International Journal of Water Resources Development

ISSN: 0790-0627 (Print) 1360-0648 (Online) Journal homepage: http://www.tandfonline.com/loi/cijw20

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**To cite this article:** André F. van Rooyen, Peter Ramshaw, Martin Moyo, Richard Stirzaker & Henning Bjornlund (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: 10.1080/07900627.2017.1321530

**To link to this article:** http://dx.doi.org/10.1080/07900627.2017.1321530



Published online: 19 May 2017.

INTERNATIONAL JOURNAL OF WATER RESOURCES DEVELOPMENT, 2017
VOL. 33, NO. 5, 804–823
https://doi.org/10.1080/07900627.2017.1321530

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# Theory and application of Agricultural Innovation Platforms for improved irrigation scheme management in Southern Africa

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**ABSTRACT**
Many small-scale irrigation systems are characterized by low yields and deteriorating infrastructure. Interventions often erroneously focus on increasing yields and rehabilitating infrastructure. Small-scale irrigation systems have many of the characteristics of complex socio-ecological systems, with many different actors and numerous interconnected subsystems. However, the limited interaction between the different subsystems and their agents prevents learning and the emergence of more beneficial outcomes. This article reports on using Agricultural Innovation Platforms to create an environment in which irrigation scheme actors can engage, experiment, learn and build adaptive capacity to increase market-related offtake and move out of poverty.

**ARTICLE HISTORY**
Received 28 June 2016
Accepted 9 April 2017

**KEYWORDS**
Agricultural Innovation Platforms; complex systems; smallholder irrigation; market-oriented development; Mozambique; Tanzania; Zimbabwe

## Introduction

The research and development community, like the farmers in the world's semi-arid areas, often cites low and/or unreliable rainfall as the most important factor contributing to low productivity and food insecurity (Mancosu, Snyder, Kyriakakis, & Spano, 2015; Rockström, 2003; Van Duivenbooden, Pala, Studer, Bielders, & Beukes, 2000). Overcoming water scarcity by irrigation appears self-evident, hence the promotion of irrigation development in the developing world, and specifically in sub-Saharan Africa (Burney & Naylor, 2012; Fischer, Tubiello, van Velthuizen, & Wiberg, 2007; Mancosu et al., 2015). Irrigation, along with improved seeds, fertilizer and agrochemicals, has been a pillar of the Green Revolution in North America, Europe and much of Asia. In sub-Saharan Africa, however, the success of irrigation has been mixed at best, and many schemes are under-utilized or have been abandoned (Inocencio et al. 2007; Hope, Gowing, & Jewitt, 2008; Manzungu, 1995; Smith, 2004; van Averbeke, Denison, & Mnkeni, 2011).

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Irrigation scheme development requires a huge engineering investment in constructing storage or diversion infrastructure and the associated canals. In addition, irrigation demands the human capacity and institutional arrangements to manage the water, ensure equitable distribution, collect water payments, carry out repairs to maintain the scheme, and manage disputes (Amede, 2015; Mutiro & Lautze, 2015). For these reasons, irrigation cannot be a subsistence activity (Kadigi, Tesfay, Bizoza, & Zinabou, 2013). The linkages to input and output markets and the ability to secure sound technical information, credit and other services are critical. Moreover, irrigation development displaces some farmers and imports new farmers, leading to social and political tensions over land tenure.

Development initiatives encouraging the adoption of technology that can improve water productivity must operate within this complex institutional landscape. Hounkonnou et al. (2012) argue that agricultural development in sub-Saharan Africa has underestimated the crucial role of this institutional setting, and hence overestimated the value of technological investment. It appears that gaining control over water comes at such great cost, both financial and institutional, that many irrigation schemes are often referred to as socio-economic failures (Hunt, 1988; Mutiro & Lautze, 2015). Considering all of the above, irrigation systems are complex systems with many actors at various levels, scales and subsystems, which need to interact and share knowledge in a coordinated way to be fully functional. We hypothesize that the disconnect between these actors (farmers, water authorities, business community, policy makers and markets), the lack of feedback loops (returns on investments) and the lack of information flow (regarding water and nutrient management, and input and output market intelligence) leads to low productivity and profitability, and eventual system breakdown and/or abandonment. Trying to address system breakdown with new technology and hardware alone is a misdiagnosis of the problem.

This article addresses the question of whether the Agricultural Innovation Platform (AIP) process is able to facilitate institutional arrangements (and associated information flows) that will increase the performance of irrigation systems. We use the innovation systems approach to address the institutional context limiting irrigation potential in six schemes in Africa. We define institutions, both formal informal, according to North (2005), as the rules of the game that reduce uncertainty in human interactions. The innovation systems framework was developed to provide insight into the 'rules of the game' and hence the complex relationships between the diverse stakeholders, be they farmers, retailers, processors, policy makers, researchers, donors or entrepreneurs. The innovation systems framework aims to identify and analyze new opportunities and to facilitate the collective action needed to bring about desirable change (Ostrom, 2009; Spielman, Ekboir, Davis, & Ochieng, 2008).

Although using the concepts of complex adaptive system and innovation systems to understand and address complex agricultural problems is not new (Hall & Clark, 2010; Spielman et al., 2008), the focus of this article is to report on the practical application of these concepts in the context of small-scale irrigation systems. We develop the argument that small-scale irrigation systems have many of the characteristics of complex socio-ecological systems: they have many different actors (water authorities, irrigators, support services, policy makers and market agents), and they are composed of numerous subsystems (the source of the water, i.e. catchment, with a dam or river system, hardware, soil, water, crops, etc.). However, they often lack interaction between the different subsystems and their agents, preventing learning and the emergence of more beneficial outcomes.

## Complex system theory and Agricultural Innovation Platforms

In trying to unravel the challenges irrigation systems face, it is necessary to distinguish the research methodologies that have delivered technological advancement from approaches needed to understand the agricultural system as a whole. Reductionist approaches break down larger systems into components in order to infer cause-and-effect relationships without the 'interference' of the rest of the system. Reductionism has produced individual technologies that perform in predictable ways. The larger agricultural context into which these technologies are deployed is a complex socio-ecological system where the dynamics and interaction between its many subsystems often give unpredictable and even highly surprising outcomes (Ostrom, 2009; van Mil, Foegeding, Windhab, Perrot, & van der Linden, 2014).

Complex systems comprise large numbers of components, which are often organized into hierarchical structures or subsystems, which in turn have their own sub-subsystems (Gatrell, 2005). The agents interact by sending and receiving signals or information, which results in learning, adaptation and the development of feedback systems. This leads to the adaptive capacity of complex systems, then referred to as complex adaptive systems (Allen & Holling, 2010; Anand, Gonzalez, Guichard, Kolasa, & Parrott, 2010; Folke et al., 2002; Olsson, Folke, & Berkes, 2004). The adaptive capacity of these systems allows them to change in response to new information and to recover from external shocks, leading to higher resilience.

Small-scale irrigation schemes often suffer from poor access to markets (Oates, Jobbins, Mosello, & Arnold, 2015; World Bank, 2007). Input suppliers do not communicate effectively with producers, while producers do not, or cannot, communicate with output markets. It is not possible for the small-scale farmer to decide which production system to follow, based on the integration of information about soil, rainfall, local capacity and availability of inputs, distance to markets and, ultimately, potential profit margins. Using the principles of functional complex adaptive systems, AIPs can facilitate communication and coordination of all agents and subsystems to identify better configurations of system components or stakeholders. AIPs can also identify where the wrong configurations have perpetuated low productivity by locking the stakeholders into dysfunctional regimes.

