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: Sithembile Ndema Mwamakamba, Lindiwe Majele Sibanda, Jamie Pittock, Richard Stirzaker, Henning Bjornlund, Andre van Rooyen, Paiva Munguambe, Makarius Victor Mdemu & Japhet J. Kashaigili (2017) Irrigating Africa: policy barriers and opportunities for enhanced productivity of smallholder farmers, International Journal of Water Resources Development, 33:5, 824-838, DOI: 10.1080/07900627.2017.1321531

To link to this article: http://dx.doi.org/10.1080/07900627.2017.1321531

Published online: 19 May 2017.

INTERNATIONAL JOURNAL OF WATER RESOURCES DEVELOPMENT, 2017
VOL. 33, NO. 5, 824–838
https://doi.org/10.1080/07900627.2017.1321531

Routledge
Taylor & Francis Group

Irrigating Africa: policy barriers and opportunities for enhanced productivity of smallholder farmers

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ABSTRACT

African governments have ambitious plans to expand irrigated agriculture, though existing smallholder schemes have largely failed to use land and water sustainably or become profitable. Six government-owned irrigation schemes in Mozambique, Tanzania and Zimbabwe were assessed to identify common policy barriers and opportunities for higher productivity among smallholder farmers. Issues like insecure land tenure systems, unclear institutional arrangements and poor access to markets have contributed to limited profitability. Reform of currently insecure land tenure, strengthening farmer organizations and reforming policies are recommended so that governments step back from scheme management and foster market linkages to enable more profitable irrigated agriculture.

ARTICLE HISTORY
Received 24 March 2016
Accepted 15 April 2017

KEYWORDS
Africa; agriculture; smallholder irrigation; policy barriers; governance mechanisms; market access

Introduction

Sub-Saharan Africa (SSA) is facing a daunting challenge of feeding over 2 billion people by 2050 (Canning, Jobanputra, & Yazbeck, 2015; United Nations Development Programme, 2012). The World Bank estimated in 2008 that 85% of the people in SSA lived in rural areas and depended primarily on rainfed agricultural production with generally low yield levels for their livelihoods. Only 4% of arable land in SSA is irrigated, compared to about 20% globally and 38% in Asia (Food & Agriculture Organisation, 2009; Shah, van Koppen, Merrey, de Lange, & Samad, 2002). There is an urgent need in Africa to increase productivity and improve the resilience of agricultural production systems under a changing climate (Rockström & Karlberg, 2009).

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Only 7.3 million ha are irrigated out of an estimated suitable area of 40 million ha in SSA (You et al., 2011). There are diverse irrigated agricultural systems in Africa. This article focuses on government-owned irrigation schemes for smallholder farmers, which account for 47% of all irrigated land in Africa (Makombe, Meinzen-Dick, Davies, & Sampath, 2001). The high proportion of people living in poverty in rural areas in Africa is an important driver for government programs to improve the socio-economic returns from agriculture (Jayne et al., 2003; Masters et al., 2013). This has underpinned government decisions to establish communal irrigation schemes, but these public schemes have often entrenched rather than reduced poverty by allocating irrigation plots that are simply too small for farmers to make a decent living, as at Mokoba in Zimbabwe (Moyo, van Rooyen, & Bjornlund, 2017, Table 1). Further, through government regulations or institutions like water scheduling, farmers are directed to grow staple food crops that are not profitable enough to sustain irrigation scheme operations and farmers' livelihoods (van Rooyen, Ramshaw, Moyo, Stirzaker, & Bjornlund, 2017).

While some areas of Africa experience physical water scarcity, economic water scarcity limits greater development of available water resources for irrigated agriculture. The capital to develop irrigation infrastructure and the institutions to fund ongoing operations and maintenance do not warrant the production of 'cheap staples' without government support (Stirzaker & Pittock, 2014; You et al., 2011). The irrigation opportunity is for intensification and diversification of agricultural production with two or more high-value crops per year to draw in labour from less profitable dryland agriculture, increase employment during the lean season and reduce poverty (Carswell, 1997). Often the most profitable irrigated crops will not be staple foodstuffs, so enhancing the productivity of smallholder irrigation often requires exporting non-staples from the locality in exchange for irrigators purchasing staple foods.

Irrigation in SSA has had major difficulties providing an adequate return on investment, due to weak water governance institutions, weak market integration, and significant degradation and abandonment of irrigated land (Stirzaker & Pittock, 2014). The question is, what policy and investment environment can support productive smallholder irrigation, given an understanding of past and current failures?

