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TRANSFORMING SMALLHOLDER IRRIGATION SCHEMES IN AFRICA

A guide to help farmers become more profitable and sustainable

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Jamie Pittock, Peter Ramshaw, Henning Bjornlund, Emmanuel Kimaro, Makarius V. Mdemu, Martin Moyo, Sithembile Ndema, Andre van Rooyen, Richard Stirzaker and Wilson de Sousa.

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PREFACE

Across Africa, smallholder irrigation schemes have performed poorly, leading to calls for their 'revitalisation', 'reoperation' or 'rehabilitation'. Generally, this leads to another donation or costly government-funded repairs to failed infrastructure that is destined to fail again. In this guide, we argue that this 'build – fail – rebuild' cycle is wrong, focusing solely on infrastructure repair rather than enhancing the capacities of local people and institutions through investment.

We present knowledge generated through four years of research intervention at six irrigation schemes in Mozambique, Tanzania and Zimbabwe. We present our understanding of what has worked to turn five of these schemes around, from situations where the infrastructure was poorly maintained or broken, the farmer organisations were weak, soil fertility was low, water was failing to reach the tail end of irrigation canals, a large number of plots were underutilised or abandoned, crop yields were very low and, most worryingly, farmers were living in poverty.

We argue that smallholder irrigation schemes are complex systems that only function profitably and sustainably when there is a substantial investment in the capacities of the farmers, their institutions and the formal and informal governing rules. Broken infrastructure is usually just a symptom of a failed socioeconomic and socioecological system. We argue that no single intervention will make these irrigation schemes work; rather, multiple complementary interventions are needed for farmers to use their irrigation schemes to generate good livelihoods sustainably.

In this guide, we have provided a summary of our best advice on good practices needed for more sustainable irrigation. Each short section can be used alone, although a number of different complementary interventions are usually required to achieve better socioeconomic and environmental outcomes.

We have not attempted to describe the full range of positive interventions for sustainable irrigation schemes, but rather, report on those that we have tried and that have worked. The ideas described here have been developed through the project *Increasing irrigation water productivity in Mozambique, Tanzania and Zimbabwe through on-farm monitoring, adaptive management and agricultural innovation platforms* that was largely funded by the Australian Centre for International Agricultural Research (project FSC/2013/006). This first edition of the guide will be revised around 2020, and we would welcome your advice on elements that can be improved.

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Disclaimer

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Shortened forms

ACIAR	Australian Centre for International Agricultural Research
AGRITEX	Agricultural Technical and Extension Services, Government of Zimbabwe
AIP	agricultural innovation platform
ANU	Australian National University
CSIRO	Commonwealth Scientific and Industrial Research Organisation
FANRPAN	Food, Agriculture and Natural Resources Policy Analysis Network
GIS	geographic information system
GPS	Global Positioning System
ICRISAT	International Crop Research Institute for the Semi-Arid Tropics

INTRODUCTION

Across Africa, national governments are setting agricultural development targets for millions of hectares of new irrigation areas and funders are investing billions of dollars in new projects. The reasons proffered for this expansion include the need to reduce poverty, secure food supplies, enhance resilience to climate change and increase economic growth.

Sadly, most smallholder irrigations schemes in Africa are performing poorly and failing to achieve the objectives for which they were established, namely, to lift farmers out of poverty and significantly increase food security (Bjornlund et al. 2017; Mutiro and Lautze 2015). These schemes are complex systems, so common interventions (such as concrete lining of canals) by themselves will do nothing to address the many economic, institutional and technical reasons for their failure. For these reasons, a number of simultaneous interventions are required to lift the performance of these socioecological systems to new, more beneficial and sustainable states (Denison and Manona 2007).

The reasons that smallholder irrigations schemes fail and farmers remain in poverty are many. From our research, they include a great many institutional barriers. For instance, a lack of documented entitlement to farm plots means that farmers are not keen to invest and are unable to access finance. Another example is government requirements to grow low-profit staple food crops. Consequently, farmers decide to use their plots for low input/low output (yield) agriculture, and irrigation organisations are unable to raise fees to pay for scheme maintenance and renewal (Mwamakamba et al. 2017). Limited farmer knowledge of how to measure water application and use different fertilisers has resulted in over-watered fields leached of nutrients, producing poor crops at the head end of irrigation canals. It also means erratic water supplies to plots at the tail end of canals, resulting in limited crop production and community conflicts, as well as large numbers of underutilised or abandoned plots (Stirzaker et al. 2017). Aggravating the system failures is the absence of avenues for collective farmer negotiations with suppliers of transport and farm inputs to agree on seed supply, chemicals and transport services. The absence of platforms for farmers to engage with markets has led to the production of crops for which there is little demand or profit, undermining the whole system (van Rooyen et al. 2017).

'...a number of simultaneous interventions are required to lift the performance of these socioecological systems'

Why the guide is needed

This guide is needed to provide practical advice to farming leaders, community organisations and government officers on interventions for sustainable and profitable irrigation that work. It should help ensure that public investments in repairing existing smallholder irrigation schemes or building new projects are not wasted. There are other excellent sources of advice, such as 'Principles, approaches and guidelines for the participatory revitalisation of smallholder irrigation schemes: A rough guide for irrigation development practitioners for South Africa' (Denison and Manona 2007). This guide seeks to complement, not supplant, such advice with knowledge from our research

Figure 1 Location of the six irrigation schemes.

in three African nations: Mozambique, Tanzania and Zimbabwe and six irrigation schemes located in Figure 1.

The information in this document is based on research that showed that solving system-level problems while simultaneously increasing farmer crop production led to significantly increased farmer income and reduced conflict. System-level issues, such as links to markets, problems with water supply and water sharing, land abandonment and ageing farmers, were resolved by using the participatory problem-resolving approach called agricultural innovation platforms (AIPs). In addition, the simple tools 'Chameleon' for soil moisture and 'FullStop' for nutrients provided feedback on farmer management actions that led to farmers changing their irrigation and fertiliser practices, resulting in increased yields and reduced water and labour inputs. Water and nutrient management needs to improve on-farm before any infrastructure intervention. If this is done first then any future technical intervention will reap much greater benefits and, because of increased income, may be properly maintained. This two-pronged approach proved effective across the varied schemes studied in Mozambique, Tanzania and Zimbabwe. The outcomes of the combined tools + AIP approach are increased productivity and profitability, which are critical for the transition into sustainable irrigation communities. The problems faced by smallholder irrigation schemes, the interactions between AIPs and the tools and the resulting outcomes are shown in Figure 2.

'Many of the measures in this guide focus on how to better invest in people'

Who the guide is for

The information in this guide should be useful for a number of stakeholder groups:

- **Funders of irrigation schemes development** – African governments have policies for a massive expansion of irrigated agriculture, and the national and international funders of such developments have obligations to ensure that this public expenditure maximises benefits for farmers while minimising social and environmental impacts. Many of the measures in this guide focus on how to better invest in people rather than a misplaced focus on simply funding infrastructure.
- **Government agencies** – Government organisations at national and subnational scales are under tremendous pressure to both devolve responsibilities to farmer organisations and generate better performances from the irrigation schemes that they oversee. This guide describes some important ways to engender more profitable and self-sustaining schemes.
- **Non-government organisations** – NGOs play key catalytic roles in introducing new ideas and linking information across scales that may greatly help irrigators. The ideas in this guide can add to the suite of tools available to improve the livelihoods of irrigation farmers.

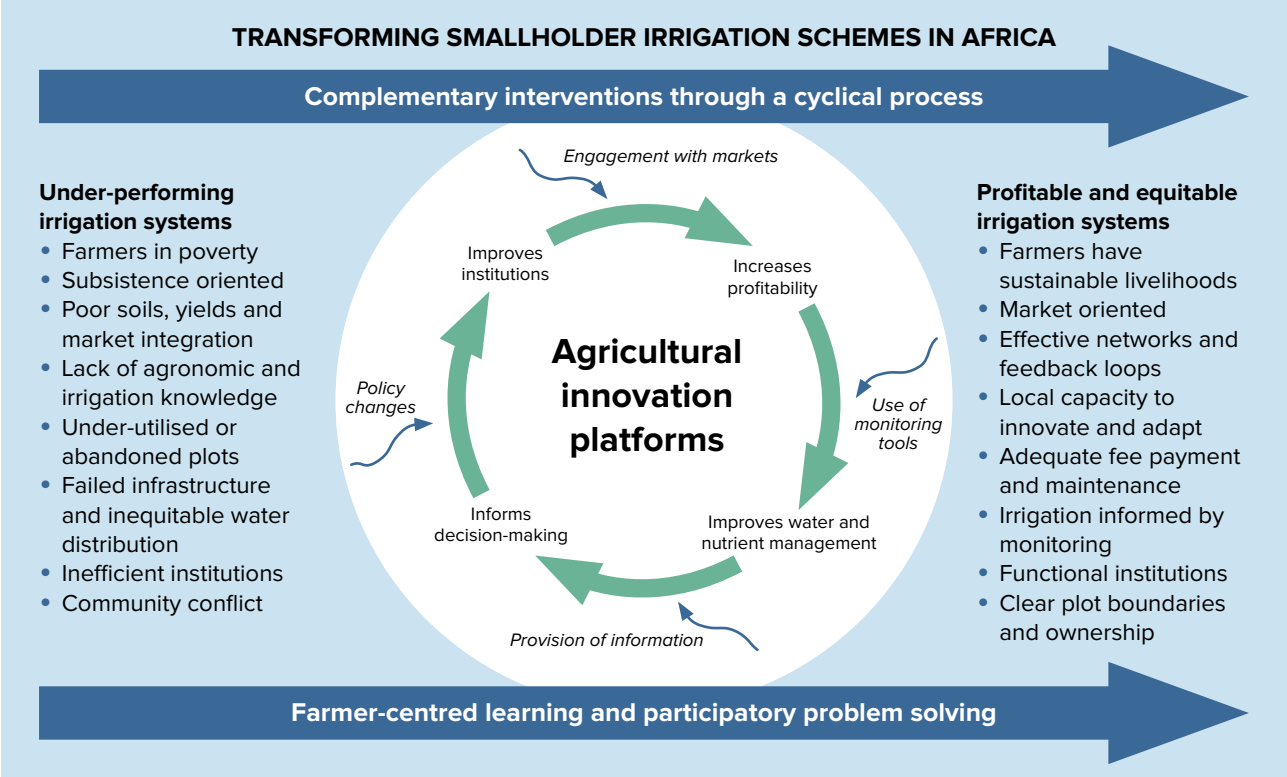


Figure 2 Diagram of the combined Tools+AIP approach.

- **Irrigators' organisations** – These organisations have opportunities to improve the lives of their farmer members. Ideas in this guide can help irrigators' organisations take greater control of the future of their schemes, to ensure that infrastructure is maintained, better ways of farming are constantly found, farmer profitability is increased and social cohesion is maintained or increased.

How the guide is structured

In this introductory section, we explain the reasons why schemes are failing, why this guide is needed and for whom it is intended.

Section 1 outlines the enabling team. Section 2 outlines smallholder irrigation scheme stakeholders and initial data collection. Section 3 introduces the AIP approach used to identify key issues and approaches to address them. Sections 4, 5 and 6 include examples of the issues that arise in smallholder schemes and the approaches that were developed with farmers to address these, such as business plans, market linkages and scheme mapping. Section 7 covers the tools used in monitoring the soil and water that result in farmer learning. Sections 8, 9, 10 and 11 cover cross-cutting issues including equity, monitoring, policy and working across governance scales.

Throughout the guide, we also present some case studies to illustrate the mechanisms that we advocate. We deliberately do not define terms and concepts in detail. Instead, we invite readers who wish to know more to follow up the academic references sparingly cited, including the open access edition of the *International Journal of Water Resources Development*, listed in Annex 1 of this guide.

We hope that you find the ideas, advice and experience in these pages of great use in your work for enhancing the livelihoods of farmers and improving the sustainability of smallholder irrigation farming.

'Ideas in this guide can help irrigators' organisations take greater control of the future of their schemes'

SECTION 1

FORMING A TEAM FOR SUSTAINABLE IRRIGATION

The 'building – failing – rebuilding' cycle so common to irrigation schemes in Africa is a symptom of irrigation being largely the domain of engineers alone. While the design and establishment of the infrastructure is the responsibility of the engineering world, others responsible for operating the irrigation system need to be empowered to ensure effective feedback loops between production and markets and between operational and managerial maintenance costs.

Assembling a team to facilitate the transition of dysfunctional irrigation schemes into fully functional, adaptive and sustainable systems requires careful consideration to include the people who can effect positive change. While each system component may have its own range of players, a team too large for effective management and guidance may also become too costly and ineffective.

Initially, determine the:

- AIP facilitator(s) of the change process
- active players on the ground, such as water user associations, market players, water authorities, government bodies, extension staff and NGOs
- different roles and responsibilities required and the comparative advantages and complementarities among them.

Considering the different components of irrigation schemes and their functioning in the larger socioeconomic environment will help identify the appropriate facilitators and sectors to include in this process. A key selection is that of the AIP facilitator or facilitators. A facilitator needs to have interpersonal and organisational skills that enables them to step back from their personal views, listen to participants, synthesise and repeat ideas back to participants, manage conflicts and focus on outcomes. Independent facilitators can be expensive to hire and lack an understanding of the local context. Government officers and local community leaders need to be able to adopt the mindset of a facilitator rather than that of a top-down director. Researchers need to be willing to respect local peoples' knowledge and follow their issues and desires rather than imposing their knowledge and a pre-determined view of the options and solutions. In our projects, we have tried (in different places) consultants, researchers and government facilitators. The personal qualities of the individual facilitator are more import for a successful community process than the organisation that employs them.

