mozambique, thanks to the AIP interventions in the irrigation schemes, farmers have become more aware of the various requirements and policies of different financial institutions. The AIPs have allowed an open space to ask questions and get answers in language that was very helpful to the farmers. Because of this newfound knowledge, farmers at one scheme were able to organize themselves and obtain a loan to buy a motor pump for irrigating a new area within the irrigation scheme.

More efficient resource use: In all the countries, the monitoring of soil water and nutrients monitoring tools and exchange of information, innovation and knowledge between the stakeholders and farmers demonstrate significant contribution to improved incomes and to improved food security among the farmers. The reduction of irrigation frequency and water use resulting from the adoption of the learnings from the tools used to manage soil moisture and soil nutrients as well as the timing of irrigation events has contributed to increased productivity, labour saving, and more effective use of fertilizers. All this has led to increased profitability, household income and food security in the schemes. In Mozambique, the TISA household survey found that on average, farmers who four years ago watered after 4.7 days now start watering after 7.4 days. This has had an important impact on farmers' income, as they have reduced the amount spent to buy fuel to pump water as well as being able to reallocate labour.

In Tanzania, scheme-based field trials on improved crop varieties in 2020, demonstrated that farmers can double the size of maize cobs by growing improved varieties and that the improved varieties can grow well in their schemes. The farmers have adopted these varieties.

Better market access: In Mozambique, AIP meetings were held with the irrigation farmers associations schemes and TECAP (commercial agricultural inputs and services provider) representatives). They debated the main opportunities to facilitate better access to agricultural inputs. This resulted in the identification of models for local distribution of the key inputs, as well as the seasonal distribution of inputs according to the association's plans. Agricultural supply shops were then established in the irrigation schemes managed by the farmer associations with assistance from TECAP. The farmers are now benefiting from quality agricultural inputs and services. The farmers have also developed production plans in each scheme and on the integration of individual needs into the association's plan.

In Zimbabwe, farmers at different irrigation schemes started producing crops under contract farming arrangements. Sugar beans were the most contracted crop. This has provided farmers with assured markets for bulk buying of their produce and the ability to receive lump sum

income. Additionally, in the absence of credit facilities, it has allowed farmers to access inputs such as quality seed from some of the contractors. At the Lungwalala irrigation scheme, farmers were contracted by the Agricultural Development Authority (ARDA) and World Wide Fund for Nature (WWF) to produce small grain seeds (sorghum and pearl millet seed). With the improved crop production on schemes such as Landela, Hauke and Tshongokwe, there was establishment of value-addition activities at schemes to enhance farmers' incomes. These activities included oil seed crushing and pressing, grading and packaging of sugar beans, processing of crop residues to improve the feed value for livestock, and on-scheme and off-scheme shelling of cereals.

Through the AIP process, the capacity of farmers in gross margin analysis was developed and farmers were also introduced to high value crops. The end-of-project survey found that these activities had a positive impact on the household income. This also applied to AIP activities that aimed at improving market linkages. Over 80% of farmers that participated in these activities experienced increased household income. The fivefold increase in water use efficiency from 0.2 kgs/m^3 at the baseline and improved market linkages have increased household incomes and had a positive impact on the well-being of the majority of farmers. Most farming households reported that their capacity to pay for their children's education, meet their food and health requirements had increased during the first phase of the project. At least 80% of the farmers by the end of the project have indicated that their wellbeing had either remained unchanged or had further increased.

7.3.2 Social impacts

The project has had considerable social impacts in terms of greater equity, cultural changes including greater farmer self-confidence, building trust among the scheme stakeholders and reduced conflicts. Examples from each of the countries include:

Equity

The research has several important impacts on the improvement of equity (we have defined equity broadly to include gender, and other disadvantaged groups) in each country, the following are examples.

In Mozambique, new irrigation plots were created, and male and female young farmers were given access to these plots. Land access is a key barrier for young farmers to enter farming; hence, scheme-initiated implementation of new institutional arrangements to improve access is an important impact.

During TISA, using the Chameleon soil water sensors and Wetting Front Detectors has led to a decrease in water usage. This has made farmers feel that water distribution was fairer and that the water supply became more dependable. These changes in water supply, coupled with higher household incomes, motivated farmers to become more willing to engage in scheme maintenance and cover the costs of using water. These developments have had several positive effects. Firstly, they enhanced the sense of fair water sharing among the farmers. Secondly, it made the water supply more reliable and consistent. This, in turn, encouraged

farmers to actively participate in maintaining the irrigation system ensuring the sustainability of the scheme.

In Tanzania, female-headed households on Kiwere (unmarried females and married females) have increased their farm and non-farm incomes as a proportion compared to male-headed households. At Magozi, unmarried female-headed households increased their non-farm income as a proportion of male- and married female-headed households. On both schemes there has also been a significant increase in more balanced and cooperative decision-making between spouses for rainfed and irrigated crop production.

TISA interventions on soil water monitoring tools have contributed to greater equity in water access within the schemes and between head-end, middle and tail-end farmers. For example, the introduction of Chameleon soil water sensors and Wetting Front Detectors and monitoring in schemes such as Kiwere, Lipuli, Igomelo, Nyamahana and Mafuruto demonstrated that farmers at the head end allowed more water to flow to tail end plots by reducing irrigation frequency and reduced time for irrigating a plot. As a result, crop production and income of tail end farmers increased, enabling these farmers to participate in community development activities.

Initial results in a TISA research paper found that the TISA two-pronged approach has contributed to increases in income and household spending for the disadvantaged group, and a narrowing of the gap in income between households.

In Zimbabwe, unmarried female-headed households increased their farm income between the beginning and end of the project. Tail-end users' farm, non-farm and net income was less than head-end users on Silalatshani at the beginning of the project, but by the end of the project tail-end users' income exceeded head-end users. This is an important equity impact, as tail-end users often face water supply issues when supply is limited.

Culture

Reduced conflicts. In each country household and water conflicts have diminished, for example:

In Mozambique, farmers reported that conflict over land has been reduced as result of the participatory mapping, AIP process and local authority's interventions. In the 25 de Setembro irrigation scheme, some farmers from outside who had a dispute with farmers from the scheme have now been integrated into the scheme association and given a portion of the land to cultivate.

In Tanzania, water use conflicts have decreased, which has been good for the social relations between farmers. However, both the Magozi and Mlenge schemes were negatively impacted by the 2020 and 2021 floods, and diversion of the river course through the schemes.

In Zimbabwe, water use conflicts between farmers in the schemes have been reduced or eliminated. Results from the end of the project survey showed that because of the reduction in the irrigation events, about 60% of farmers had reallocated the time they had saved from irrigation activities to household work and being with their children.

Individual and community confidence. Individual and community confidence has increased as result of project activities, some examples include:

In Mozambique, the project invested in building farmers capacities, creating incentives and opportunities to increase communication, knowledge sharing and learning. As a result, farmers claim to have more robust farmer organisations, conflict in the community was reduced due to better cooperation and dialogue in the decision-making processes. The farmers are more confidence in their skills in relation to irrigation and application of fertilisers. Farmers also state that their ability to better manage production costs, calculate gross margins and control the level of profitability is increasing farmers' incomes, resulting in improved livelihoods.

In Tanzania, farmers have had the chance to interact with farmers from other schemes and share experience. These interactions have enabled them to learn new farming practices such as the use of improved varieties, and both yields and incomes have improved.

In Zimbabwe, the social benefits are linked to economic impacts. Farmers report an improved ability to afford social services such as education and health of the family members, as well as reduced household conflicts.

Increasing trust and unity in the schemes

The participatory mapping process in all three countries increased trust, unity and agency by clarifying plot sizes and identifying problems affecting some farmers productivity and their causes. Knowledge of the problem became public and hence a shared responsibility for resolving the problems emerged (Mdemu et al., forthcoming paper).

In Mozambique, participatory mapping of irrigation schemes had several important benefits. Firstly, it has improved INIR’s ability to plan effectively by providing a clear picture of how the irrigation scheme is structured. Participatory mapping has made it easier to identify and resolve problems, such as damaged infrastructure and areas of land that were not being used efficiently. In some irrigation schemes, areas that were not in production are now rented by other farmers who want to expand their farming practices.

Furthermore, the collaborative approach has had a positive impact on the farming community. It has encouraged farmers to get more involved in the management of the irrigation scheme, fostering a sense of ownership and responsibility. Farmers are now more aware of what is happening within the scheme and where improvements are needed. This increased awareness has led to a more engaged and proactive farming community.

In Tanzania, the mapping exercise has enabled farmers to know the size of plot owned by individual farmers so that they understand exactly amount each farmer should contribute in fees to the scheme. Previously, farmers didn’t trust size of plots reported by their fellow farmers, since most of farmers were under reporting sizes of their plots and it was not clear who held each of the plots in the scheme. The mapping exercise brought farmers together and increased awareness of the challenges in the scheme. Through discussions the farmers build trust and unity among themselves and their leaders.

Bank officers used the certificates of land holding and discussions with farmers to decide on loans. One of the conditions to receive loan was to be trusted by fellow farmers. The farmers were responsible for advising on who should be given a loan and how much s/he should be lent. To receive a loan in the next season, all loans were supposed to be repaid. This created an incentive for the community to ensure that everyone paid back his or her loan.

Teamwork, roles and responsibilities. The AIPs have fostered teamwork and the roles and responsibilities of various stakeholders have been clarified.

7.3.3 Environmental impacts

Irrigation schemes can have considerable negative environmental impacts. The TISA interventions have enabled farmers to reduce the application of water onto fields by a third to a half.

At the scheme level, as farmers have increased their understanding of the water needs of their plots and crops, the numbers of irrigation events have reduced. This has reduced water logging and leaching of fertilizers and pesticides. The leached nutrients may enter water and river systems and so contribute to pollution and the build-up of nitrogen. For example, in the Igomelo scheme, a male farmer (45 years) used to irrigate almost every day. Whenever he saw water running in canal he used to irrigate even if it was not his turn, when we introduced the tools the irrigation organisation leaders proposed that he take readings with an extension officer. The first season he continued with his behaviour and produced 70 onion bags of 120 kg each, but after learning from neighbouring farmers that their yield was 90-120 bags of 120kg each with less irrigation, he decided to reduce irrigation frequency.

There have been challenges trying to scale up the benefits. In Tanzania, the team engaged with the Rufiji River Basin Water Board to encourage them to adopt the tools in all irrigation schemes. However, tool deployment was a low priority for the Board as they have inadequate funds to acquire them.

The mapping of irrigation schemes identified areas with salinity, flooding and water logging, some of their causes as well as solutions, the affected farmers, and the other farmers contributing to the problem. The knowledge of these challenges has enabled communities to identify solutions. In some cases, scheme leaders communicated the need for support to government authorities. For example, the mapping of the Magozi scheme enabled the irrigation organisation to use the data on scheme size to negotiate with Rufiji River Basin Board to review and increase their water permit.

Jevon’s paradox suggests that using water more efficiently may result in greater water use and concomitant environmental impacts in river systems that are water scarce in the dry season. TISA has not directly addressed this risk. Each of the national governments have ambitious plans to expand irrigation infrastructure but have limited capital to do so. In our view, the increase water efficiency catalysed by TISA demonstrates the sustainable agricultural intensification need to feed a growing population with limited land and water.

7.4 Communication and dissemination activities

Our academic publications continue to be well received.

Since start of TISA, 41 journal articles, and book chapters have been published and a further four articles are under review. Additionally, conference papers, web pages, videos and news articles have all been presented or published; details are contained in Annex 10.1

The two *International Journal of Water Resources Development* special issues continue to be well received; by the 18th August 2023, the first issue of 10 papers had 61,278 views, 273 CrossRef citations, and a total Altmetric of 120. The second special issue published in 2020, has already seen considerable interest, with 92,541 views, 222 CrossRef citations, and a total Altmetric of 166. The papers in both special issues have had 163,928 views, 546 CrossRef citations and an Altmetric of 295; details are contained in Annex 10.5.

