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146

AgWater Solutions Project
Country Synthesis Report

Investing in Agricultural Water Management to Benefit Smallholder Farmers in Tanzania

Alexandra E. V. Evans, Meredith Giordano and Terry Clayton, Editors

International Water Management Institute

Research Program on Water, Land and Ecosystems

AgWater Solutions: Improved livelihoods for smallholder farmers

Stockholm Environment Institute

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Project

The AgWater Solutions Project was implemented in several countries in Africa and Asia between 2009 and 2012. The objective of the project was to identify investment options and opportunities in agricultural water management with the greatest potential to improve incomes and food security for poor farmers, and to develop tools and recommendations for stakeholders in the sector including policymakers, investors, non-governmental organizations (NGOs) and smallholder farmers. This report synthesizes the research findings and contributions made by the team and stakeholders in Tanzania over the project period.

The leading implementing institutions were the International Water Management Institute (IWMI), the Food and Agriculture Organization of the United Nations (FAO), iDE, the International Food Policy Research Institute (IFPRI) and the Stockholm Environment Institute (SEI).

For more information on the project or for detailed reports, please visit the project website (http://awm-solutions.iwmi.org/home-page.aspx) or contact the AgWater Solutions Project Secretariat (AWMSolutions@cgiar.org).

Contents

Summary

This Working Paper summarizes research conducted as part of the AgWater Solutions Project in Tanzania between 2009 and 2012. Agriculture employs over 80% of the workforce and makes up 45% of the country's gross domestic product (GDP) and 30% of its export earnings. Tanzania has sufficient water resources and there is tremendous irrigation potential with some 44 million hectares (Mha) deemed suitable for irrigation, but only 10 Mha (23%) is actually cultivated and of that only 227,000 hectares (ha) is irrigated. This irrigation potential is not being realized because the millions of smallholder farmers that comprise the majority of the agricultural sector in Tanzania are currently unable to take advantage of improved irrigation techniques and technologies. Significant investments in infrastructure, institutions and human resources will be required to achieve the government's stated goal of increasing the irrigated area to 7 Mha by 2015 and raising paddy yields from 2 tonnes per hectare (t/ha) to 8 t/ha.

Researchers from the AgWater Solutions Project examined conservation agriculture (CA), rainwater harvesting and storage systems, communal irrigation schemes (community managed river diversions), water-lifting devices, drip irrigation, power tillage and tower gardening. On the basis of stakeholder consultations, the first four options were selected for further research. Research methodologies included rapid rural appraisals, interviews, survey questionnaires, participatory mapping and literature reviews.

The main findings of the project indicate that:

- Upgrading community managed river diversion irrigation schemes leads to gains in water productivity and household income. To maximize the livelihood benefits of communal irrigation schemes, investments should be made to improve infrastructure and to develop farmer skills in agronomic and irrigation practices and business skills. Micro-credit is a vital ingredient.
- Access to surface water and groundwater resources through motorized pumps can raise yields, allow higher cropping intensities and diversification, and increase incomes. Investments to improve the ability of farmers to select, buy, rent and use motor pumps would enable them to grow high-value vegetables in the dry season. Farmers require training to select the right pumps for the job and to maintain them well. They may need affordable credit or pumps to rent.
- Farmers using conservation agriculture techniques have higher yields and see more environmental benefits, but it takes several years to recover the cost of the investment. The formation of farmer groups, training and demonstration from one farmer to another can enhance the spread of conservation agriculture techniques.

At a 50% adoption rate, these measures have the potential to reach up to 17 million people.

INTRODUCTION: SMALLHOLDER AGRICULTURAL WATER MANAGEMENT

Across Africa and Asia, a growing number of smallholder farmers are finding ways to better manage water for agriculture to increase yields and income, and diversify their cropping and livelihood options. Farmers buy or rent irrigation equipment, draw water from nearby sources, and individually or collectively build small water storage structures. This development is often overlooked by external investors, yet the smallholder agricultural water management (AWM) sector is contributing to food security, rural incomes, health and nutrition. While small-scale AWM practices could potentially benefit hundreds of millions of farmers, this potential is far from being realized.

The AgWater Solutions Project examined this trend together with the opportunities and constraints associated with smallholder AWM in five countries in Africa, Tanzania, Burkina Faso, Ghana, Ethiopia and Zambia, and two states in India, West Bengal and Madhya Pradesh. Through this, the project identified a number of ways in which the potential of the smallholder AWM sector can be realized, including:

- **Building supportive institutional structures:** Existing governing bodies typically cater for public irrigation systems and are often not adapted to capitalize on the opportunities and to handle the challenges posed by this alternative mode of irrigation development. Traditional agricultural institutions rarely focus on market-oriented smallholder crop production, such as high-value vegetable production in the dry season.
- **Overcoming value chain inefficiencies:** Market inefficiencies negatively affect farmer decision-making and access to technology. Inefficiencies include: poorly developed supply chains; high taxes and transaction costs; lack of information and knowledge on irrigation, seeds, marketing and equipment; and uneven information and power in output markets.
- **Improving access to technology for all sectors of society:** Better-off farmers have greater access to information and technology than their poorer counterparts and women who face several hurdles: high upfront investment costs, absence of financing tools, and limited access to information to make informed investment and marketing choices.
- **Managing potential trade-offs:** While smallholder AWM can be beneficial for an individual farmer, its uncontrolled spread can have unexpected consequences. If not managed within the landscape context, the many small dispersed points of water extraction, can negatively impact downstream users and cause environmental damage.

