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Communal irrigation systems in South-Eastern Africa: findings on productivity and profitability

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ABSTRACT

Significant expansion of irrigated agriculture is planned in Africa, though existing smallholder schemes perform poorly. Research at six schemes in Mozambique, Tanzania and Zimbabwe shows that a range of problems are exacerbated by poor management, with limited market linkages leading to underutilization and a lack of profit. Improving sustainability of these complex systems will require: multiple interventions at different scales; investing in people and institutions as much as hardware; clarity in governments' objectives for their smallholder irrigation schemes; appropriate business models to enable farmers; and better market linkages.

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Introduction

African governments and donors have policies for a significant expansion of irrigated agriculture (Sullivan & Pittock, 2014). Yet existing smallholder irrigation schemes have largely failed to reduce farmer poverty, use the land and water sustainably or maintain the irrigation infrastructure. There is a complex array of reasons for this, ranging from limits to farmers' skills, through poor market access, to dysfunctional institutions (Bjornlund, van Rooyen, & Stirzaker, 2017; Stirzaker & Pittock, 2014).

This special issue of the *International Journal of Water Resources Development* focuses on initial research findings from the project, Increasing Irrigation Water Productivity in Mozambique, Tanzania and Zimbabwe through On-Farm Monitoring, Adaptive Management and Agricultural Innovation Platforms. The project was primarily supported with AUD 3.2 million in 2013–17 from the Australian Centre for International Agricultural Research (project FSC/2013/006) to identify means of improving the environmental and socio-economic sustainability of smallholder irrigation communities. The project is a partnership of eight African and Australian research and governmental organizations led by the Australian National University and including the Commonwealth Scientific and Industrial Research Organisation (Australia), University of South Australia, National Institute for Irrigation in Mozambique,

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Ardhi University in Tanzania, International Crop Research Institute for the Semi-Arid Tropics in Zimbabwe, University of Pretoria, and the Food, Agriculture, Natural Resources and Policy Analysis Network.

The project objectives were to improve the productivity of the smallholder irrigation schemes through Agricultural Innovation Platforms (AIPs); on-farm monitoring of soil and water; and policy reform. Research was undertaken in six irrigation schemes: in Mozambique, 25 de Setembro and Khanimambo; in Tanzania, Kiwera and Magozi; and in Zimbabwe, Silalatshani and Mkoba.

At the six irrigation schemes baseline assessments were undertaken to inform the subsequent research (de Sousa, Cheveia, Machava, & Faduco, 2015; Moyo, Moyo, & van Rooyen, 2015; Mziray & Mdemu, 2015). The project provided simple tools to farmers to enable them to measure soil water and fertility to develop their own, more efficient agronomic practices (Stirzaker, Mbakwe, & Mziray, 2017).

The project also facilitated AIPs at six schemes to identify barriers and opportunities and to develop solutions for more profitable farming (van Rooyen, Ramshaw, Moyo, Stirzaker, & Bjornlund, 2017). An AIP is a forum established to foster interaction among a group of relevant stakeholders around a shared agricultural interest. The stakeholders play different but complementary roles in the development, dissemination and adoption of knowledge for socio-economic benefit. AIPs seek to harness innovations related to technology processes and institutional and social-organizational arrangements. To promote these innovations, partnerships along and beyond agricultural value chains must be fostered to bring on board actors with a special mix of skills (Makini, Kamau, Makelo, & Mburathi, 2013).

An independent review found that, in its first three years, the project has had significant success, giving farmers the knowledge and confidence to source better-quality farm inputs, reduce application of water, improve use of fertilizer, reduce labour and engage in more profitable markets. This has led to less conflict over water, more effective local institutions and improved management of the irrigation schemes (de Lange & Ogotu, 2016).

In this paper we synthesize the research findings from the project and identify key options for improving the environmental and socio-economic sustainability of smallholder irrigation communities.