Since 2017, 65 meetings and conferences have been attended at both national and international levels, for details see Appendix 10.6.1. For example, the *World Water Conference* (WWC) in 2021 in Daegu, Korea included the IWRA XVII Congress Special Session supported by ACIAR. We had two special sessions and presented ten papers.

TISA was successful in winning the Gold Award in the Ecosystem Development category of the2022 European Foundation for Management Development (EFMD) Excellence in Practice Award.

To share lessons from our work, FANRPAN organised Regional Climate Smart Agriculture Policy Dialogue from 13-15 March 2023, at the University of Pretoria, Future Africa Campus under theme '*Transitioning to climate-resilient farming systems in Sub-Saharan Africa.'* It provided an opportunity for stakeholders from Sub-Saharan (SSA) to reflect together and develop recommendations to help to build Climate Smart and Resilient Farming Systems, as well as to craft massages to feed, into the UN 2023 Water Conference deliberations. Many of the team gave presentations including Dr Moyo who presented: *The transition of dysfunctional irrigation schemes towards Complex Adaptive Systems: The role of Agricultural Innovation Platforms.*

FANRPAN has continued to widely disseminate TISA results and policy briefs, which provide policy options recommendations and seek to inform practice to key stakeholders across the African continent as well as globally. Most of the engagements have been anchored on the CAADP Framework and the performance of Africa in the Biennial Review process. Following the launch of the Third Biennial Review Report of the CAADP Malabo Declaration commitments, FANRPAN recently convened a multi-stakeholder regional dialogue to discuss the results and explore strategies for scaling up, out and deep TISA and other irrigation interventions to improve the agricultural performance of the Southern African region and continent.

For a full list of publications, see Annex 10.1 an excel file, which tracks published documents in the ACIAR format. Also see Annex 10.6 'Communications and dissemination activities', which includes references for the published book chapter and journal papers, as well as academic

papers under review and outlines key conference at which TISA related presentations were given.

8 Conclusions and recommendations

8.1 Conclusions

The TISA 2 project demonstrated how integrating socio-institutional innovations and technical interventions can transform dysfunctional government-controlled irrigation systems into functional, profitable, and adaptive schemes. Decaying infrastructure and ineffective water user associations are obvious problems. Classic irrigation revitalization projects focus on rehabilitating infrastructure and strengthening water user associations. These are, however, merely the symptoms, focussing on these only results in the well-known irrigation build-decay-rehabilitation cycle.

The research assumed that irrigation schemes are complex systems. There are many interacting stakeholders within and beyond the scheme, numerous components and factors determining the flow of stock, different incentives, often conflicting objectives, and considerable inequalities. The multiple interactions and feedback mechanisms between the parts and stakeholders govern the overall 'behaviour' of the system. Consequently, the system generates its own behaviour, often with unexpected outcomes. Thus, single interventions that only treat the symptoms will not bring about positive change.

What are the underlying causal relationships? And how does one fix them?

The AIPs spent significant time analysing the challenges from the farmers' perspective, the extension system, and, in some cases, the irrigation management systems. Finding the root causes of the apparent problems provided critical insights into the schemes' challenges. The diverse challenges often interacted with one another, resulting in systemic blocks. For example, unpaid water bills in Silalatshani compelled ZINWA to shut off water supplies to the farmers during critical production stages - creating animosity between farmers and the water authority and ultimately reducing production capacity. Similarly, the government regulating the cropping calendar and the types of crops to be grown reduced profitability and, therefore, the incentives to utilize irrigated plots effectively. Unprofitable enterprises reduce the incentives and capacity to invest – so farmers do not pay fees, and scheme infrastructure decays. The root causes of scheme decays are thus complex - and require more than technical interventions and stricter water management bodies. The AIP process identified similar blockages in Tanzania and Mozambique.

Inefficient irrigation strategies, various challenges with inputs, and disputes over land and water all resulted in poor yields in most schemes. In Mozambique, plots were not demarcated, resulting in unequal plot sizes and differences in water payments. In Tanzania, upstream plots received more water than downstream plots. Cases of poor-quality inputs (seeds and fertilizer) were common, market access was skewed, and farmers knowledge was incomplete. As a result, all farmers irrigated their fields above plant requirements and leached nutrients below the root zone, resulting in very low yields and water productivity.

Putting the Chameleon and the Wetting Front Detectors into the farmer's hands triggered farmer experimentation and learning about irrigation frequency and the amount of fertilizer leaching

beyond the root zone. Therefore, information about the amount of nutrients leaching became a firm negative feedback mechanism, reducing the frequency and amount of irrigation. Yields increased significantly, and profits increased from accessing better markets. Farmers can now spend more money on purchasing food, paying for education and human health and investing more in production. They pay water fees more readily and engage in scheme maintenance. Other unintended consequences based on feedback mechanisms emerged. Farmers save time when not irrigating that they can invest in other livelihood activities. Further, saving water reduces conflicts over limited water.

The TISA project taught us much about scaling these strategies. AIPs can be scaled by increasing the number of irrigation schemes within an AIP. AIPs undertaken at the district and national scales accelerated bottom up and top down learning, enabling faster adoption of innovations. Further, we supported farmers to train farmers in new schemes; in scheme management, and with those who were experienced tool users to train, this resulted in rapid learning and knowledge sharing.

These strategies are self-reinforcing as success generates greater innovation.

Scale up to enable innovation at greater geopolitical scales.

Through the analysis of the implementation of the TISA project over a ten year period, the scaling dimensions, strategies and mechanisms utilised to scale agricultural innovations were effective in five key areas: i) expanding the geographical and institutional coverage of the innovations; ii) embedding innovations into the culture of institutions and communities; iii) changing policy, behaviour and practices; iv) delivering impacts at the right scale; and v) contributing to the enhancement of irrigation development at different levels. We also found the following:

- Once the AIPs at small geopolitical scales are successfully, when scaling up innovations it is necessary to invite representatives from the new areas to take part in some of the AIP meetings to gain experience. It is important to ensure that the communities which take part in AIPs have similar production activities and common problems.
- AIP leadership is crucial to ensure the sustainability of AIP process. The leadership should consist of a mix of farmers who are leaders in the scheme and farmers who are not leaders in the scheme. In Tanzania, one of the lessons learnt was that AIP leaders who were also scheme leaders were more active.
- Scaling AIPs at a greater geopolitical scale is costly, but the benefits outweigh the cost of running the AIPs. For example, in Tanzania the benefits of AIPs were spread to nearby schemes that were not part of AIPs; TISA farmers were able to access loans of over 1.3 billion Tshs through the AIP processes, nonetheless non-TISA schemes farmers also benefitted, receiving a further 50 million Tshs of loans. AIPs which extend in more than one district do not perform well due to long distances, different stakeholders operating in each district, different bylaws and sometime different approaches to addressing issues.

- We found that investing in a mix of hardware, software and orgware innovations and creating spaces for them to be embedded into institutions at different levels results in the scaling impacts being sustained with limited intervention from external entities.

Scale out to new irrigation schemes.

Scale out to new irrigation schemes has a been a critical part of the phase of research, we have found that:

- By using lead farmers rather than experts to share lessons and experience to new irrigation schemes, the farmers tend to adopt the innovations more rapidly.
- Once institutional and technical interventions were successfully introduced in one location, it is possible to out-scale them with considerably less external input and at considerably lower cost.
- The rate of change is also accelerated by synergies between out scaling of technologies and upscaling of institutions. Upscaling of the AIPs to the regional level covering several schemes facing similar production and market challenges has allowed stakeholder to transfer solutions gained in one scheme to other schemes at a much faster pace and at much lower cost.

More effective use of technical interventions

The introduction of the tools and farmers field books have initiated a sustained process of farmer to farmer learning resulting in ongoing experimentation with frequency and duration of irrigation and the introduction of new crops and varieties. Over time the reliance on the tools declined as farmers gained confidence with their new irrigation management regime.

Resilience and climate change adaptation

We found that irrigation schemes participating in TISA were more resilient to the shocks from the COVID-19 pandemic compared to those that were not involved. Greater resilience stemmed from more profitable farming systems, greater wealth, more diversified local economies and higher social capital that enabled problem solving.

Critically, we found evidence that the TISA interventions have enabled more sustainable intensification of the irrigation schemes in a changing climate. A key indicator is the greater water productivity for schemes that frequently face water scarcity. These agronomic and socio-economic characteristics amount to a basis for successful adaptation to climate change.

Equitable economic empowerment

The equity changes are evidence that participatory multi-stakeholder scheme planning processes combined with a technological intervention have improved equity impacts.

Including ‘representatives’ in participatory processes was important, as this increased the understanding needed to make the solutions arising from AIP processes more inclusive.

Finally, our research on young people on schemes identified the importance of intervening more broadly than the scheme and having multi-generational plans and policies. Given the mostly finite number of irrigation plots on schemes and the lack of mechanisms to support the elderly (or others) to exit farming, there is a need to stimulate the local economy around schemes. Our research has shown that scheme-scale plans with multi-stakeholder contributions have been effective in stimulating profitability and more opportunities for youth and others in the local economies.

Policy support

The second Biennial Review report of the CAADP/Malabo Declaration demonstrates that the member nations' existing performance in agriculture, and notably irrigation, justifies an immediate overhaul. We shared evidence from the TISA research with governments and developmental partners, as we feel they should think about pairing investments in hardware and technology with the introduction of multistakeholder processes. This would enable identification and removal of existing barriers to farmers to increase yields and convert yield increases into increased profitability. This would effectively transform small-scale irrigation systems in the regions of East and Southern Africa. With the added challenges posed by climate change, the adoption of the soil monitoring tools, and the use of AIPs becomes even more critical. By adopting these strategies, small-scale irrigation systems can be transformed to improve the livelihoods of farmers and contribute to sustainable agricultural development in the region.

8.2 Recommendations

We have found that smallholder schemes could have a role in stimulating their surrounding local economy. This reflects that irrigation scheme households' livelihoods are not solely centred on irrigation farming, with non-farm activities integrated into diversified strategies and important income flow between activities. It also reflects the lack of livelihood opportunities for young people around many small-scale schemes, including lack of access to scheme plots for own-account farming. Our publications all include many recommendations, a few examples are included below:

Participatory planning

Participatory planning and innovation forums with multi-stakeholder representation have proved essential for transforming irrigation schemes into more profitable and sustainable systems. With extended representation and a broader mandate, AIPs may aid problem solving and sustainable development for the broader local communities. Strategic plans at this local scale can be used to focus appropriate investment and effort across other scales: ministries, policy and development agencies.

Members on these forums should include representatives from those who are more vulnerable or less empowered, and consideration could be given to having sub-groups comprising vulnerable cohorts (e.g., women, youth, elderly) who could contribute to understanding constraints and provide a conduit for learning and implementation from the forums.

Scaling AIPs

We have shown that that low cost, effective innovation is possible at the district scale with AIPs that are convened by government officials and local stakeholders with a 'facilitation mindset'. It is also possible to scale up these complex interventions for more profitable and sustainable irrigation at regional and national scales, but it takes successful case studies, a long time (around a decade) and engagement of government leaders.

Enhancing social inclusion and economic empowerment

Policy approaches for small-scale irrigation schemes should incorporate multi-generational land access and scheme decision-making to support intergenerational renewal and scheme sustainability. Consideration could be given to setting aside areas for small groups of young farmers. There is also a need to initiate dialogue to address the complex and sensitive rural development questions of how to support those who might wish to exit farming and relinquish their scheme plots (elderly farmers, for example).

Donors and complex adaptive systems.

Work with CAADP, WB, FAO and large funders to design and manage irrigations as complex adaptive systems and not merely as infrastructure to manage water supply. In the ten years of the TISA project, we worked with governments with massive irrigation expansion plans and international donors wedding to business as usual models for irrigation projects. At least two governments participating in TISA have changed their policies to put irrigation on a more sustainable and profitable development path. We have not yet succeeded in changing the international donors. As a funder of international financial institutions, the Australian Government could advocate for such changes. Development partners and donors must develop schemes with local partners in the driving seat, where self-organization, autonomous management, business models, and investment returns are carefully calculated and transparent.