The value of the AIP lies in the inclusive nature of the stakeholders, representing traditional entities (agricultural engineers, irrigation management committees and water authorities) as well as stakeholders not normally associated with irrigation schemes (value chain players). The AIP stakeholders therefore represent the larger socio-ecological system within which the irrigation scheme functions. It is multidisciplinary in nature and establishes cognitive diversity (Mitchell & Nicholas, 2006), increasing the capacity to analyze and solve technical problems and address systemic challenges. While these stakeholders may have the same or similar overall goals, their individual objectives (and therefore their requirements and contributions) will differ markedly. For example, the objectives and needs of input suppliers are different from those of producers, whose objectives and needs are in turn different from those of output markets and other value chain stakeholders. Although these objectives are different, they are often complementary and mutually beneficial, fostering trust and respect of the roles of different stakeholders and their contribution to the functioning of the larger system. Essentially, it is the integration of different types of knowledge from diverse stakeholders that becomes the precondition for problem solving (Berkes, 2007). The process of articulating individual challenges and contributions along the value chain provides a basis for mutual understanding and cooperation among the stakeholders. The collective understanding of the systemic challenges they face, and how positive interactions between stakeholders and/or new configurations can contribute to resolving these issues, is critical to the success of the innovation process.

## The four stages of AIP implementation

*Stakeholder identification*. The first stage in establishing an AIP is to identify and ensure participation of a diverse and committed range of stakeholders, identified based on local expert knowledge, so that it is the local people and/or their representatives that identify the perceived challenges. They often include government and/or NGO representatives, extension agents, scientists familiar with the area, and private-sector representatives. This means that there is already a common understanding, yet often only in generic terms, of the challenges. In many cases, this stage includes literature and baseline surveys (for this project refer to Mdemu, Mziray, Bjornlund, & Kashaigili, 2017, for Tanzania; de Sousa, Cheveia, Machava, Faducoa, Ducrotb & Bjornlund, 2017, for Mozambique; and Moyo, van Rooyen, Moyo, Chivenge, & Bjornlund, 2017, for Zimbabwe) to obtain as much information on the socio-economic and technical environment as possible. This is vital in informing and substantiating the initial findings of the AIP. Once a core stakeholder group, those critical to bring about change, has committed to the process, one can initiate the AIP implementation.

*Identification of system challenges*. The second stage is to use the diverse nature of the AIP participants and their collective knowledge of the system to probe the finer nuances, which are often lost when discussing challenges in broad terms. Generic challenges such as poor access to inputs, high production risk and poor market access are explored in the specific context of the local conditions. This process enables the identification of the role and responsibilities of each stakeholder, and how they can contribute to a better outcome. All stakeholders should be able to articulate their incentives and/or reasons for being part of the platform.

The AIP must identify the current challenges their irrigation scheme faces, as well as any opportunities that may exist to improve the situation, without the pressure of what donors might be offering. Experiences from this project suggest that many stakeholders are keen to express their challenges and, if they fail to do so initially, will reiterate their problems and not move on. For the initial process, the participants are divided into groups, e.g. farmers (could be gender-specific to identify any gender-related nuances), technical support staff and private-sector representatives. The process has four steps. Each group has to (1) list and prioritize challenges and opportunities; (2) conduct a root-cause analysis by asking the 'why' question to get to the root cause of the challenge; (3) identify potential solutions for each of the root causes; and (4) identify partners critical for the implementation process. The latter is important because some key stakeholders may not be present in this initial meeting. Once this process is completed, participants report to the larger group and discuss, clarify and confirm their findings.

*Visioning*. The third stage, after a shared understanding of the current challenges is developed, is to visualize a desired future state or a shared goal – where the stakeholders want to see the system go (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 if the pathway to the destination is still unclear. The visioning process puts the roles and responsibilities of all stakeholders in context and clarifies individual responsibilities and incentives. Stakeholders work in separate groups (farmers: men and women, private-sector players, support services, etc.) to capture their collective perceptions and aspirations. Rich pictures allow people to (1) articulate the scheme's current state, including the location of households and their immediate surroundings, including markets and other infrastructure; (2) articulate the desired future state – participants express their needs and goals within what is achievable in five years; and (3) develop a strategy for how the transition from the current situation to the visioned future can be achieved. This includes the changes and improvements required both on and off farm, and often includes policies and institutional issues.

*Innovation process.* The fourth stage involves stimulating the innovation process that will be necessary to achieve their vision. Analyzing the pictures and associated strategies developed during the visioning process allows contextualization of isolated lists of challenges and their root causes, and makes the transition from technical interventions to a more holistic and shared development process. Participants explore different pathways from the current situation to the desired future situation by producing an annotated list of potential strategies. To address those strategies, the process can then begin selecting opportunities, identifying incentives and addressing challenges and root causes. The strategies may be within the control of the farmers and/or their organizations, or might also require larger system-related changes that are out of their reach. The latter can be caused by barriers associated with policy, infrastructure, markets (input and output), and knowledge and information. Each strategy may have numerous pathways for implementation, and the diverse AIP stakeholders may develop multiple 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, particularly farmers, and the incentive framework 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' 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 and learn from the experience (Figure 1).

## Implementing Agricultural Innovation Platforms in irrigation schemes

The AIP process was implemented in six small-scale irrigation schemes in Zimbabwe, Mozambique and Tanzania. The schemes and baseline surveys are reported in detail in the three country-specific articles in this issue: for Zimbabwe by Moyo et al. (2017); for Tanzania by Mdemu et al. (2017); and for Mozambique by de Sousa et al. (2017), summarized by Bjornlund, van Rooyen, and Stirzaker (2017).

A critical part of the AIP process is the facilitator. The lead author conducted workshops at all six schemes to explain the four stages of the AIP process. Local facilitators were then chosen and trained, and mentored as they ran AIP meetings at each scheme. The process was documented to facilitate learning on the job and ongoing improvement of the methodology. Results from one scheme in Tanzania and one in Zimbabwe are discussed in more detail below.