For research and development projects, as facilitators of change (i.e. the core project team) may need access to a range of specialists:

- economists, to deal with value chains as well as household economics and profitability

Farmers from Magozi Irrigation Scheme, Tanzania.

Photo: Peter Ramshaw

- social scientists, to deal with the dynamics between different stakeholders, household and livelihoods, including aspects of gender and youth, social learning and knowledge sharing
- agronomists, to assist with crop production efficiencies
- soil scientists, to address water and nutrient dynamics
- systems scientists, to guide the development of integrated, functional and adaptive systems.

Good leadership is paramount for project management, to keep the diverse group focused on appropriate issues and the big-picture analysis based on the work done in the different countries and schemes.

Working closely with the team will be individuals and institutions who can be seen as more permanent support services and governance systems (that is, they are not specific to the project but are not active value chain players either).

These include government bodies such as the ministries related to water, energy, agriculture and their extension and support services, irrigation management committees, and local and provincial governments, as well as non-government organisations working in the schemes. The process needs to be embraced by these groups, as they are people who can help to facilitate change. Their capacity to understand and continue the facilitation process beyond the project is paramount for establishing sustainable systems. Moreover, if capacity is built of these participants, it will increase the impact footprint, as many of them also work with, or have jurisdiction over, other irrigation schemes.

‘Good leadership is paramount for project management’

SECTION 2

ASSESSING IRRIGATION SCHEMES AS COMPLEX SYSTEMS

Once the team has been assembled, it is critical to work with farmers and other stakeholders to understand the complex system that the scheme operates in. This will require enquiry into production issues, links with input and output markets, equity issues and relationships with key institutions such as government water and agricultural departments.

Initially, conduct a situation analysis to establish both the biophysical, socioeconomic and institutional situations of the scheme. Part of this analysis can be based on existing secondary data obtained from central and local government departments, basin or water catchment organisations, non-government organisations, etc. Information will be needed, such as soil type, irrigation infrastructure, rainfall, hydrology, crop production, extension services, the irrigation management committee, water scheduling and land tenure. After studying the secondary existing data, a site visit is critical to observe the condition on the ground and discuss the issues with local representatives, including managers of irrigators' organisations, farmers, extension officers and other key stakeholders identified in the secondary sources as well as during the site visit. This is critical, to ground the secondary existing data in the local context. There are often discrepancies between what central authorities perceive to be the situation and what actually happens on the ground. The situation analysis should result in a comprehensive report, which would then be discussed with key stakeholders. This should be ready for the first meetings of the AIP process.

Once a thorough understanding is established of the physical and institutional context, conduct a survey to establish the baseline current conditions at the time the project starts. The survey design should be based on the situation report and the associated site visits and stakeholder interviews, and should reveal:

- the property characteristics of the farms, including who controls land and other production assets
- the socio-demographic conditions and farming practices of the farm household, including decision-making processes within the household
- what farmers perceive to be the main barriers to improve their profitability
- how farmers perceive the institutional arrangements within the scheme, such as water scheduling, cropping calendars, enforcement of rules and conflict resolution.

It is critical that the questionnaire design fits the conditions and issues within each scheme, facilitating analysis of gender and generational issues as well as differences between perceptions and realities between top-end and tail-end users. Once designed, the questionnaire needs to be thoroughly piloted with farmers and then reassessed following the pilot. Finally,

Farmers from Mkoba Irrigation Scheme, Zimbabwe.
Photo: Andre F van Rooyen

respondents should be carefully selected, to ensure representation of different groups within the scheme, for example, based on gender, age, asset ownership and position on the water supply canals (top-, mid- and tail-end farmers).

Once the data have been analysed, it is essential to hold feedback sessions with respondents to discuss and verify the results obtained and conclusions made. This will ensure that your interpretation of the results is vested in the local context and that there are good relationships between the project team and all stakeholders.

The results will provide valuable insights to help team members and the AIP identify the most appropriate entry point(s) to facilitate the transition to a more productive and profitable scheme. The AIP process is outlined in Section 3. The assessment will also identify disadvantaged groups within the scheme and their problems. This insight is important in managing equity issues during the project and helping tailor interventions to ensure that these groups benefit from, or at least avoid harm from, the intervention (see Section 8).

'...a site visit is critical to observe the condition on the ground and discuss the issues with local representatives'

SECTION 3

ESTABLISHING AND OPERATING AGRICULTURAL INNOVATION PLATFORMS

Agricultural innovation platforms are multistakeholder groups, formed by outside agents, to deal with complex problems that are not being addressed through current processes. In the AIPs, the different stakeholders each have diverse objectives who, by cooperating to diagnose problems, seek opportunities and implement new strategies to collectively test and develop solutions to make the larger systems function better. In short, AIPs create a space for stakeholders to learn together and change, and they aim to increase the adaptive capacity of a system.

The goal of an AIP is to bring about systemic change in at least two different ways. The first is to link and integrate stakeholders into more functional networks, through increased communication, knowledge sharing and learning (i.e. institutional change). The second is to test and evaluate new processes, strategies and technologies – creating incentives and opportunities to increase system benefits. As such, AIPs facilitate and guide positive change.

Apart from working towards an improved future, an AIP, through its functioning and additional training, builds the local capacity to innovate. An outcome of this is that local stakeholders have the confidence, procedural tools and experience to take control of their development process.

To initiate the innovation process, it is important to identify the right entry points, the aims of the systems and the incentives that will lead to positive changes in the behaviour of the actors. Once established and agreed upon by a core group of stakeholders, the process can begin. It is critical to select an effective facilitator (as outlined in Section 1). There are a number of more detailed guides to innovations platform procedures and rules (e.g. Makini et al. 2013). Here, we outline five stages of AIP implementation: identification of stakeholders, identification of system challenges, visioning, innovation, and implementation and evaluation.

i) Stakeholder identification

The first stage, before establishing an AIP, is to identify and ensure participation of a diverse and committed range of stakeholders. They should be identified by locals, so that local people and/or their representatives identify with the process. Stakeholders often include government and/or non-government organisation representatives, extension agents, scientists familiar with the area

Farmers with sweet potatoes, Silalatshani Irrigation Scheme, Zimbabwe.
Photo: Andre F van Rooyen

and private sector representatives. This means that there is already a common understanding, even if only in generic terms, of the challenges. In many cases, this stage includes literature and current situation surveys (as discussed in Section 2), to obtain as much information as possible on the socioeconomic and technical environment. Once a core stakeholder group (people critical to bring about change) has committed to the process, the platform meeting is initiated.

ii) Identification of system challenges and opportunities

The initial AIP meeting should have as diverse a range of participants as possible, as their collective knowledge of the complex system within which the irrigation scheme is critical for gaining an understanding of the nuances – these are often lost when discussing challenges in broader terms. AIPs work through a series of meetings where the participants identify the current state and agree on a vision for their irrigation system. Generic challenges, such as poor access to inputs, high production risk and poor market access, are further explored in the local context to enable identification of the roles and responsibilities of each stakeholder. Agreed solutions are implemented in between meetings. As such, all stakeholders need to be enabled through the facilitator, so that they can articulate their incentives and reasons for being part of the platform.

The first task of an AIP is to identify the current challenges facing the irrigation scheme, as well as any opportunities that exist to improve the situation. Experiences from our project suggest that stakeholders are keen to express their challenges and will reiterate a key challenge until it is satisfactorily addressed. This is often a de facto test for the stakeholders of whether the AIP process is useful. It is important for the project and AIP facilitator to focus the stakeholders on an initial challenge that

‘The first task of an AIP is to identify the current challenges facing the irrigation scheme’

Farmer irrigating plot, Zimbabwe.
Photo: Andre F van Rooyen

'A clear and common vision defines a potential end-state or goal that the participants believe is achievable and have ownership of'

the stakeholders have the agency to resolve; solving an initial problem is a vital, confidence-building step.

For the initial process, the participants are divided into groups (e.g. farmers (could be gender-specific, to identify any gender-related issues), technical support staff and private sector representatives). Each group has to (i) list and prioritise challenges and opportunities, (ii) analyse the 'causes' of the problems, by asking 'why' they happen, in order to get to the root cause of the challenge, iii) identify potential solutions for each of the root causes and (iv) identify partners critical for the implementation process. This is an important step to increase the range of useful stakeholders. Once this process is completed, participants report to the larger group and discuss, clarify and confirm their findings.

iii) Visioning

After developing a shared understanding of the current challenges, the next step is to visualise a desired future state and which direction the stakeholders want to see the system develop (Tenywa et al. 2011). A clear and common vision defines a potential end-state or goal that the participants believe is achievable and have ownership of, even though the pathway to the destination is still unclear. The visioning process places the roles and responsibilities of all stakeholders into context and clarifies individual responsibilities and incentives. It involves i) producing pictures describing the scheme's current state, including the location of households and their immediate surroundings, markets and infrastructure and ii) producing pictures describing the desired future state, staying within reason of what is achievable within a period of about five years.

iv) Innovation process

The innovation process involves working out what participants need to do to achieve their vision and how this is to be implemented. Analysing the pictures developed during the visioning process allows the individual challenges and their root causes to be seen in context and enables farmers to transition from being recipients of technical interventions to directing development processes and strategies that directly meet their needs. Participants explore different pathways from the current situation to the new target situation by producing an annotated list of potential strategies with notes on the actions and resources required to achieve the future state. To address those strategies, they can then begin selecting opportunities, identifying incentives and addressing challenges and root causes. The strategies may be within the control of the farmers and their organisations to implement. However, some issues might also require larger system-related changes, such as those associated with policy, infrastructure, markets (input and output), knowledge and information. There may be numerous approaches to address each strategy, and the diverse stakeholders may develop alternatives to address the same challenge. The value of the innovation process lies in identifying the most effective and practically feasible approach, taking into consideration the capacity of the stakeholders and the incentive to change their behaviour.

Once a plan has been identified, smaller groups of relevant stakeholders focus on individual tasks, resolve challenges and test solutions (innovations). Much of the actual innovation process, therefore, takes place 'outside' of the AIP meetings, which should be the coordination process rather than the engine room of innovation. These task-based groups will then report their progress to the AIP, which will document the changes and conduct the monitoring and evaluation to track progress, learn and adapt from the experience. It helps to focus on only one or a small number of the most important innovations at one time, to make progress and build the capacities and confidence of stakeholders.

v) Implementation, evaluation and feedback

While the AIP coordinates the process, most of the actual activities take place outside of the formal meetings. This allows people who are unable or unwilling to attend lengthy stakeholder meetings to be involved. Private sector players are particularly averse to meetings where activities they consider not relevant are discussed; they lose interest and do not attend future meetings. Therefore, it is best to work on more focused interactions where private sector needs are addressed in an efficient manner. Feedback from such activities to the larger group is paramount; it brings about transparency and the ability to evaluate progress and change direction as required. Throughout the iterative cyclic process of designing new strategies, implementation, evaluation, feedback and then adjustments and refinements, stakeholders begin to learn and understand the value of the process and often gain confidence to take greater leadership in this process.

'The value of the innovation process lies in identifying the most effective and practically feasible approach'

CASE STUDY

SILALATSHANI CASE STUDY

The Silalatshani Irrigation Scheme agricultural innovation platform was established through a workshop facilitated by a researcher from International Crop Research Institute for the Semi-Arid Tropics (ICRISAT) held on 18–19 November 2013 (see Annex 2). This workshop involved all the Insiza district main stakeholders who had been invited through the facilitator, ICRISAT and the Insiza AGRITEX (government agricultural extension) office. Stakeholders connected to the irrigation scheme attended the initial AIP meeting, together with those from higher levels within government and interested organisations. The participants indicated that the establishment of the AIP was a major breakthrough, as they had never had a chance to meet as stakeholders to discuss the issues related to the Silalatshani Irrigation Scheme. The stakeholders included representatives from the head offices of the:

- Ministry of Agriculture
- Mechanisation and Irrigation Development
- Ministry of Environment, Water and Climate
- water catchment authority.
- At the provincial level, there were representatives from the:
- Zimbabwe National Water Authority (ZINWA)
- Ministry of Agriculture provincial offices (AGRITEX, Department of Irrigation and Department of Mechanisation).

At the district and local levels, there were a wide range of representatives including the:

- Department of Public Works
- Ministry of Youth Development
- AGRITEX
- Department of Irrigation
- Insiza Rural District Council local government (the district administrator and the local chief)
- Department of Livestock Production
- Forestry Commission
- Ministry of Lands and Rural Resettlement
- District Development Fund
- Ministry of Social Welfare and the police
- farmer representatives (irrigation management committee representatives)
- financiers (AGRIBANK)
- market representatives (local agro-dealers)
- Non-government organisations including the Zimbabwe Agricultural Incomes and Employment Development Program and Bulawayo Projects Centre.

Introducing the agriculture innovation platform concept

The AIP concept was presented by the ICRISAT facilitator, who explained why this new approach was required: to assist the stakeholders identify the challenges they were currently facing and identify opportunities for them to enhance their livelihoods. The AIP explained that the current systems were characterised by low inputs and outputs as well as inefficiencies (with high risks), and there was increased need for external support. Otherwise, farmers in these systems will remain trapped in poverty. Because of poorly developed markets and institutions, the need for complete transformations in some of these systems was discussed.