Evidence base irrigation policies

There is need to support the development of evidence-based irrigation policies, that will enhance the creation of smallholder schemes that are more profitable, equitable and self-sustaining. Governments and developmental partners need to invest in transforming dysfunctional irrigation schemes towards achieving the CAADP/Malabo targets.

Actions that can enable profitable irrigation include reforming land tenure, supporting farmer organisations, and developing market links for small holder farmer. For the schemes to succeed, the irrigation associations need to be developed towards a substantial autonomous and adaptive capacity. For this to occur national governments, need to clarify responsibilities and enable irrigators more while directing less. As an example, the recent Mozambique irrigation regulations are a strong step in this direction by providing the mandate and responsibility for irrigation associations to become self-funding, develop and implement business plans to become more autonomous.

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9.2 List of publications produced by project.

The following is a list of academic publications produced. For a full list of all publications see Appendix 10.1

Abebe, F., Zuo, A., Ann Wheeler, S., Bjornlund, H., van Rooyen, A., Pittock, J., Mdemu, M. and Chilundo, M., 2020. Irrigators' willingness to pay for the adoption of soil moisture monitoring tools in South-Eastern Africa, *International Journal of Water Resources Development,* **36**(sup1): S246-S267. Available at: 10.1080/07900627.2020.1755956

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10 Appendixes

10.1 LWR-2016-137 Publication list 2017-23.xlsx (excel file)

10.2 TISA project - Tracking key indicators

Group	Indicator	Mozambique	Tanzania	Zimbabwe	Totals
District AIP processes	Target number of district AIPs (5)	Boane Magude Moamba Manica / Vanduzi	Iringa Mbarali	Insiza Lupane Binga Bubi Hwange	11
	District AIPs processes established	Boane Magude Moamba Manica / Vanduzi	Iringa Rice producers AIP Iringa- Vegetable producers AIP Mbarali – started as a scheme level AIP	Insiza Lupane Binga Bubi Hwange	12
Irrigation schemes	Target number of schemes (38) (includes training institutes = 3)	12	11	15	38
	Current engagement	12	12	20	44
Tools	Target number of sensors for installation	327	388	1,067	1,782
	Sensors installed	205	386	395	986
	Total farmers on VIA	138	247	369	754
	Sensors used in training sessions, others to replace the damaged ones.	41	0	75	116
	Remaining sensors	81	2	597	680
Tools training events	**Tool training events**	28/08/2019 - Bloco I Scheme 29/08/2019 -Bloco II Scheme 19-24/08/2019 - Nhamandembe, Nhaúmbue and Campo 4 Schemes 02-02/03/2020 – Gaza Province (districts of Guijá, Chibuto, Xai-Xai and Bilene) 15-21/03/2020 – Manica Province (districts of Manica, Sussundenga and Vanduzi)	2/7/19 - Mafuruto farmers 5/7/19 - Igingilanyi farmers 7/7/19 - Nyamahana farmers 1-8/Aug/2017- Nane Nane Exhibitions in Mbeya. Anatalia Kilienyi farmer from Kiwere was exhibitor. 11-12 Dec 19 VIA masterclass 20/12/2019 -Lipuli farmers	25/9/19 Binga - Lungwalala, Mlibizi and Nabusenga farmers. 2/10/19 Hwange -Lungwalala, Mlibizi and Nabusenga farmers. 12-14 Nov 19 VIA masterclass 19-21 Oct 21 Masterclass, Extension officers. 25-29 October, Gross Margin training Silalatshani, Lungwalala, Lukosi, Tshongokwe farmers.	

Group	Indicator	Mozambique	Tanzania	Zimbabwe	Totals
		17-22/08/2020 and 1-4/09/2020 - Gaza Province (in the schemes of Makateco, Rivoningo, Chitsoguanine, and Chihozório) 29/10/2020 - The first VIA Masterclass Training (online) 12-18/11/2020 - Bloco I Scheme 29/09 to 12/10/2021: theoretical-practical trainings in tool use for 77 farmers was led by farmers proficient in the use of the instruments from the 25 de Setembro, Manguiza, Mafuiane and Bloco I schemes	21/8/2019- demonstration on the use of soil and water monitoring tools to Permanent Secretary (Ministry of Agriculture) during the policy dialogue in Dodoma. 54 participants from different institutions attended. 11-13/7/2019 there was Agriculture event held in Iringa town, 55 people visited to learn about the tools (Mr Daud Chilagane demonstrated about the tools) 1-8 Aug 2018, Nane Nane Exhibitions in Mbeya. Abdala Tave a farmer from Kiwere was exhibitor. 1-8/Aug/2020 Nane Nane Exhibitions in Mbeya. Yuda Vakulule a farmer from Nyamahana scheme was exhibitor. 2nd August and 10th September 2021 – tools training for farmers from Mbuyuni and Mwendamtitu schemes. NIRC staff on use of soil and water monitoring tools and establishment of innovation platforms 1-8/Aug/2023 Nane Nane Exhibitions in Mbeya. Mridi Kidumba a farmer from Igomelo scheme and Anatalia Kilienyi a farmer from Kiwere were exhibitors	VIA Master Class (Farmer Soil & Moisture Monitoring Toolkits) Training Workshop, facilitated by Dr. Richard Stirzaker on 22-23 June 2023. This was attended by extension staff from Matabeleland North and South as well as staff from ZITC, Harare	

Group	Indicator	Mozambique	Tanzania	Zimbabwe	Totals
	Number of participants (all events)	594	1,272	484	2,350
	• **Number of farmers**	296	184	444	924
	• **Number of government staff**	168	42	40	250
	• **Number of other trained / awareness**	130	1,046	-	1,176
Farmer field book	Number of farmers with FFB	132 Farmers with FFB	190 for season 2018/19 (90 without tools, 100 with tools) 71 for season 2019/20 (both with monitoring tools)	351 -but note, that although distributed to all (11) the schemes where we distributed tools, only 3 schemes (Hauke, Makhovula and Landela) had a crop during the season, the rest did not have because of drought, while Hwange and Binga schemes received their tools towards the end of the year.	744
	Number of FFB processed by TISA team (related to activity 2.1)	57 FFB have been processed. 21/11/2019 - end of season workshop held in the district of Magude for Macuvulana I and Macuvulana II schemes (24 FFB processed) In the Boane district 20 FFB were processed (10 in 25 de Setembro and 10 in Manguiza) 2021/2022 - From December 2020 to March 2021, 13 FFB were	240 FFB were processed for the season of 2019/2020 2018/19 end of season workshop was conducted on 11th and 12th September 2019 for Nyamahana and Mafuruto schemes 60 farmers attended. -255 FFB have been processed for the farming season 2020/2021 from 9 irrigation schemes.	17 FFB have been processed for the season 2018/2019 season. Landela Block in Silalatshani, 12 out of 20 farmers with tools returned complete FFB. At Makhovula 5 farmers with tools returned FFB, this was out of 5 with the tool. During the 2019/2020 season, a sample of 48 FFB was analysed for the generation of gross margins for sugar beans and green maize	994[13]

[13] *This is more than the row above as several FFBs were processed for more than one season.*

Group	Indicator	Mozambique	Tanzania	Zimbabwe	Totals
		completed, and 20 crops are under monitoring have been processed	-240 FFB were processed for the farming season 2021/22	(Silalatshani, Lukosi, Tshongokwe, Makhovula and Nabusenga)	
	Gross margin	GMs have been calculated for 6 crops: Sugar cane (Macuvulana I and Macuvulana II); tomato, onion, maize, and sweet pepper (In 25 de Setembro and Manguiza). An end of season workshop was held in May 2020 in three irrigation schemes to discuss the GMs with the farmers. End of season workshops were held between the 3rd and 6th of May 2021 in the schemes of Manguiza, 25 de Setembro, Mafuiane and Bloco I, to discuss the GMs analysis with the farmers	Gross margin for 199 FFB (2019/20 season) has been calculated. Data compiled from extension officers for gross margin analysis from 8 irrigation schemes. -Gross Margin (2020/21) for those 255 FFB have been calculated from 9 irrigation scheme -Gross Margin for 240 FFB for 2021/22 farming season has been calculated for 9 irrigation schemes	A combination of what is contained in the farmer field books and FGD will be used to produce GM for the 4 schemes that had a crop in the 2019. In October 2021 a total of 222 farmers were capacitated in gross margin budgeting, with GM for green mealies and sugar beans, the two most common crops in the schemes GM calculated.	922

10.3 Project gender and equity guidelines for the African irrigation project

	Other – ANU, CSIRO, UniSA and FANRPAN			Mozambique			Tanzania			Zimbabwe		
SECTIONS	**Yes**	**No**	**Comments**	**Yes**	**No**	**Comments**	**Yes**	**No**	**Comments**	**Yes**	**No**	**Comments**
A. Researchers within the ACIAR project												
1) Are you sensitive to the gender balance of project team? What steps have been taken to ensure gender balance in project team?	Yes		The lead representatives in all organisations are men, but both FANRPAN and UniSA have women as part of the project team. We will seek female candidates to fill vacant positions as they arise.	Yes		The project staffs at INIR have 3 male technicians; however, there is the collaboration of 4 female INIR technicians in the execution of field activities.	Yes		Ardhi engaged Sophia Bongole as the project research assistant in January 2019.	Yes		A female PhD Student, Xolile Ncube is part of the project from late 2021.
2) Are you being sensitive to power relations between: gender, age, race/culture, and levels of management?	Yes			Yes		Yes, we are being sensitive. We treat all members with respect	Yes			Yes		
3) Are you conscious of your authority in your group? Do you ensure that you do not use that authority to make anyone feel uncomfortable?	Yes			Yes			Yes			Yes		ICRISAT is a professional institute that follows properly laid out policies in all its work.
4) Do you encourage less senior or well-established members of the scientific community, e.g., women and young professionals?	Yes			Yes			Yes			Yes		Research Associates are encouraged to lead paper writing and exposure to international

												conferences. Our student interns are leading the farmer trainings and he installation of the tools at the schemes, being given an opportunity to lead the project and learn.

	Other – ANU, CSIRO, UniSA and FANRPAN			Mozambique			Tanzania			Zimbabwe		
SECTIONS	**Yes**	**No**	**Comments**	**Yes**	**No**	**Comments**	**Yes**	**No**	**Comments**	**Yes**	**No**	**Comments**
B. Workshops, AIP meetings, or field visits (*Within your project teams or rural communities*)												
1) Are you sure that the season, day, or time of the workshop does not constrain participation by any particular group? • E.g., women who are primary care givers. (Of children or elderly) • E.g., people celebrating religious holidays? • E.g., people with specific occupations • E.g., specific groups involved in planting/harvesting. • E.g., students attending meetings during school time			NA	Yes		Our strategy is to put women in charge of arranging the meetings	Yes		Activities are arranged with involvement of farmers, most of time farmers suggests dates for different activities	Yes		Meetings are conducted between 09.00-13.00 hours, and this allows women to take care of their households thereafter.
2) Are the participants given ample notice so that people of different social categories (including those			NA	Yes		Yes, the women arranging the meetings consider this.	Yes			Yes		We make invitations through AGRITEX, and all social classes are well

	Other – ANU, CSIRO, UniSA and FANRPAN			Mozambique			Tanzania			Zimbabwe		
SECTIONS	**Yes**	**No**	**Comments**	**Yes**	**No**	**Comments**	**Yes**	**No**	**Comments**	**Yes**	**No**	**Comments**
with many responsibilities / burdens) can attend?												represented in the AIP meetings.
3) Are there measures to support care-giving responsibilities? • E.g., day care or allowance of children's attendance at the meeting?			NA		No	Many women are attending the meetings. Children are left at home with other siblings / family.		No	Women come with their children to the meetings, or they leave them at home with other siblings / family	Yes		Extension staffs are allowed to bring in child minders for training workshops. Women come with their children to the meetings
4) Are participants in attendance reflective of the actual gender/age/class balance of the community? • If not, should they be?			NA	Yes			Yes			Yes		There is usually gender balance in the meetings and workshops. However, for farmer trainings, and workshops, we note that it is mostly women who attend.
5) Have you considered whether this meeting separates men and women for any reason?			NA		No	No, we think that men and women have the same opportunities. And they work together as an association		No	Both men and women are given same opportunities		No	There is no need to separate the two as from our experiences, as this works together well, and articulation of issues comes out well when both are present.
6) Are all women's opinions or concerns accurately reflected in the workshop? • Either via women vocalizing their opinions or through other socially constructed ways • How do you know? / How can, you be sure?			NA	Yes		All the information shared with the farmers are later assessed with the farmers themselves informally before proceeding	Yes		During the AIP Meeting in Iringa, two women were invited to present on the use of the tools. During the Iringa Agricultural Show, a woman from Kiwere scheme was the main exhibitor on the simple tools	Yes		Yes indeed. As indicated, for most of the farmer meetings, many of the participants are women, and they tend to lead the meetings and discussions.