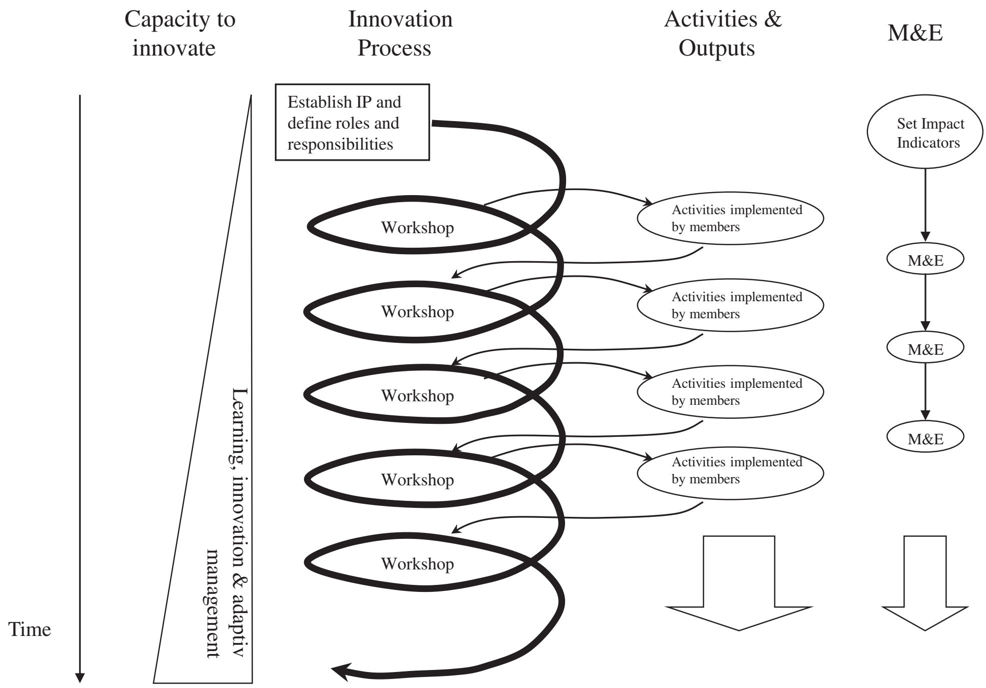


**Figure 1.** The innovation platform process. Once established, the multi-stakeholder forum convenes to identify challenges and opportunities, and test and evaluate new strategies as well as technical, institutional and policy interventions in order to work towards the desired state. Stakeholders engage in a participatory monitoring and evaluation (M&E) process to measure progress.

## Results

### *Stage 1: Stakeholder identification*

Stakeholders connected to the irrigation schemes were identified and attended the initial AIP meetings, together with those from higher levels of government and interested organizations. In the initial meetings, other relevant stakeholders were identified and invited to subsequent meetings. As the process unfolded, and AIPs started to work on specific identified topics, meetings included only relevant stakeholders, to ensure that those unrelated to the immediate process did not lose interest. Sharing the outcomes of these interactions with the rest of the AIP is, however, crucial to maintain momentum.

### *Stage 2: Identification of system challenges*

In most cases, 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 preconceived ideas. The main challenges identified in early meetings tended to be very generic (Table 1), and, while providing some insight into the main challenges of the specific irrigation system, their role in guiding stakeholders towards potential and viable solutions was limited.

**Table 1.** Challenges identified during Agricultural Innovation Platform sessions in Mozambique, Tanzania and Zimbabwe.

| Country, scheme *Main crops grown* | Common challenges |
|---|---|
| Mozambique Khanimambo | Ageing population in the scheme, leading to a lack of productive labour |
| | Irregular water supply due to broken-down pump that was damaged by flooding |
| *Horticulture* | Poor quality, incorrectly labelled seeds, and weak links to input suppliers |
| | No reliable markets (buyers are very far away, except for some middlemen in the village) |
| 25 de Setembro | High pumping costs |
| *Horticulture* | Poor infrastructure – canals are not lined |
| | No reliable markets (the transport network is poor, leading to high transport costs, which lead to high costs for inputs) |
| | Farmer capacity building – lack of knowledge (the majority of farmers rely on their own knowledge regarding all crop, livestock and market-related decisions; very few farmers use extension officers as they have been largely absent) |
| | Access to finance and lack of inputs |
| Tanzania | Reduced amount of water available |
| Kiwere | Poor infrastructure – canals are not lined |
| | Outdated agricultural equipment (requires mechanization) |
| *Horticultural* | High price of inputs (fertilizers are tampered with) |
| | No reliable markets |
| Magozi | Right to irrigate during only one of the two seasons |
| *Rice* | Water does not reach all irrigators' plots – poor infrastructure |
| | Farmers lack knowledge/capacity to improve rice production |
| | Limited access to and improper use of inputs |
| | Lack of post-harvest management and processing equipment |
| | Limited farmer capacity and education |
| | Low price of rice |
| Zimbabwe | Poor and infertile sandy soils |
| Mkoba | Poor markets (the output markets are unreliable and there is usually a glut of produce, causing low prices). Markets are generally far from the scheme, leading to high input costs, and at times there are shortages of inputs such as fertilizers and seeds |
| | Low dam capacity due to heavy siltation, and therefore limited irrigation during the dry season |
| *Horticulture* | An ageing population, leading to a lack of productive labour (hence, production has been compromised, as these elderly farmers are no longer that productive in terms of labour) |
| | Financial constraints due to limited production, hence a failure to reinvest in irrigation, leading to limited purchases of inputs |
| Silalatshani | Water payment arrears to Zimbabwe National Water Authority |
| *Maize, wheat, vegetables* | Plot allocation and management |
| | Infrastructure maintenance (fences and canals) |
| | Crop selection |
| | Farmer capacity building |
| | Water management and allocation |

**Table 2.** An example of the results of group work within the Agricultural Innovation Platform focusing on the challenges, their root causes, possible solutions and the partners that may be able to assist in addressing these challenges.

| Challenge | Root causes | Solution | Partners who can assist |
|---|---|---|---|
| Low price of rice | Lack of a joint market for farmers to sell their rice | Farmers have to organize themselves and sell their rice collectively | Farmers |
| | Market flooded with different varieties of rice, each in small quantities | There is a need for storage warehouses to store rice while waiting for better price | Iringa District Council |
| | High transportation costs to the market | Grow varieties which are in high demand by customers | Financial institutions such as NMB, NGOs, members of parliament |
| | Selling paddy instead of rice | Acquire and install rice-hulling machines | Ministry of Agriculture, Food Security and Cooperatives |
| | Imported rice from abroad sold at a lower price compared to domestic rice | Adopt expert technical advice on growing, processing and marketing | Savings and Credit Cooperative Society |
| | | Advocate that the government give priority to locally produced rice before permitting imports | Private investors (rice hullers) |

Participants gained a deeper understanding of the challenges and their perceptions (Table 1) by asking the 'why' question to clarify the root causes. They then brainstormed to identify possible local solutions and to identify and list potential partners who might be able to help implement these solutions (Table 2).

### *Stage 3: Visioning*

The visioning process developed rich pictures of the current situation and the future desired state of the system (Figures 2 and 3). This generated great excitement among stakeholders as it stimulated the belief that they could be active decision makers of their own future. Taken together, the pictures of the current situation and the vision gave a general overview of what needed to be done. The pictures illustrated the interconnected nature of many of these challenges and placed them in context of the larger system. The exercise of depicting the system on paper made it clear that there was no single solution, but several issues that needed to be worked on concurrently.

*Magozi Scheme (present situation, Figure 2a).* Of the 1300 hectares that could be irrigated, only 750 ha are under cultivation and produce low rice yields of 1–2 t/ha. Currently each farmer plants his or her own variety, many of which are of poor quality. Rudimentary farming equipment is available, which is time- and energy-consuming. Farmers also engage in poultry and livestock keeping. Agricultural extension officers from the Iringa District Council provide support services; however, demand for these services is higher than supply, illustrating the desire to learn. The scheme has many water-related issues, including: a water diversion license for only the wet season; only 7.5 km out of 29 km of canals lined with concrete; unlevelled plots; and lack of knowledge of water-use efficiency. The scheme does not have good road infrastructure, and transport to and from the farms is difficult.