The main objectives of the AIP were to:

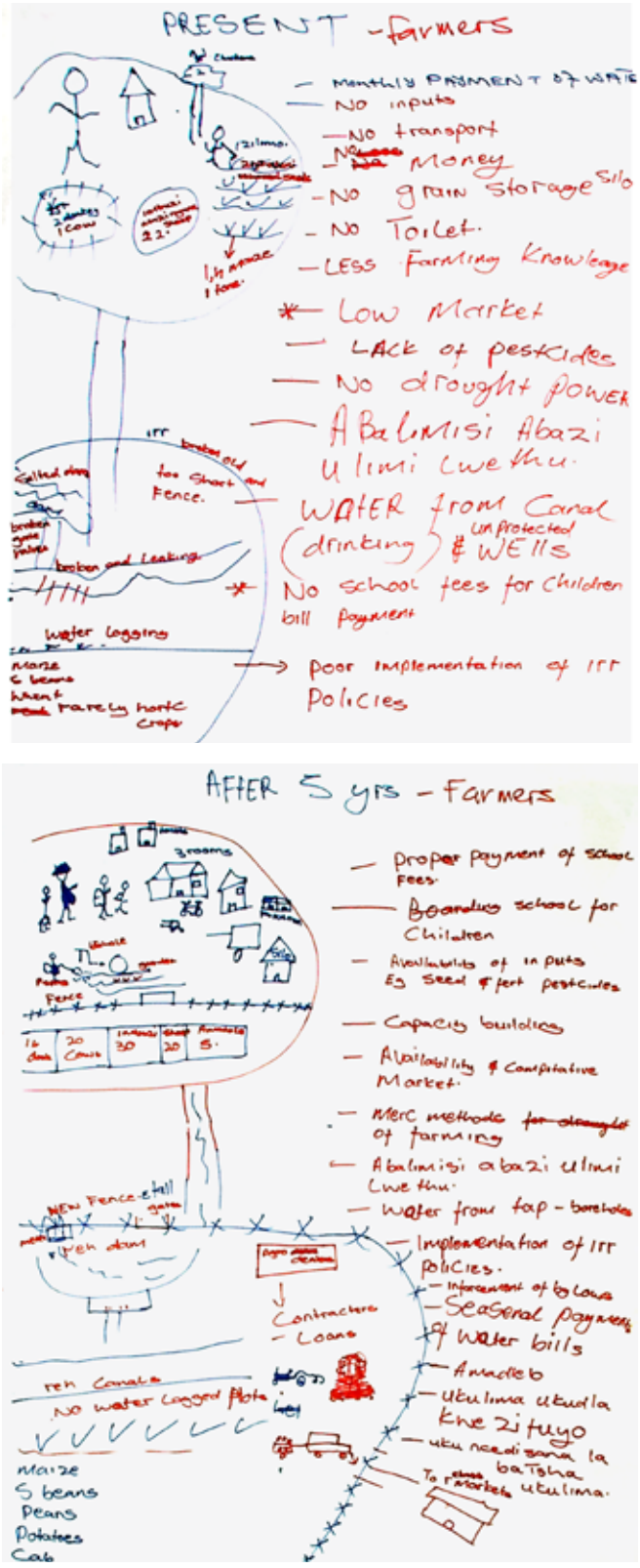
1. develop local capacity to innovate and analyse challenges and opportunities, reducing risk and increasing potential income
2. identify and promote technologies that will improve agricultural production at the household level, increasing the adoption of technologies
3. identify and implement strategies that will improve market efficiency and reduce transaction costs along the value chain, increasing the efficiency of the overall system, allowing more money to flow to the producer and thereby increasing the incentive for improved farming practices
4. improve communication among role-players within the entire value chain, from farmers to consumers.

During the first AIP, the stakeholders were happy that the water authority, ZINWA, had attended. The main issue at the scheme had been the delivery and pricing of water, a resource all the stakeholders felt was the most important at the irrigation scheme. The Insiza District Administrator and the other stakeholders indicated that there was a need for dialogue with the water authority so that irrigation production at the scheme could be resuscitated and improved. The workshop agreed to set up a subcommittee that could be facilitated by ICRISAT to look into the water issue, as it seemed a major bottleneck to progress within the irrigation scheme.

The visioning exercise

The workshop participants were divided into three groups: the technical and extension personnel, the water management and infrastructure staff, and the farmers and local leaders. They were asked to come up with an irrigation development vision for their communities, linked to the broader farming system. Generally, the workshop participants were able to identify the main constraints and key opportunities to overcome the challenges faced at the schemes.

By envisioning a better, functional irrigation system with more prosperous farmers, the stakeholders were able to identify opportunities available to them (Figures 2–4). The farmers said that they currently had a poorly run irrigation scheme, characterised by high debt, little use of fertilisers and pesticides and few improved crop varieties. They also said that they did not have any grain silos, lacked knowledge of improved farming systems and had minimum draught power. It was also apparent that the extension personnel were not fluent in the local languages, limiting their effectiveness. The farmers were very concerned about water poaching along the 12-km supply canal.



In the visioning exercise, the farmers indicated that they wanted to be self-sufficient in irrigation management and food security (Figure 3). They wanted better policies on water fees and maintenance of infrastructure, and they proposed seasonal payments of the water bill. They envisioned that with a well-functioning irrigation scheme they could improve their lives in many ways. They wanted to integrate their cropping and livestock systems with the production of fodder crops, especially on the currently fallow lands. The farmers wanted to produce high-quality food to command a good market price so that their incomes could increase. They envisioned a more diversified cropping calendar, with the introduction of horticultural crops (such as potatoes and leafy vegetables), an indication that the current crops (maize, sugar beans and wheat) are not very profitable. They saw an irrigation scheme that fully integrated women and the youth into agricultural production, to ensure continuity in the scheme. Higher incomes were important to pay school fees so that their children could go to better schools. The farmers envisioned improved access to clean water through boreholes and improved ablution facilities, unlike the existing situation where even drinking water is abstracted from the open canal.

The technical and extension personnel's visions (Figures 4 and 5) were similar to those of the farmers; both wanted to see the farmers become self-sufficient in irrigation management and food security, with the irrigation scheme generating higher incomes. They wanted a well-functioning scheme with improved water management systems in place, including the use of water-measuring devices by ZINWA and a better water fees system

Figure 3 Farmers' current situation and 5-year vision for the irrigation scheme

for farmers. The vision of the technical and extension personnel included higher crop yields and to increase incomes through more effective marketing. They envisioned a more efficient irrigation scheme with sprinkler and drip irrigation systems being introduced. Further, they wanted better management of the catchment area, with silt traps installed to maintain the capacity of the supply dam. They also saw opportunities to integrate crop and livestock systems.

Identification of system challenges

During the first AIP meeting, the morning session of the first day was very generic and its role in guiding stakeholders towards potential and viable solutions was limited, but it was crucial in providing some insight into the main challenges of the Silalatshani Irrigation Scheme. As the meeting progressed through to the afternoon of the second day, participants gained a deeper understanding of the challenges and their perceptions by asking the "why?" question to clarify the root causes. They then brainstormed to identify possible local solutions as well as identified and listed potential partners who could help implement these solutions. The stakeholders showed a strong desire to articulate their challenges and active listening was crucial in building credibility, trust, a deeper understanding and verification/falsification of pre-conceived ideas.

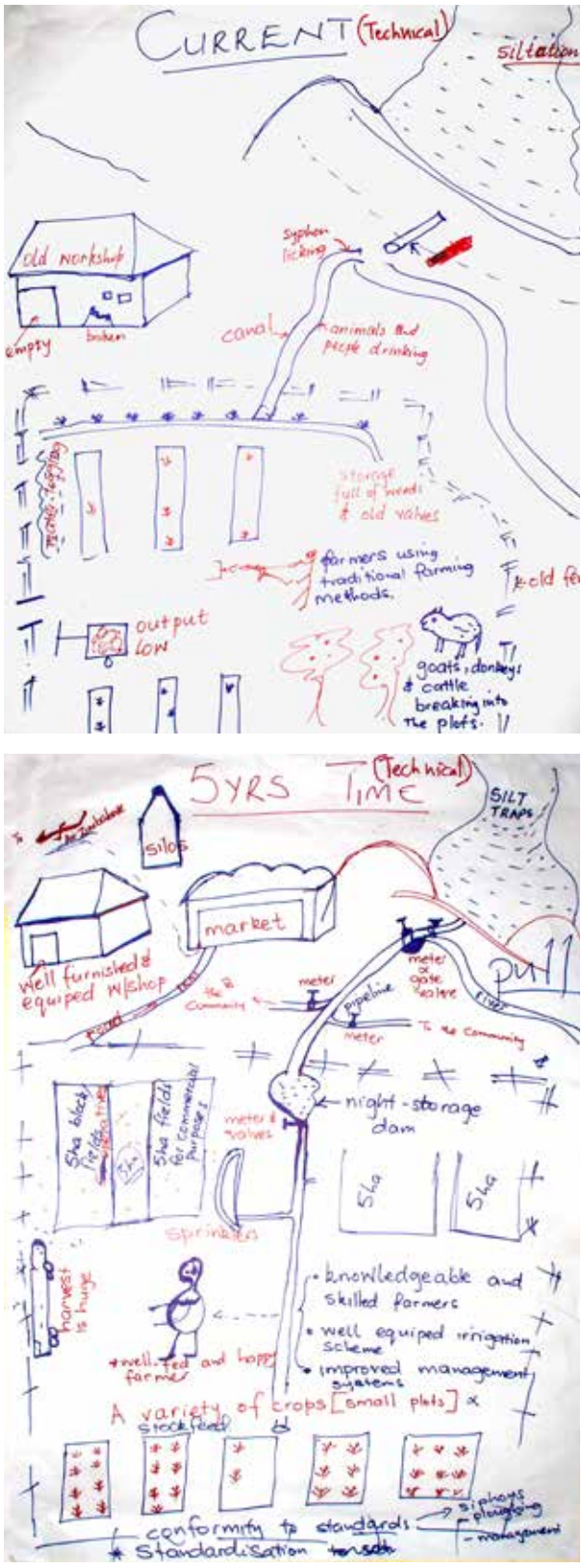
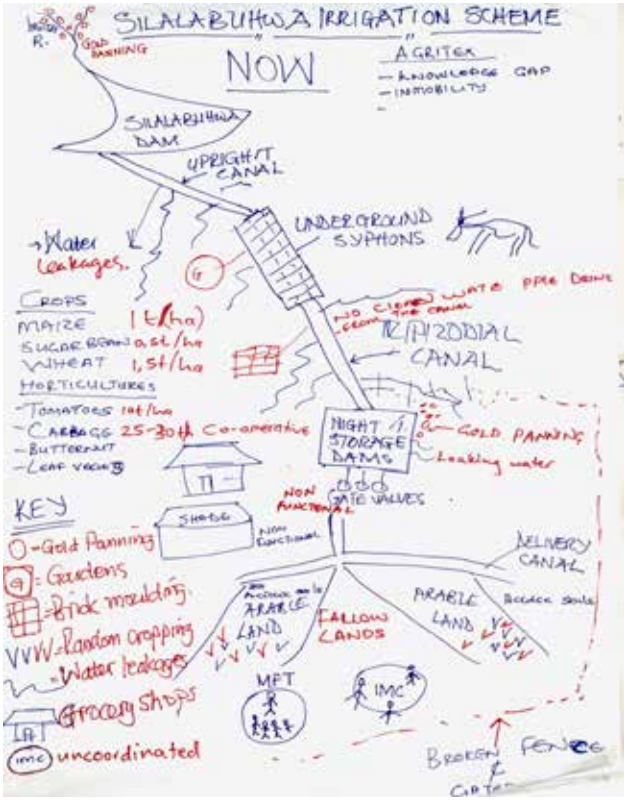
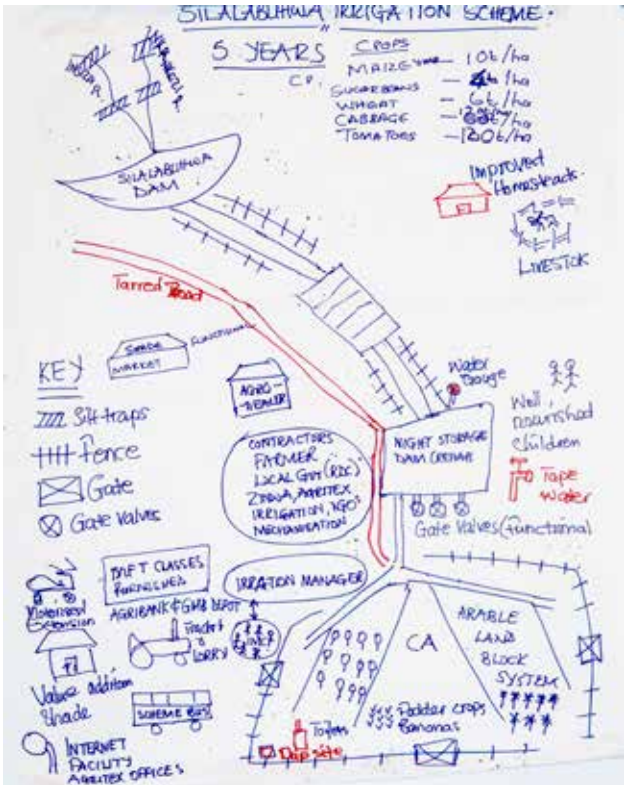


Figure 4 Technical team's current situation and 5-year vision for the irrigation scheme





Starting the innovation process

On the second day, after the root cause analysis, the Silalatshani scheme AIP embarked upon a process to develop intervention strategies to set the innovation process into motion. However, during the AIP meeting, stakeholders identified various challenges and factors that would, if not addressed, prevent progress. In Silalatshani, it was the issue of the very large debt of US$280,000 to the Zimbabwe National Water Authority (ZINWA). Farmers indicated that they were not willing to continue with the AIP if this issue was not resolved. The facilitator then intervened and tasked a committee composed of the district leadership, ZINWA and the irrigation management committee to further negotiate outside the main meeting so that some progress could prevail in the initial meeting. It was through the intervention of the facilitator that the AIP meeting continued, with the development of intervention strategies to set the innovation process in motion finally taking place. The activities identified largely fell into the following groupings: capacity building of both farmers and extension services; governance of organisations and tenure issues; demonstration and research; inputs and finance; challenges pertaining to markets and value chains; and scheme and plot management.