	Other – ANU, CSIRO, UniSA and FANRPAN			Mozambique			Tanzania			Zimbabwe		
SECTIONS	**Yes**	**No**	**Comments**	**Yes**	**No**	**Comments**	**Yes**	**No**	**Comments**	**Yes**	**No**	**Comments**
7) If the sex or social category of the AIP representative/meeting leader affects the dynamics of the meeting, are these impacts acceptable? • Do you always automatically ask a man to chair and a woman to rapporteur? If so, consider changing this up!			N/A		No	It might and might not influence the process. We try to involve more women during most of the meeting so that other women in the communities feel free to speak			N/A			N/A
C. Research implements												
Baselines												
1) Are you disaggregating data by gender and other social categories? • E.g., do activities like baselines or VCMs specify men and women, girls, and boys?			N/A	Yes			Yes			Yes		For example, the publications we have reflect on the disaggregated data.
2) Do any data inputs assume certain gender- or age- dependent categories? • For example, planting times, labour inputs, access to ploughs or other technologies, etc. might be different depending on the sex (or another social category) of the farmer. • If so, you should search for the correct data and disaggregate your baseline.			N/A		No			No			No	Yes, looking at the Social Network Analysis done, there is disaggregation of our research by gender.
Follow up surveys												

	Other – ANU, CSIRO, UniSA and FANRPAN			Mozambique			Tanzania			Zimbabwe		
SECTIONS	**Yes**	**No**	**Comments**	**Yes**	**No**	**Comments**	**Yes**	**No**	**Comments**	**Yes**	**No**	**Comments**
1) Are you disaggregating by gender and other social categories?			N/A	Yes			Yes			Yes		Looking at the Social Network Analysis done, there is disaggregation of our research by gender.
2) Are your questions accidentally leaving out certain groups?			N/A		No			No			No	
3) Are your questions phrased appropriately, given the cultural context? • Could the social categories of respondent (men, woman, and head of household) affect the answer? • If so, figure out a way to deal with this, e.g., trying to have as many female respondents as possible and disaggregate the analysis base on gender. Also, triangulation by using data from surveys, FGs, in-depth-interviews and observations. • E.g., if you ask about food/water/resource security, different members of the household might have different perspectives. Perhaps the male head of household eats first and well, followed by the young men in the household, but the wife			N/A	Yes			Yes			Yes		Our questions are appropriately phased and in all the interviews we do, we try to ask more than one *member* and triangulating data through interviewing secondary sources such as AGRITEX and DoI as well as agro dealers etc. and through FGs.

	Other – ANU, CSIRO, UniSA and FANRPAN			Mozambique			Tanzania			Zimbabwe		
SECTIONS	**Yes**	**No**	**Comments**	**Yes**	**No**	**Comments**	**Yes**	**No**	**Comments**	**Yes**	**No**	**Comments**
and children are often left hungry.												
4) Are you addressing your questions to the person most apt to answer them? • Certain tasks are culturally determined to be within one gender's role. So, for example, questions about weeding or household chores might be more suitably presented to women.			N/A	Yes			Yes		In project surveys it is the household heads, Husband and wife for married households, Mother for women headed households	Yes		We have realised that most of the work is usually done by women, so we do try to interview the women irrigators, but we also make it a point that the husbands are involved as Heads of Households wherever possible.
5) Could the social categories (e.g., gender, ethnicity, age) of the person asking the question (or others present during the interview) affect the answer? • If so, consider changing up who is asking the question, or disaggregate for this to check that it is not biasing your results.			N/A	Yes				No			No	
Moisture and solute measuring technologies												
1) Do you know who is going to be using your technology, and are you consulting them in the project design? • Is the process participatory and inclusive of the target audience?			Application at the country level	Yes		The process is participatory, and first step is to work with the ones who are willing to use it (currently at least 50% of the farmers who have tools are women, without any pressure of the team).	Yes		Farmers, agriculture and extension officers and the National Irrigation Commission which is promoting the technology	Yes		We are now making use of the Social Network Analysis to identify the strong nodes within the irrigation schemes who will thereafter receive the tools. We also stand guided by the IMCs

	Other – ANU, CSIRO, UniSA and FANRPAN			Mozambique			Tanzania			Zimbabwe		
SECTIONS	Yes	No	Comments	Yes	No	Comments	Yes	No	Comments	Yes	No	Comments
												and extension staff on the best placed farmers who can adopt and help other farmers use the technology
2) Does the technology or project design consider the differences in users and user needs? • E.g., different literacy levels, age, strength, time and responsibilities, liquid capital for investments			Literacy is a particular challenge in both Mozambique and Tanzania for all genders	Yes			Yes		One of the role model farmers in using the soil water monitoring tools has never been to school. She has however, been able to demonstrate the technology not only to fellow farmers only but in zone agricultural shows and national level policy dialogue organised by the project	Yes		We are now making use of the Social Network Analysis to identify the strong nodes within the irrigation schemes who will thereafter receive the tools. We also stand guided by the IMCs and extension staff on the best placed farmers who can adopt and help other farmers use the technology
3) Could this have unintended negative impacts on already marginalized populations, including elderly, young or girls? • E.g., is it going to add to the work burden of anyone? • E.g., is it located in an onerous and/or insecure area? • E.g., who will be responsible for maintenance of the technology? • E.g., if the technology costs money or labour, will that			The technology has helped reduce labour needs for irrigation, which has been freed up for other uses.		No			No			No	

	Other – ANU, CSIRO, UniSA and FANRPAN			Mozambique			Tanzania			Zimbabwe		
SECTIONS	**Yes**	**No**	**Comments**	**Yes**	**No**	**Comments**	**Yes**	**No**	**Comments**	**Yes**	**No**	**Comments**
money mean cutting out other important household expenditure, like education or health care for the children?												
D. M&E, analysis, and project reporting												
1) Are you checking for any diversity in the stories emerging from your gender/etc. disaggregation? • In addition, are you considering what implications it might have for your or other work? (E.g., could your results feed into better science for one of the other project teams or your institution?)	Yes			Yes			Yes			Yes		One of the valuable lessons that have come out of using the Social Network Analysis has been to identify that the strongest nodes are usually the women irrigators. This is valuable lessons for planning purposes and for technology uptake.
2) Are you considering positive or negative impacts that your research is having on different social groups, including women? • Is the project likely to have the same positive and/or negative effects on women and men, girls and boys? • What can the project do to enhance its gender benefits?	Yes			Yes			Yes			Yes		
3) Are you using gender-neutral language in all your reports and communications outputs?	Yes		We are trying to.	Yes			Yes			Yes		
4) How are women and girls benefiting from project activities			Applicable at country level	Yes		Many women are involved in all project activities (whether in	Yes		Women have demonstrated leadership in adoption	Yes		As indicated, we have realised it is mostly women

	Other – ANU, CSIRO, UniSA and FANRPAN			Mozambique			Tanzania			Zimbabwe		
SECTIONS	**Yes**	**No**	**Comments**	**Yes**	**No**	**Comments**	**Yes**	**No**	**Comments**	**Yes**	**No**	**Comments**
						the field or in the office)			of introduced innovations and technologies. Women and girls are equally participating in all project activities			farmers that are involved in trainings, that monitor the Chameleon sensors and collect data, so yes, the project is benefitting women and girls.
5) Is there any potential negative impact on gender equality and women's empowerment? What can the project do to mitigate this?			Applicable at country level		No			No			No	
6) Are the activities and outcomes that targeted understanding gender in the project design being realised? • If not, what are the reasons? Can further steps be taken to ensure that the needs of all participants are met?			Applicable at country level	Yes				No		Yes		
7) Have new gender-related activities and/or opportunities been discovered that were not foreseen at project design? • If yes. Have new strategies been proposed for addressing these as the project progresses? Are these strategies feasible within the current scope and constraints of the project?			Applicable at country level		No		Yes		Women farmers have shown more commitments to demonstrate the use and benefits of soil water monitoring tools including adoption of new and good agronomic practices leading to improved productivity and profitability	Yes		Making use of women farmers as lead farmers with the sensors is more realistic as evidenced from the SNA.
8) Do men and women perceive positive and negative impacts of the project differently?			Applicable at country level		No	We have not identified different perception among the farmers		No			No	

	Other – ANU, CSIRO, UniSA and FANRPAN			Mozambique			Tanzania			Zimbabwe		
SECTIONS	**Yes**	**No**	**Comments**	**Yes**	**No**	**Comments**	**Yes**	**No**	**Comments**	**Yes**	**No**	**Comments**
• Are the benefits likely to be distributed equitably? How can negative effects be mitigated?												

10.4 Reports available on request.

CSIRO

- CSIRO country reports Feb19.pdf
- TISA Mozambique 13 Feb 2019.pdf
- TISA soil and crop data uploading and downloading diagrams.pptx
- TISA soil and crop data uploading and downloading.docx
- TISA Tanzania 13 Feb 2019.pdf
- TISA Zimbabwe 13 Feb 2019.pdf
- Users and uses of the data on the Via database.docx
- ZRBF Graduate Student_Charity Mapira.pdf

FANRPAN

- Benefits of transforming_smallholder irrigation schemes towards achieving the Malabo_DRAFT.pdf
- eesc-2018-Final Declaration - 04633-00-10-decl-tra-en_clean.pdf
- ESA Food Systems Dialogue CONCEPT NOTE.docx
- ESA Food Systems Dialogue Programme_DRAFT.docx
- FANRPAN 2019 Regional Policy Dialogue Resolutions.pdf
- FANRPAN Dialogue TISA CSA Pittock 20Oct20.pptx
- National Policy Dialogue on Agric in Mozambique - A Focus on Irrigation Dev and PHM Oct 2018 mc.doc
- Policy Brief Issue 01.2019 - Smart Water Governance.pdf
- Policy Brief Issue 02.2019 - Smart Water Management Technologies.pdf
- Policy Brief Issue 1.2018 - Pathways for Irrigation Development Tanzania.pdf
- Policy Brief Issue 2.2018 - Pathways for Irrigation Development Zimbabwe.pdf
- Targeted Platforms for the TISA Project Outputs.pdf
- Transitioning-Smallholder-Irrigation-Systems-_Success-Stories_2021.pdf

Mozambique

- 20201029_SPILLOVER_Treinamento Online_WDS.docx
- Description of Tools Training and data collection_22-09-2020.docx
- Discurso Reuniao Anual TISA 24Julho 2018.pdf
- Equipamentos de Monitória de ╡gua e Solutos no Solo_VIA_INGLES.docx
- Guide to undertake participatory mapping in the schemes_INGLES.pdf
- Irrigation helps women farmers in Mozambique weather climate extremes - Alliance for Science.pdf
- Irrigation helps women farmers in Mozambique weather climate extremes.pdf
- Licoes Apreendidas no Estabelecimento de AIPs_02.02.2021.Rev1.docx