There are no scales, so farmers are compelled to use middlemen and the common but unfair means commonly known as *lumbesa*: i.e. filling a container until it overflows. There

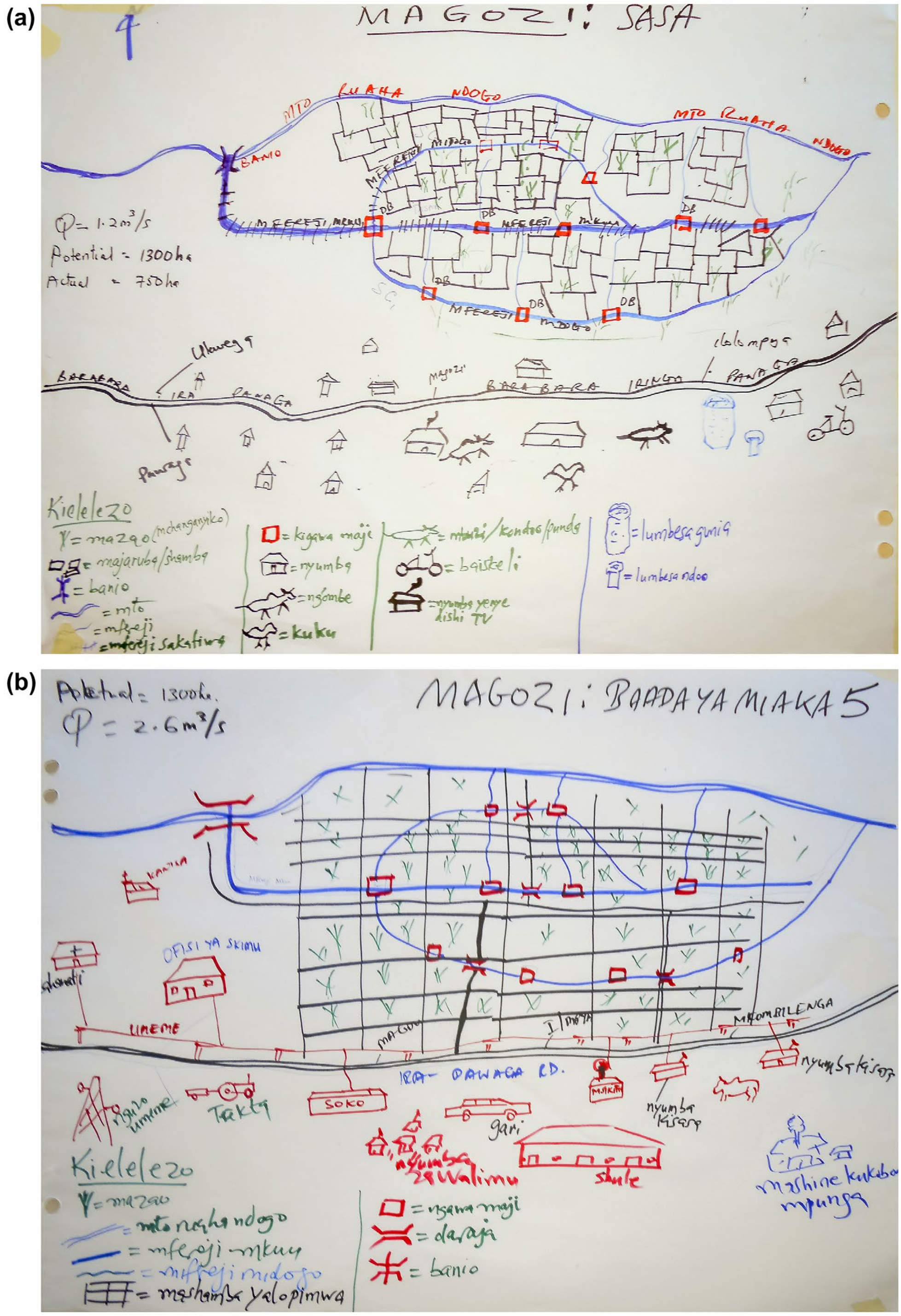


**Figure 2.** Examples of (a) the current situation and (b) the desired state, produced by stakeholders during the first Agricultural Innovation Platform sessions in Magozi, Tanzania. Result from group work.

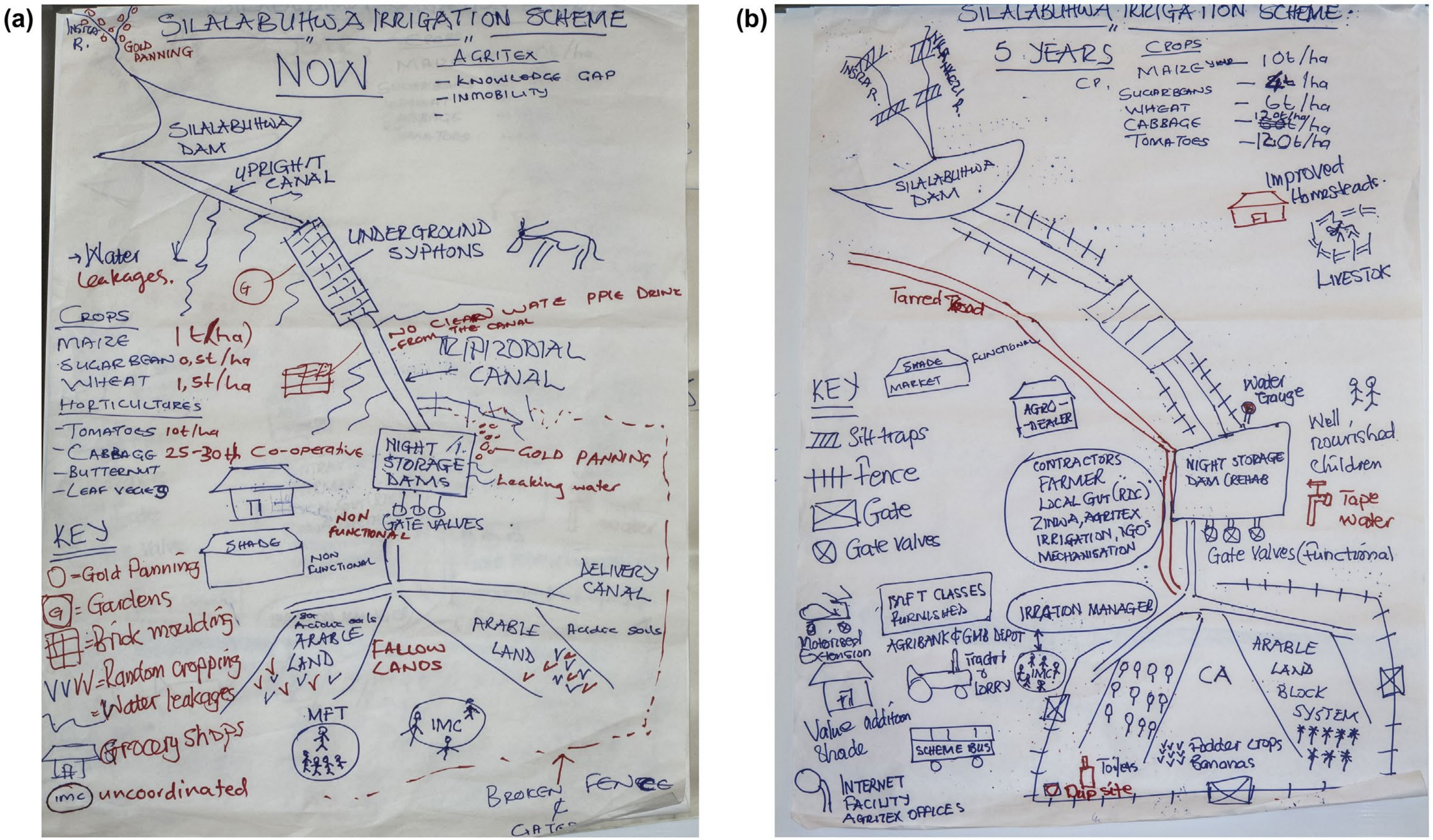


**Figure 3.** Examples of (a) the current situation and (b) the desired state, produced by stakeholders during the first Agricultural Innovation Platform sessions in Silalatshani, Zimbabwe. Result from group work.

are no rice storage facilities. There is no marketing body coordinating how, to whom and when to sell produce. Farmers act independently, based on their own decisions, often at their peril. Poverty dominates the area; the house types in the area evidence this. Few households own TV sets or bicycles, which are local indicators of wealth.