During this initial meeting, other relevant stakeholders who had not attended this meeting were identified and invited to subsequent meetings. These included the microfinance companies and the input suppliers who were identified as crucial to the process. In this initial meeting it was made clear that as the process unfolds, and the AIP starts to work on specific

Figure 5 Extension team's current situation and 5-year vision for the irrigation scheme

identified topics, meetings were only going to include relevant stakeholders, to ensure those unrelated to the immediate process did not lose interest. It was further highlighted that the sharing of the outcomes of these interactions with the rest of the AIP was going to continue, as this is crucial to maintain momentum. In reaction to recurring challenges with regards plot ownership and rights to land, the Insiza Rural District Council agreed to embark on a land audit to verify ownership and resolve absentee plot ownership, to free up land for irrigation. It was then also agreed that the AIP was going to continue dealing with many innovations outside the main meeting, including the water bill/debt that still had to be taken care of. It was agreed that continuous dialogue and discussions were going to continue and an agreement would be reached.

SECTION 4

CREATING A BUSINESS PLAN

During the AIP process, some of the farmers identified the development and implementation of a business plan as an important approach for improving the irrigation schemes. Business plans are documents that illustrate how to organise a particular business by undertaking and implementing a set of activities necessary for the business to succeed.

The plan identifies objectives for improving production processes and linkages to input and output markets. It is an essential tool for planning, directing and running a business enterprise such as farming. The plan clarifies the operational and financial objectives, action plan and resources needed to realise the objectives. It also identifies opportunities, threats and risks and how to overcome them and provides the organisational structure for managing the business. Irrigators' organisations, and the farmers they represent, have resources (e.g. land, water and infrastructure) in which they invest their time, money and efforts; a business plan can help use these resources profitably and sustainably.

Four steps are needed to develop a business plan:

i. **Identify a need** – Farmers identify a business plan as one of their needs during an AIP meeting.

ii. **Build capacity** – Through the AIPs, farmers and other stakeholders are trained by a local trainer on business plan development and implementation. During the training process, participants develop and agree on the business plan outline and action plan for drafting the document.

iii. **Develop the plan** – The action plan outlines the process for data collection, collation and review, and write-up:

- Data collection: The initial task of data collection for the plan is shared among the AIP stakeholders, including representatives from the irrigation organisation and the farmers. The extension officers provide support on the development of content of the outlines distributed to the farmers.
- Collation and review: At the next AIP meeting, the data is reviewed and the first draft plan developed. The plan consolidates existing farmer and irrigation organisation resources, focusing on improving production and identifying resources needed to achieve the scheme vision. The key components of the plan are agreed.
- Write-up. A write-up committee is then identified and established. It includes farmers, project researchers, local government, extension officers and accountants. The committee oversees the finalisation of the business plan and, if necessary, meets. The draft plan should be circulated to a number of stakeholders, including representatives from government, the private sector and farmers, for their input that is then incorporated to produce the final version of the plan.

Farmers from Khanimambo Irrigation Scheme, Mozambique.
Photo: Peter Ramshaw

iv. **Implement the plan** – The irrigation association and farmers then use the plan to guide scheme activities, including being able to seek potential funders to implement elements of the plan. Regular monitoring and adaptation of the plan are important components of implementation.

‘It is an essential tool for planning, directing and running a business enterprise’

MAGOZI CASE STUDY

CASE STUDY

The Magozi Irrigation Scheme farmers, in south-west Tanzania, identified the development and implementation of a business plan for their rice production as one of their key strategies to achieve their vision during the second AIP meeting. An expert from the Research, Planning and Project Write-up Organisation, a local non-government organisation based in Iringa town, was invited by the AIP facilitator to train the farmers and other stakeholders about business plan development and implementation. At the end of the two-day AIP meeting, the farmers had developed a tentative business plan outline. An action plan for developing the contents was agreed upon. This involved farmers in developing the plan contents with the support of the extension officer from Iringa District Council and the project's field officer (AIP facilitator). In November 2015, a fourth AIP meeting was organised to produce the first draft of the business plan. A committee that included farmers, project researchers, officers from the Mbeya Zonal Irrigation Office and Irrigation Commission headquarters, Iringa District Council and the write-up organisation was established at the end of the meeting to oversee the completion of the business plan. The committee met once in March 2016 to finalise the draft plan. The plan was circulated to a number of stakeholders, both public (Ministry of Agriculture Livestock and Fisheries, National Irrigation Commission, Iringa District Council, Mbeya Zonal Irrigation Office, Big Results Now agriculture team, researchers) and private organisations (Tanzania Staples Value Chain Project and Rural Urban Development Initiatives) and the farmers for their input. Their feedback was incorporated to produce the final version of the plan. The business plan has been built on existing irrigation schemes resources. The farmers, through their irrigators' organisation, are currently looking for potential funders to support elements of the plan. The implementation of the plan aims to enable the farmers to attain rice sales of an estimated value of 5.4 billion Tanzanian shillings.

25 SETEMBRO CASE STUDY

CASE STUDY

Most Mozambican farmers operate on a small scale, and many involve only their families in agriculture activities. At the 25 de Setembro Irrigation Scheme, near Maputo in Southern Mozambique, during the AIP process, farmers identified that they did not have a good understanding or management control of their farming. They did not understand the relationship between the costs of inputs and returns gained from their outputs. Therefore, the farmers were trained in the use of farm activity logbooks. The logbooks were used to track expenses and returns and created a means for farmers to better understand their agricultural productivity. The process of creating business plans was then based on those logbooks and included a market analysis and simple gross margins analysis. In the process, the farmers learned to organise, control, and predict their financial, input and market needs for their activities. These small-scale farmers practice agriculture as their main source of income, so reducing risk with new practices is important.

Many of the irrigators' organisations, including 25 de Setembro, have been subject to interventions from one or more development projects that have resulted in no continuity. Consequently, new interventions need processes (e.g. AIPs) that develop trust and ownership by farmers so that they become self-sufficient and are able to achieve ongoing benefits. All these aspects need to be considered to improve the chance of success of any new activity.

To develop a business plan and market analysis program for farmers, through the AIP, we asked farmers, extension offices and the local Boane District Development Authority (SDAE-Serviços Distritais de Actividades Económicas) questions along the following lines:

- What do you (the farmers) know about business plans?
- Thinking about previous projects in this irrigation scheme area, which aspects worked and which did not? Why did this happen? What did you learn from those experiences?
- Do you (the farmers) have any records of your expenses?
- What are the major crops produced?
- How and to whom do you (farmers) sell your crops?
- Do the extension officers have experience with business plans and marketing?

Because some participants could not read or write, the AIP process was made as simple as possible. Work at 25 de Setembro started in 2014, and by 2016 a number of farmers were proud to show visitors their personal business plans with gross margin analysis of crops that they were growing. These farmers reported increased profits from their more business-oriented approach to farming.

With an AIP in place and a business plan in operation, the scene is set for turning increased production into more profitable outcome. In our project, this was done through improving market linkages, discussed in the next section of this report. The second prong of our research, using soil moisture and nutrients monitoring tools, is covered in Section 7.

SECTION 5

MARKET LINKAGE

Traditionally, research on how to improve irrigation water productivity focuses on the 'hardware', such as rehabilitating irrigation equipment, rather than the 'soft' issues, such as access to markets and information. Interventions are not holistically investigating other challenges faced by farmers in the schemes such as knowledge gaps when it comes to marketing their produce or improving their agronomic practices.

One of the main challenges small-scale irrigation farmers are facing is access to both agricultural inputs and outputs markets; in each of the AIPs, this was identified as an issue. Discussions with farmers reveal that they often farm the same crop produce without an understanding of market requirements in terms of quality and consistency of supply. Furthermore, farmers continue to produce and sell individually even though experience has shown that farming and selling as a group is more profitable, as they are in a better position to be reliable suppliers for buyers who require consistent suppliers who can deliver bulk orders.

Widespread community benefits can be achieved by linking farmers with stakeholders such as input providers and microfinance service providers, organising farmers in groups, providing training to the farmers on better agronomic practices, and improving on-farm water management. Through our research, a number of challenges related to inputs, on-farm production and markets experienced by farmers have been identified, including their drivers (e.g. lack of proper arrangements among farmers for accessing better-quality seeds, poor education among farmers on appropriate use of farm inputs). Addressing these challenges and drivers will help increase farmers' incomes.

Linking farmers to markets is not a job for one organisation. It requires a consortium of skills, with the know-how and networks to help farmers improve their production and to participate competitively in local markets. There is a need to improve the extension and advisory services, to make sure those farmers are educated about improved agronomic practices. There is a need to expand the agriculture dealer network, to make sure that farmers access quality seed and other inputs in a timely manner. There is a need to improve the market information system, so that farmers have access to pricing information before they go to the markets so that they negotiate better prices. There is also a need for farmers to work together, so that they can produce large quantities that are required by buyers.

Finally, policymakers also have a role to play in addressing market challenges faced not only by irrigation farmers but also smallholder farmers in general. They have to help create the necessary conditions for profitable smallholder agriculture, by implementing policies that strengthen access to both input and output markets. No single group working independently and in isolation can generate, use or promote effective use of the required technologies, knowledge and approaches. Specific policies that lead to improved farming practices include promotion of high-value crops,

on-farm value addition, expansion of systems for extension and technical support, and investment in smallholder technologies.

Farmers selling beans, Zimbabwe.
Photo: Andre F van Rooyen

‘Linking farmers to markets is not a job for one organisation’

SECTION 6

MAPPING THE IRRIGATION SCHEME

During the AIP process, a variety of irrigation scheme boundary issues were identified. One strategy to address this was the development of scheme maps. Mapping provides a powerful tool for collecting spatial and non-spatial information that can be used for various purposes. Over the years, mapping technologies have been simplified and integrated into mobile applications. This has enabled mobile phones to integrate GPS systems to collect relevant information at different levels of accuracy.

Small-scale irrigation schemes are often poorly documented, and as a result, farmers do not know the exact sizes of their plots. Mapping of the scheme boundary and individual farmers' plots provides important information for planning and decision-making. When undertaking mapping, it is important to determine the purpose of the map and choose the approach that involves minimal complexity but collects sufficient and relevant spatial and ground information.

Participatory mapping is one of the best approaches for aiding community management of resources such as plots in an irrigation scheme. The participation of the farmers is important because of the need to identify plot ownership, boundaries and other physical and social infrastructure. The data, which can be captured through community mapping of an irrigation scheme using handheld devices, may include scheme and plot boundaries and size, ownership status, soil types, irrigation canal networks, farm access roads, gradients and drainage networks. Outputs from this process include both maps and scheme databases.

Participatory mapping can be achieved through the following steps:

1. Create awareness with farmers of the benefits of mapping (e.g. during the AIP workshop to identify strategies and then subsequent workshops with the farmers). Discuss with farmers what information will be collected and how the collected information will be used in decision-making.
2. Seek farmers' approval through the consultation meetings to undertake mapping and find out how they will contribute to the process. A key principle is enabling farmer ownership of the exercise by actively involving them in all mapping aspects, particularly their need to work together with the collectors of GPS coordinates of the farmers' plots.
3. Identify key actors among the stakeholders who will participate in the mapping process.
4. Consult the local government to obtain standard sheets and other spatial information that cover the mapping area.
5. Conduct a detailed survey of farmers to obtain all necessary data needed for map production.

6. Analyse the collected data.
7. Make a map using Arc GIS software or other mapping software. The details to be indicated on map include scheme and plot boundaries, plot numbers, irrigation canals (primary, secondary, tertiary, if any, and drainage), farm access roads and main roads near the scheme. Other details which should be recorded separately are size of the plot (ha) and the name of the farmer who owns it.
8. Produce a map in print format. The printed map can be displayed in the office of the irrigators' organisation. The map can be used to identify plots in the schemes that are not farmed, transferred to other farmers or whose owners have not paid seasonal or annual water fees.

When mapping irrigation schemes, note the following:

- Letting local government know about the mapping may result in a greater provision of services.
- In Tanzania, to use the collected data for issuing customary 'right of occupancy' certificates, the responsible authorities for issuing these certificates need to be involved in mapping.
- A computer with GIS software for entering GPS coordinates into a digitised or scanned map will be needed.
- The mapping team should include members who have mapping skills and knowledge about coordinating the exercise.
- To reduce the cost of the mapping process, students with mapping knowledge (high levels of education) can be engaged to collect GPS coordinates, which are used as inputs for mapping.