Table 1. Overview of the six irrigation schemes.

Country / irrigation scheme	Area (ha)	Water access	Major crops	Average plot size per farmer (ha)	Farmer population
Mozambique					
Associacão de 25 Setembro, District of Boane, Maputo Province	40	River pumped	Vegetables (cabbage, green beans, tomatoes) and maize	1.0	38
Kanimambo, District of Magude, Maputo Province	16	River pumped	Vegetables and maize	0.59	27
Tanzania					
Kiwere, Iringa District, Iringa Region	194	Gravity canal	Tomato, onions, leafy vegetables, green maize, rice	0.78	168
Magozi, Iringa District, Iringa Region	939	Gravity canal	Rice, tomatoes, leafy vegetables	1.24	1850
Zimbabwe					
Mkoba, Vungu District	10	Gravity canal	Maize, vegetables	0.11	75
Silalatshani, Insiza District	442	Gravity canal	Maize, wheat, sugar beans, groundnuts	0.41	845
Total	1641			0.55	3003

Policies and institutions

Because many smallholder irrigators are growing low-value staple crops with poor support, and have inadequate or expensive access to farm inputs and to markets, their returns are insufficient to maintain and revitalize irrigation schemes (Shah et al., 2002). Two million of the seven million hectares of irrigation-equipped land in SSA are not in production. Rehabilitation of this land has an estimated average internal rate of return of 28%, in contrast to new large dam-based projects, where a potential 1.3 million ha of profitable expansion had an internal rate of return of 12% (Burney, Naylor, & Postel, 2013).

Historically, governments have managed irrigation development in the region, and this has been identified as a factor in their failure (Mutiro & Lautze, 2015). In the last 10 years, policies on SSA irrigation have emphasized a dramatic scaling-up of irrigated area to promote food security and ameliorate rural poverty. This however has not been translated into development on the ground, with the average rate of growth of irrigated area in SSA of just 1.1% in 2000–03 (Svendsen, Ewing, & Msangi, 2009). Incomplete FAO statistical data limits a more current analysis, but to contribute to feeding the world's growing population, the area equipped for irrigation in SSA is projected to increase by only 0.67% per year between 2005 and 2050 (Bruinsma, 2009). In 2002, the African Ministers' Council on Water was established to provide political leadership, policy direction and advocacy in the provision, use and management of water resources for sustainable social and economic development and maintenance of ecosystems (AMCOW, 2002). In the same year, the Maputo Declaration was established, adopting the Comprehensive African Agriculture Development Programme (CAADP) framework for investment in agriculture in Africa, with special emphasis on water control (NEPAD, 2003). In 2004, the Sirte Declaration focused on ways to implement integrated and sustainable development of agriculture and water in Africa (African Union, 2004). The 2005 report of the Commission for Africa, titled *Our Common Interest,* highlighted the need for investment in water and energy infrastructure, but progress remains limited.

In terms of regional policy instruments, the Southern Africa Development Community (SADC) instruments for water cooperation include the Regional Water Policy, adopted in 2005; the Regional Water Strategy, adopted in 2006; and the Regional Strategic Action Plan on Integrated Water Resources and Development Management, approved in 1998 (SADC, 2012). The Regional Water Policy calls for joint planning and construction of water storages to better support irrigated agriculture and poor communities (SADC, 2005). SADC's Regional Indicative Strategic Development Action Plan of 2001 prioritizes poverty reduction and clearly recognizes the developmental role of water.

However, the challenge remains how to turn concept and strategy into practical action on the ground. At national levels, a number of countries in Africa have been active in developing appropriate policies and implementing initiatives to promote better irrigation practices (Sullivan & Pittock, 2014). Of the 14 SADC nations, 10 had adapted CAADP plans or road maps by 2015, but the extent to which they focus on enhancing irrigated agriculture is not clear (NEPAD, 2015).