- Macuvulana I End of Season report.pdf
- Mafuiane Irrigation Scheme.pdf
- Map report of Macuvulana I and II.pdf
- Mapa do Regadio BLOCO I - 15-09-2020 A3.pdf
- Mapa do regadio de Macuvulana I - 14-09-2020.pdf
- Mapa do regadio de Macuvulana II - 15-09-2020.pdf
- Mapa do regadio de Manguiza_15-09-2020.pdf
- Mapa Regadio de Mafuiane_A3 Final_10-09-2020.pdf
- Maps of Mafuiane and Manguiza irrigation schemes.docx
- Minutes w SDAE Director Mar19.docx
- National Irrigation Institutes advisory council.pdf
- Paul cooking with Mama Caroline - last recipe.jpeg
- Paul in irrigation scheme with Wilson.jpeg
- Plot Allocation Process in Small-Scale Irrigation Schemes in Mozambique.docx
- Relatorio da Missao_Disseminacao de Tools_GAZA_01 a 04-09-2020.docx
- Relatorio da Missao_Disseminacao de Tools_GAZA_17 a 22-08-2020.docx
- Relatorio de Missao-Entrega dos Mapas_14.10.2020_Final.pdf
- Relatorio de Missao-Instalacao dos Tools & Colecta de Dados e Monitoria_Final_23112020V3.pdf
- Relatorio de Missao-Instalacao dos Tools e Divulgacao do Decreto Lei_13.11.20.pdf
- Relatorio de Missao-Pesquisa sobre o Impacto dos Tools nos Regadios_06 a 12.04.2021.pdf
- Relatorio de Missao_Colecta de dados e preparacao do End of Season Workshop_18 a 22.2021.pdf
- Relatorio de Missao_Colecta de Dados, Monitoria dos Regadios e Partilha dos Resultados_03 a 06.05.21.pdf
- Relatorio de Missao_Distribuicao de Kits e Realizacao de Focus Goups_21 a 25.05.2021.pdf
- Relatorio de Missao_End of Project Survey_25 de Setembro_Manguiza.08 a 17.12.2021.pdf
- Relatorio de Missao_End of Project Survey_Bloco I_17 a 24.03.2022.pdf
- Relatorio de Missao_End of Project Survey_Mafuiane.03 a 10.03.2022.pdf
- Relatorio de Missao_End of Project Survey_PSK_14 a 22.06.2022_PRELIMINAR.pdf
- Relatorio de Missao_Facilitacao do Acesso aos Insumos nos Regadios_24 a 27.08.2021.pdf
- Relatorio de Missao_Focus Groups Discussions_05 a 14.07.2021.pdf
- Relatorio de Missao_Treinamento, Instalacao dos Tools, Monitoria e colecta de dados_29.09 a 12.10.21..pdf

- Relatorio Geral_Mapeamento_Bloco I_updated.pdf
- Relatorio sobre as principais licoes aprendidas no estabelecimento de AIP's (DRAFT).docx
- Relatorio_Monitoria da Parceria entre a TECAP e os Produtores_Instalacao de Tools_16 a 19.11.2021.pdf
- Summary of the Focus group Discussion.pdf
- Summary of the realization of the Focus group Discussion_PR_MT_V2.docx
- Targeted Platforms for the TISA Project Outputs.pdf
- TISA Video_Script_English_MT.26.08.2023.docx
- Tisa_MANGUIZA.jpg
- Training of extension officers on installation and monitoring of tools in Gaza.pdf
- Treinamento e instalaçao de Tools nos regadios de Makateco e Rivoningo.pdf
- Treinamento e instalaçao dos Tools nos regadios de Chihozoro e Chitsoguanine.pdf
- Treinamento sobre a instalaç ╞o e uso dos TOOLS em Manica.pdf
- WaPOR 2 inception workshop in Mozambique WaPOR, remote sensing for water productivity Food and Agriculture Organization of the United Nations.pdf

Tanzania

- 2nd WRM Forum Proceedings_Finalsmall.pdf
- AIP MEETING IN JUNE 2021.docx
- AIP Workshop proceeding_IRINGA_Warsha ya Wadau.pdf
- Binga District AIP meeting report.docx
- BRIEF REPORT ON FLOODING IN IRRIGATION SCHEME 10 June 2020-pr.docx
- FIELD VISIT OF NIRC TO TISA SCHEMES.docx
- IDODI scheme map.pdf
- Kinyonga_2019_Ek_MM-Copy.pub
- kiwere map crop.pdf
- Kubadilisha skimu za umwagiliaji za wakulima wadogo barani_19June2022.docx
- Mafuruto Irrigation scheme 2.pdf
- MAGOZI scheme map 2.pdf
- Nane nane report 2018.pdf
- National policy dialogue workshop Tanzania.pdf
- NON WORKING CHAMELEON READERS.docx
- Nyamahana 5edited 20 Aug.jpeg
- Progress of on farm monitoring under TISA.docx
- SOLAR DRIER PROJECT IN KIWERE SCHEME 28 Jan 2022.docx
- Stakeholder engagement report_SB_LK.docx
- Summary of mapping activity in Iringa District.docx

- Surveyed schemes_google image.pdf
- sw1536228599-FINAL SWAHILI TANCAID PAMPHLET FF- Copy (2).pdf
- sw1628949716-Kinyonga_2019 - Copy.pdf
- Tanzania report on flooding in irrigation schemes 10 June 2020.pdf
- Tungamalenga Scheme map 2.jpeg
- VIA CC Poster 2023 swahili-1.pdf
- Wi-Fi Brochure - Swahili.pdf
- Workshop report July2017.doc

Zimbabwe

- Agricultural Research Council Provincial Consultation.pdf
- AIP and tools workshop Matopos Oct Nov 2018.pdf
- Background and Objectives of R and D Provincial Consultative Forum.pdf
- BINGA AIP MEETING REPORT.docx
- BUBI DISTRICT AIP MEETING REPORT F.docx
- BUBI DISTRICT AIP MEETING REPORT1.docx
- Crop Production Key Research Areas.pdf
- D25326-Report on the up and out scaling of TISA work in Matabeleland North province.docx
- D25980-Capacitate government staff on the SNA methodology and the use of the soil moisture and nutrient monitoring tools.docx
- D25981-Capacitate farmers on the schemes that were impacted by the floods and drought in Zimbabwe.docx
- Hauke Multi-purpose Grain Sheller.pptx
- Hwange District AIP meeting report.docx
- Lupane AIP Meeting - Preliminary Report Mar19.pdf
- LUPANE AIP MEETING-REPORT.docx
- Map results for Bubi Irrigation Schemes.docx
- Map_result_Hwange_Binga_Lupane.docx
- Masterclass Training Workshop-October 2021.docx
- MATUKIO SAKINA DISEMBA 3.MP3
- Meeting Report between ICRISAT and DoIRR 29 04 2018.docx
- Ndebele Manual for Farmer Training_CHAMELEON.pdf
- NON-TISA SCHEME END-OF-SURVEY REPORT.docx
- Participatory Mapping First Draft- 2 June 2021.docx
- Screen Shot 2018-06-20 at 12.00.35.png
- Silalatshani FGD.docx
- Silalatshani Irrigation Scheme AIP Meeting report (2).docx
- Silalatshani Irrigation Scheme AIP Meeting report.docx

- Silalatshani Value-addition Unit.pptx
- Soil Moisture Nutrient Monitoring Tools Workshop for ECRIMS-ICRISAT.docx
- Sustainable Irrigation Development in Zimbabwe Oct17.pdf
- Sustainable Irrigation Development in Zimbabwe.docx
- TISA VIA Master Class workshop.docx
- TISA-VIA DoI DCL meeting at ICRISAT Nov18.docx
- TISA-VIA Masterclass Training Report-November 2021.docx
- TISAI END-OF-PROJECT-SURVEY REPORT.docx
- TISAII END-OF-PROJECT SURVEY REPORT.docx
- Tools Distribution Table December 2019.docx
- Trip Report to Harare, Department of Irrigation-4-5 December 2022.docx
- Tshongoke Irrigation Scheme-SNA Report_FINAL.docx
- Tshongokwe FGD.docx
- Zimbabwean farmers step into the future of farming _ New Frame.pdf
- ZRBF Graduate Student_Charity Mapira.pdf
- ZW irrigation map.pdf

10.5 Table of citations

The first International Journal of Water Resources Development special issue as of 18/8/23 when accessed on https://iahr.tandfonline.com/toc/cijw20/33/5 had the following citations:

			Citations		
Article	**Authors**	**Published date**	**View**	**CrossRef citations**	**Altmetric**
Exploring the productivity and profitability of small-scale communal irrigation systems in Sub-Saharan Africa	Henning Bjornlund & Jamie Pittock	19-May-17	2,329	13	6
Profitability and productivity barriers and opportunities in small-scale irrigation schemes	Henning Bjornlund, Andre van Rooyen & Richard Stirzaker	20-Dec-16	6,681	45	17
Irrigation and crop diversification in the 25 de Setembro irrigation scheme, Mozambique	Wilson de Sousa, Raphaëlle Ducrot, Paiva Munguambe, Henning Bjornlund, Andre Machava, Etevaldo Cheveia & Joaquim Faduco	13-Jan-17	3,651	19	1
Barriers to and opportunities for improving productivity and profitability of the Kiwere and Magozi irrigation schemes in Tanzania	Makarius V. Mdemu, Nuru Mziray, Henning Bjornlund & Japhet J. Kashaigili	6-Jun-16	5,804	42	3
Irrigation development in Zimbabwe: understanding productivity barriers and opportunities at Mkoba and Silalatshani irrigation schemes	M. Moyo, A. van Rooyen, M. Moyo, P. Chivenge & H. Bjornlund	29-Apr-16	21,606	41	9
An overview of extension use in irrigated agriculture and case studies in south-eastern Africa	Sarah Ann Wheeler, Alec Zuo, Henning Bjornlund, Makarius Victor Mdemu, Andre van Rooyen &Paiva Munguambe	14-Sep-16	3,291	37	0
Income inequality within smallholder irrigation schemes in Sub-Saharan Africa	Ana Manero	2-Mar-16	2,325	17	1
A soil water and solute learning system for small-scale irrigators in Africa	Richard Stirzaker, Ikenna Mbakwe & Nuru Ressa Mziray	19-May-17	4,041	30	6
Theory and application of Agricultural Innovation Platforms for improved irrigation scheme management in Southern Africa	André F. van Rooyen, Peter Ramshaw, Martin Moyo, Richard Stirzaker & Henning Bjornlund	19-May-17	14,571	48	35
Irrigating Africa: policy barriers and opportunities for enhanced productivity of smallholder farmers	Sithembile Ndema Mwamakamba, Lindiwe Majele Sibanda, Jamie Pittock, Richard Stirzaker, Henning Bjornlund, Andre van Rooyen, Paiva Munguambe, Makarius Victor Mdemu & Japhet J. Kashaigili	19-May-17	4,326	19	4

Article	Authors	Published date	Citations		
			View	CrossRef citations	Altmetric
Communal irrigation systems in South-Eastern Africa: findings on productivity and profitability	Jamie Pittock, Henning Bjornlund, Richard Stirzaker & Andre van Rooyen	19-May-17	2,762	13	47
Total			71,387	324	129
Total in June 2022			61,278	273	120
Change in numbers			10,109	51	9
Percentage increase			16%	19%	8%

The second International Journal of Water Resources Development special issue as of 18/8/23 when accessed on https://www.tandfonline.com/toc/cijw20/36/sup1, had the following citations:

Article	Authors	Published date	Citations		
			View	CrossRef citations	Altmetric
Transforming failing smallholder irrigation schemes in Africa: a theory of change	Jamie Pittock, Henning Bjornlund & André van Rooyen	6-Oct-20	2,677	15	1
Why agricultural production in sub-Saharan Africa remains low compared to the rest of the world – a historical perspective	Vibeke Bjornlund, Henning Bjornlund & Andre F. Van Rooyen	5-May-20	66,258	76	108
Exploring the factors causing the poor performance of most irrigation schemes in post-independence sub-Saharan Africa	Vibeke Bjornlund, Henning Bjornlund & André F. van Rooyen	17-Sep-20	9,768	23	44
The dynamics between irrigation frequency and soil nutrient management: transitioning smallholder irrigation towards more profitable and sustainable systems in Zimbabwe	Martin Moyo, André Van Rooyen, Henning Bjornlund, Karen Parry, Richard Stirzaker, Thabani Dube & Mthulisi Maya	21-May-20	2,022	17	1
Do agricultural innovation platforms and soil moisture and nutrient monitoring tools improve the production and livelihood of smallholder irrigators in Mozambique?	M. Chilundo, W. de Sousa, E. W. Christen, J. Faduco, H. Bjornlund, E. Cheveia, P. Munguambe, F. Jorge, R. Stirzaker & A. F. van Rooyen	18-Jun-20	1,744	14	1
The role of soil water monitoring tools and agricultural innovation platforms in improving food security and income of farmers in smallholder irrigation schemes in Tanzania	M. Mdemu, L. Kissoly, H. Bjornlund, E. Kimaro, E. W. Christen, A. van Rooyen, R. Stirzaker & P. Ramshaw	30-Jun-20	2,772	19	-
Identifying leverage points to transition dysfunctional irrigation schemes towards complex adaptive systems	André F. van Rooyen, Martin Moyo, Henning Bjornlund, Thabani Dube, Karen Parry & Richard Stirzaker	19-May-20	1,787	17	1
The importance of learning processes in transitioning small-scale irrigation schemes	Karen Parry, André F. van Rooyen, Henning Bjornlund, Luitfred Kissoly, Martin Moyo & Wilson de Sousa	22-Jun-20	2,426	24	1

			Citations		
Article	**Authors**	**Published date**	**View**	**CrossRef citations**	**Altmetric**
Growth and inequality at the micro scale: an empirical analysis of farm incomes within smallholder irrigation systems in Zimbabwe, Tanzania and Mozambique	A. Manero, H. Bjornlund, S. Wheeler, A. Zuo, M. Mdemu, A. Van Rooyen & M. Chilundo	17-Sep-20	1,606	4	4
Irrigators' willingness to pay for the adoption of soil moisture monitoring tools in South-Eastern Africa	Fentahun Abebe, Alec Zuo, Sarah Ann Wheeler, Henning Bjornlund, Andre van Rooyen, Jamie Pittock, Makarius Mdemu & Mario Chilundo	7-Jun-20	1,481	13	5
Total			92,541	222	166
Total for both special issues			163,928	546	295

10.6 Communication and dissemination activities

Many communication activities continue to be undertaken to introduce project research to stakeholders, including the development of academic publications (see Appendix 10.1 'LWR–2016-137 publication list 21-22', which tracks published documents in the ACIAR format) and conference presentations. Key communication outputs include the following:

10.6.1 Conference and meeting participation:

2017

- July 7, a one-day workshop for irrigation stakeholders on organised by Ardhi University in collaboration with the National Irrigation Commission to disseminate research results of phase I and explore opportunities for a national irrigation platform. The workshop brought participants from the project research team (Australia, Mozambique, Tanzania, South Africa), ESRF, Ministries (Water &Irrigation, Agriculture), World Bank, WWF, government entities (TANESCO, SAGCOT, Water Institute), JICA, WR2030.
- July 17 - 21. The project annual meeting workshop in Iringa, Tanzania with parallel workshops for TISA and VIA projects. Disseminated results to government staff, who are partners to the project (i.e., National Irrigation Commission, Iringa District Council, and Iringa Regional Secretariat).
- August 1-9. Exhibition of the Chameleon sensors and WFD in the Annual Agricultural Show in Mbeya, Tanzania. The TISA exhibition was held in Iringa District Council pavilion. The tools were demonstrated to more than 300 visitors, the majority of whom were interested in the technology.
- August 15-17. Dr Moyo attended and presented at the FANRPAN Regional Multi-Stakeholder High-level Food and Nutrition Security Policy Dialogue (held in Durban, South Africa). He presented at the side event on *Enhancing Resilience in Agriculture Production Systems.* The side event provided a platform to highlight on- going agriculture resilient production systems development and research initiatives, which promote a robust and consistent approach that is responsive to a changing climate. The deliberation results of the session were shared in a plenary session where outputs from all other parallel sessions were also presented (see: http://dialogue2017.fanrpan.org/).
- August 28 -31. Dr Pittock, Dr van Rooyen and Ms Mwamakamba participated in Stockholm World Water Week. See activity 3.1.
- August 28 -31. Dr Mdemu met with representatives from the Silver Lands Company that has invested in production of livestock feed using maize and soybean as input. It offers potential market to farmers and adoption of soil moisture tools in their farming activities.
- September 4-8. Ms Mwamakamba participated in the seventh African Green Revolution Forum (AGRF): "Accelerating Africa's Path to Prosperity: Growing Inclusive Economies and Jobs through Agriculture" in Abidjan, Cote d'Ivoire from. See activity 3.1.
- September 11-15. The Tanzania team conducted scoping exercise field visit for potential irrigation schemes to scale out under TISA. Visited schemes in Iringa (Igingilanyi, Tanangozi, Mlenge, Mafuruto, Nyamahana, Idodi, Mapogoro, Tungamalenga, and Isaka) and Mbarali Districts (Chosi, Ipatagwa, Herman,

Igomelo, Mbuyuni, Njombe, Ruanda Majenje, and Uturo) and disseminated project information to farmers in those schemes.

- October 4-5. Dr Mdemu presented at the Multi Sectoral Forum for National water Resources Management, organised by WRG2030.
- November 21 -22, Ms Mwamakamba participated in the eighth SADC Multi-Stakeholder Water Dialogue in Johannesburg, South Africa from held under the theme: “Water Development in SADC-Fostering Regional Value Chains and Job Creation through the Water-Energy-Food Nexus Approaches”. See activity 3.1.
- December 3-6. Dr van Rooyen attended the 3rdInternational Conference on Global Food Security. Cape Town, South Africa.

2018

- January 19. Dr Mdemu facilitated a setup of demonstration plot by Monsanto of tomato seeds (Firenze) and onion. Three farmers volunteered to set up the demonstration plots.
- January 29-30, Ms Mwamakamba participated at the first ever Water for Food International Forum. It was convened by the Daugherty Water for Food Global Institute at the University of Nebraska and the World Bank, in partnership with the U.S. Department of Agriculture and the U.S. Agency for International Development, under the theme: “Farmer-led irrigated agriculture: Seeds of opportunity,” from at the World Bank in Washington, D.C., USA. See activity 3.1.
- March 14. Dr Chilundo made a presentation on the project to the Faculty of Agriculture and Forestry Engineering, at University Eduardo Mondlane.
- March 15-16. Dr Mdemu organised a project-planning meeting with key research partners (Zonal Irrigation Commission, Iringa and Mbarali District Councils). Clarified project rationale, project research areas, and jointly developed a plan of activities with key responsibility assigned to partners.
- March 19-23. Prof Bjornlund attended the World Water Forum in Brasilia and presented the TISA case study for the IWRA / K-Water report.
- May 15. Mr Cheveia and Dr Chilundo made a presentation to the Namaacha District Administrator and her staff regarding the TISA project and the monitoring tools.
- June 7-8, Dr Mdemu met project stakeholders to disseminate results, introduce TISA to wider range of stakeholders and initiate joint planning for engaging stakeholders in the AIP, both at scheme and district level. Representation of participants included farmers, ward councillors, district councils (Iringa and Mbarali), training and research institutions, financial institutions, government entities (National Crop Board, Rufiji Basin Water Board), NGOs
- June 11-14, Drs Mdemu, Pittock and Christen disseminated project results to development partners in Tanzania including World Bank, FAO, IFAD, and USAID. Explored potential partnership with ESRF and NIC to scale out the TAIP approach to other scheme through spill over funding and policy dialogues.
- July 24-27. The TISA project annual meeting workshop was held in Maputo, Mozambique. Results disseminated results to partners to the project (i.e., irrigation associations, Eduardo Mondlane University, District Services for Economic Activities (SDAE) and district representatives from the National Directorate of Extension Service (DPASA)).
- July 2 to August 8, Exhibition of the Chameleon sensors and WFD in the Annual Agricultural Show in Mbeya, Tanzania. See Annex 3.4 ‘*TZ Nane nane report 2018’*.doc

- August 2-3. A Mozambique National Policy Dialogue was held, with INIR staff and Ms Mwamakamba present during the ‘*’National Policy Dialogue on the Challenges of Agriculture in Mozambique in Focus with Irrigation and Post-Harvest Management.”* The Ministry of Agriculture and Food Security (MASA), FANRPAN and the FANRPAN Node in Mozambique, represented by the Faculty of Agronomy and Forestry Engineering of Eduardo Mondlane University, convened the event. This was part of the implementation of the TISA project and Post-Harvest Management Projects in Sub-Saharan Africa (PHM-SSA).
- August 22-23. Dr Moyo presented at the Water management for food production in an era of changing development agendas session. Swedish Development Research Conference (DevRes). University of Gothenburg, Sweden. https://globalstudies.gu.se/forskning/development-research-conference-2018
- September 12-15. Prof Bjornlund attended the Korean International Water Week and presented the TISA case study for the IWRA/K-water report during the launch of the report.
- September 19-21. During the INIR national irrigation meeting in Mozambique, TISA activities were disseminated during the session on “Irrigate to Produce More, Sustainable and Resilient to Climate Change”.
- October 3-6. Dr Moyo presented at the Global Water Security Conference for Agriculture and Natural Resources. Organised by the American Society of Agricultural and Biological Engineers (ASABE) and the Indian Society of Agricultural Engineers (ISAE). Taj Krishna, Hyderabad, India.
- November 2018. Invited by UNESCO, Mr de Sousa attended and presented TISA activities at the African Water Week in Libreville Gabon.
- November 8-9, the then FANRPAN CEO, Munhamo Chisvo disseminated results and introduced TISA to approximately 80 representatives from civil society coming from the Southern African Development Community (SADC), the ACP and the EU at the 16th Regional Seminar of ACP-EU Economic and Social Interest Groups in Windhoek, Namibia.
- November 14th. TISA was represented by Drs Mdemu and Christen in the second National Multi-Sectoral Forum for Water Resources Management, which was held at Serena Hotel in Dar es Salaam. Dr Mdemu participated in a panel discussion on irrigation financing;

2019

- January 30, Andre van Rooyen presented TISA research in “Collaborative solutions for complex problems in Southern Africa” at the Fenner School of Environment and Society at ANU. The audience included representatives from ACIAR, DFAT and academics. https://fennerschool.anu.edu.au/news-events/news/collaborative-solutions-complex-problems-southern-africa
- February 12-15, the Australasian Agricultural and Resource Economics Society (AARES) hosted its annual conferee in Melbourne. This year’s theme was “Dynamic Changes in agriculture and resources”, including several areas such as water, agricultural production, productivity and efficiency. Dr Ana Manero presented a paper that addressed the concept of “water equity” and why it is important for smallholder irrigators in Tanzania. Through an interactive presentation, Ana involved the audience to illustrate the multiple accepts of “water equity”, which go beyond widely used volume metrics.
- March. National Water Forum, Adelaide. Prof Bjornlund presented.
- April 2 – 4. Seeds of Change Conference: Gender Equality through Agricultural Research for Development held at University of Canberra funded by ACIAR and

CGIAR. Prof Bjornlund was a panel speaker on the side event: 'Rethinking agriculture: is sustainable, inclusive intensification possible?'