There are many benefits of mapping. In Tanzania, it enables government agencies to issue farmers with a customary certificate of land use, which can help reduce land disputes and can be used to access finance. As the concept of finance guaranteed by land is generally new to farmers and has potential risks, they will need to receive independent advice regarding protection of their title.

Involving farmers in the mapping process increases farmers' trust in the fairness of area-based water-use fees, resulting in higher rates of payment of these monies for scheme maintenance. In addition, having a list of who is farming which plot and their contact details facilitates communication by the irrigators' organisation.

'Mapping of the scheme boundary and individual farmers' plots provides important information for planning and decision-making'

MAGOZI CASE STUDY

CASE STUDY

The Magozi Irrigation Scheme is located about 65 km north-west of Iringa in Tanzania. The construction of the scheme started in 2005 and was completed in 2007. The scheme is managed by the Mkombilenga Ilolo-Mpya and Magozi (MKILMA) irrigators' organisation, whose membership as of June 2016 was 503 farmers (comprising 383 males and 120 females). The scheme and irrigators' organisation bring together three neighbouring villages. Rice is the main crop produced by the farmers during the rainy season.

During the initial stages of the research and AIP process, farmers reported different figures on the size of the irrigated area in the scheme. As the scheme is not well laid out and infrastructure is incomplete, it was not possible to know the plot sizes for each farmer. During the AIP meeting, it was decided to address the issue by developing a physical map of the scheme boundaries and all the irrigated plots. Doing so helped the farmers address issues raised in the AIPs, including the ability to resolve boundary conflicts between farmers, ensure they were charged the correct water fees and enable them to gain access to a customary certificate of registered occupancy. Building on positive interactions in the AIP, two research assistants worked closely with the farmers to locate GPS plot boundary points over three weeks in August 2014. The data points were processed in ArcGIS to produce a map illustrating scheme boundaries, individual plot boundaries, irrigation canals and access roads. A database of irrigated plots in terms of plot number, owner of the plot and size of the plot was also developed. A printed copy of the scheme map seen in Figure 6 was provided to MKILMA, the village executive officers for Magozi, Ilolo-Mpya and Mkombilenga villages, the Ward Councillor, Iringa District Council and the Iringa Region Secretariat. MKILMA was also provided with a paper-based database of the irrigated plots.

The mapping provided valuable information to other AIP processes such as business plan development in terms of the total size of the scheme under-irrigation, farmers' plot sizes and ranges, and plot ownership. However, farmers in the scheme, through their leaders, identified other important uses. They are using the map and databases to enforce collection of the right water fees for a given size of plots. Before mapping, this was not possible, and collection of the water levy depended on estimated sizes of the plots that individual farmers provided. Through the mapping scheme, leaders have learned the total area that the limited water supplies reach and the area that is not reached; this has enabled them to establish a more effective roster for water use.

The map has also been instrumental in demonstrating and describing the irrigation scheme. The farmers used the map to describe the irrigation scheme when the then Tanzanian Prime Minister visited the scheme in April 2015. It was used again when the then Permanent Secretary of the Ministry of Agriculture and the Director-General of the National Irrigation Commission visited in May 2015. The Director-General mentioned that it

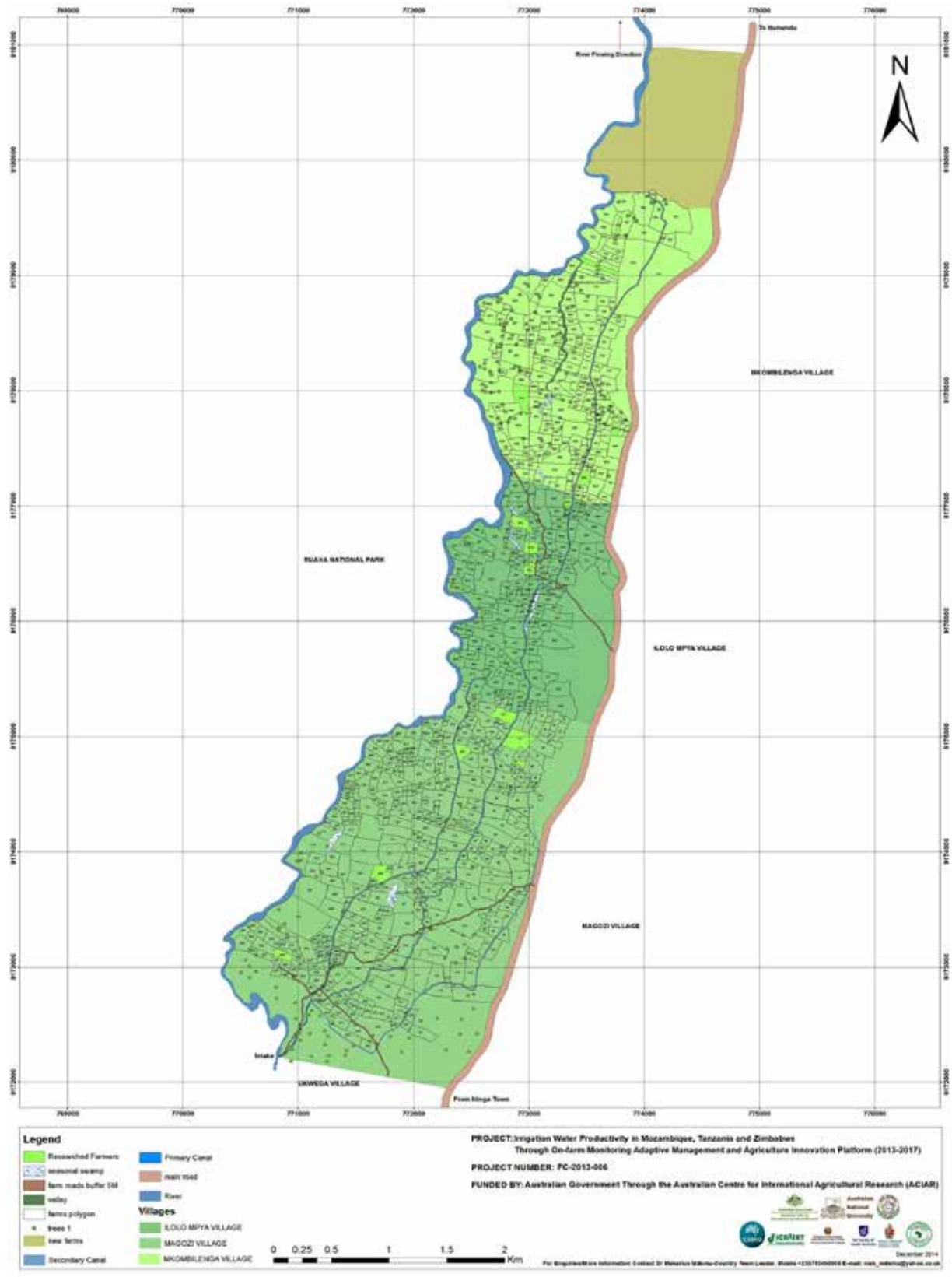


Figure 6 Map of Magozi irrigation scheme, Tanzania

was the first time he had seen a scheme with a complete map of the scheme layout with demarcated plot boundaries. He proposed adopting the mapping practice by other schemes in Tanzania and vowed to explore the opportunity of using them to offer Certificates of Customary Right of Occupancy to the farmers. These certificates may be used as collateral in accessing credit from financial and microfinance institutions in Tanzania. Access to finance is key in overcoming a major barrier to improved productivity of smallholder farmers in Tanzania (Mdemu et al. 2017).

MONITORING SOIL AND WATER

SECTION 7

Better yields of high-value crops are necessary for a profitable irrigation industry scheme that provides decent livelihoods for farmers. However, many irrigation schemes are failing, in part because of poor water and nutrient management, which reduces crop yields. Many farmers lack the knowledge needed to identify whether their crops have too much or too little water or access to the requisite nutrients in the soil to thrive.

We argue that farmers need the capacity to monitor soils and water themselves, so that they can identify and apply the best agronomic practices. Water and nutrient management must be improved on-farm before any new infrastructure interventions. If management is improved first then any future technical intervention will reap much greater benefits, and because of increased farmer incomes, the infrastructure may be properly maintained.

There are two ways of tackling this irrigation knowledge problem. The method favoured in training materials is a first principles approach that uses climate, crop and soil data to calculate a predicted irrigation volume that farmers should apply. This approach is not successful in smallholder irrigation schemes where farmers lack access to the technicians who can do this and need to adapt recommendations to fit with the specific constraints of their own situation. The alternative, better approach, is farmer-centred learning, where farmers use observation, monitoring and feedback to optimise water and fertiliser application.

The need for better management was self-identified in the AIPs by farmers who said that they do not have knowledge of or access to 'advanced farmer techniques'. To address this, we developed a suite of simple soil and water and solute monitoring tools. These fit the farmers' mental models, and so engage them in a learning-by-doing approach.

The first tool, the FullStop Wetting Front Detector, is a funnel-shaped device buried in the soil with an indicator above the soil surface. Water infiltrates the soil with a wetting front being the boundary between the wet soil above and the drier soil below. The depth the wetting front moves is a function of the amount of water applied, soil type and the initial soil water content. If the wetting front reaches the buried funnel FullStop, some of the infiltrating water is collected. As water moves down the funnel, the soil water content increases as the cross-sectional area of the funnel decreases, until saturation occurs. This water flows into a reservoir and activates a simple, visible magnetically latched indicator. By extracting the soil water sample captured by the detector, the electrical conductivity (salinity) and nitrate (fertility) can be monitored using simple colour test measurements. Installation of two FullStops, one in the mid-root zone and one at the bottom of the root zone, can facilitate farmer learning about the movement of water and nutrients through the soil.

Farmers discussing the Chameleon tool, Kiwere Irrigation Scheme.
Photo: Andre F van Rooyen

'...farmers use observation, monitoring and feedback to optimise water and fertiliser application'

The soil moisture monitoring tool is called the Chameleon. This consists of an array of three or four sensors that are permanently buried at different soil depths. A portable handheld reader connected to each sensor array displays the soil moisture as coloured lights. Each light represents a single depth and can read blue (wet soil), green (moist soil) or red (dry soil). The lights give a picture of soil water conditions from the top to the bottom of the root zone. Successive readings through the season give a colour pattern that illustrates the wetting and drying of the soil, the depth of rooting and how well irrigation or rain refills the soil. The Chameleon measures soil tension so that the colours have the same meaning for the farmer, regardless of the soil type. Farmers make decisions about whether to irrigate based on the different coloured lights together with their visual assessment of the crop. Both the Chameleon and the FullStop are described more fully at the Virtual Irrigation Academy: https://via.farm/.

On that site Chameleon data has been seasonally collated and can be seen in Figure 7.

Most of the nitrogen available to plants is in the form of nitrate, which largely moves with water and so is highly susceptible to leaching out of the root zone by irrigation. Many farmers start the season with enough nitrate in their soils, but due to over-irrigation, the nitrate is leached out and they obtain low crop yields. Water is measured at four depths. At the start of the season, the soil is dry (red). Irrigation (blue) followed by crop root extraction (green and red) generates the subsequent pattern. The nitrate is collected from the FullStop Wetting Front Detector and tested with a colour strip. We see here that most of the nitrate is at a deeper level in the soil (50 cm), whereas most of the root activity is in the 0–30 cm zone (i.e. where the Chameleon pattern shows green).

The Chameleon simplifies complex soil water content data to patterns so that

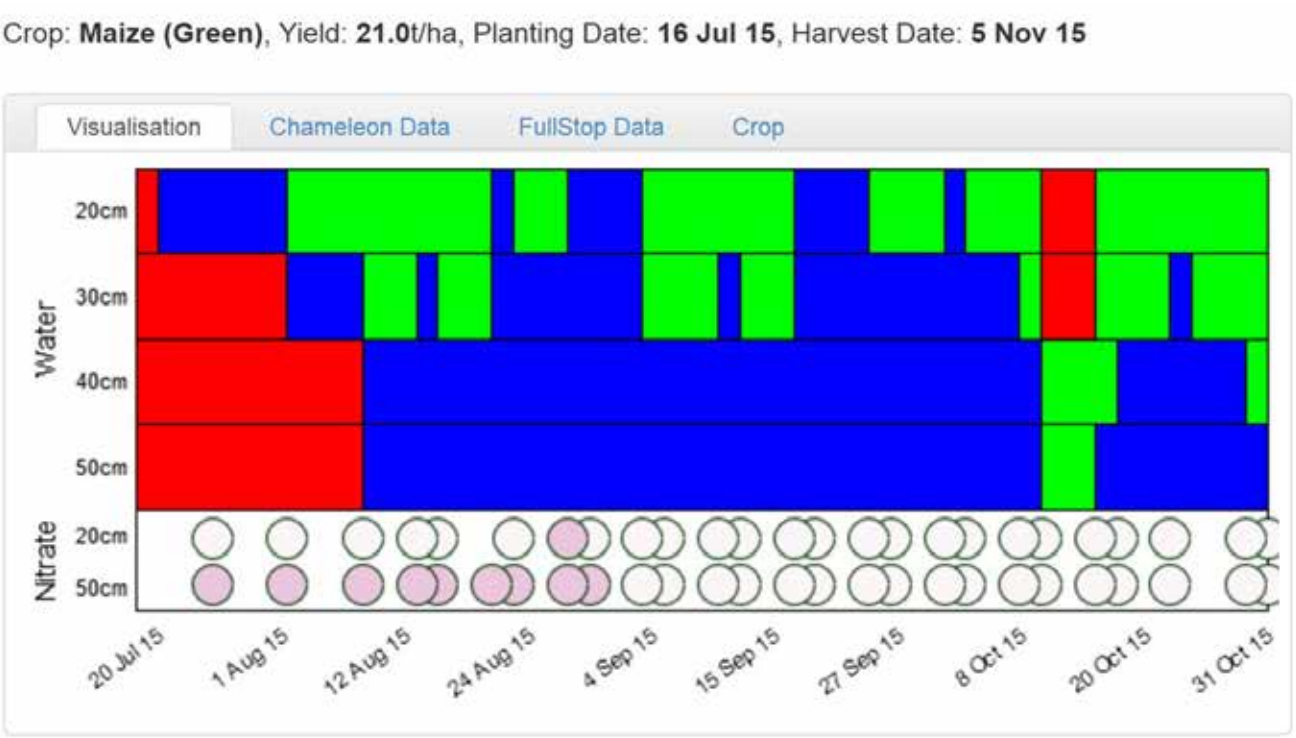


Figure 7 The Chameleon pattern showing water available to plants as blue (wet), green (moist) and red (dry) and nitrate level as adequate (pink) or deficient (white).