We consider that governance of natural resources, in this case irrigation schemes, comprises a web of government and non-governmental institutions at different scales, from local to national (Durant, Chun, Kim, & Lee, 2004). Among these, the key role of water user associations and local farmers in the governance of irrigation schemes has been the subject of extensive analyses, including the issues around the reluctance of government agencies

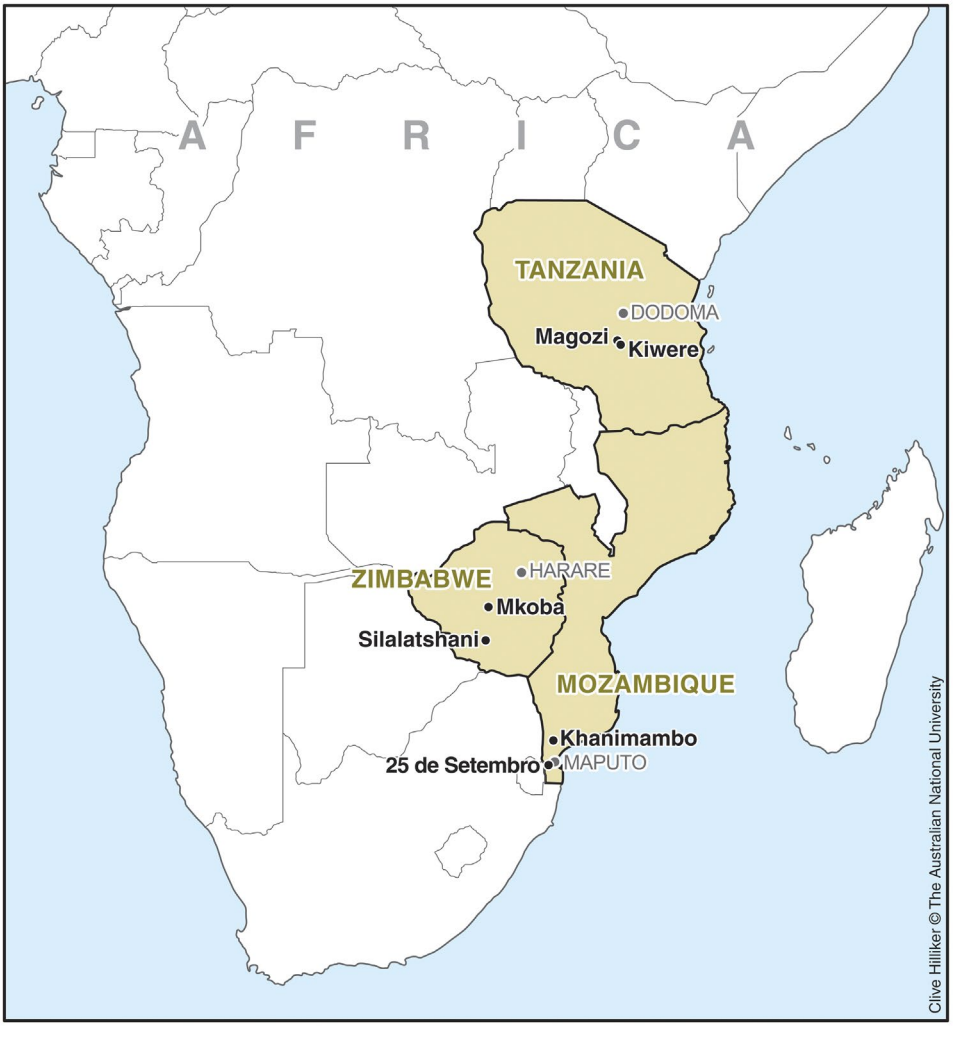

Figure 1. Locations of the six irrigation schemes.

to share power with non-state actors (McCornick & Merrey, 2005). Given the limited capacity of government agencies to make optimal day-to-day governance decisions on local use of resources like land and water for agriculture, we argue that a key role of governments is to enable effective non-governmental governance institutions. For these reasons this research focusses on government institutions for regulating and enabling smallholder irrigation.

In this article, assessments of six smallholder irrigation schemes in Mozambique, Tanzania and Zimbabwe are drawn on to identify common barriers and opportunities for sustainable irrigation (Figure 1).

Methodology

These six irrigation schemes are the subject of the research project Increasing Irrigation Water Productivity in Mozambique, Tanzania and Zimbabwe through On-Farm Monitoring,

Adaptive Management and Agricultural Innovation Platforms. These countries were chosen as the locations for this research following a scoping study in 2012 that considered nine nations in eastern and southern Africa. The selection was based on a combination of interest from national government authorities, in-country research capacity, contrasting stages of irrigation development, and relevance to regional African institutions like CAADP and SADC (Pittock, Stirzaker, Sibanda, Sullivan, & Grafton, 2013).