Addressing these challenges requires a fresh look at new and existing AWM technologies, products and practices to enhance the potential of the smallholder AWM sector and find solutions.

WHY INVEST IN SMALLHOLDER AWM IN TANZANIA?[1]

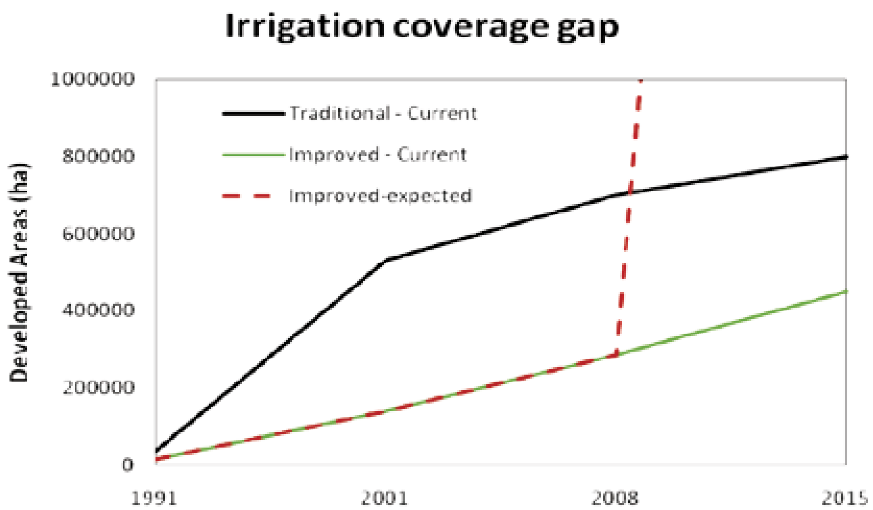
The agricultural sector drives economic growth in Tanzania. It contributes to 45% of the country's GDP and to 30% of its export earnings. Over 80% of the nation's workforce is employed in the agricultural sector, cultivating over 5 Mha, with food crops being grown on 85% of this land. Tanzania has sufficient water resources with three major lakes, nine river basins and ample groundwater, but there is currently little irrigation (official estimates show less than 300,000 ha

[1] This section is based on AgWater Solutions Project 2009, 2010.

under irrigation). Farmers, fishers and pastoralists all suffer the effects of periodic droughts.Thus, AWM holds the key to stabilizing agricultural production and improving livelihoods.

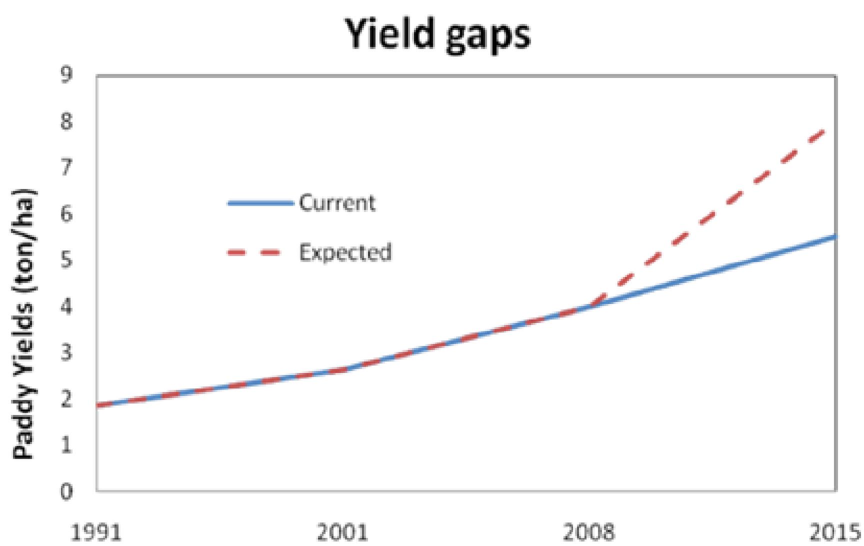
Tanzania has tremendous irrigation potential with some 44 Mha deemed suitable for irrigation, but only 10 Mha (23%) is actually cultivated and of that only 227,000 ha is irrigated (Government of the United Republic of Tanzania 2005). The Tanzanian Government has recognized this potential and aims to increase the country's irrigated area to 7 Mha by 2015 and raise paddy yields from 2 to 8 t/ha, a fourfold increase (Figures 1 and 2). How this will be achieved is still under discussion. The big challenges in the sector are how to increase labor and land productivity, how to mitigate the consequences of inappropriate technologies, and the heavy dependence on unreliable and irregular rainfall.

FIGURE 1. Current and proposed irrigated area.



Source: Keraita 2011.