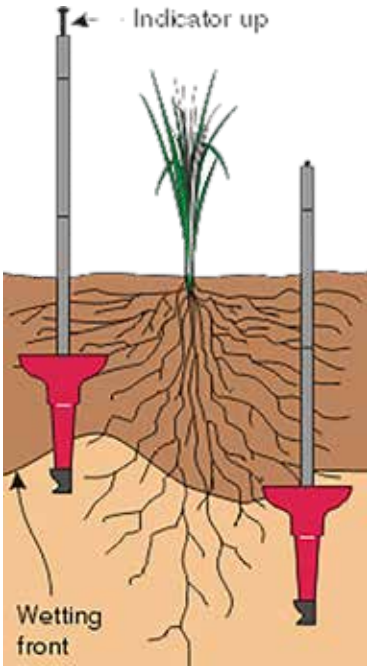
farmers can quickly assimilate a large amount of information. In Mozambique, Tanzania and Zimbabwe in 2014–17, we found that farmers quickly learned from the tools and changed their management within a short period. As a result, these irrigators applied water less often than before (about 50% reduction in the number of irrigations) and obtained higher yields (about doubled). Among the benefits identified by farmers as a result of using Chameleons were a reduction in conflict over access to water and a freeing up of farmers' time to engage in other activities.

If a large number of farmers in an irrigation scheme use the tools then the two largest problems in implementing the system have been i) the cost of employing project staff to take readings, record data and enter it into databases and ii) errors in transcribing data, as farmers sometimes move sensors to different crops or switch plots with others. In response, we have developed an automated system that farmers can operate. The sensor array now has an ID chip that is recognised by the Chameleon reader. The reader sends the identified data to the cloud via the hotspot on a mobile phone. In situations where the cellular network is intermittent, the reader will store the data locally and then upload it when it picks up the designated wi-fi access point. The farmer then can instantly visualise their data on a phone, without the intervention of project staff.

The data from the tools can also be used at a larger scale, such as to identify problems with the water supply in schemes, to compare water use and productivity over time and to underpin government-supported enforcement of water access rules. This mix of potential benefits should enable the tools to be widely distributed. The cost of implementing such a learning system is a small fraction of that incurred when setting up irrigation schemes and should be factored into the design of irrigation projects. The tools seen in Figure 8 can be accessed from the Virtual Irrigation Academy: https://viashop.csiro.au/

Chameleon Soil Water Sensor

The Chameleon Soil Water Sensor measures how hard it is for plants to suck water out of the soil and the data is displayed as coloured lights.



FullStop Wetting Front Detector

The FullStop Wetting Front Detector tells you how deep water moves into the soil during and shortly after irrigation. It also captures a soil water solution sample which can be extracted using a syringe.

Measuring Nutrients

Nitrate test strips are used to indicate the amount of nitrate moving in the root zone. Nitrate (the main form of soluble nitrogen in soils) moves with water and is easily leached from the soil by over-irrigation.

Measuring Salt

Pocket EC meters (Electrical Conductivity) are used to show whether salt is building up in the root-zone (under irrigation) or being continually flushed out (over-irrigation).

Figure 8 The Virtual Irrigation Academy tools (image from https://via.farm/the-tools/)

KIWERE CASE STUDY

When we first introduced the Chameleon and FullStop tools at the Kiwere Irrigation Scheme in Tanzania, farmers were not fully aware of the importance of soil moisture and nutrient monitoring in their irrigated plots. Through AIP training workshops and demonstration in their plots, farmers started to realise the value of these tasks.

How soil and water was monitored in Kiwere scheme

Twenty farmers' plots were identified in mid-2014 for installation of one set of Chameleon sensor arrays and two sets of FullStops. The plots were selected to represent upstream, midstream and downstream farms as well as the major irrigated crops, including tomato, green maize and onions. In each farm plot, the Chameleon sensors were installed at 20 cm, 30 cm and 40 cm below the ground surface while the FullStops were installed at 20 cm and 40 cm below the ground. The sensors were monitored by a trained field agriculture officer stationed at the scheme and the farmers' representative through recording the status of soil moisture at different depths using a portable handheld solar-powered Chameleon reader. Water collected in a FullStop funnel was tested on site for nitrates and salinity using nitrate strips and an EC meter, respectively. Both the Chameleon and FullStop data were recorded once per week between July 2014 and July 2015. The frequency of measurements was increased to twice per week from August 2015 in order to count days with and without irrigation.

On measurement days, soil moisture and nutrient status readings for each plot/farm were communicated to plot owners through face-to-face conversations or by mobile phone. Farmers used the information on soil moisture, nutrient status and the physical condition of the standing crop to make decisions about irrigation and fertiliser application.

Benefits of using Chameleon and FullStops in Kiwere scheme

About 90% of farmers whose plots have the tools have reported reducing their irrigation frequency by about 50% over three years. Before installation of the tools, farmers used to irrigate between three and seven times a week. Their decision on irrigation was based on visual observation of the soil surface only. As result, they over-irrigated and water demands increased, leading to conflicts over-irrigation water and low water productivity.

By using the FullStops, about 80% of farmers reported that they have reduced the number of fertiliser applications, from up to three times per crop to only twice per crop season. The change in irrigation frequency using the Chameleon data implies that farmers have been able to control leaching of nutrients, thus enabling plants to use the reduced amount of fertiliser more effectively.

Farmers who used soil and water monitoring tools said that they have doubled or tripled the yields in their plots. Water productivity for maize, onion and tomato increased by 50% in the first crop season after farmers starting to use the

CASE STUDY

tools. The farmers are realising increased profits and benefits such as saved labour because of the tools.

How to introduce the tools to a scheme

Who should get the tools?

- Any farmer who wants to optimise effective use of irrigation and nutrients under surface, sprinkler and drip irrigation. Current versions of the tools work for all types of irrigated crops except in the flooded conditions when farming rice.

How do they buy the tools?

- Payment can be made electronically through the website https://viashop.csiro.au/

How many Chameleons readers are needed compared to sensor arrays?

- One Chameleon reader can reliably make recordings from 20 sets of sensors in a day, and potentially up to 100 sets. The main issue would be the distance between sensor arrays across the scheme. With increasing distance more effort will be required to collect data, and if time is a constraint, more readers may be needed. As the technology continues to improve, Chameleons readers with mobile phone wireless internet connectivity (wi-fi) and capacity to automatically record and transfer data into the Viashop web platform will be available in the near future.

How widely can the data be shared?

- Visual interpretation of the Chameleon reader and FullStop Wetting Front Detectors and records of these interpretations can be directly shared between farmers, extension officers and researchers. Recorded data are either automatically or manually uploaded into https://viashop.csiro.au/ and metadata in this platform is accessible to everyone. However, access to details contained in the metadata is subject to permission by the manager of the Via platform.

How much do we know and can we suggest?

- Over-irrigation, under-irrigation, nutrient leaching and saline conditions can easily be detected from records of Chameleon and FullStop measurements. Appropriate suggestions for how to improve crop yield are provided to the farmers by the recorder, the extension officer or the field project officer. Other challenges related to poor performance of the crop and agronomic practices can also be identified and communicated to scheme extension officer or agricultural officers at district level.

Who would collect the data and would they be paid?

- Individual farmers can collect data if they have access to their own Chameleon reader and sensor arrays. However, where the Chameleon is centrally accessed and also when the tools are installed for research purposes, a data collector is inevitable. For centralised recordings, farmers may contribute to the payment of recorders on a crop-cycle or crop-season basis.

ADDRESSING EQUITY ISSUES

SECTION 8

When we implement a project, it is critical to consider how to involve all segments of the community, especially groups who may be disadvantaged, such as women, youth and irrigation canal tail-end farmers. There can be other groups, such as those based on culture or religion; these should be identified as part of the situation analysis (see Section 2).

The reality is that this is an investigation of power relationships within the farming community. Addressing equity issues in irrigation projects requires an active and conscious effort, as it will not necessarily happen as a by-product of other project efforts. In fact, inequity can be made worse by ill-considered interventions. Equity issues are important from a moral perspective, but also because no irrigation system can be efficient and sustainable if inequity persists. Only if all groups are considered in an equitable way can we expect all members to contribute to maintenance and payment of fees and other collective actions. Below are a number of actions for consideration by project teams in addressing equity issues.

The first step is to identify relevant equity issues in the local context through the situation analysis and baseline survey (see Section 2). The second step is to assess the skill set and knowledge of the core project team, to ensure that it has the skills needed to address the identified issues. Many water professionals have an education in engineering but have little experience in incorporating gender and social equity approaches in their work. If the team does not have adequate skills and knowledge to address equity issues, it will be important to promote diversity by adding people with the necessary skills. Alternatively, the project can invest in capacity-building activities, which can provide concrete help to integrate a gender perspective into the project. A project gender checklist is one tool that can offer some practical guidance on how teams can better mainstream gender equity (for an example, see Annex 3).

Equally, it is important is to understand gender-based differences in access to, control over and preferences for irrigation technology and irrigation schemes in the targeted communities. Conducting a gender analysis focusing on norms, roles, stereotypes and power issues associated with men and women (including married women and women heads of household), youth and members of other identified disadvantaged groups is critical. This can also be done through the situation analysis and the baseline survey. Such an analysis can help project teams set achievable objectives and assess the potential trade-offs in providing greater opportunities for disadvantaged people through project interventions.

Consideration of equity issues should be an integral part of planning all project activities. In particular, it needs to be considered in two main processes: i) the selection of participants and timing of meetings, accommodating specific needs of these groups to ensure their participation in all activities and ii) the

Farmer selling cabbages, 25 de Setembro Irrigation Scheme, Mozambique.
Photo: Jamie Pittock

'Addressing equity issues in irrigation projects requires an active and conscious effort... In fact, inequity can be made worse by ill-considered interventions'

collection and analysis of data. Project teams should collect data so they can be disaggregated for the identified disadvantaged group to facilitate monitoring and analysis. Specific monitoring and evaluation indicators for the different activities of projects should be developed to identify their impacts on each of the disadvantaged groups. Linked to this is the need to systematically document processes that lead to successful participation of members of the disadvantaged groups in water projects and how this participation actually improves their livelihoods. The following case study at the 25 de Setembro Irrigation Scheme illustrates how equity issues can be addressed.

25 DE SETEMBRO CASE STUDY

The government has been promoting the integration of women and youth in decision forums all around the country. The local government extension officers have also been promoting gender equity activities. The 25 de Setembro Irrigation Scheme involves many older farmers, both men and women, who influence scheme decisions with their traditional values and beliefs. During decision-making, in the presence of their husbands or elders, women tend to speak little or not at all in some debates. This was the same for youth in the scheme, mainly because they were new and trying to fit in.

Since 2013, when the project AIP was formed, asking direct questions to the women was an important way to empower them to speak in meetings. However, when the subject is sensitive, women still do not speak in the presence of elders or their husbands. This was addressed by organising separate forums just for women. The process of always involving them in the irrigators' organisation discussions has shown the men in the room that they can get very important contributions from women, especially because they are the ones who are most often in the schemes.

For youth, it is now very different; they speak freely, particularly the young women. The main challenge was to motivate these young farmers to practise more agriculture. The scheme had some farmers who no longer always used their plots. Many of those farmers rented their plots to other farmers; however, the plots were only used for some seasons and not others. In early 2014, during the AIP process, this was identified as not being good for the scheme and community, as the burden of maintenance costs was shared by fewer farmers. Also, there is less production to jointly market and there is less labour for shared activities, thereby reducing profits. The project AIP facilitator and extension officers started to work with young farmers who worked at weekends in their family plots, motivating them to produce simultaneously in other plots not used by the existing owners. Two young farmers were identified and allocated unused plots, and with support they have succeeded in farming. They have demonstrated to the organisation board members what they could do for the scheme and what could be achieved if more young farmers were allowed to be involved in the scheme.