*Magozi Scheme (desired state, Figure 2b)*. By 2019, all 1300 ha are under cultivation, with one marketable and high-producing rice variety. The scheme has higher efficiency and modern labour/time-saving equipment. Farmers engage in more efficient poultry and livestock keeping. Agricultural extension services are more efficient. The scheme has more efficient water management structure and strategies, and more equitable water-use licenses; all the canals are lined with cement, all plots are levelled, and farmers know how to irrigate efficiently. The scheme has better roads and rice storage and milling facilities. Produce scales are available so that farmers are no longer compelled to use *lumbesa*. A marketing body is in place and functioning, and there is coordination between whom, when and how to sell produce. Poverty is diminishing in the area.

*Silalatshani Scheme (present situation, Figure 3a)*. The cropping programme devised in the 1960s, commanding the production of low-value crops such as maize and wheat, is still followed even though farmers cannot make a profit from these crops. Yields are very low, often similar to those obtained under rainfed conditions. Post-harvest infrastructure is non-functional, with the sheds and grading infrastructure damaged. There are disputes over very high, unpaid water charges to the local water authority, Zimbabwe National Water Authority (ZINWA), and many farmers have opted out of the scheme, thus increasing the burden of water charges and maintenance on the remaining irrigators. There are no agreed structures to transfer unproductive and fallow land to other prospective land users. The extension service providers, mainly the Department of Agricultural Technical and Extension Services (AGRITEX), lack the confidence to promote new techniques and higher-value crops and cannot access training courses to improve or update their knowledge. Water from the long canal between the dam and the scheme is used for brick making, livestock and home gardens, but members of the scheme have to pay all the water costs. The Irrigation Management Committee is largely defunct and does not have a voice in the running of the scheme. Failing infrastructure leads to water losses, and broken fences mean livestock stray onto the scheme. Land degradation is evident, with areas of low pH or high water tables. Illegal gold panning contributes to land degradation and canal damage.

*Silalatshani Scheme (desired state, Figure 3b)*. The participants want the unpaid water charges resolved before they are prepared to continue any significant activities. They believe that the scheme can be much more productive, with maize yield rising from the current 1 t/ha to over 4 t/ha. Diversification from staples to high-value crops such as garlic and other vegetables is a central strategy. This will require coordinated marketing, as the scheme is a long way from urban areas. Mobile technology has great potential for market information exchange and technical support services. The participants want to have financial institutions linked to farmers so farmers can access credit for purchasing inputs. Higher-value crops would allow farmers to invest in more inputs and in water-saving techniques such as drip irrigation. They have identified that currently unused land could be profitably used to grow fodder crops for fattening stock, while others want to diversify into broiler production. Participants want to see improved mechanization (more tractors) and infrastructure such as road, fence and canal repair, as well as opportunities for post-harvest storage and processing. They want to improve conservation measures, with silt traps and catchment area management plans in place.

### *Stage 4: Innovation process*

The danger of Stage 2, identification of system challenges, is to see technological intervention as the quick-fix solution to the immediate problem. While technology is important, the visioning process allows participants to place these technologies in the larger development context of the system. Furthermore, the visioning process brings to the fore the 'people' side of the problem, which is more difficult to articulate.

Each scheme embarked on a process to develop intervention strategies to set the innovation process into motion. The activities identified largely fall into the following groupings: capacity building of both farmers and extension services; governance of associations and tenure issues; demonstration and research; inputs and finance; addressing challenges pertaining to markets and value chains; and scheme and plot management. Table 3 provides examples of the solutions pursued at each scheme.

During the AIP meetings, stakeholders identified various challenges and factors that would, if not addressed, prevent progress. In Silalatshani, it was the issue of the very large debt to the water authority ZINWA (Table 3). Farmers indicated that they were not willing to continue with the AIP if this issue was not resolved. As discussed, the AIPs dealt with many innovations outside the main meeting. Various discussions took place between the local and national authorities, the Irrigation Management Committee and ZINWA. The analysis of this situation suggested that once the various parties realized the importance of the issue (no significant production will take place if this is not resolved) and the futility of the expectation to recoup this large sum of money from poor farmers, a resolution would emerge – particularly since the magnitude of the debt was primarily a function of multi-digit inflation and unrealistic exchange rates during the transition from ZAR to USD. ZINWA recalculated the USD 280,000 debt, reducing it by USD 200,000, and offered the farmers the remaining USD 80,000 financed by a loan with an annual interest rate of 1%. The farmers and the committee accepted this offer and started paying back the outstanding amount. They pay USD 14/ha per month × 0.5 ha = USD 84 per year per farmer, and if all 880 pay this amount they will be able to pay off the debt in just over a year. At the time of publication regular payments were being made by most farmers. This created significant goodwill, trust and confidence in the AIP process, the stakeholders and other role-players.

In reaction to recurring challenges with regard to plot ownership and rights to land, the Rural District Council agreed to embark on a land audit to verify ownership and resolve absentee plot ownership, to free up land for irrigation.

## Discussion

Rainfall is highly variable, and mid-season droughts can have devastating impacts on food production; but it falls at no cost. Irrigation, on the other hand, comes at substantial cost, both financial and institutional. In many instances governments or donors pay for the infrastructure associated with storage and conveyance systems, and only a fraction of the real cost is recovered from irrigators. At first irrigation appears to farmers as a windfall, but soon a set of negative feedback loops begin to manifest. Irrigated fields are prone to leaching,

**Table 3.** Summary example activities from the six schemes.

| | Mkoba, Zimbabwe | Silalatshani, Zimbabwe | 25 de Setembro, Mozambique | Khanimambo, Mozambique | Kiwere, Tanzania | Magozi, Tanzania |
|---|---|---|---|---|---|---|
| Capacity building | Agronomy, soil water management, leadership, record keeping, farmer exchange visits to other functional schemes, value addition | Farmer exchange visits to other functional schemes, agronomy, soil water management, crop budgets, value chains, leadership, commercial farming and value addition, capacity building of extension personnel | Farmer capacity on agronomy, field visit by farmers from both schemes to a vegetable project and vice versa | Field visit by farmers from both schemes to a vegetable project and vice versa | Farmer knowledge and capacity on soil moisture, fertility management, agronomic practices, irrigators' organization leadership | Scheme visioning, problem analysis and solving, use of residual soil moisture, improved rice production, business planning, irrigators' organization leadership, soil fertility |
| Demonstration and research | Management of soil fertility, soil water management, soil moisture and solute monitoring (wetting front detectors and Chameleon moisture sensor) to assist in changing irrigation scheduling | Cropping design including coordinated growing along individual canals to address water management issues, soil moisture and solute monitoring (wetting front detectors and Chameleon moisture sensor) to assist in changing irrigation scheduling | Installing the FullStop wetting front detector and humidity sensors to monitor water and nutrients in the soil in the field plots | Installing the FullStop wetting front detector and humidity sensors to monitor water and nutrients in the soil in the field plots | Soil moisture and soil nutrient monitoring and management, soil salinity management, farm record keeping, appropriate use of agro-chemicals | Good rice agronomic practices, improved rice varieties and fertilizer use, growing cowpea from residual soil moisture in rice plots |
| Governance | Constitution and by-laws: adoption, ratification, enforcement; streamlining roles of various stakeholders | Plot ownership audit; water payment; plot allocation and management; streamlining roles of various stakeholders | Admittance of young farmers in the scheme; piloting of new water user association legislation | Meeting involving Serviços Distritais de Actividades Económicas, livestock farmers and producers; restructuring of farmers' association to admit new members in order to fully explore the scheme | Mapping of irrigation plots, amendments of farmers' water use fee | Mapping of irrigation plots, audit and verification of members of irrigators' organization, water allocation based on seasonal calendars, accountability in implementation of solutions to address barriers to improved rice productivity (rice milling machine, storage house, etc.) |