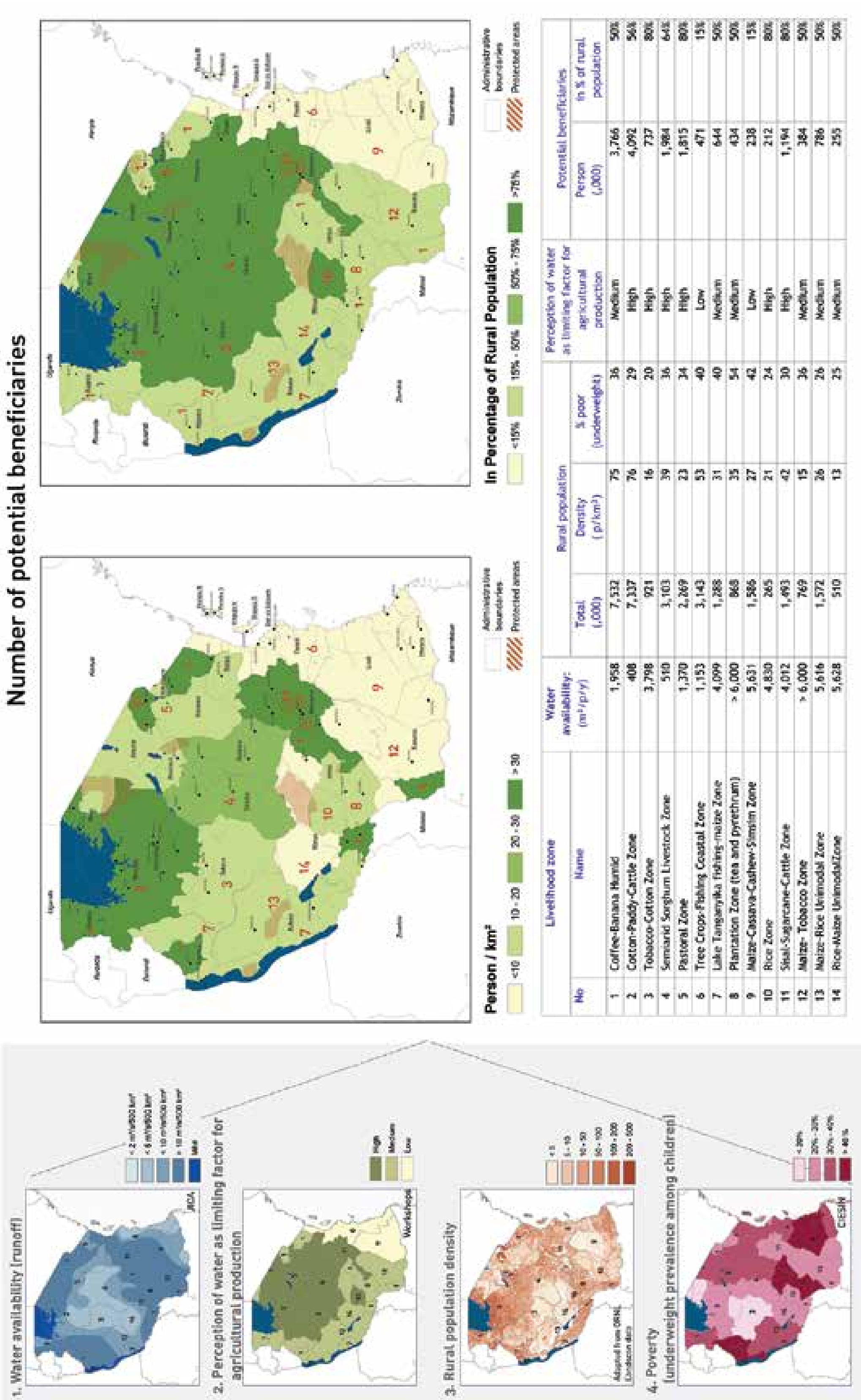
FIGURE 2. Irrigation coverage gap in Tanzania.



Source: Keraita 2011.

The Agwater Solutions Project mapped the potential for AWM to improve the livelihoods of smallholder farmers in Tanzania and found that just over 17 million people could benefit - half the rural population (Figure 3).

FIGURE 3. Potential beneficiaries of agricultural water management.



Livelihood zone		Water availability: (m³/p/y)	Rural population			Perception of water as limiting factor for agricultural production	Potential beneficiaries	
No	Name		Total (,000)	Density (p/km²)	% poor (underweight)		Person (,000)	In % of rural population
1	Coffee-Banana Humid	1,958	7,532	75	36	Medium	3,766	50%
2	Cotton-Paddy-Cattle Zone	408	7,337	76	29	High	4,092	56%
3	Tobacco-Cotton Zone	3,798	921	16	20	High	737	80%
4	Semiarid Sorghum Livestock Zone	510	3,103	39	36	High	1,984	64%
5	Pastoral Zone	1,370	2,269	23	34	High	1,815	80%
6	Tree Crops-Fishing Coastal Zone	1,153	3,143	53	40	Low	471	15%
7	Lake Tanganyika fishing-maize Zone	4,099	1,288	31	40	Medium	644	50%
8	Plantation Zone (tea and pyrethrum)	> 6,000	868	35	54	Medium	434	50%
9	Maize-Cassava-Cashew-Simsim Zone	5,631	1,586	27	42	Low	238	15%
10	Rice Zone	4,830	265	21	24	High	212	80%
11	Sisal-Sugarcane-Cattle Zone	4,012	1,493	42	30	High	1,194	80%
12	Maize- Tobacco Zone	> 6,000	769	15	36	Medium	384	50%
13	Maize-Rice Unimodal Zone	5,616	1,572	26	26	Medium	786	50%
14	Rice-Maize UnimodalZone	5,628	510	13	25	Medium	255	50%

Source: FAO 2012a.

AWM Investment Opportunities in Tanzania

The AgWater Solutions Project identified many existing AWM practices that could support the realization of the estimate that 17 million people could benefit from AWM in Tanzania. The project initially considered conservation agriculture (CA), rainwater harvesting and storage systems, communal irrigation schemes (community managed river diversions), water-lifting devices, drip irrigation, power tillage and tower gardening. After stakeholder consultations, the first four of these options were selected for research. A series of recommendations were made regarding ways to increase smallholder farmers' adoption and sustained use of these options (Table 1).