In-country research partners chose two irrigation schemes in each of the countries that were operated by smallholder farmers; produced a range of different crops; were accessible to in-country researchers; and were supported by local authorities (Table 1; Figure 1). None of the irrigation schemes were self-sustaining, that is, they relied on external funders for infrastructure maintenance, and the current farming systems were barely profitable (de Sousa et al., 2017; Mdemu, Mziray, Bjornlund, & Kashaigili, 2017; Moyo et al., 2017). The issues of profitability of small-scale irrigation schemes in the SSA region are covered in more detail by Bjornlund, van Rooyen, and Stirzaker (2017).

Baseline situation reports were prepared after at least two meetings had been held with farmers and other local stakeholders at each irrigation scheme. A common template was used, and the reports were prepared by staff of the National Institute for Irrigation (INIR) in Mozambique, Ardhi University in Tanzania, and the International Crops Research Institute for the Semi-Arid Tropics in Zimbabwe (Moyo, Moyo, & van Rooyen, 2015; Mziray & Mdemu, 2015; de Sousa, Cheveia, Machava, & Faduco, 2015). The situation reports were assessed for this study, supplemented with data from the articles in this issue, notably three country case studies (Mdemu et al., 2017; Moyo et al., 2017; de Sousa et al., 2017). Qualitative analysis was undertaken to identify barriers and opportunities of national government policies with respect to land tenure, irrigation farmer organizations (also known as water user associations), water use, and enabling profitable irrigation. The identified policy issues are summarized in the results and discussion section, where results are tabulated and discussed issue by issue. Two key policy issues are not included in this analysis. Agricultural extension services are assessed by Wheeler, Zuo, Bjornlund, Mdemu, and van Rooyen (2017) in this issue, and gender equity is the subject of forthcoming work. This analysis is supplemented by a review of national policy documents from Mozambique, Tanzania and Zimbabwe, as well as those related to CAADP (NEPAD, 2003).

Results and discussion

This review of the six irrigation schemes found key policy challenges in land tenure, irrigation farmer organizations, water use, and enabling profitable irrigation.

Land tenure

In all six schemes there were issues with insecure land tenure. The status of land tenure in the six schemes is summarized in Table 2.

In Africa, how land is used, possessed, leveraged, sold, or in other ways disposed of within societies may be established by the state or by custom, and rights may accrue to individuals, families, communities, or organizations (Garvelink, 2012). Although customary rules of land tenure are dominant in Africa, they may or may not be recognized by the state (ECA, 2004). As a result, land tenure remains a major issue of concern among smallholder farming

Table 2. Status of land tenure at each irrigation scheme.

Country	Scheme	Land tenure
Mozambique	25 de Setembro and Khanimambo	Community-based Right of Use of Land (DUAT) is held by the irrigation associations. However, there is some unused land (de Sousa et al., 2015). The approval of new national regulations in 2015, Legal Framework of the Associations of Irrigators, is intended in part to facilitate reallocation of irrigation plots by irrigation associations (with a provision for INIR to act if required) to ensure that all land is actively farmed (Boletim da República, 2015)
Tanzania	Magozi and Kiwere	The schemes are managed by the communities through the irrigators associations. A Customary Certificate Registration of Occupancy may be issued to irrigators to formally record their tenure, but the application process is expensive
	Magozi	People from old Ilolo were relocated to Magozi and given land by the government following the incorporation of their former land into Ruaha National Park. The original landowners in Ilolo Mpya (new) and Magozi Village were allowed to maintain part of their land, while other parts were redistributed to relocated people (Mziray & Mdemu, 2015)
	Kiwere	Land ownership is governed by a traditional system, with the majority of farmers having acquired land through inheritance. However, there are a few farmers who buy or rent land from landowners (Mziray & Mdemu, 2015)
Zimbabwe	Mkoba and Silalatshani	Communal ownership, where the land is owned and administered by the government under the Communal Land Act of 1982 (Moyo et al., 2017). The Rural District Councils have the responsibility for allocating the land for use by local community members. Many plots are fallow or underused

communities. African governments are at varying stages of revising their land tenure legislation and experimenting with ways to register individual and collective rights to land and natural resources (Bruce & Migot-Adholia, 2016; Garvelink, 2012).