Results

The research in the six irrigation schemes in Mozambique, Tanzania and Zimbabwe identified a range of barriers to more profitable and sustainable irrigation (de Sousa et al., 2017; Mdemu, Mziray, Bjornlund, & Kashaigili, 2017; Moyo, van Rooyen, Moyo, Chivenge, & Bjornlund, 2017). These include:

- (1) Governments often require farmers to grow low-value staple food crops instead of more profitable cash crops (like sugar-cane in Mozambique).
- (2) Farmers lack control over water scheduling and thus do not have the flexibility to grow different crops.
- (3) There is limited information on prices of agricultural produce in major urban markets to inform farmers' decisions on what crops to grow.
- (4) Plot holders lack tenure over their land, limiting their ability to access finance or to acquire additional plots.

- (5) The authorities responsible for assigning plots to farmers often do not ensure that the land is farmed (for example, where the farmers have moved to cities as labourers), increasing the costs for the remaining farmers (e.g. for canal maintenance and water payments) and reducing the economies of scale for agricultural businesses.
- (6) There is often a lack of clarity over whether the government or farmers are responsible for maintaining key pieces of infrastructure, like primary canals, and consequently the farmers do not understand the service that they receive in return for paying water fees.
- (7) There is a negative feedback cycle where farmers are unwilling to pay fees to irrigation associations when they often receive poor service in terms of water supply, jeopardizing the resources needed for irrigation scheme maintenance.
- (8) Irrigation associations lack clear powers to make decisions and enforce scheme rules, resulting in stray cattle damaging infrastructure and crops, water theft, inequitable water distribution within schemes, and lack of participation in maintenance work or payment of water fees.
- (9) Administrative and judicial processes that on paper may address such problems (for instance, issuing certificates of occupation of land or prosecuting farmers who do not pay fees) are effectively out of reach of farmers. The government agencies responsible are usually located in major towns, requiring extensive travel to access, charging fees and taking time that the farmers cannot afford.
- (10) Farmers are often the victims of counterfeit or low-quality seeds and fertilizers.
- (11) The irrigator associations have been unable to ensure adequate water supply to all farmers, and the resulting conflicts have eroded trust in collective actions, such as canal maintenance. A further consequence is lack of institutional trust or capacity to order agricultural inputs and transport services in bulk to lower costs, or to schedule crop production to maximize returns across the season.
- (12) Farmers have no communication with buyers to ascertain the timing and quality desired and maximize the prices they receive for their produce.

While the lack of maintenance and breakdown of irrigation infrastructure are readily visible in many schemes, we argue that they are a symptom of failed institutions, illustrated by the barriers detailed here, reinforcing the need to invest in the capacities of local people. The baseline survey and AIPs suggested that the most critical barrier to more successful irrigated agriculture is market access (de Sousa et al., 2015; Moyo et al., 2015; Mziray & Mdemu, 2015; van Rooyen et al., 2017).

The diversity of irrigators within schemes was illustrated at the 25 Setembro in Mozambique, where seven different irrigator types with different crop diversification strategies were distinguished, their differences reflecting farmers' resource access (de Sousa et al., 2017). Most farmers in the scheme produce traditional food crops, and while there are opportunities to grow more profitable crops, few do this. Income disparities within the six smallholder irrigation schemes show that inadvertently, nation-wide strategies may overlook high inequality at smaller scales (Manero, 2017). Consequently, development policies should be tailored to more specific areas of intervention, such as issuing official documents to farmers on their land-use entitlements so that they can more readily access finance (Mdemu et al., 2017). Further, it was found that increasing earnings from agriculture will not even out inequalities, as families with more diverse, off-farm income sources have the highest total income (Manero, 2017).

Confusion over the role and powers of the irrigation associations contributes to the lack of profitability and sustainability of the schemes, as highlighted in the case of Zimbabwe (Moyo et al., 2017). There the government owns and operates the headworks and the irrigators manage the infield works, but there is a lack of clarity over who owns, operates, maintains and pays for conveyance structures. While the legality and authority of the associations remains unclear, the loss of water, theft, limited fee collection and confusion over what these funds are used for, and lack of enforcement of rules, reduces maintenance of infrastructure and scheme productivity. In response to these issues, in Mozambique, new regulations seek to provide clarity on the roles and responsibilities of associations (Mwamakamba et al., 2017).