TABLE 1. Review of AWM options, recommendations and potential beneficiaries.

AWM option	AWM investment opportunity	Beneficiary households (% of rural households)*	Area in hectares (% of total agricultural land)*	Estimated investment costs (USD)
Community managed river diversion schemes	*Upgrading community managed river diversion irrigation schemes leads to gains in water productivity and household income.* To maximize the livelihood benefits of communal irrigation schemes, investments should be made to **improve infrastructure** and to **develop farmer skills** in not only agronomic and irrigation practices but also in business skills. **Micro-credit** is a vital ingredient.	153,000-509,000 (2-8%)	153,000-509,000 (1-2%)	4,250/ha
Motor pumps	*Access to surface water and groundwater resources through motorized pumps can raise yields, allow higher cropping intensities and diversification, and increase incomes.* Investments to improve the ability of farmers to select, buy, rent and use motor pumps would enable them to grow vegetables in the dry season and increase their incomes. They require **training** to select the right pumps for the job and to maintain them well. They may need **affordable credit** or pumps to rent.	532,000-781,000 (8-12%)	426,000-625,000 (1-2%)	400/household
Conservation agriculture: In-situ rainwater harvesting	*Farmers using CA techniques experience higher yields and environmental benefits. However, it can take a few years for them to make up the cost of the investment.*	317,000-1,447,000 (5-23%)	568,000-2,678,000 (2-9%)	300/ha
Conservation agriculture: Terracing	**The formation of farmer groups, training and demonstration from one farmer to another** can enhance the spread of CA techniques, and yield improvements have been achieved.	20,000-314,000 (up to 5%)	38,000-581,000 (< 2%)	600/ha

Source: This study; all data: FAO 2012a.

Note: * Figures assume that out of the total potential beneficiary households calculated, 50% adopt the AWM option.

These findings are derived from an approach that combines primary and secondary data collection, stakeholder involvement and mapping. Details of the approach taken by the AgWater Solutions Project and the related studies are given in Box 1 and elaborated in subsequent chapters. Further information, including case studies and mapping data can be found on the project website (http://awm-solutions.iwmi.org).

Box 1. AgWater Solutions Project approach.

Situation analysis and selection of AWM options: An initial analysis was undertaken of the conditions in each country and the AWM practices already being undertaken. These were reviewed with stakeholders and some of the most promising practices were selected.

Field-scale and community-level case studies: Researchers used a participatory opportunity and constraint analysis and methodology to understand the complex interaction among social, economic and physical factors that influence the uptake and success of AWM options, and to identify technologies appropriate to different contexts in each of the project countries.

Watershed-level case studies: Researchers used a multi-disciplinary approach to look at how the natural resource base impacts on, and is impacted by, AWM in four watersheds in Tanzania, Burkina Faso, West Bengal (India) and Zambia. The analysis concentrated on the hydrological impact of current and potential AWM interventions; the current resource-based livelihoods and dependencies on sources of water and water management practices; an impact assessment of potential AWM scenarios; and a review of formal and informal institutional capacity to deal with AWM interventions and potential emerging externalities.

National AWM mapping: Maps were developed to help assess where AWM will have the greatest impact within a country or state, and where specific interventions will be most viable. The steps followed were to use a participatory process in which experts defined the main livelihood zones based on farming typologies and rural livelihood strategies, and the main water-related constraints and needs in the different rural livelihood contexts. Using this, the potential for investment in water to support rural populations could be mapped based on demand and availability of water. A further step was to map the suitability and demand for specific AWM interventions, such as motor pumps or small reservoirs, and to estimate the potential number of beneficiaries, application area and investment costs. These allow investors to choose entry points and prioritize investments in AWM that will have the most beneficial impacts on rural livelihoods.

Regional AWM analysis: Researchers used geographic information system (GIS)-analysis, crop mix optimization tools and predictive modeling techniques to assess the regional potential for the 'best-bet' AWM technologies in South Asia and sub-Saharan Africa in terms of: potential application area (in hectares), number of people reached, net revenue derived and water consumption. Scenarios were also developed to factor in climate change and potential changes in irrigation costs.

(Continued)

Box 1. AgWater Solutions Project approach. (Continued)

Stakeholder engagement and dialogue: An integral part of the entire project was the engagement of stakeholders from the initial assessment of AWM opportunities through to the identification of possible implementation pathways. The dialogue process was used to ensure that project results reflected stakeholder perceptions and addressed their concerns. National and sub-national consultations, dialogues, surveys and interviews were fed into all stages of the project.

AWM OPTIONS REVIEWED

Community Managed River Diversion Schemes[2]

Investing in improvements to community managed river diversion irrigation schemes leads to gains in water productivity and household income.

Where the opportunity lies

There is much scope for improvement in community managed river diversions. Over 90% of existing schemes are 'traditional' schemes (Box 2) initiated and managed by farmers. Infrastructure is poor, yields are low, and water-use efficiency varies from only 15 to 30% (Keraita 2011).

Box 2. Definitions of traditional and improved irrigation schemes.