Without tenure rights it is difficult for farmers to secure loans, because land tends to be an important source of collateral. Farmers in the six schemes assessed have very limited access to finance; for example, only 20% of farmers in Tanzania and only 13% of farmers at Mkoba in Zimbabwe had obtained a loan (Mdemu et al., 2017; Moyo et al., 2017). This limits the ability of farmers to buy large quantities of good-quality seeds and farm chemicals at lower prices per unit. While Tanzanian farmers can apply for formal land titles, the cost is usually prohibitive, although through our project Ardhi University is helping farmers obtain a Customary Certificate Registration of Occupancy (Mdemu et al., 2017). Land tenure reform is difficult and can often take a long time. Further research is needed to ascertain whether this quicker, formal acknowledgement of land occupancy through certificates (as in this Tanzanian example) is sufficient for farmers to access the scale of finance required, given that they still do not have a realizable asset in the land, which may be required as collateral for a larger loan. Another alternative to land ownership by farmers as a precondition for access to finance is illustrated by Mozambique, where project partner INIR is helping farmers obtain identity cards cheaply, to make them eligible to apply for loans from microfinance organizations (de Sousa et al., 2017).

Farmers at the research sites in Mozambique and Zimbabwe are treating irrigation as a secondary source of livelihood, with a large portion of irrigable plots being unused or underused. In Zimbabwe, only 20% of the land at Silalatshani and 70% at Mkoba was being used (Moyo et al., 2017). Many households receive income from remittances, other jobs or dryland farming; for instance, at 25 de Setembro in Mozambique, 32% of farmers have

off-farm income (de Sousa et al., 2017). This poses the question as to why farmers would choose dryland farming over irrigated plots – do they prefer the uncertainty of weather over the uncertainty of institutional arrangements? If water is the most limiting factor in dryland farming, then why abandon irrigated land when it is almost freely available? We argue that the answer is that irrigated farming is currently not profitable in these publicly owned smallholder schemes.

Further, unused or underused plots increase the costs for the remaining farmers, including costs for additional weeding, and for a greater share of water and infrastructure maintenance (Moyo et al., 2017). In Mozambique the national government has codified the opportunity and the responsibility of irrigation associations to allocate irrigation plots to active farmers. In Zimbabwe, many farmers are unsure who owns the irrigated land, compounded by the overlapping mandates of the national government agencies, traditional rural leaders and irrigation associations (Moyo et al., 2017).

The plots in these irrigation schemes average only 0.55 ha per farmer (Table 1). The small areas cultivated by single irrigator families make it harder to access mechanization to increase labour productivity, reduce production costs and increase profits. While many of the irrigation farmers have other lands or income sources, profitable farming could be enhanced by property build-up or expansion, which depends on land tenure systems that facilitate such transactions. There is a need for long-term tenure for farmers to make long-term commitments and for financiers to provide credit against the land as collateral. Enhanced land tenure empowers farmers to invest more in production if they are assured of tenure security (Jacobs, 2013).

Irrigation farmer organizations

All of the schemes assessed here have irrigation (or water user) associations (Table 3), but often they have been ineffective, lacking the most basic institutions, such as business plans. The associations were hampered by incomplete membership from scheme farmers, as at Magozi in Tanzania, where only 28% of the 1850 famers were members of the Mkilma irrigator organization (Mdemu et al., 2017).

Over more than 30 years, a substantial body of knowledge and community of practice has been generated in understanding how communities at the local level organize and implement systems for managing water for agriculture (Peacock, Ward, & Gambarelli, 2007; Rosegrant & Perez, 1997; Woodhouse & Ganho, 2011). According to McCornick and Merrey (2005), governments throughout SSA are in the process of transferring responsibility for irrigation management to farmer-based organizations, largely due to financial pressures.

Government agencies remain intimately involved in the management of the six irrigation schemes that are the subject of this research, with many of the same issues reported by Mutiro and Lautze (2015). For example, governments have transferred responsibility, but not authority, to collect fees and maintain infrastructure. Irrigator associations often have responsibility for collecting user fees but no easy way to enforce payment, for example authority to expel irrigators from a scheme if they don't pay. Consequently, many irrigators pay no fees at all (Mdemu et al., 2017; Moyo et al., 2017; de Sousa et al., 2017).

In all three countries the irrigator associations have not had annual business plans, which could incorporate such essential measures as clarity on roles and responsibilities; a crop budget; infrastructure maintenance schedule; cooperative buying of inputs and transport services; and production schedules to better meet market demands. Such business plans

Table 3. Governance of schemes and responsibility for infrastructure.