By 2016, there were 17 young farmers involved; however, such a decision was not taken lightly, as the existing farmers feared their land would be taken from them. To mitigate this, most of these new farmers are people who have relatives already in the scheme. Others are relatives of deceased members of the scheme, whom the existing farmers tracked down. They were invited to visit their relatives' plots and have since decided to stay. Though agreed during the AIP process, there was some concern from the older farmers about involving new younger farmers in the scheme; however the existing farmers now greatly appreciate the importance of involving new people as it is sharing maintenance costs and task, enabling the full utilisation of the scheme area, allowing for succession in the scheme, and to enabling enough food to be grown for themselves, their families and the community.

CASE STUDY

SECTION 9

MONITORING, EVALUATING AND LEARNING

Keeping basic records of agricultural inputs, tool readings, resource conditions and crop production can help farmers evaluate how they farm, maximise their learning from the monitoring tools and enhance their agricultural practices. While farmers benefit from the immediate 'tactical' data provided by monitoring tools, longer-term 'strategic' learning is enhanced by keeping and analysing records. The challenge is to design monitoring and evaluation systems that have requisite simplicity and provide the right balance between effort required and obtaining sufficiently useful information. The aim is that farmers will collect and use the data themselves.

In the context of our African irrigation research, the introduction of soil and water monitoring tools and AIPs and the monitoring and evaluation of individual farmers' actions and progress is critical for at least two purposes. First, if farmers keep using ongoing records of their decision-making based on the tools, the AIP actions and other advice, they can more effectively assess their progress and change their decisions. That is, farmer learning is maximised based on one season's results and later on by comparing results from one season with those from previous seasons. Only then can this learning be communicated to other farmers. Second, only if there is ongoing monitoring and evaluation is it possible to assess the efficiency and effectiveness of the project and continuously adapt and improve it, to maximise benefits within the irrigation communities.

In addition to monitoring and evaluating individual farmers' actions, it is also important for system managers and policymakers to monitor the impact of the project within the wider community. This can help justify the spending of resources on the project and identify changes needed to maximise the socioeconomic benefits for the community members not directly involved in the project.

To maximise their learning, farmers can maintain a field book during each cropping season, so that final productivity and gross margins can be analysed at the end of each season in the light of actions taken and input provided, including the information below.

The first entry in the field book for each season should be the decision about the size of land committed to each crop, the farmer's rationale for choosing the crop and their expectations of where they will sell the crop and the price they expect to receive.

Maize drying, Magozi, Tanzania.
Photo: Peter Ramshaw

For each week during the cropping season, the following data should be recorded:

- Fieldwork carried out, such as land preparation, seeding, fertilisation, spraying, weeding, irrigating, for example:
  - irrigating – whether or not to do it, how many hours, labour required
  - seeding – planting rate of seed, type of seed, quantity of seed, price of seed
  - fertilising – what fertiliser was used, quantity used, the price, labour required
  - spraying – which spray was applied, why it was applied, quantity applied, the price, labour required
  - weeding – the crop that was weeded, the area, labour required
  - harvesting – the crop, the area, the quantity, labour required
  - cost of non-family labour.
- Use of harvested crop, how much was kept for home consumption and how much was sold, to which market/buyer, at which price and rationale for choice of market/buyer.
- Reading from the Chameleon and the FullStop:
  - colour of the first, second and third sensor
  - rainfall
  - nutrient and salinity measures
  - air temperature
  - how this data influenced the farmer's irrigation decisions.

The final entry will be post-harvest and include:

- the gross margin for each crop
- post-harvest losses, how much of each crop and why
- the farmer's main lessons from the season
- the plan for next season
- reflection on use of markets
- reflection on sources of advice.

Farmers need to be trained on the use and benefits of using the book and how to compute crop gross margins.

'...only if there is ongoing monitoring and evaluation is it possible to assess the efficiency and effectiveness of the project and continuously adapt and improve it'

At the end of the first season, farmers should meet and compute their gross margin based on their records. Trained extension officers, scheme management staff or other relevant people could facilitate this. Farmers should then discuss their experiences with using the book and their results and learnings from the process.

To facilitate system learning for project adaptation, it is necessary to be able to identify the main socioeconomic characteristics of each household. The first page in the field book should be filled in by the person introducing the system and the tools and should include:

- age and gender of household head and partner, roles within the community
- age and gender distribution and size of household, including education and % of working time spent on- and off-farm
- % of total household income derived from off-farm work
- control of land: size of dry and irrigated land, location within the system (upstream/midstream/ downstream), gender of person controlling each plot of land.

Sample templates are shown on page 41.

To assess overall impact within the wider irrigation community, a set of socioeconomic monitoring indicators needs to be developed that can be followed regularly based on publicly available data or a small number of interviews or focus groups. The indicators need to be developed in the specific local context and in collaboration with local stakeholders through interviews, workshops or focus groups. However, indicators should measure impacts such as gender roles in decision-making, involvement of youth, level of various services and businesses, availability and use of financial instruments, market integration, input use relative to need and quality, availability of non-farm job, access to processing facilities and commodity prices. The relevance of each indicator and the ability to access the necessary data will vary from location to location.

	Female	Male	Education	% work on-farm	% work off-farm
Total household size					
Age					
0–7 (preschool)					
8–16 (School)					
17–40 (young farmers)					
41–65 (farmers)					
66+ (retired)					
1 not started school; 2 at school; 3 some primary school; 4 some secondary school; 5 some post-secondary; 6 never went to school					

Plot	Size	Location within the scheme (upstream /midstream / downstream)	Age of person controlling	Gender of person controlling
Irrigated plot 1				
Irrigated plot 2				
Rainfed plot 1				
Rainfed plot 2				
Livestock	**Number**			
Cattle				
Sheep				
Etc.				

SECTION 10

ENGAGING WITH NATIONAL POLICY PRIORITIES

Policy plays a critical role in creating an enabling environment for irrigation. It can guide the actions of smallholder farmers, water authorities and extension services providers and define the principles of interaction, communication and collaboration. In addition, supportive irrigation policies can harmonise the efforts of different actors and create incentives for smallholder farmers.

There are a number of ways to influence national policies: there is no one 'right way' to do policy engagement. The issues vary, as do the opportunities, entry points and approaches, and the appropriateness of each depends on the context. However, in all cases, it usually requires a considerable amount of time to identify key policy issues and options, build partnerships to influence decision-making and eventually see changes in policies and practices.

The starting point is to understand the national processes for policy development. This requires institutions and stakeholders mapping their roles and effective power, and identifying platforms for policy dialogue and the various steps required for different sorts of policy outcomes. During the project, a stakeholder mapping exercise conducted by Food, Agriculture and Natural Resources Policy Analysis Network (FANRPAN) enabled the Zimbabwe project team to identify stakeholders to engage with on challenges related to dam siltation caused by illegal land encroachment in the catchment area around the Makhoba dam. Table 1 shows relevant actors in the irrigation sector in Zimbabwe (Mosello et al 2017).

Any policy engagement approaches that are developed must fit into national processes. Subsequently, an evidence base on the particular issue is vital for influencing national policymakers. Policy decisions are not always evidence-based, but targeted analysis can always inform policy decision. At a national level, a rapid review to determine the policies and politics that have shaped irrigation practice and performance in the country would help to identify opportunities for innovation in irrigation policy and practice. A combination of a policy review and compilation of life stories and experiences from the field can strengthen the case of farmers in processes of policy development.

While a clear strategy for policy engagement is important, windows of opportunity should also be taken advantage of. These could range from a new minister for agriculture coming into office to a change in the political party in power or an ongoing process to develop a national sector strategy. These are potentially favourable moments for engagement in the country's policy processes and should be seized whenever they emerge. It is therefore be important to keep track of such events and opportunities.

Table 1 Irrigation stakeholders in Zimbabwe

Scheme level
• Irrigation management committees: constituted on a voluntary basis; responsible for the management of irrigation schemes • Village chiefs: traditionally have a role in allocation of lands
District/province level
• Representatives of Ministry of Agriculture, Mechanization and Irrigation Management (MAMID), Agricultural Technical and Extension Services, Government of Zimbabwe (AGRITEX), Ministry of Environment, Water and Climate (MEWC) • Catchment and subcatchment councils: represent MEWC at local level; issue and enforce water permits according to river system outline plans
National level
• MEWC: leads water sector at national level; is represented at provincial and district levels • Zimbabwe National Water Authority (ZINWA): parastatal organisation; in charge of water planning, management and fee collection • MAMID: different departments – irrigation, economics and markets – responsible for planning, management (including rehabilitation) and development of irrigation schemes • AGRITEX: extension services to farmers at scheme, district and provincial level • Agricultural research centre: conducts research on agricultural products; inputs, technologies and livestock • National Climate Change Office (in MEWC): develops and implements National Climate Change Strategy (and draft policy under preparation); coordinates contributions of government authorities in other sectors
International non-governmental organisations / multilateral and bilateral donors
• Food and Agriculture Organisation: focus on smallholder irrigation (especially rehabilitation of communal schemes) and support of policy efforts of Government of Zimbabwe (MAMID); coordination with international organisations • European Union: portfolio of projects worth $244 million, including on agricultural growth and irrigation (focus on smallholder farmers in communal areas), livestock support, and climate resilience, natural resource management and livelihoods • Swiss Agency for Development and Cooperation: since 2011, project on smallholder irrigation in Masvinga province (rehabilitation of irrigation infrastructure and institutional capacity building of irrigation management committees, market linkages) • International non-governmental organisations (World Vision, Care International, Netherlands Development Organisation): irrigation infrastructure rehabilitation and capacity building as a strategy to improve smallholder farmers' resilience to climate change impacts (especially drought), linked to food security, nutrition and disaster risk reduction programming • United Nations Development Programme-Global Environmental Finance : manages a portfolio of 171 projects focused on climate change mitigation and increased climate resilience of beneficiaries • Others: Japan International Cooperation Agency (provision of technology and capacity building), German Agency for International Cooperation and Department for International Development (focus on agricultural markets), 'new' donors (e.g. Chinese and Brazilians) focusing on technology transfer

'A combination of a policy review and compilation of life stories and experiences from the field can strengthen the case of farmers in processes of policy development'

'Advocacy raises awareness about issues and the policy changes needed to address them'

Furthermore, it is important to seek opportunities to leverage programmatic work by participating in policy-oriented discussions. Through engaging with decision-makers in policy advocacy or dialogue, this can assist in influencing policies by providing information and credible, well-packaged evidence and demonstrating the benefits of a specific intervention. Advocacy raises awareness about issues and the policy changes needed to address them. Successful advocacy and dialogue needs continuous and long-term engagement at all levels. It demands an in-depth knowledge of contents, actors and structures and requires compromise and strategic timing. Advocacy needs to start with an understanding of the policy process and the political realities that decision-makers face at all levels.

From FANRPAN's experience in Africa, one effective way to inform policy processes is to convene national policy dialogues, which bring together diverse interest groups to focus on a regulatory policy or planning issue that is of common interest and then seek to formulate practical solutions. During the project, FANRPAN convened a regional policy dialogue at which the project was presented and feedback was provided with some high-level policy actors committing to take up the issues raised.

Finally, good communication is critical in the process of engaging with national policy priorities. While a research project often produces research reports and academic papers targeted at journals, it is important to develop communication products targeted at policymaking audiences. Policy briefs containing a concise summary of particular issues, relevant policy options, and some recommendations are an important tool for influencing policy.

WORKING ACROSS SOCIETAL AND GOVERNANCE SCALES

SECTION 1

Many of the most pressing challenges facing the management of water resources extend beyond traditional scales of analysis and management. Water connects across sectors, places and people, as well as geographic and temporal scales. To varying degrees, countries have allocated increasingly complex and resource-intensive responsibilities to subnational governments, resulting in interdependencies across levels of government that require coordination to mitigate fragmentation. Projects working across societal and governance scales need to consider a number of critical factors.

First, there is a need to ensure a shared vision with relevant stakeholders and consistent understanding of each partner's role in the project. At the beginning of the project, this could be done through a project common vision meeting. For this project, an inception meeting was convened in Maputo, Mozambique, and it served to introduce project team members, country partners and donor representatives to each other. Site selection was discussed during the inception meeting in Maputo, and two sites were selected in each country (six sites in total). The case study sites were reviewed (by all participants led by ANU) to ensure that they were the best places to undertake the research; a range of different irrigation practices were represented by the sites; the local organisations and people were interested in participating; and that we understood the history of past management at these sites.

During project implementation, it is important to check for evolving understandings of partner roles, stakeholder and project priorities. In this project, an annual project meeting was held to review progress, share knowledge across countries and collaborators, refine project operations and identify research findings. The meeting reviewed the project outputs and outcomes by scheme, country and overall. The initial meeting was held in Iringa, Tanzania on 3–6 June 2014. The second one was held in Bulawayo, Zimbabwe on 8–12 June 2015. The third was held in early August 2016 in Maputo, Mozambique.

Linked to this is the need to understand the project context. A scoping study can help project partners and country teams identify and narrow down country-specific and regional priorities. The project team should also understand past management of the field sites and institutional interplay. In this project, country teams compiled situation reports and site profiles of the irrigation schemes that were identified for the project. Establishment of baseline water, solute and agricultural conditions occurred during the initial phase of the project, and many of the baseline

Farmer with Chameleon sensor, Zimbabwe.
Photo: Andre F van Rooyen

'...there is a need to ensure a shared vision with relevant stakeholders and consistent understanding of each partner's role in the project'

conditions at the six schemes have been captured in the baseline survey reports.