Traditional irrigation schemes: are characterized by temporary diversion weirs, which often get washed away by floods and have to be reconstructed at the end of each rainy season. Canal intakes usually have no gates to control the flow. The conveyance system consists of unlined earth channels and the losses are high. The distribution systems have no water control structures and the drainage system is usually lacking or inadequate. The category includes schemes developed and managed by farmers themselves using local skills and materials.

Improved traditional irrigation schemes: usually have concrete diversion weirs, gated canal intakes and water diversion boxes. The layout of irrigation canals and drainage system is usually well defined.

Source: Government of the United Republic of Tanzania 2005.

There are large differences in productivity between farmers in the same irrigation scheme, suggesting that infrastructure is not the only challenge. On-farm water management and farming practices also need attention.

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[2] This section is based on Keraita 2011; and AgWater Solutions Project 2011a.

The research

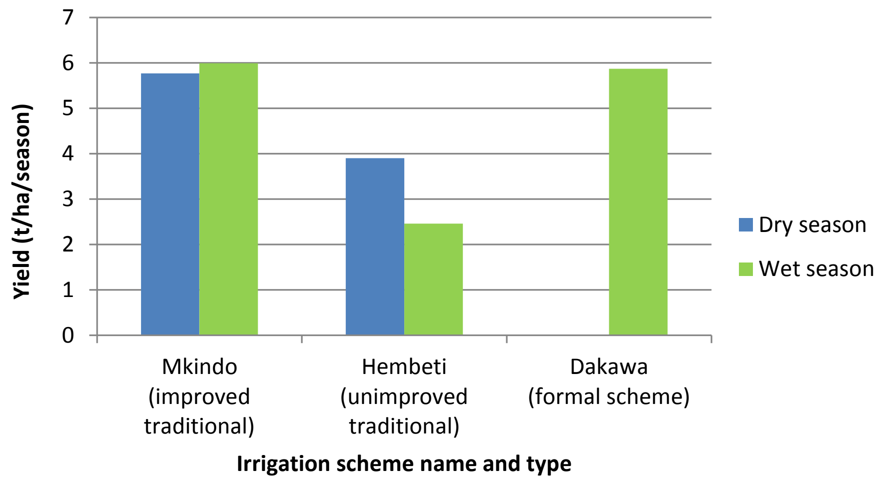
Researchers from the AgWater Solutions Project conducted rapid rural appraisals across five administrative regions: Tanga (Sunga, Kitivo), Iringa (Itipingi), Moshi (Shirimugungani, Lower Moshi), Mbeya (Mbarali) and Arumeru (Chem Chem). They also conducted in-depth studies in three representative communal irrigation schemes across the Mvomero District in Morogoro Region. The schemes were Hembeti (an unimproved traditional scheme of 30 ha), Mkindo (an improved traditional scheme of 60 ha) and Dakawa (a formal scheme of 2,000 ha). In total, more than 200 farmers were interviewed.

Where to invest

Expand and improve infrastructure, concentrating on off-takes and main canals

The improved traditional scheme (Mkindo) and the formal scheme (Dakawa) had similar rice yields of approximately 6 t/ha, whereas farmers in the unimproved scheme (Hembeti) reported much lower yields (Figure 4). Rehabilitating and improving schemes, especially. main canals will therefore have a significant impact on crop productivity by improving farmers' ability to control and manage water. Other projects have tested and supported this theory, including the 'smallholder paddy rice irrigation in semi-arid and marginal areas project' funded by the International Fund for Agricultural Development (IFAD), and the 'River Basin Management and Smallholder Irrigation Improvement Project' funded by the World Bank (World Bank 2004).

FIGURE 4. Comparison of yields from different types of irrigation schemes in Mvomero (n=127).

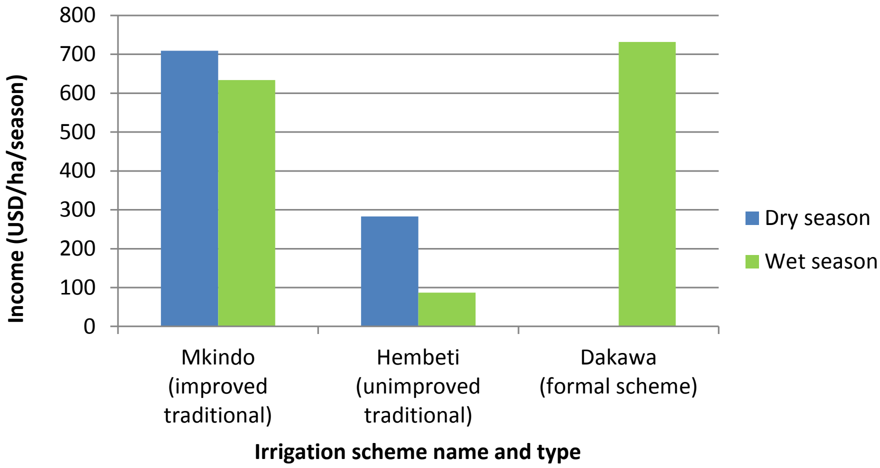


Source: Adapted from Keraita 2011.

How farmers would benefit

The gains from improved irrigation efficiency translate into higher incomes for farmers. Studies carried out by the AgWater Solutions Project showed that farmers irrigating in the improved traditional scheme in Mkindo and the formal scheme in Dakawa earned considerably more than those in the unimproved scheme in Hembeti (Figure 5). Irrigation revenues from community managed river diversion schemes contributed more than 85% to incomes in irrigating households.

FIGURE 5. Irrigation efficiency translates directly into higher income for farm households.