(*Continued*)

**Table 3.** (*Continued*).

| | Mkoba, Zimbabwe | Silalatshani, Zimbabwe | 25 de Setembro, Mozambique | Khanimambo, Mozambique | Kiwere, Tanzania | Magozi, Tanzania |
|---|---|---|---|---|---|---|
| Inputs and finance | Farmers pooling resources for input purchases, scheme market research committee liaising with local agro-dealers to stock needed inputs | ZINWA water payment arrears, farmers pooling resources for input purchases, scheme market research committee liaising with local agro-dealers to stock needed inputs | Farmers linked to finance institutions for access to credit | Finding ways among seed providers to ensure good-quality seed delivery, discussing farmers' access to credit with input suppliers | Finding ways to ensure supply of good-quality seed and ways to reduce input prices, improving access to farming implements | Finding ways to ensure supply of good-quality seed and ways to reduce input prices, improving access to farming implements |
| Markets | Market analysis of which crops to grow and what value addition can be done; crop diversification | Product marketing, value addition, growing high-value crops including groundnut and soybean (contract farming for United Refineries Pvt Ltd) | Creating a business plan, market analysis, support application for Japanese donation for transport equipment and a new tractor with its implements, seek advice on good and high-value varieties for cultivation | Seek advice on good and high-value varieties for cultivation, market analysis | Create a business plan and explore ways to improve tomato price including working with local tomato processing factory, input suppliers such as YARA and Bytrade, market reliability, market information, transport | Create a business plan and explore ways to improve price of rice by building rice storage, processing the rice and growing higher-value varieties; explore diversification, second crops; trialling cowpeas |
| Scheme and plot management | Irrigation infrastructure maintenance: dam wall maintenance, fence maintenance, canal maintenance, catchment area management | Plot management in the scheme, repair and installation of gate valves on night storage dams, canal rehabilitation, fence maintenance, road maintenance | Maintenance; avoid planting trees along canals and within the scheme; scheme rehabilitation activities, including canal lining, plot levelling to ensure good flow of irrigation water in the plot, construction of pumping house with erosion control technique, and small storage facility | Acquisition of new pump, replacement of damaged pipeline, construction of small storage facility, rehabilitation of pumping house | Routine canal cleaning and maintenance, provision of drainage channels for downstream plots, manure incorporation to reduce salinity levels, plot management and levelling | Irrigation system repair and maintenance (including canal silt removal), plot levelling |

and cropping intensity can lead to soil degradation and disease build-up. Leakage from unmaintained canals, combined with poor irrigation management, makes schemes vulnerable to waterlogging and salinity. Growing low-value food crops on small plots of land with poor market access results in farmers being unable to pay the required fees, and as a result they abandon the land, leaving behind unpaid water bills (Moyo et al., 2017).

The delays in these feedbacks mean that little is done until the system is close to collapse, at which point schemes are considered for revitalization. Rehabilitation and revitalization (Denison & Manona, 2007) of a degraded scheme is generally less expensive than developing a new scheme, and more likely to attract funding. The problem is viewed as 'hardware breakdown', a problem we know how to fix. Although the breakdown of infrastructure is the most visible symptom, it masks the real problem: failure of the institutional arrangement to facilitate a form of agriculture than can pay the real costs.

The central thesis of this article is that the solutions to the many challenges faced by small-scale irrigation schemes reside in (1) the transition from subsistence irrigated agriculture towards market-oriented production systems and (2) the institutional changes required to facilitate this transition. Changing the goals of the system and the paradigm on which the system is based are very effective entry points to achieve impact (Meadows, 1997). Success will require new thinking, the active involvement of new and diverse stakeholders, and substantial institutional reform. This is a new and challenging way of working for many of the traditional stakeholders.

Our research shows that irrigation schemes display many of the characteristics of complex adaptive systems, but have not developed the capacity to adapt to the external environment in the absence of donor support. We found that the AIP approach effectively promoted the development of more adaptive behaviour in the system by bringing together a wide range of actors and institutions. Central to this is the development of a common vision, articulating the requirements of each actor, as well as the role(s) each actor can play in achieving the vision. The AIP actively identifies and promotes synergies emanating from cooperation. By facilitating and strengthening linkages and interaction between the stakeholders, new institutional arrangements and partnerships develop, increasing the efficiency of the system. The diverse actors bring together different types of knowledge, and when integrated, this results in new knowledge and learning about how to improve the functioning of the system. Through these interactions and partnerships, feedback mechanisms strengthen the linkages and dynamics between the stakeholders, evolving into a more functional constellation of actors and institutions.

The visioning step defines a commonly understood and desired state, creating a collective understanding of the direction of change, the challenges and opportunities, as well as the roles and responsibilities of the stakeholders in addressing these. The visioning process replaces the classic linear 'problem identification and technological-intervention-oriented fix' with a process to analyze challenges and their root causes in the context of the system, transitioning towards the desired state. In doing so it makes the future tangible, creating a sense of ownership and revealing how cash requirements for education and human health can be met through increased income from irrigated agriculture. The rich pictures define the desired state and often link irrigated agriculture with the rest of the system, such as the need for input and output markets, the relationship between irrigated and dry-land cropping, and the potential link between livestock and irrigation by using crop residues, or growing fodder crops on irrigated land.

Including these diverse stakeholders in the innovation process is, therefore, crucial to being able to identify the opportunities and design strategies to increase returns on investments. Integrating the diverse perspectives and previously unconnected knowledge facilitates the generation of new knowledge and approaches to address systemic challenges (Mitchell & Nicholas, 2006). It is a very powerful process when buyers articulate price in relation to the grades and standards required, while input suppliers explain how these grades and standards can be achieved through investment in good seed, fertilizers, irrigation management and disease control. With relevant agronomic advice provided by extension officers, farmers not only begin to understand relationships between improved production and returns at the market, but also have the incentive to engage.

By the time participants come to identify intervention options, the clearest message tends to be to become more market-oriented. Many irrigation schemes start with the objective of growing staples, but history shows that the return from growing staples on small plots is not economically sustainable, except perhaps for the cultivation of rice (World Bank, 2007). Markets, if accessible and functional, provide both the cash to invest and the incentives to improve performance, establishing a positive feedback loop. The positive relationship between inputs (water, seed, fertilizer and labour) and crop production and ultimately food security is clear (Figure 4). Examples of changes in behaviour include:

(1) ZINWA reduced the water bill on the realization that their business model depended on full use of the scheme and profitable farmers who were able to pay water charges.
(2) Extension officers realized that growing certain crops was not a viable economic option after a gross margin comparison.
(3) Farmers were prepared to increase investments in production after they realized that they could reap the benefits in the market.