Country	Scheme	Governance of schemes and responsibility for infrastructure
Mozambique (*Boletim da República*, 2015)	25 de Setembro and Khanimambo	The adoption of the Legal Framework of the Irrigators Associations in 2015 clarified their rights and obligations. The associations will be responsible for the irrigation infrastructure and are required to develop business plans and collect member fees to ensure the sustainable operation and maintenance of the schemes. 25 de Setembro and Khanimambo are pilot schemes for implementation of the framework in the Maputo region
Tanzania (Mdemu et al., 2017)	Kiwere and Magozi	Water use permits are accessed through the irrigator associations, which are mandated by the National Water Policy and the Irrigation Act 2013. These organizations own the irrigation infrastructure, and through them the irrigators are responsible for maintaining, managing and improving them. The associations however have no authority to enforce payment of fees by irrigators. As a result, they lack the much-needed resources to carry out substantial infrastructure maintenance
Zimbabwe (Moyo et al., 2017)	Mkoba and Silalatshani	Land is owned and administered by the government under the Communal Land Act 1982, according to which the Rural District Councils allocate land for occupancy and use. In allocating the land, the councils must consult and cooperate with the chiefs. Both schemes are flood-irrigated with water supplied by the Zimbabwe National Water Authority. The respective roles of government and irrigators in the ownership and management of infrastructure are not well defined or understood by the irrigators, which leads to confusion over management

will now be required in Mozambique following the adoption of new, national regulations for water user associations, approved in 2015. At the Magozi scheme in Tanzania, the voluntary preparation by the irrigator association of a business plan has supported the development of a machinery hire service, and further rice processing and storage facilities, aimed at increasing the financial returns to the local farmers (Mkombilenga & Magozi, 2016).

Further, there are few government mechanisms for building the capacities of these local farmer organizations. In Tanzania with village governments and in Zimbabwe with traditional governments, there are overlapping governance mechanisms that limit the autonomy of the farmer organizations (Moyo et al., 2015; Mziray & Mdemu, 2015). In all countries there is a need for extension services to build the autonomous capacity of irrigator organizations, as opposed to aiding only individual farmers. Building the capacities and self-reliance of farmer organizations should be a key policy objective to improve farm profitability and maintain irrigation infrastructure.

Overlapping or ambiguous mandates with other governmental institutions were rife in the schemes. In the case of water distribution infrastructure it was unclear to the farmers where government ownership of headworks stopped and where farmer ownership and responsibility for tanks, canals and pipes began. For instance, the ownership of the 12-km-long canal from the dam to the Silalatshani irrigation scheme is disputed, leading to lack of maintenance, extensive leaks, water theft, and argument over who pays for water transmission losses (Moyo et al., 2017). The question, is how can an irrigation association be responsible for managing and maintaining an infrastructural component of the system if they do not

have ownership of it? We argue that responsibility without authority and authority without responsibility will never have functional outcomes.

Consequently, all schemes were stuck in a cycle of government or donor infrastructure investment, running down of hardware, and demands for publicly funded renewal. Clarifying ownership and responsibility for maintenance of each piece of hardware is an essential reform for sustaining irrigation schemes. All of the schemes had problems with adequately maintaining infrastructure. For example, at the Khanimambo scheme in Mozambique, the flooding and breakdown of the pump meant that the irrigation scheme ceased operating until the INIR replaced it. None of the schemes had saved sufficient funds for rapid repair of damage or replacement of equipment (de Sousa et al., 2015).

Water use

While there is a lot of rhetoric at the global and national scales about using water more efficiently to produce crops, in practice there are many reasons to over-apply water in these irrigation schemes and insufficient knowledge to use water more efficiently. Water use by individual farmers is not measured at any scheme. Farmers in Tanzania and Zimbabwe pay only a set fee per hectare, which provides no incentive for conservation. At Silalatshani in Zimbabwe this means that the few farmers actively using their plots are disadvantaged by many who are not actively farming and not paying their share of the collectively levied water fees (Moyo et al., 2017). At 25 de Setembro and Kanimambo in Mozambique, there is a modest incentive to reduce the cost of energy needed to pump water from the rivers (de Sousa et al., 2015).

In terms of better crop yield from more effective application of water and less loss of nutrients, prior to this project, farmers had little knowledge of how to determine and practice more efficient water scheduling. The farmers using the FullStop wetting front detector and Chameleon soil moisture sensor in this project report using less than half the water they used to now that they can measure soil moisture, saving significant labour (Stirzaker, Mbakwe, & Mziray, 2017). Further, water is now regularly reaching the tail end of canals, enabling farmers who were reduced to labouring on others' plots to farm (Manero, 2017). These results are similar to findings for use of wetting front detectors in Ethiopia (Schmitter et al., 2016). At Kiwere and Magozi in Tanzania, and Mkoba in Zimbabwe, the limited water supply means that better water management could raise the productivity of the area under irrigation (Mdemu et al., 2017; Moyo et al., 2017). At Kiwere and Magozi, water saved by more efficient practices near the head of the supply canal is benefitting farmers at the tail end of the canals (Mziray & Mdemu, 2015).