Source: Adapted from Keraita 2011.

Infrastructure is not the only challenge

Differences in yield and income were also found within the same scheme. This suggests that water delivery is not the only problem, but that on-farm practices play an important role as well as farmers' ability to profit from their crops. Providing training to enhance farmers' skills would have a significant impact on their livelihoods. Innovative approaches such as those practiced by the Kilimanjaro Agricultural Training Centre (KATC) under the Supporting Systems for Spread of Irrigated Agriculture in Tanzania (TANRICE) project show that providing improved information to farmers can lead to yield increases of 30-75% (KATC 2008). Similarly, farmers who participated at farmer schools in rice cultivation conducted by the Mkindo Farmers' Agricultural Training Centre consistently achieve higher yields (by 30-200%) than their farmer colleagues (Kaihura et al. 2008).

Strengthen micro-credit facilities

Farmers need credit to fund improvements in agricultural practices and tertiary level irrigation infrastructure. Currently, micro-finance institutions (MFI) are reluctant to give credit to farmers. When the MFIs prepare repayment terms, the terms do not match farmers' income streams. One particular MFI, Hembeti Savings and Credit Cooperative (SACCO), is experimenting with a system in which farmers repay their debt with bags of paddy. Since most farmers sell their paddy at the same time of year, prices are usually low. The MFI stores the paddy and sells it when prices are high, thereby making its required margin.

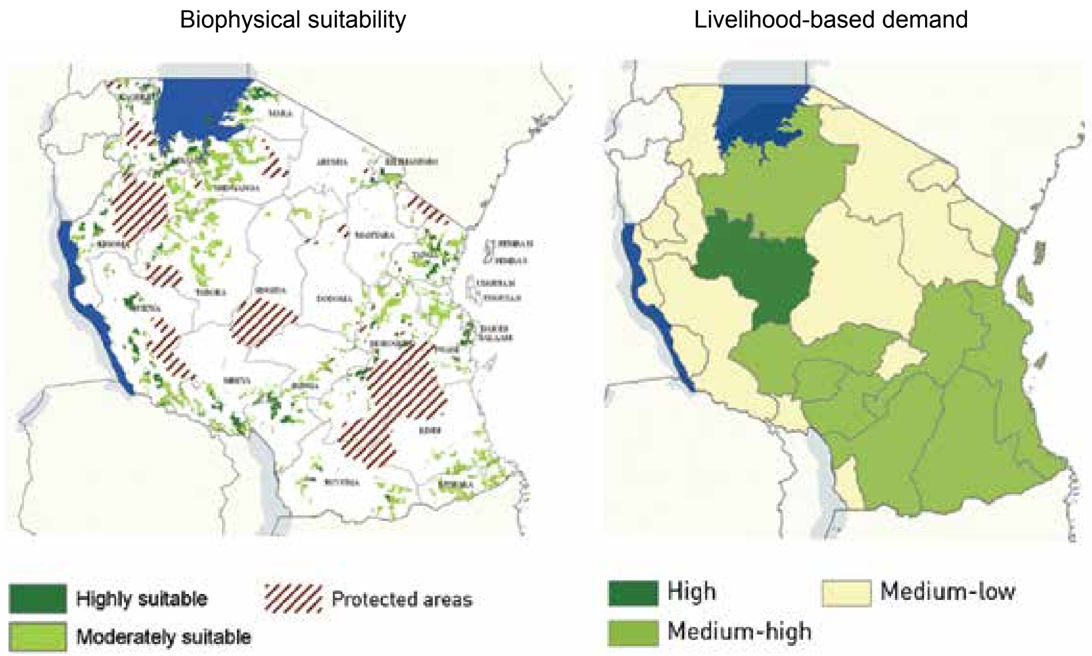
SACCOs, like the one in Hembeti, are present in nearly every farming community in Tanzania. The SACCO mode of operation, however, has changed over time, becoming more inflexible in repayment terms and charging higher rates of interest. As a result, many farmers (in particular, women) with little or no collateral do not apply for loans from SACCOs. One of the reasons for this change is the switch in funding sources for SACCOs from international NGOs and funding agencies (where little or no interest was charged) to funding from commercial banks. The simplest and most direct way of improving the existing credit facilities would be to separate SACCOs from the banking system, and then for donors, the government and NGOs to invest directly in credible SACCOs and enforce transparent lending terms.

Investment potential

Using biophysical criteria of travel time to markets, proximity to perennial rivers and aridity index, combined with livelihood maps, the AgWater Solutions Project estimated that community managed river diversion schemes could benefit between 153,000 and 509,000 households, which is equivalent to 2 to 8% of rural households. These figures are based on a 50% adoption rate.

The potential application area is 153,000 to 509,000 ha, which is about 2% of the total agricultural land area in Tanzania. For details on where community managed river diversions could have the greatest livelihood benefits, see Figure 6.

FIGURE 6. Potential for community managed river diversions to improve livelihoods.



Source: adapted from FAO 2012a.

Taking into account river basin hydrology, environmental constraints, yield improvements, costs of the investment and price impacts of expanding crop production, the potential area expansion for East Africa is 5.4 Mha and 30.7 million people (or 6 million households) (IFPRI 2012a).

Stakeholder recommendations.

When stakeholders in Tanzania were consulted on their opinions about community managed river diversion schemes, they made the following recommendations:

- Invest in databases on river diversion schemes and infrastructure to facilitate repair and investment.