The research in Mozambique and Zimbabwe found that the major barriers to more profitable and sustainable irrigation were poorly functioning markets, poor infrastructure and soil fertility, and limited access to high-quality farm inputs, farm implements and agricultural knowledge (de Sousa et al., 2017; Moyo et al., 2017). This resulted in low crop yields, food insecurity and negative farm income. The study in Tanzania highlighted that lack of finance is a key barrier as it affects farmers' timely access to adequate supply of high-quality agricultural inputs, machinery, and transport to profitable markets. However, it was also stressed that access to capital alone would not necessarily solve the problem, as under current market arrangements farmers did not have the confidence to borrow money as it was uncertain whether they could sell the produce at a profitable price (Mdemu et al., 2017).

Strengthening institutions and improving the linkages between them are crucial for more efficient and sustainable irrigation systems. In Mozambique it was reported that an improved extension service that helps identify cropping strategies better aligned with market demand would significantly improve irrigation profitability (de Sousa et al., 2017). Marketing of produce is uncoordinated at most irrigation schemes, but mobile telephone technologies are reported as offering opportunities for timely dissemination of market information in Mozambique and Zimbabwe (de Sousa et al., 2017; Moyo et al., 2017). More generally, institutions are needed to provide the feedback mechanisms within agricultural value chains to allow irrigators to align their operations to market demands and improve the viability of irrigation systems (Moyo et al., 2017). These results stress that first point of entry for reform is the 'soft systems', and that once the soft systems are fixed the hardware systems will be much easier to maintain, to facilitate more profitable and sustainable irrigation (Moyo et al., 2017).

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 potential interventions for more profitable and sustainable smallholder irrigation. The irrigation schemes displayed many characteristics of complex adaptive systems (Bjornlund et al., 2017; 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.

Extension services were identified as the main source for information for the majority of irrigation farmers, and it was also found that those who use irrigation extension services are more likely to adopt hard-technology innovations (Wheeler et al., 2017). When farmers were provided with simple soil water and solute monitoring tools they learnt to change their management practices (Stirzaker et al., 2017). The cost of implementing this kind of farmer learning system is a small fraction of the capital cost of setting up irrigation schemes, and should be factored into the design of projects, rather than being added when schemes are starting to fail.

AIPs were helpful at all schemes as they facilitated stakeholder interactions (beyond the traditional agricultural engineering group), enhanced relationships among them, and enabled information exchange and knowledge sharing throughout the system and associated value chains. Moreover, by discussing challenges and opportunities, and working together to improve the irrigation system towards a shared vision, innovative solutions were developed and tested (van Rooyen et al., 2017). The need to develop profitable markets was the clearest message. AIPs are facilitating the development of responsive learning systems, able to adapt and re-organize in response to information and change.

In terms of overarching policies, development of publicly owned smallholder irrigation schemes has erred in focusing on small plots producing staple food crops that are barely (if at all) profitable. Policy responses could include reform of land tenure, strengthening farmer organizations and fostering market linkages to enable profitable irrigation (Mwamakamba et al., 2017). To gain from new investments in irrigation, without repeating past failures, it is critical to develop business models for small-scale irrigation schemes (Bjornlund et al., 2017).

In their independent review of the Increasing Irrigation Water Productivity project, de Lange and Ogutu (2016) found that AIPs combined with soil moisture and nutrient measuring can substantially increase crop yields and incomes of farmers, and make irrigation schemes more self-sustaining. They noted that improved yields, profits and problem-solving were achieved before infrastructure investments were made in Tanzania and Zimbabwe, thereby strengthening the likely benefit and sustainability of future infrastructure investments. They concluded that the project enabled smallholder farmers and related stakeholders to achieve success in a traditionally difficult sector, which is also currently a top priority for African governments and international donors.