These examples illustrate how improved and integrated knowledge can facilitate the development of feedback systems. Input suppliers were often inspired by the business opportunities, and the role they could play in helping producers grow crops that comply with market requirements. Output market representatives better understood their role in providing clear information on price and quality standards. In particular, the roles played by those beyond the farm gate came into sharper focus. Local authorities were made acutely aware of their roles and responsibilities and how their actions (and local-level policies) could

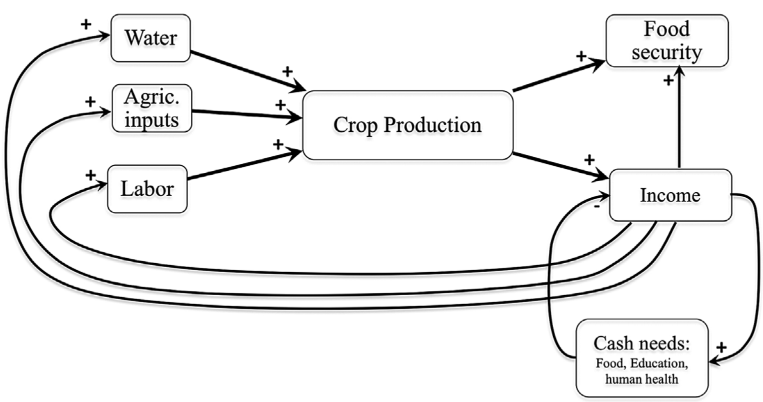


**Figure 4.** Simplified influence diagram illustrating causal loops in small-scale irrigation schemes.

be stifling positive change. For example, the ownership of infrastructure is often contested, as no one wants to claim the responsibility for maintenance. In various schemes, Silalatshani in particular, farmers are now self-organizing and investing their time and money in maintaining the infrastructure, because they can reap the benefits.

Centralized control stifles innovation in government-managed irrigation schemes. The implementation of plans without consideration of the markets or farmers' preferences prevents the positive feedback loops between farmers and markets from developing. The critical issue is that it does not allow any form of experimentation (with crops and markets, or watering regimes), and the learning and development of local experience and the incentives to learn and self-organize that come with it (see also Mutiro & Lautze, 2015). Many participants recognize the need to reduce central control over irrigation systems by the public sector in favour of local-level coordination, where stakeholders are able to interact, learn, experiment, self-organize and adapt.

The inclusion of new and non-traditional institutions, and therefore the development of new institutional arrangements, is critical in creating an environment in which the irrigation system can function and evolve through the refinement of relationships and interactions and the subsequent development of feedback mechanisms. Institutions such as water and local government authorities, who have great control over systems via previously unidirectional directives, now become part of the multidirectional information-sharing and innovation process. They perceive their impact on the system in a much better light, and are more prepared to act in ways that facilitate development rather than controlling or stifling it. ZINWA reducing their bill and the Regional District Council engaging in a land audit proved to advance progress, and not only generated greater mutual understanding and goodwill, but also facilitated new interest in working irrigated plots.

The primary role of the AIP is to facilitate the transition of a system from a poorer to an improved state. However, the development of local capacity to innovate has much longer-term implications. Through the iterative process, participants learn to analyze problems and determine their root causes. More importantly, stakeholders develop the skills required to develop formal and informal linkages, collaborate based on comparative advantages, and develop partnerships to address problems and achieve objectives. The sources of knowledge grow in depth and diversity, and the integration of different types of knowledge, as indicated, results in significant changes in behaviour. In some cases, the incentive for collective action and cooperation is clear, and stakeholders are able to organize this themselves, such as the canal maintenance in Silalatshani. These are strong indicators of a movement towards resilience (Folke, Colding, & Berkes, 2003) and adaptive capacity in the system. This, together with the feedback mechanisms which maintain the system, such as the impact of knowledge systems and their interactions with markets, may also suggest transitions towards more sustainable systems.

The recurring question remains: How to create impact at a larger scale? Based on this ongoing work, we propose to scale out the lessons and innovations rather than replicating the AIPs. In the examples listed here, the AIP focussed on single irrigation schemes, while most of the stakeholders and institutions work with or have influence over many more irrigation schemes. Future work will therefore aim to (1) increase the geographical footprint of existing AIPs by including more of the schemes that are within their spheres of influence, and (2) share the outcomes and lessons learnt with an influential audience at higher levels of organization, with the aim to augment the paradigm shift from 'technological interventions' to a focus on better and more inclusive institutional arrangements which facilitate system efficiency and local adaptive capacity.

## Conclusion

Irrigation schemes often fail because of hardware breakdown, and therefore technological fixes are most often the point of intervention. We argue that hardware failure is a misdiagnosis of the problem. Small-scale irrigation systems have many of the characteristics of complex socio-ecological systems. They have many different actors, and they are composed of numerous subsystems. However, they often lack interaction between the different subsystems and their agents, preventing learning and the emergence of more beneficial outcomes. AIP is therefore effective in bringing a wide range of stakeholders together to forge new ways of doing business around complex agricultural systems (Swaans et al., 2013). The AIP develops greater understanding of the importance of the inclusion of nontraditional stakeholders and the interrelationships between players to work towards mutually agreed goals. It can bring about systemic change, primarily as a result of the diversity of actors, their interactions and their collective knowledge and skills to define and evaluate improved strategies, as well as the associated rearrangement of institutions. This is critical because it goes beyond the single technological approach of traditional irrigation management (Lam & Ostrom, 2010) and takes the first steps towards a situation where institutional reform can facilitate technological development (Clark, 2002).

## Acknowledgements

The research in this article was part of the project Increasing Irrigation Water Productivity in Mozambique, Tanzania and Zimbabwe through On-Farm Monitoring, Adaptive Management and Agricultural Innovation Platforms, partially funded by the Australian government via the Australian Centre for International Agricultural Research. The project was also supported in Zimbabwe by the CGIAR Research Program on Water, Land and Ecosystems and CGIAR Fund Donors.

## Disclosure statement

No potential conflict of interest was reported by the authors.

## Funding

This work was supported by the Australian Centre for International Agricultural Research under [grant number FSC/2013/006].

## References

Allen, C. R., & Holling, C. S. (2010). Novelty, adaptive capacity, and resilience. *Ecology And Society, 15*, 24.

Amede, T. (2015). Technical and institutional attributes constraining the performance of small-scale irrigation in Ethiopia. *Water Resources and Rural Development, 6*, 78–91. doi:10.1016/j.wrr.2014.10.005

Anand, M., Gonzalez, A., Guichard, F., Kolasa, J., & Parrott, L. (2010). Ecological systems as complex systems: Challenges for an emerging science. *Diversity, 2*, 395–410. doi:10.3390/d2030395

Berkes, F. (2007). Understanding uncertainty and reducing vulnerability: Lessons from resilience thinking. *Natural Hazards, 41*, 283–295. doi:10.1007/s11069-006-9036-7

Bjornlund, H., van Rooyen, A., & 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:10.1080/07900627.2016.1263552

Burney, J. A., & Naylor, R. L. (2012). Smallholder irrigation as a poverty alleviation tool in Sub-Saharan Africa. *World Development, 40*, 110–123. doi:10.1016/j.worlddev.2011.05.007

Clark, N. (2002). Innovation systems, institutional change and the new knowledge market: Implications For third world agricultural development. *Economics of Innovation and New Technology, 11*, 353–368.