(Continued)

Stakeholder recommendations (Continued).

- Strengthen water users associations (WUAs), including their management, financial skills and institutional capacity.
- Improve the design of schemes based on availability of water and command area.
- Integrate schemes with water storage, e.g., rainwater harvesting and construction of dams.
- Combine schemes with livestock watering ponds.

Source: FAO 2012b.

Water-lifting Technologies[3]

Farmers who depend on rainfall but can potentially access surface water or groundwater, could increase their yields with supplemental irrigation using diesel and electric pumps. If used to irrigate dry-season vegetable crops, small pumps could substantially increase household incomes. Pumps would also reduce the labor load on those who do most of the manual irrigating, which is often carried out by women and children.

Where the opportunity lies

Over 85% of irrigators in Tanzania still use buckets and watering cans. Farmers are well aware of motor and treadle pumps but choose not to use them for a number of reasons, despite the fact that motor pumps offer the potential for irrigating a dry-season crop and yields are generally higher for motor pump users. Better yields and dry-season cropping contribute to higher household incomes, and labor requirements for motorized pumps are significantly lower than when manual methods are used (Table 2).

TABLE 2. Hours spent on irrigation.

Water-lifting device	Time spent irrigating (hours/ha/year)
Motorized pumps	267
Buckets, watering cans	2,730
Treadle pumps	2,510

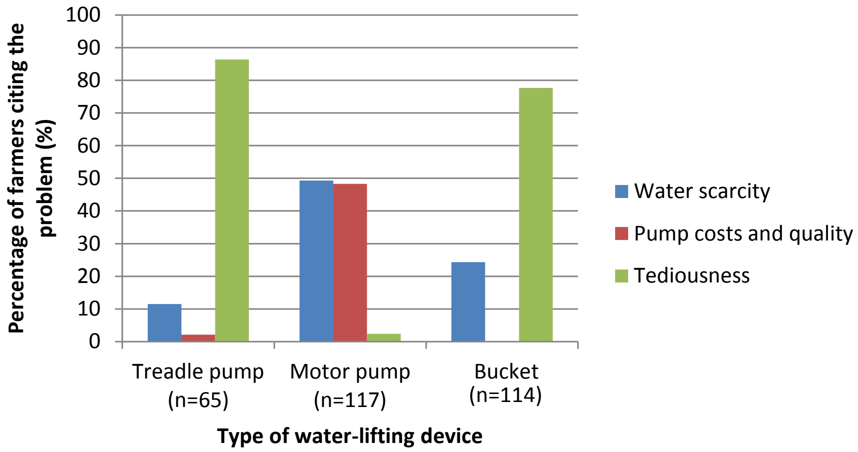
Source: Keraita and de Fraiture 2011.

The research

Researchers from the AgWater Solutions Project identified cost, pump quality and knowledge as limits to wider use (Figure 7).

[3] This section is based on Keraita and de Fraiture 2011; and AgWater Solutions Project 2011b.

FIGURE 7. Problems associated with water-lifting technologies that limit adoption.



Source: adapted from Keraita and de Fraiture 2011.

The initial cost of purchasing a motor pump varies but is around USD 250. Nearly half the farmers in project surveys cited cost as the main reason for not investing. In some areas, diesel, gasoline and electricity are expensive or not easily available. If these costs can be met, motor pumps provide the best return when used to irrigate dry-season vegetables such as tomatoes (Table 3). Cheaper motor pumps are available, but they are usually of poor quality and frequently break down. Spare parts are non-existent or hard to come by.

Many farmers do not have the knowledge they need to make informed choices about pump size and quality when making a purchase. They also lack technical expertize to use and maintain their pumps. This results in frequent breakdowns and eventual abandonment of the technology. This impacts the overall adoption process because other farmers see these failures and decide the investment is not worth the return.

Treadle pumps and buckets are considered to be tedious and time consuming by over 70% of the interviewees. They also cited water scarcity as a reason for not adopting water-lifting technologies, especially motor pumps.

TABLE 3. Profitability of tomato production using different water-lifting technologies.

	Motor pumps	Treadle pumps	Buckets and watering cans
Average capital cost of a pump (USD)	254	87	3
Average capital cost of accessories (hoses, pipes, filters, etc.) (USD)	137	48	0
Total	391	135	3
Morogoro District			
Expenditure (USD/ha)	861	737	655
Revenue (USD/ha)	1,809	1,584	1,504
Profit (USD/ha)	948	847	790

(Continued)

TABLE 3. Profitability of tomato production using different water-lifting technologies (Continued).

	Motor pumps	Treadle pumps	Buckets and watering cans
Dodoma District			
Expenditure (USD/ha)	1,190	1,175	1,130
Revenue (USD/ha)	3,464	2,661	2,810
Profit (USD/ha)	2,274	1,486	1,680

Source: adapted from Keraita and de Fraiture 2011.

Where to invest

More flexible credit

Farmers need loans to purchase water-lifting technologies and to invest in inputs such as vegetable seeds. As with community managed river diversions, many smallholder farmers rely on SACCOs, which are now entirely dependent on commercial banks for their financing. A government credit assurance scheme would allow SACCOs to develop more flexible loan packages suitable for smallholder farmers.

Pump rentals

Many farmers are able and willing to rent pumps, but there are few available. More pumps could be made available for rent using an 'irrigation service provider' model (Box 3), in which small entrepreneurs hire out pumps on a short-term basis. The service provider takes care of maintenance and offers technical and agricultural advice.