Project teams should invest in constant and detailed communication between partners, with explicit attention given to identifying those key points of intersection where one partner's work plan is critically dependent on another. This is vital to prevent problems in one work stream from cascading through the entire project. In the initial period of the project, communication activities focused on introducing the project to stakeholders and establishing networks. In subsequent project years, many external communication activities were undertaken, including popular articles, academic publications and conference presentations.

The results from the cross-cutting thematic research in the areas of information, extension, farmer learning and engagement in the value chain point to a number of the potential interventions for more profitable and sustainable smallholder irrigation. The irrigation schemes displayed many characteristics of complex adaptive systems (Bjornlund et al. 2016; van Rooyen et al. 2017). This indicates the need for complementary interventions at different scales to promote greater profitability and sustainability, such as linking soil and water monitoring tools within the context of functioning markets, as was done in this project using AIPs.

Finally, monitoring and evaluation should play a central role in projects across societal and governance scales. An effective monitoring and evaluation system that allows for continual information gathering, learning and adjustment of operational approaches and models (Medema et al. 2008) will ensure transparency regarding project progress and results. It will also help project partners identify areas where problems and delays are typically experienced. Projects should also plan to have internally facilitated annual reviews to review progress, share knowledge across countries and collaborators, refine project operations and identify research findings. In addition, mid-term and end-of-project reviews facilitated by external consultants should be planned and budgeted for.

ANNEXES

SECTION 12

Annex 1: International Journal of Water Resources Development special issue

The following open access special issue of the *International Journal of Water Resources Development* in 2017 has more detailed academic analyses of the topics summarised in the above guide.

Bjornlund H. and Pittock J. 2017. Exploring the productivity and profitability of small-scale communal irrigation systems in Sub-Saharan Africa. International Journal of Water Resources Development, 33(5), 685–689. doi: http://dx.doi.org/10.1080/07900627.2017.1326881

Bjornlund H., van Rooyen, A. and Stirzaker, R. 2017. Profitability and productivity barriers and opportunities in small-scale irrigation schemes. International Journal of Water Resources Development, 33(5), 690–704. doi: http://dx.doi.org/10.1080/07900627.2016.1263552

de Sousa W., Ducrot R., Munguambe P., Bjornlund H., Machava A., Cheveia E., et al. 2017. Irrigation and crop diversification in the 25 de Setembro Irrigation Scheme, Mozambique. International Journal of Water Resources Development, 33(5), 705–724. doi: http://dx.doi.org/10.1080/07900627.2016.1262246

Manero A. 2017. Income inequality within smallholder irrigation schemes in Sub-Saharan Africa. International Journal of Water Resources Development, 33(5), 770–787. doi: http://dx.doi.org/10.1080/07900627.2016.1152461

Mdemu M.V., Mziray N., Bjornlund H. and Kashaigili J.J. 2017. Barriers to and opportunities for improving productivity and profitability of the Kiwere and Magozi irrigation schemes in Tanzania. International Journal of Water Resources Development, 33(5), 725–739. doi: http://dx.doi.org/10.1080/07900627.2016.1188267

Moyo M., van Rooyen A., Moyo M., Chivenge P. and Bjornlund H. 2017. Irrigation development in Zimbabwe: understanding productivity barriers and opportunities at Mkoba and Silalatshani irrigation schemes. International Journal of Water Resources Development, 33(5), 740–754. doi: http://dx.doi.org/10.1080/07900627.2016.1175339

Mwamakamba S.N., Sibanda L.M., Pittock J., Stirzaker R., Bjornlund H., van Rooyen, A., et al. 2017. Irrigating Africa: policy barriers and opportunities for enhanced productivity of smallholder farmers. International Journal of Water Resources Development, 33(5), 824–838. doi: http://dx.doi.org/10.1080/07900627.2017.1321531

Pittock J., Bjornlund H., Stirzaker R. and van Rooyen A. 2017. Communal irrigation systems in south-eastern Africa: findings on productivity and profitability. International Journal of Water Resources Development, 33(5), 839–847. doi: http://dx.doi.org/10.1080/07900627.2017.1324768

Stirzaker R., Mbakwe I. and Mziray N.R. (2017). A soil water and solute learning system for small-scale irrigators in Africa. International Journal of Water Resources Development, 33(5), 788–803. doi: http://dx.doi.org/10.1080/07900627.2017.1320981

van Rooyen A.F., Ramshaw P., Moyo M., Stirzaker R. and Bjornlund H. 2017. Theory and application of agricultural innovation platforms for improved irrigation scheme management in Southern Africa. International Journal of Water Resources Development, 33(5), 804–823. doi: http://dx.doi.org/10.1080/07900627.2017.1321530

Wheeler S. A., Zuo A., Bjornlund H., Mdemu M.V., van Rooyen A. and Munguambe P. 2017. An overview of extension use in irrigated agriculture and case studies in south-eastern Africa. International Journal of Water Resources Development, 33(5), 755–769. doi: http://dx.doi.org/10.1080/07900627.2016.1225570

Annex 2: Increasing irrigation water productivity in Zimbabwe

Dates: 18–19 November 2013

Venue: Insiza Rural District Council Board Room, Filabusi, Zimbabwe

Facilitator: Dr Martin Moyo

Purpose

The workshop is for the project *Increasing irrigation water productivity in Mozambique, Tanzania and Zimbabwe through on-farm monitoring, adaptive management and agricultural innovation platforms*, which aims to find means of meeting the African government's plans for greater food security while using limited water resources more sustainably. The project is funded by the Australian Government via the Australian International Food Security Centre of the Australian Centre for International Agricultural Research, with additional contributions from participating organisations.

The project is led in Australia by the UNESCO Chair in Water Economics and Transboundary Water Governance at The Australian National University, with contributions from CSIRO Land and Water and the University of South Australia. Partners in Africa include the Food and Natural Resources Policy Analysis Network, the International Centre for Crop Research in the Semi-Arid Tropics, the University of Pretoria, Ardhi and Sokoine University of Agriculture in Tanzania, and the National Institute for Irrigation in Mozambique.

Specific objectives

1. To reach a common understanding of the project goals, concept, approach and methodologies.
2. To understand the stakeholders and their work and develop relationships and teams that enable a smooth implementation.
3. To develop working arrangements between the stakeholders with clear roles and responsibilities.
4. To elaborate monitoring and evaluation and learning mechanisms for effective implementation.
5. To establish the Silalatshani Irrigation Scheme Agriculture Innovation Platform and develop a work plan for the project implementation.

Program: Day 1

Time	Presentation	Person responsible
08:30	Welcome and introductions	Mr A. Mhike (AGRITEX)
08:45	Workshop objectives	Dr Martin Moyo
09:00	Opening remarks	Mr Sibanda (PAEO)
09:30	Experiences of using agriculture innovation platforms: A case study from goat production and marketing in Gwanda	Dr Andre van Rooyen
10:00	**Tea**	
10:30	Experiences on irrigation development in Insiza district	Mr A. Mhike (AGRITEX)
11:00	Irrigation development in Matabeleland. South	Mr T. Moyo (provincial irrigation engineer)
11:30	Irrigation experiences • Partners working on irrigation development in Insiza district • What is being done • How we can collaborate in the project	World Vision Zimbabwe; ZimAEID; Christian Aid
12:30	Irrigation development in Zimbabwe • Issues that shape/determine viability in irrigation schemes	Mr Jonathan Tsoka (Irrigation Department, Head Office)
13:00	**Lunch**	
14:00	Understanding the irrigation scheme • Challenges and opportunities • Group work on identifying key research areas	Dr Martin Moyo
15:00	**Tea**	
15:30	Water use and governance policies	Mr M. Nyikadzino (Ministry of Environment, Water and Climate)
15:30	Plenary discussions led by Dr Martin Moyo	
16:30	**End of Day 1**	

Program: Day 2

Time	Presentation	Person responsible
08:30	Visioning session and action planning • Key research themes in irrigation schemes • Negatives and positives in the past 5 years • Where do we see ourselves 10 years from now? • What steps are necessary to reach our goals? • What barriers exist that might hinder us reaching our goals? • What do we need to do to overcome these barriers? • What are the priority areas that we need to address? • Who will be the main partners? • What is the role of the partners? • What are the deadlines for this work?	Dr Martin Moyo and Dr Andre Van Rooyen
13:00	**Lunch, end of seminar and departure**	

Annex 3: Gender and equity checklist for ACIAR project activities

Introduction to the guidelines

"We're disaggregating data by gender in all our surveys. Is that enough?"

The Gender and Equity Checklist was developed in response to that very question, originally posed at a project team meeting.

Gender-aware research is critical to the success of experimentation and implementation within this ACIAR-funded project; yet, not all project teams have readily available gender expertise or experts upon whom to call when developing and revising research design, activities and outputs. In their absence, this checklist offers some practical guidance on how researchers can more easily identify whether current/planned activities adequately consider gender.

The questions posed in these guidelines are meant to easily identify where and how gender might be missed in AIP activities. Each question is meant to provoke project teams into a diagnosis of whether their planned activities are gender appropriate so that both the process of asking the question and the answers themselves are useful. This information, and any feedback from it, could also inform ACIAR and global gender perspectives.

Guidance for use

The checklist can be used for two main purposes:

- Overall 'auditing': Project teams should apply this checklist to their plans and activities to assess current gender sensitivity. Some sections of this checklist will be more-or-less appropriate to different projects. However, no sections should be skipped until thoroughly explored and examined.
- Ongoing monitoring: Researchers themselves can use this checklist in an ad hoc manner. The questions are divided based on types of project activities. For instance, each time a model is developed or used, researchers are encouraged to quickly ask themselves the questions in the 'models' section.

Once completed, the checklist can be used in a number of ways: to inform gender action plans; as a baseline for projects on the extent of their gender mainstreaming; as the basis for adjustments to methodologies, models and activities; as the basis for adjustments to plans; as an indication of capacity needs, etc.

Also note:

- The checklist is not exhaustive and should be further contextualised for use in different countries and sites.
- The phrase 'social categories' refers to the different categories that a person could be classified by, and which often have links to power, incomes, etc. These categories include gender, race, ethnicity, nationality, age, education level, health status, occupation, religious affiliation, income level and class.

Please read, interpret and answer each of the following questions, giving a yes or no answer. If you are not ticking the YES box, you should rethink your activity to try to be more gender sensitive and equitable.

Completed by:		Date:		Location:	

Workshops, AIP meetings, or field visits (within your project teams or rural communities)	YES	NO
1. Are you sure that the season, day or time of the workshop does not constrain participation by any particular group? For example, • women who are primary caregivers (of children or elderly) • people celebrating religious holidays • people with specific occupations • specific groups involved in planting/harvesting • students attending meetings during school time.		
2. Are the participants given ample notice so that people of different social categories (including those with many responsibilities/burdens) can attend?		
3. Are there measures to support care-giving responsibilities (e.g. day care or allowance of children's attendance at the meeting)?		
4. Are participants in attendance reflective of the actual gender/age/class balance of the community?		
5 Have you considered whether this meeting separates men and women for any reason?		
6. Are all women's opinions or concerns accurately reflected in the workshop? Do women vocalise their opinions or communicate through other socially constructed ways?		
7. If the sex or social category of the AIP representative/meeting leader impacts the dynamics of the meeting, are these impacts acceptable (e.g. do you always automatically ask a man to chair and a woman to rapporteur)?		

Implementing research	YES	NO
Baselines		
1. Are you disaggregating data by gender and other social categories (e.g. do activities like baselines or vulnerable community members specify men and women, girls and boys)?		
2. Do any data inputs assume certain gender- or age-dependent categories? For example, planting times and access to technology might be different depending on the sex or other social category of the farmer.		
Follow-up surveys		
1. Are you disaggregating by gender and other social categories?		
2. Are your questions including all groups?		
3. Are your questions phrased appropriately, given the cultural context?		
4. Could the social categories of respondent (man, woman, head of household) affect the answer? If so, figure out a way to deal with this, such as asking more than one member and triangulating data and/or disaggregating data and checking to see if it matters. For example, 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 and children are often left hungry.		
5. 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. For example, questions about weeding or household chores might be more suitably presented to women.		
6. Could the social categories (e.g. gender, ethnicity, age) of the person asking the question (or others present during the interview) affect the answer?		
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?		
2. Does the technology or project design take into account the differences in users and user needs, such as different literacy levels, age, strength, time and responsibilities, liquid capital for investments?		
3. Could this have unintended negative impacts on already marginalised populations, including elderly, young or girls? For example, • is it going to add to the work burden of anyone? • is it located in an onerous and/or insecure area? • who will be responsible for maintenance of the technology? • if the technology costs money or labour, will that mean cutting out other important household expenditure, like education or health care for children?		

Monitoring and evaluation, analysis and project reporting	YES	NO
1. Are you checking for any diversity in the stories emerging from your gender etc. disaggregation? Are you considering what implications it might have for your or other work? For example, could your results feed into better science for one of the other project teams or your institution?		
2. Are you considering positive or negative impacts that your research might have on different social groups, including women?		
3. Are you using gender-neutral language in all your reports and communications outputs?		

Researchers within the ACIAR project	YES	NO
1. Are you being sensitive to power relations between gender, age, race/culture and levels of management?		
2. Are you conscious of your authority in your group? Do you ensure that you do not use that authority to make anyone feel uncomfortable?		
3. Do you encourage less senior or well-established members of the scientific community, such as women and young professionals?		

SECTION 13

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