Discussion

Building on these results, we now consider the key lessons emerging from this research on irrigation schemes in Mozambique, Tanzania and Zimbabwe.

Solving problems in complex systems

The six irrigation communities studied illustrate that irrigation schemes are complex systems. While they are commonly perceived through the lens of their water infrastructure, the research reported here shows that a range of different social institutions need to operate well if irrigation schemes are to use natural resources sustainably, become profitable, and can thus afford to maintain irrigation infrastructure. Conversely, one ill-considered intervention may have a range of unintended and often negative consequences for irrigation scheme profitability and sustainability, as illustrated by a frequent government requirement to grow unprofitable staple food crops, leaving no incentives for increased investments.

The project demonstrates that multiple, concurrent interventions identified, tested and implemented by the stakeholders themselves are required to transform these smallholder irrigation schemes into new, more profitable and sustainable states. In most schemes an initial successful intervention engendered the trust and commitments needed for farming communities to begin more challenging changes. The initial gains for farmers from the soil and water monitoring tools, which raised their crop yields and reduced labour, generated a

willingness to discuss other barriers and opportunities through the AIPs. Then within the AIP processes at Silalatshani, for example, the AIP's role in facilitating an agreement to reduce the debt on water to the government was a catalyst for the farmers to embrace trials of new crops and water scheduling systems. Similarly with the AIP at 25 Setembro, the government's willingness to help repair infrastructure generated the goodwill to tackle harder problems, like reallocating unused farm plots to new, young farmers.

These complex irrigation systems require different and complementary measures (at various scales) to become more profitable and sustainable. This shift will include greater equity and ownership, increased cooperation between all stakeholders, information sharing and learning, and developing local adaptive strategies to evolve in response to their own pressures and opportunities.

Invest in people as much as hardware to overcome multiple barriers

Hard barriers are the physical limits to more successful irrigation associated with availability of resources like land and water, and of infrastructure. At Mkoba, for example, limited storage capacity meant that irrigation water supplies were exhausted in the 2015–16 drought. Soft barriers are where key services are not available, including where institutions prevent successful farming. In Tanzania, for example, farmers were unable to access finance to buy farm inputs until they acquired a certificate of customary occupancy of their land, which was a difficult bureaucratic process. It may be possible to issue similar, formal land use entitlement documentation in other countries.

The research in Mozambique, Tanzania and Zimbabwe showed that there are multiple soft and hard barriers that need to be addressed in an integrated way if irrigation schemes are to be transformed to more profitable and sustainable states. In Mozambique, the parlous state of the pumps and canals meant that the local people were not ready at first to address the challenges of lowering input costs and finding profitable markets for their produce. At 25 Setembro, once there was progress towards repair of the physical infrastructure the farmers then embraced people-centred reforms, such as reallocating unused plots to younger farmers, accessing certified seeds and scheduling production to better match market demand.

In general, at each of the six schemes it was the soft barriers that were most limiting for the farmers. In particular, primary concerns were reducing costs and increasing the investments in crop inputs, while growing crops that would meet market demands and maximize returns. Greater donor and government investments in people and institutions are needed to help smallholder irrigation schemes become more profitable and sustainable. In this project AIPs were able to bring diverse stakeholders together to resolve issues and foster improved relations, building the local capacity to innovate and work towards collective goals.

Governments need to clarify their objectives and empower farmers

The parlous state of the smallholder irrigation schemes before this project started should be a salutary warning to the donors and African governments who seek expansion without addressing the underlying reasons for this poor performance. Governments should not conflate the objectives of reducing poverty, increasing food security and boosting the economy by imposing rules that constrain farmers' abilities to access more land within schemes and

produce more profitable crops. We argue that the focus should be on reducing poverty by enabling smallholder farmers to produce profitable crops for local markets, to expand their enterprise where they can within a scheme and increase household income. While staple food crops may not be grown in irrigated plots, greater household income should enable such foodstuffs to be purchased, boosting local agricultural markets, or grown on the irrigation farmers' dryland plots (such as at Silalahani and Makoba). In other words, governments need to reconsider the concept of food security and move away from a focus on producing staple food in irrigation schemes, allowing farmers to grow profitable crops to be food secure. There is a dire need to define the role of irrigation systems in developing countries and develop business models and management strategies suitable for those objectives.