In Zimbabwe, water distribution in both schemes (Mkoba and Silalatshani) is guided by a duty roster. Water distribution in Mkoba is fixed compared to Silalatshani, where irrigators claim they can request water at any time without restrictions (Moyo et al., 2017). At both schemes, the irrigation management committee makes all the decisions about when to supply to individual irrigators.

Policy reform is needed to achieve greater water-use efficiency in irrigation, to extend irrigated cropping and to benefit other water users. National governments can act to promote uptake of basic soil nutrient and water monitoring by farmers, support flexible water scheduling, and ensure that energy and water costs encourage conservative use of these resources.

Improving market access and quality of inputs

Across the three project countries, there is generally limited access to input and output markets. Prominent among the input market challenges are high cost of fertilizers, low-quality inputs such as seeds, and inability to get reduced input costs based on bulk purchases. At each of the schemes farmers mentioned that they buy small quantities of supplies individually at higher prices from a limited number of local suppliers (Mdemu et al., 2017; Moyo et al., 2017; de Sousa et al., 2017). Three key issues arise from our assessment: access to high-quality seeds; market access; and importation of agricultural equipment.

Access to high-quality seeds

The farmers in the three countries report buying and planting seeds that are labelled incorrectly and with low germination rates, compromising productivity (Table 4). The lack of a well-developed and regulated seed sector impedes smallholder farmers' ability to plan for and achieve higher productivity because they are working with compromised inputs (Sperling & McGuire, 2010; Tripp & Rohrbach, 2001). Irrigated crop output would be enhanced by government policies that further aid access to improved seeds and enforced seed quality standards, information on prices, and financial services.

The Food and Natural Resources Policy Analysis Network has been working to enforce and promote the SADC Harmonized Seed Regulatory System, an ensemble of rules needed to facilitate enhanced seed trade in the region (FANRPAN, 2012). These can increase the availability of high-quality seed to farmers through rationalizing and removing national regulatory barriers for the movement of seed across borders.

Market access

In the six irrigation schemes, access to output markets was identified as a major challenge, with much produce being sold at the farm gate at low prices and with high post-harvest losses. The schemes assessed in Tanzania and Zimbabwe are a long way from cities; hence, transport costs are high, and the farmers are unaware of prices in major urban markets (Mdemu et al., 2017; Moyo et al., 2017). In Mozambique, farmers are disadvantaged by cheap South African imports (de Sousa et al., 2017). While many of the irrigation associations were recording the planting and expected harvest times of crops, planting was not being scheduled so as to bring produce to market at times when better prices might be expected. Further, no cooperative marketing was being undertaken, raising the costs for individual farmers. Lack of information on prices of irrigated crops in markets in major urban areas was a barrier to farmers' realizing better returns on their produce in all three countries (Table 5).

Table 4. Extent of farmer access to high-quality seeds.

Country	Scheme	Farmer reports on access to seeds
Mozambique	25 de Setembro and Khanimambo	Reports of purchasing low-quality seeds or seeds that are labelled incorrectly; evidence in the fields of the use of chemicals which are prohibited in Mozambique and the country of manufacture
Tanzania	Kiwere and Magozi	Reports of using local seed varieties of poor quality
Zimbabwe	Mkoba and Silalatshani	While high-quality seeds are available and often used, many farmers still use retained seed because the cost of seed cannot be recouped at the marketplace – the crops are used for household food security

Table 5. Extent of farmer access to market information for crops.

Country	Access to market information
Mozambique	Market price data are collected but are not readily accessible to rural farmers
Tanzania	Aggregated average market prices of major staples in major regional markets are reported in the daily English government newspaper, which is not accessible to farmers in rural areas. Project tailored market information for agricultural commodities, which is accessible through mobile short messages, has been trialled in specific project areas (see e.g. Mobile Kilimo, http://mkilimo.esrf.or.tz/)
Zimbabwe	Market price data are collected but are not readily accessible to rural farmers, even though mobile phone technologies are available in the irrigation areas

This information would enable farmers to make more informed decisions on the most profitable crops to grow and where best to sell them. The work of the National Institute for Irrigation at the 25 de Setembro scheme in Mozambique illustrates how information on market prices could be used to plan for more profitable irrigation (de Sousa et al., 2017). Governments could establish institutions in key cities to record prices of produce at agricultural markets and then make this information available to producers on a daily or weekly basis via radio, internet, or SMS.