- Mozambique - The project team facilitated the filming of the ACIAR Good Cooks program at one of the irrigation schemes in Mozambique. The Australian, Paul West was the celebrity chef on this episode; he was incredibly impressed with the amazing skills and flavours incorporated into the recipes he learnt. He was especially impressed with the truly special experience of cooking the final recipe of the episode (and the series) with Mrs Carolina of Xiguinha de Kakana (Figure 4) with the help of her granddaughter without the need for a translator through simple body language and a mutual appreciation for cooking and family in the kitchen. The recipes of xima and matapa, xiguinha de kakana, and fresh seafood from the Maputo Fish Market all highlighted the importance of improving productivity of the food value chain in Mozambique. Paul was especially eager to share his love for sustainable food production the people he met, as well as spread the word about the great work of ACIAR and the ANU have been doing here in southern Africa with the Chameleon.
- https://www.aciar.gov.au/goodcooks/mozambique

Figure 4. Mama Caroline with Paul West, photo credit ACIAR.

- July, Bjornlund, V.; Bjornlund, H. and van Rooyen, A. (2019): The evolution of agricultural water management in sub-Saharan Africa. Environmental History World Congress, Florianópolis, Brazil
- August 28, Mr. Miguel Tafula made a presentation of the Project in the District Services of Economic Activities of Moamba
- September, Bjornlund, H.: The use of smart technologies and institutions for small-scale irrigation schemes in Southern Africa. Korea International Water Week - Smart Water Management Platform: IoT-Based Precision irrigation for Small and Medium Scale Farmers,
- November 5-7, FANRPAN convened a Regional Policy Dialogue, which focused on Enhancing Climate Resilience and Food and Nutrition Security in Kigali, Rwanda. Dr Makarius Mdemu from Ardhi University gave a presentation on Transforming smallholder irrigation into profitable and self-sustaining systems throughout-scaling in southern Africa, to over 100 key stakeholders.

- December 3rd. Dr Mdemu, participated in the National Multi-sectoral Forum on water resources that was conducted at Julius Nyerere Conference Centre. The theme of this year's forum was "Bringing in key players in Water Resources Management" The Multi-sectoral Forum provides a platform for dialogue on enhancing stakeholder's participation for improved water security in Tanzania. It is coordinated by the Ministry of Water in collaboration with Water Resources 2030 of the World Bank Group. The forum provided a platform for sharing knowledge on the status of water resources in Tanzania, private sector initiatives in the water sector, and Habari za Maji Awards that is aimed at catalysing Tanzanian media coverage and advocacy on water resources management.

2020

- February, Bjornlund, H. Increasing urban supply by implementing Smart Water management and Smart Institutions in the irrigation sector: Lessons from sub-Saharan Africa presented at the Water and the City Conference held at the Asia Research Institute at the National University of Singapore.
- March 19, Mr. Miguel Tafula made a presentation and training on the monitoring tools, during the province's Extension Officer Recycling Event, organized by the Provincial Directorate of Agriculture and Rural Development (DPADER), which was represented by extension officers from all the districts of the province of Manica.
- October. Dr N. Nyoni – Irrigation development and agricultural water management in Africa: transitioning implementation for sustainable adaptation, convened on the 15th of October 2020 by the African Union Commission in collaboration with FAO, IWMI and the World Bank to promote Member States' internalization of the African Union' Irrigation Development and Agricultural Water Management (IDAWM) Framework;
- October. Prof J. Pittock and Dr N. Nyoni – FANRPAN Multi-stakeholder Annual Regional Policy Dialogue convened on 20-22 October 2020 under the theme 'Building Better and Resilient Agriculture and Food Systems.' The Policy Dialogue was convened in collaboration with the Common Market for Eastern and Southern Africa (COMESA); the Southern African Development Community (SADC), CARE International, the International Development Research Centre (IDRC), GRA, OXFAM, the GCRF-AFRICAP - Agricultural and Food-system Resilience: Increasing Capacity and Advising Policy Programme, and the Australian Centre for International Agricultural Research (ACIAR). In this meeting, Prof Jamie Pittock delivered a presentation on how the TISA interventions have transformed the irrigation schemes and livelihoods of target beneficiaries.
- November. Dr N. Nyoni – African Union Cultivate Africa conference, convened on 17-18 November 2020, was organized by the Africa Union Commission in partnership with Hallpax. The main objective of Cultivate Africa was to unlock a concerted multi-stakeholder partnership toward a sustained and effective response leading to averting potential adverse effects of the COVID-19 pandemic on food security and nutrition and food systems (production, distribution, trading and market access of agricultural commodities and services). The event was attended by key stakeholders from across the African continent and the globe.
- November. Prof J. Pittock and Dr N. Nyoni – Knowledge to action and action to knowledge: how collaborative processes can address climate change, convened on 19 November 2020 and organized by the Climate Change Institute, Australian National University. In this meeting, three case studies to demonstrate how collaborative processes between researchers and policymakers can work in practice and what the ingredients for success were discussed. Various stakeholders, including academics, CSOs and government officials attended this webinar.

2021

- May. Dr Andre Van Rooyen and Dr N. Nyoni – Building Resilient and Sustainable Food Systems in Africa: Mobilizing African Voices and Building Momentum for the UN Food Systems Summit -East and Southern Africa Regional Food Systems Dialogue convened by FANRPAN and Akademiya2063 on 31 May 2021. This meeting, which brought together a wide range of stakeholders directly involved in moving food from farm to fork, sought to increase understanding of critical issues around challenges and opportunities to transforming African food systems and develop a summary statement consolidating African voices on best practices, game changing solutions, and recommendations from the dialogue.
- April. Bjornlund, V; Bjornlund, H. and van Rooyen: 'History matters – Implications for Agricultural Research for Development in Southern Africa' at the Australian National University.
- June. All project partners – Improving the Performance Ratings of the Southern African region in the CAADP/Malabo Declaration Biennial Review Process through Transformed Irrigation Systems, convened by FANRPAN on 15 June 2021. The meeting focused on sharing TISA outcomes, and mobilizing resources to scale up, out and deep project interventions.
- June. Van Rooyen, Bjornlund and Pittock, keynote address at the 2021 IWRA online conference on 'One Water, One Health: Water, Food and Public Health in a Changing World': How can managing water in agriculture contribute to food security and public health? Evidence from Africa, and propositions for further work.
- Early in the FY21-22, a short YouTube video about the TISA project in Tanzania was released by ACIAR: https://youtu.be/MVs139ZZhcc
- 6th-9th July 2021, Dr N. Nyoni – Pre-Feasibility Study for Programme for Integrated Development and Adaptation to Climate Change in the Zambezi Watercourse - PIDACC Zambezi 2021.
- 21st July FANRPAN –Forging Effective Partnerships to deliver Sustainable Agriculture and Food Systems, FANRPAN Partners' Meeting,
- 13th August, the TISA Tanzania team presented "The role of soil water monitoring tools and AIPs in improving food security and income of farmers in smallholder irrigation schemes in Tanzania" during a meeting of private stakeholders in irrigation organised by NIRC. Following this meeting, the NIRC Chairman of the Board asked TISA to prepare a brochure on Soil water Chameleon Sensors and WFD in Swahili language. The brochure was prepared and submitted to the Chairman.
- 30th August. Biennial Review Validation Workshop of South Africa Progress Report on the implementation of 2014 Malabo Declaration Commitments,
- 28th-30th September. FANRPAN and TISA project partners – Catalysing Action to Transform Africa's Food Systems. FANRPAN 2021 Annual Policy Dialogue,
- Late November/early December. International Water Resources Association (IWRA) XVII Congress Special Session. UniSA led the organization of TISA participation at the World Water Congress (WWC) in Daegu, Korea. Due to COVID, only two team members were present, one from Mozambique who presently is doing her PhD in Bonn, Germany and our field officer from Mozambique. Other participated remotely. We paid for virtual presentation and virtual audience. We had two special sessions and presented ten papers:
    - Henning Bjornlund, University of South Australia: introducing to TISA.
    - Jamie Pittock, Australian National University: 'Rebooting failing irrigation systems.'

  - Makarius Mdemu, Ardhi University: 'The impact of innovations in soil moisture-nutrient monitoring and agricultural innovation platforms on food security and income of farmers in smallholder irrigation schemes in Tanzania.
  - Martin Moyo, ICRISAT, Zimbabwe: 'The dynamics between irrigation frequency and soil nutrient management: transitioning small-scale irrigation towards more sustainable systems in Zimbabwe'.
  - Felicidade Jorge, Mozambique, Bonn University 'Do Agricultural Innovation Platforms and soil moisture and nutrient monitoring tools improve the production and livelihood of smallholder irrigators in Mozambique?'
  - Karen Parry, PhD Candidate, University of South Australia: 'The importance of learning processes in transitioning small-scale irrigation schemes towards complex adaptive systems.
  - Andre van Rooyen, ICRISAT, Ethiopia: 'Identifying leverage points to transition dysfunctional irrigation schemes towards complex adaptive systems".
  - Ana Manero, post-doctoral research fellow, Australian National University: Growth and inequality at the micro scale: an empirical analysis of farm incomes within smallholder irrigation systems in Zimbabwe, Tanzania and Mozambique"
  - Karen Parry, PhD Candidate, University of South Australia: 'Youth and Small-scale Irrigation Schemes – opportunities and challenges'
  - Mr. Emmanuel Kimaro, Tanzania, MA student University of Dar es Salaam: Participatory mapping of irrigation schemes in Tanzania, Mozambique and Zimbabwe
- UniSA mentored a young Zimbabwean woman Georgina Mukwirimba to be a youth envoy at the World Water Congress, Daegu in November/December and in her career building after her honour's degree. She participated very successfully presented her paper and was one of the closing plenary panels.
- 13th-14th December. Crawford fund Annual conference - Michael Wellington participated and held productive conversations on his work and the TISA project, identifying several follow-up opportunities.

2022

- 2nd Feb 2022, Dr N. Nyoni – Strengthening Accountability and Utilization of Biennial Review Results - the Role of the Media and Non-State Actors; this African Union Commission (AUC) meeting focused on how best to drive implementation of the ambitious Malabo targets of Ending Hunger in Africa by 2025.
- 10th March FANRPAN – The launch of the third (3rd) CAADP Biennial Review (BR) Report. This launch by the AUC aimed to increase awareness and advocacy among all stakeholders and to build momentum behind the CAADP Agenda for increased political, policy and financial commitment.
- 29th March, TISA Mozambique team participated in WaPOR Phase 2 Project (remote sensing for water productivity (FAO project)) inception workshop held in Maputo, Mozambique. The workshop had 31 participants, from a wide range of backgrounds and institutions including the Municipal Council of the city of Maputo, the Ministry of Agriculture and Rural Development as well as the National Institute of Irrigation, the Water Research Institute and the International Institute for Tropical Agriculture, among others. At this meeting, the TISA team shared information about the tools and associated beneficial impacts on farmers' livelihoods. Following this meeting, the TISA team and WaPOR are working together to find ways collaborate.

https://www.fao.org/in-action/remote-sensing-for-water-productivity/news-and-events/news/news-details/en/c/1505365/