Denison, J., & Manona, S. (2007). *Principles, approaches and guidelines for the participatory revitalisation of smallholder irrigation schemes: Volume 1 – a rough guide for irrigation development practitioners*. Report No TT, 308(07). Pretoria: Water Research Commission.

de Sousa, W., Ducrot, R., Munguambe, P., Bjornlund, H., Cheveia, E., & Faduco, J. (2017). Irrigation and crop diversification at 25 de Setembro irrigation scheme in Boane district. *International Journal of Water Resources Development*, 33 (5), 705–724. doi:10.1080/07900627.2016.1262246

Fischer, G., Tubiello, F. N., van Velthuizen, H., & Wiberg, D. A. (2007). Climate change impacts on irrigation water requirements: Effects of mitigation, 1990–2080. *Technological Forecasting and Social Change, 74*, 1083–1107. doi:10.1016/j.techfore.2006.05.021

Folke, C., Carpenter, S., Elmqvist, T., Gunderson, L., Holling, C. S., & Walker, B. (2002). Resilience and sustainable development: Building adaptive capacity in a world of transformations. *AMBIO: A Journal of the Human Environment, 31*, 437–440.

Folke, C., Colding, J., & Berkes, F. (2003). Synthesis: Building resilience and adaptive capacity in social-ecological systems. In F. Berkes, C. Folke, & J. Colding (Eds.), *Navigating socioecological systems building resilience for complexity and change* (pp. 352–387). New York, NY: Cambridge University Press.

Gatrell, A. C. (2005). Complexity theory and geographies of health: A critical assessment. *Social Science and Medicine, 60*, 2661–2671. doi:10.1016/j.socscimed.2004.11.002

Hall, A., & Clark, N. (2010). Working paper series what do complex adaptive systems look like and what are the implications for innovation policy? *Journal of International Development, 1*, 308–324. doi:10.1002/jid.1690

Hope, R. A., Gowing, J. W., & Jewitt, G. P. W. (2008). The contested future of irrigation in African rural livelihoods – analysis from a water scarce catchment in South. *Africa, 10*, 173–192. doi:10.2166/wp.2008.061

Hounkonnou, D., Kossou, D., Kuyper, T. W., Leeuwis, C., Nederlof, E. S., & Röling, Niels (2012). An innovation systems approach to institutional change: Smallholder development in West Africa. *Agricultural Systems, 108*, 74–83. doi:10.1016/j.agsy.2012.01.007

Hunt, R. C. (1988). Size and the structure of authority in canal irrigation systems. *Journal of Anthropological Research, 44*, 335–355.

Inocencio, A., Kikuchi, M., Tonosaki, M., Maruyama, A., Merry, D., Sally, H., & de Jong, I. (2007). *Costs and performance of irrigation projects: A comparison of Sub-Saharan Africa and other developing regions*. IWMI Research Report 109. Colombo, Sri Lanka: International Water Management Institute.

Kadigi, R. M. J., Tesfay, G., Bizoza, A., & Zinabou, G. (2013). *Irrigation and water use efficiency in Sub-Saharan Africa* (No. Working Paper No. 63).

Lam, W. F., & Ostrom, E. (2010). Analyzing the dynamic complexity of development interventions: Lessons from an irrigation experiment in Nepal. *Policy Sciences, 43*, 1–25. doi:10.1007/s11077-009-9082-6

Mancosu, N., Snyder, R., Kyriakakis, G., & Spano, D. (2015). Water scarcity and future challenges for food production. *Water, 7*, 975–992. doi:10.3390/w7030975

Manzungu, E. (1995). Engineering or domineering? The politics of water control in Mutambara irrigation scheme, Zimbabwe. *Zambezia, 22*, 115–136.

Mdemu, M. V., Mziray, N., Bjornlund, H., & 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:10.1080/07900627.2016.1188267

Meadows, D. (1997). Places to intervene in a system. *Whole Earth*, *91*, 78–84. doi:10.1080/02604020600912897

Mitchell, R., & Nicholas, S. (2006). Knowledge creation in groups: The value of cognitive diversity, transactive memory, and openmindedness norms. *The Electronic Journal of Knowledge Management, 4*, 67–74. doi:10.1504/IJKMS.2006.008852

Moyo, M., van Rooyen, A., Moyo, M., Chivenge, P., & 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:10.1080/07900627.2016.1175339

Mutiro, J., & Lautze, J. (2015). Irrigation in Southern Africa: Success or failure? *Irrigation and Drainage, 64*, 180–192. doi:10.1002/ird.1892

Oates, N., Jobbins, G., Mosello, B., & Arnold, J. (2015). *Pathways for irrigation development in Africa – Insights from Ethiopia, Morocco and Mozambique* (Working paper 119) Future Agricultures.

Olsson, P., Folke, C., & Berkes, F. (2004). Adaptive comanagement for building resilience in social-ecological systems. *Environmental Management, 34*, 75–90.

Ostrom, E. (2009). A general framework for analyzing sustainability of social-ecological systems. *Science, 325*, 419–422. doi:10.1126/science.1172133

Rockström, J. (2003). Resilience building and water demand management for drought mitigation. *Physics and Chemistry of the Earth, Parts A/B/C, 28*, 869–877. doi:10.1016/j.pce.2003.08.009

Smith, L. E. D. (2004). Assessment of the contribution of irrigation to poverty reduction and sustainable livelihoods. *International Journal of Water Resources Development, 20*, 243–257. doi:10.1080/0790062042000206084

Spielman, D. J., Ekboir, J., Davis, K., & Ochieng, C. M. O. (2008). An innovation systems perspective on strengthening agricultural education and training in sub-Saharan Africa. *Agricultural Systems, 98*(1), 1–9. doi:10.1016/j.agsy.2008.03.004

Swaans, K., Cullen, B., Van-Rooyen, A., Adekunle, A., Ngwenya, H., Lema, Z., & Nederlof, S. (2013). Dealing with critical challenges in African innovation platforms: Lessons for facilitation. *Knowledge Management for Development Journal, 9*, 116–135.

Tenywa, M. M., Rao, K. P. C., Tukahirwa, J. B., Buruchara, R., Adekunle, A., Mugabe, J., … Abenakyo, A. (2011). Agricultural innovation platform as a tool for development oriented research: Lessons and challenges in the formation and operationalization. *Learning Publics Journal of Agriculture and Environmental Studies, 2*, 118–146.

Van Averbeke, W., Denison, J., & Mnkeni, P. N. S. (2011). Smallholder irrigation schemes in South Africa: A review of knowledge generated by the Water Research Commission. *Water SA, 37*, 797–808.

Van Duivenbooden, N., Pala, M., Studer, C., Bielders, C. L., & Beukes, D. J. (2000). Cropping systems and crop complementarity in dryland agriculture to increase soil water use efficiency: A review. *NJAS – Wageningen Journal of Life Sciences, 48*, 213–236. doi:10.1016/S1573-5214(00)80015-9

van Mil, H. G. J., Foegeding, E. A., Windhab, E. J., Perrot, N., & van der Linden, E. (2014). A complex system approach to address world challenges in food and agriculture. *Trends in Food Science and Technology, 40*, 20–32. doi:10.1016/j.tifs.2014.07.005

World Bank. (2007). *World development report 2008: Agriculture for development*. Washington DC: World Bank.