Importation of agricultural equipment

A major barrier to agricultural development in Africa is the legal and bureaucratic barriers to the importation of inputs. This project involved the production of simple tools, including the FullStop wetting front detector and the Chameleon sensor, that enable farmers to monitor soil moisture and nutrition in their fields to enhance their agronomic practices (Stirzaker et al., 2017). These tools have been manufactured in or transported via South Africa to Mozambique, Tanzania and Zimbabwe. While the project has not been selling them, commercial production and supply have been requested by many farmers and would be a desirable outcome to enhance agricultural productivity in these countries.

This project has continued to incur very high transport costs and considerable time delays in transporting this equipment to the irrigators, exacerbated by excessive customs processes, regulations and fees. The freight costs of transporting wetting front detectors for this project in 2015 illustrate the problem. Equipment that cost USD 2233 was transported from Cape Town to Sydney for USD 381, so freight represents 17% of the capital cost. By contrast, equipment that cost USD 712 was sent from Pretoria to Bulawayo for USD 696, or 98% of the capital cost. Even worse, equipment worth USD 712 cost USD 1570 to send from Pretoria to Dar es Salaam, 221% of the capital cost. And there were additional taxes to be paid for import into Tanzania and Zimbabwe.

This case is consistent with observations of the broader influence of politics and economics on the bureaucratic and financial hurdles on imports of agricultural inputs in many African states (Angelucci, Balié, Gourichon, Mas Aparisi, & Witwer, 2013; Jayne, Govereh, Mwanaumo, Nyoro, & Chapoto, 2002). It is perverse that African governments that have adopted ambitious targets for expanding irrigated agricultural production place so many bureaucratic and financial hurdles in the way of importing the equipment and other imports that would aid their farmers in this endeavour.

Conclusions

Irrigating Africa is a core policy objective of a great many multilateral organizations, donors and national governments, in the expectation that this will reduce poverty, increase food

security and promote economic growth and development. This research shows that the governments' objective of securing domestic supplies of staple foods from irrigation schemes conflicts with poverty reduction. While commercial and private types of irrigation schemes may be profitable in Africa, this review of six publicly owned smallholder irrigation schemes in Mozambique, Tanzania and Zimbabwe found that these schemes are currently unproductive and are not improving the livelihoods of poor farmers.

Four key reforms were identified for national and regional policies on smallholder irrigation that may enable these farming systems to improve links to markets and become vibrant and profitable:

(1) Reform land tenure systems to enable farmers to use irrigation plots as collateral for loans, invest in farming with security, and acquire additional plots to build up farming operations to more viable scales.
(2) Enhance irrigator associations by ensuring that ownership of infrastructure is clear and that they have the responsibility for collection of fees and maintenance of infrastructure; develop their business management (such as to access affordable, high-quality fertilizers and seeds) and crop marketing skills.
(3) Enable more efficient water use by (a) developing local capacity and access to appropriate tools to understand the value of accurate soil moisture monitoring and measurement to reduce leaching of nutrients and salinization and increase the overall water-use efficiency of production systems, and (b) developing the skills of agricultural extension officers to backstop the learning process of farmers.
(4) Support irrigation businesses through national government policies for: (a) adoption and enforcement of the SADC Harmonized Seed Regulatory System rules to facilitate access to high-quality seed; (b) mechanisms to record and make available to farmers via radio, internet and SMS the market prices of produce in key cities; and (c) remove tariffs and bureaucratic barriers to the import of agricultural equipment and other imports.

If smallholder irrigators are to thrive, governments need to support farmer organizations to have better defined and larger roles in management, and foster stronger links to input and output markets, to enable these systems to become profitable.

Acknowledgements

The research in this article was part of the project FSC-2013-006, Increasing Irrigation Water Productivity in Mozambique, Tanzania and Zimbabwe through On-Farm Monitoring, Adaptive Management and Agricultural Innovation Platforms, funded by the Australian International Food Security Research Centre of the Australian Centre for International Agricultural Research, and participating organizations.

Disclosure statement

No potential conflict of interest was reported by the authors.

Funding

This work was supported by Australian Centre for International Agricultural Research grant number FSC-2013-006.

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