- 21st-26th March. UniSA Attended the World Water Forum in Dakar Senegal in March where UniSA participated in three panels presenting TISA findings, including:
  - Smart Water Cities and Rural Areas Interconnected Challenges. Session 2D4 Smart Water Management.
  - An introduction to the 'Transforming Irrigation in Southern Africa' project (TISA). Session 2E3 Innovative Technologies and Productive Water.
  - Small-scale irrigation schemes as hubs for rural transformation. Session 2D2 Switching from Rural Development towards Rural Transformation.
- 12th April, TISA team participated in a workshop held in Maputo, Mozambique for the implementation of the Integrated Program for Development and Adaptation to Climate Change in the Zambezi River Basin (PIDACC-ZM). The event was carried out by the Ministry of Agriculture and Rural Development of Mozambique and IWMI Southern Africa in coordination with the Global Centre on Adaptation (GCA) with funding from the African Development Bank (BAD) and the World Bank Group (WBG). During the meeting, TISA shared information on the soil monitoring tools, and associated impacts on farmers' livelihoods and its advantages for scheme level water resources management. As a result, the tools will be integrated as one of the approaches in the Program.
- 17th May. FANRPAN – The Climate, Land, Agriculture and Biodiversity (CLAB-Africa) Project Webinar 2: Land–Water–Energy Resources Use –. This meeting, convened by FANRPAN, focused on the sustainable use of land, water and energy resources to develop recommendations for sustainable resource use and optimization of land, water and energy.
- 19th May Dr N. Nyoni – Accelerating the Impact of Irrigation and Landscape-Level Agricultural Water Management at Scale, Agrilinks Webinar -. This webinar sought to explore gaps and opportunities for future research in irrigation and landscape-level agricultural water management (AWM) for improving food security, building resilience, and providing a pathway out of poverty in Africa.
- 26th-27th May Dr N. Nyoni – The launch of the 3rd CAADP Biennial Review critical analysis, virtual meeting convened by AUC and partners.
- 15th June. All TISA project partners – Improving the Performance Ratings of the Southern African region in the CAADP/Malabo Declaration Biennial Review Process through Transformed Irrigation Systems, convened by FANRPAN. The meeting focused on sharing TISA outcomes, and mobilizing resources to scale up, out and deep project interventions. It also explored the role of smallholder irrigation schemes in building resilient food systems and fostering nutrition security in Africa and reflected on the performance of the continent against the CAADP/Malabo Declaration targets.
- June. UniSA and ICRISAT participated in the 39th International Association for Hydro-Environment Engineering and Research (IAHR) World Congress held in Granada, Spain, where three TISA papers were presented:
  - Youth Involvement in Small-scale Irrigation Schemes.
  - The value of water: a perspective from the Global South.
  - Irrigated Water and its role in Circular agri-food systems in Sub-Saharan Africa.
- October. UniSA organized a collaboration between TISA (ACIAR), ICID and IWRA to have two special sessions on TISA on the 24th ICID International Irrigation Congress to be held in Adelaide in October 2022. UniSA is serving on the International technical

Advisory Body. ACIAR funded four African team members to travel to Adelaide to attend the Congress as well as presenting papers as seminars at UniSA and ANU as well as undertake a road trip from Adelaide to Canberra to visit Australian Irrigation. The TISA team presented both at UniSA on the 7thOctober and ANU on the 13thOctober.

- European Foundation for Management Development (EFMD) Excellence. TISA was represented during the EFMD Conference from 3-6 October 2022. TISA received a Gold Award in the Ecosystem Development category in Practice Award.
- COP27 Official FANRPAN Side Event was held Monday,14th November. FANRPAN and the Common Market for East and Southern Africa (COMESA) in partnership with Global Roundtable for Sustainable Beef (GRSB) organized an official UN Climate Change Conference (COP26) side-event: Towards Resilient, Sustainable, Transformed African Agriculture and Food Systems. TISA project was presented as an example of initiatives building resilience of smallholder farmers in Africa.

2023

- March. FANRPAN in collaboration with the TISA partners, the Department of Agriculture, Land Reform and Rural Development of South Africa; the FANRAN Node Hosting Institution in South Africa the National Agricultural Marketing Council (NAMC); the Agricultural Research Council (ARC) South Africa, the Common Market for East and Southern Africa (COMESA), the SADC Groundwater Management Institute (GMI), the International Water Management Institute (IWMI), the Wine Industry of South Africa (SAWITU), Human Research Council of South Africa (HSRC), the South Africa Council for National Scientific Professions (SACNASP; and the African Agricultural Technology Foundation (AATF) with ACIAR convened a hybrid Regional CSA Policy Dialogue from the 13th-15th of March 2023. It was at the University of Pretoria's Future Africa Campus, South Africa. The dialogue's theme *was "Transitioning to Climate-Resilient Farming Systems in Sub-Saharan Africa*," focusing on the next generation of research, smart technology, policy development and best practices that are achieving breakthroughs in this vitally important mission. The dialogue's objectives were as follows:
    - Share empirical evidence on the importance of climate smart agriculture in transitioning to resilient farming communities in SSA.
    - Develop recommendations on how to build climate smart and resilient farming systems in SSA at scale.
    - Networking, and promoting partnerships and action.
- August 2023, FANRPAN in collaboration with the Centre for International Forestry Research/ World Agroforestry Centre, the Stockholm International Water Institute and the Zambezi Watercourse Commission, convened a side event at World Water Week in Stockholm. FANRPAN CEO, Dr Tshilidzi Madzivhandila delivered the welcome and framing remarks and Ms Sithembile Mwamakamba presented outcomes from the TISA project.
- August. Climate change adaptation benefits from rejuvenating irrigation schemes in Tanzania, Zimbabwe and Mozambique. Henning presented at the World Congress of the International Association of Hydrological Research, Vienna, 21-25 August 2023
- September Climate change adaptation benefits from rejuvenating irrigation schemes in Tanzania, Zimbabwe and Mozambique. Henning will present at the XVIII World Water Congress, Beijing 11-15 September 2023.

- 20 September Henning will give a half day TISA seminar at the China Centre for Agricultural Policy at Peking University
- October. 11th Biennial Rosenberg International Water Policy Forum, Cape Town, 23-27 October 2023. Henning will present Combining socio-institutional and technological innovations for sustained change in water user behaviour within small-scale irrigation schemes in sub-Saharan African. This paper might be selected for a special issue coming out of the Forum. If not, we will publish it elsewhere. It is one of the synthesis papers mentioned in the application.

10.7 Table of irrigation schemes

Country, province / region, AIP, district and irrigation scheme name	# of schemes	Number of farmers	Hectares
Manica Province			
Vanduzi			
Campo 4	1	53	29
Nhamandembe	1	34	27
Nhaúmbue	1	38	50
Manica Province Total	**3**	**125**	**106**
Maputo Province			
Boane			
25 de Setembro*	1	65	40
Manguiza 1 & 2	1	65	22
Namaancha			
Mafuiane	1	228	170
Magude			
Khanimambo*	1	22	16
Macuvulana I	1	186	199
Macuvulana II	1	65	78
Siabonga (Khomani pwi tia)	1	51	47
Moamba			
Bloco I	1	125	215
Bloco II	1	140	240
Maputo Province Total	**9**	**947**	**1,027**
Mozambique Total	**12**	**1,072**	**1,133**
Iringa Region			
Iringa			
Igingilanyi	1	35	15
Kiwere*	1	168	147
Mafuruto	1	250	127
Nyamahana	1	267	115
Lipuli	1	448	123
Iringa			
Idodi	1	379	660
Magozi*	1	512	750
Mlenge	1	10,000	3,000
Tungamalenga	1	214	659
Iringa Region Total	**9**	**12,273**	**5,597**
Mbeya Region			
Mbarali			
Igomelo	1	382	312
Mbeya Region Total	**1**	**382**	**312**
Morogoro Region			
Morogoro			
Sokoine University of Agriculture demonstration**	1		
Morogoro Region Total	**1**		
Dar es Salaam			
Kinondoni			
Water Institute of Tanzania demonstration**	1		
Dar es Salaam Total	**1**		
Tanzania Total	**12**	**12,655**	**5,909**

Country, province / region, AIP, district and irrigation scheme name	# of schemes	Number of farmers	Hectares
Zimbabwe			
Matabeleland North			
Binga District AIP			
Binga			
Lungwalala	1	218	110
Nabusenga	1	68	20
Tyaba	1	54	12
Bubi District AIP			
Bubi			
Hauke	1	80	40
Inkosikazi	1	60	20
Pollards	1	108	45
Hwange District AIP			
Hwange			
Chentali	1	42	10
Lukosi	1	73	24
Makwa	1	43	9
Lupane District AIP			
Lupane			
Tshongokwe	1	61	24
Makhovula	1	60	15
Zinaphi	1	60	8
Matabeleland North Total	**12**	**927**	**337**
Matabeleland South			
Landela scale out – Insiza District AIP			
South Insiza			
Silalatshani – Landela block*	1	237	110
Silalatshani – Mbokodo	1	116	54
Silalatshani – Nonoka	1	164	86
Silalatshani – Pelandaba North	1	161	79
Silalatshani – Pelandaba South	1	84	48
Silalatshani – Vukuzenzele	1	108	66
Matabeleland South Total	**6**	**870**	**442**
Harare Province			
No AIP			
Harare			
Zimbabwe Irrigation Technology Centre demonstration**	1	-	-
Harare Province Total	**1**	**-**	**-**
Midlands			
(blank)			
Vungu Rural			
Mkoba *	1	75	10
Midlands Total	**1**	**75**	**10**
Zimbabwe Total	**20**	**1,872**	**789**
Total demonstration / training sites	**3**		
Total number of schemes	**41**		
Grand Total	**44**	**15,599**	**7,831**

Key: TISA I original scheme level AIPs – six = *

Demonstration / training sites - 3 = **

10.8 Acronyms

Acronym	Phrase or words
ACIAR	Australia's Centre for International Agricultural Research
ACT	Agricultural Council of Tanzania
AfDB	African Development Bank
AfDB	African Development Bank
AGRITEX	Agricultural Technical and Extension Services. Zimbabwe
AIP	Agricultural Innovation Platform
ANU	The Australian National University
ARDA	Agricultural Development Authority, Zimbabwe
AUC	African Union Commission
AWM	Agricultural water management
CAADP	Comprehensive African Agriculture Development Programme
CCRO	Certificates of Customary Right of Occupancy. Tanzania
CLAB-Africa	The Climate, Land, Agriculture and Biodiversity
CSIRO	Commonwealth Scientific and Industrial Research Organization
DoI or DoIRR	Department of Irrigation, Zimbabwe
DPADER	Provincial Directorate of Agriculture and Rural Development, Mozambique
EC	Electrical conductivity meter
ECRIMS	Enhancing Community Resilience and Inclusive Market Systems
EFMD	European Foundation for Management Development
ESRF	Economic and Social Research Foundation. Tanzania
FANRPAN	Food, Agriculture and Natural Resources Policy Analysis Network
FASIMO	Farmer led irrigation in Mozambique – CultiAF funded
FFB	Farmers field book
GAPI	Sociedade de Investimentos, Mozambique
GCA	Global Centre on Adaptation
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
GoT	Government of Tanzania
ICRISAT	International Crop Research Institute for the Semi-Arid Tropics
IFAD	International Fund for Agricultural Development
IFPRI	International Food Policy Research Institute
IJWRD	International Journal of Water Resources Development
IMC	Irrigation management committee
INIR	National Institute for Irrigation. Mozambique
IO	Irrigators' organisation
IWMI	International Water Management Institute
IWRA	International Water Resources Association
KfW	German Development Bank

Acronym	Phrase or words
KIKI	Chameleon (Kinyonga) and Wetting Front Detector (Kibendera) (VIA Tanzania business)
LTA	Land Technical Assistance, Tanzania
NGO	Non-governmental organization
NIC	National Irrigation Commission
PIDACC-ZM	Program for Development and Adaptation to Climate Change in the Zambezi River Basin
RIEng	Rural Integrated Engineering
SADC	Southern African Development Community
SDAE	District Service of Economics Activities. Mozambique
SIRP	Smallholder Irrigation Revitalisation Programme
SIZIMELE	Sizimele Action for Building Resilience in Zimbabwe
SNA	Social network analysis
TAIP	Tools plus agricultural innovation platform
TECAP	Tecnologia e Consultoria Agro-Pecuária Lda. Mozambique
TISA (2)	Transforming irrigation in southern-Africa – LWR/2016/137
TISA 1	Increasing irrigation water productivity in Mozambique, Tanzania and Zimbabwe through on-farm monitoring, adaptive management and agricultural innovation platforms – FSC/2013/006
UEM	University Eduardo Mondlane. Mozambique
UNDP	United Nations Development Programme
UniSA	University of South Australia
USAID	United States Agency for International Development
VIA	Virtual irrigation academy
WaPOR	Water productivity (remote sensing FAO project)
WB	World Bank
WBG	World Bank Group
WFD	Wetting Front Detector
WLE	CGIAR Research Program flagships on Water, Land and Ecosystems
WWC	World Water Congress
WWF	World Wide Fund for Nature
ZITC	Zimbabwe Irrigation Technology Centre
ZINWA	Zimbabwe National Water Authority.
ZRBF	Zimbabwe Resilience Building Fund