Power structures are critical to unleashing the potential of farmers to create a more viable irrigation-based economy. At all six schemes the irrigation associations were too weak to perform basic functions like maintaining infrastructure, organizing collective purchases of services and scheduling production to maximize returns; and therefore farmers were not paying user fees. We raise the question of whether successful irrigator associations compete for status and authority with local governments, traditional authorities and the local offices of national government agencies. For the schemes to succeed, the irrigation associations need to be developed towards a substantial autonomous and adaptive capacity. For this to occur, national governments need to clarify responsibilities and enable irrigators more while directing them less. The recent reforms of Mozambique's irrigation regulations take a strong step in this direction by providing the mandate and responsibility for irrigation associations to become self-funding, and develop and implement business plans so as to become more autonomous (Mwamakamba et al., 2017).

The barriers and opportunities described above highlight the vital roles that information and effective institutions play in the development of responsive, profitable and more sustainable farming systems that are more resilient. Donor and government irrigation scheme developers need to invest in empowering farmers to make informed choices in the context of the larger system.

Markets as incentives for change

Research at the six irrigation schemes illustrates the need to harness the power of the markets to transform irrigation systems. In none of the schemes could farmers afford to pay water use fees sufficient to maintain irrigation infrastructure. The irrigation schemes will only be capable of self-renewal if farmers are able to produce more profitable crops. As described above, changes in government policies are important to enable the development of more profitable farming. Yet our research shows that there are many steps that farmers and businesses can take to increase returns for stakeholders in the local agricultural economy.

The AIPs provided previously unrealized opportunities for farmers to define barriers and opportunities, and then engage the relevant stakeholders in the agricultural value chain to identify mutually beneficial changes. This meant that farmers could purchase higher-quality farm inputs and transport services in bulk, reducing their production costs. It has also enabled farmers to understand from purchasers the type and quality of agricultural produce, and timing of supply, required to earn higher prices. As a result many irrigators at these schemes are moving from subsistence to more market-oriented farming, with the assurance of more reliable and profitable markets. It is the increase in returns and the resulting change

of mindset among farmers that is increasing pressure from them on governance institutions to better support irrigation farming. In our view it is this positive reinforcement from the agricultural market that will maintain more sustainable and profitable irrigation. Markets provide both the incentive and the means to invest.

Conclusions

The smallholder irrigation schemes assessed in this research exemplified institutional failure. The combination of a complex range of problems meant that the irrigation systems were not profitable, were not maintained and eventually were underutilized or abandoned. As a result the farmers reverted to risk-averse, low-input, low-output farming on lands with expensive agricultural infrastructure. Rebuilding the infrastructure does not address the underlying causes of poor performance, it only starts the cycle again.

The problems in the schemes were: lack of clarity over ownership of land and infrastructure; limited access to finance; government requirements to grow cheap, staple crops; expensive transport; fake and expensive farm inputs; limited farmer knowledge of agronomy (including water application and soil fertility); limited engagement between farmers and key markets; and low financial returns, leading to limited reinvestment in irrigation associations and infrastructure. All of these can be overcome with multiple interventions from institutional reform.

We find that: (1) irrigation schemes are complex systems that require multiple different and complementary interventions at various scales to become more profitable and sustainable; (2) the key barriers are predominantly institutional; (3) donors and governments need to invest in people as much as hardware to overcome barriers; (4) governments need to clarify their objectives for smallholder irrigation schemes and develop appropriate business models to enable farmers; and (5) development of market linkages is required to sustain more profitable and sustainable irrigation. This research focused on understanding the impacts of multiple interventions in six irrigation schemes. Further investigation is required into how such multiple interventions can be fostered at greater scales to transform more irrigation schemes more quickly.

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Disclosure statement

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