Better quality pumps

There are good quality pumps on the market, but buyers have little information other than what local merchants choose to tell them. A basic buyer's guide produced and distributed by an independent source would be welcomed.

Training extension service providers, farmers and pump dealers

Extension service officers need professional development programs to keep up with the times. Farming systems and practices are changing fast and there is a growing demand from farmers for information on irrigating high-value crops, not just traditional crops and cereals. Extension workers could also provide advice on marketing. Pump dealers could improve their sales by providing more information to farmers on choosing, using and maintaining pumps. Pump manufacturers could support farmers by providing information in local languages. This would have a net benefit for manufacturers, because when one farmer succeeds other farmers follow suit.

Box 3. Irrigation service providers.

Irrigation service providers are private entrepreneurs who rent out small pumps and offer support services to farmers who want to irrigate dry-season crops.

In many sub-Saharan countries, millions of smallholder farmers earn extra cash income from irrigated vegetable cultivation during the dry season. Most use simple hand-watering methods which are time consuming and limit the area they can cultivate. Some farmers use small pumps to expand their cultivated area and with it their profit, but only relatively well-off farmers can afford the initial investment costs and have the means to run and maintain a pump. Women farmers, in particular, face trouble accessing motorized pumps. An alternative is to hire a pump for the time required to irrigate.

An irrigation service provider owns one or more portable motorized pumps along with hoses, pipes and other accessories. The provider rents a pump set to an individual or a group of farmers for a fixed period of time. The provider takes care of the running costs, and operation and maintenance of the pump set. Farmers pay a fixed rate per hour that covers all costs and leaves a profit for the service provider. Depending on the need and the service providers' level of skill and motivation, they can extend their services to offering loans for agricultural inputs, agronomic advice and credit.

Benefits:

- For local entrepreneurs: a profitable business opportunity.
- For farmers: affordable access to motorized pumping as individuals (no need to organize into a collective); potentially related services (agronomic and marketing advice, and credit); and higher profits from vegetable farming due to larger areas and better water supply.

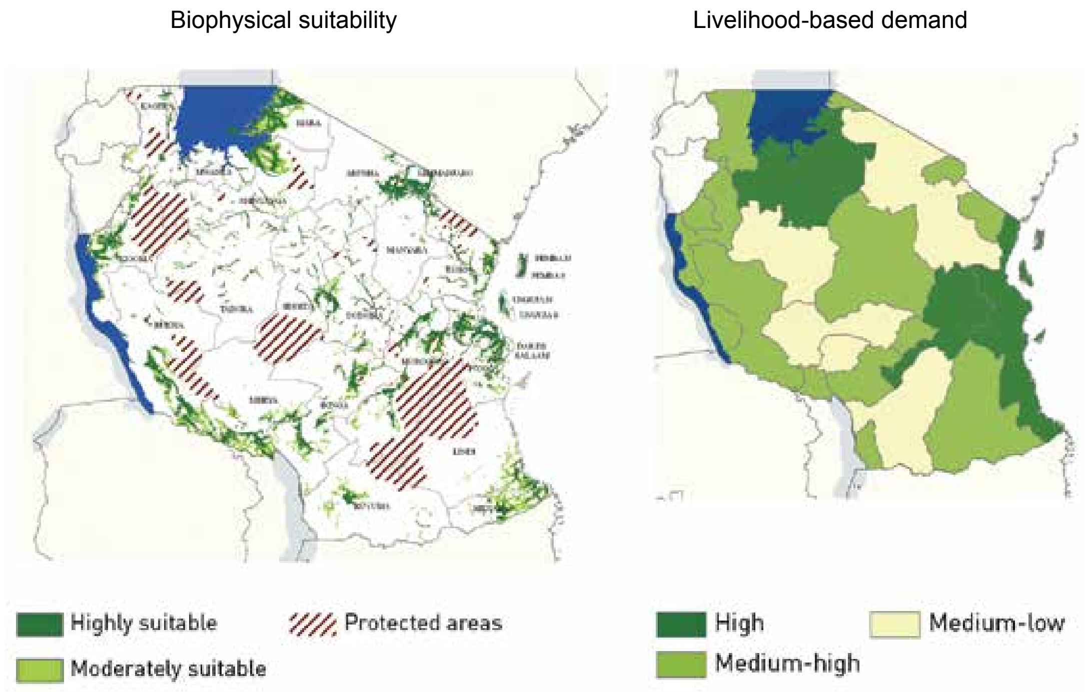
Who benefits and where

Using the biophysical criteria of travel time to markets, availability of surface water and soil type (as a proxy for availability of shallow groundwater), combined with livelihood-based demand, the AgWater Solutions Project estimated that, at a 50% adoption rate, low-cost motor pumps could benefit 532,000 to 781.000 households (8 to 12% of rural households) (Figure 8).

The potential application area is 426,000 to 625,000 ha (1-2% of total agricultural land) in Tanzania. For details on where motor pumps could have the greatest livelihood benefits, see Figure 8.

Taking river basin hydrology, environmental constraints, yield improvements, costs of the investment and price impacts of expanding crop production into account, the potential area expansion for East Africa: 7.3 Mha and 46.5 million people (or 9 million households) (IFPRI 2012b).

FIGURE 8. Potential for low-cost motor pumps to improve livelihoods.



Source: adapted from FAO 2012a.

Stakeholder recommendations.

Stakeholders felt that improving access to, and availability of, good quality pumps, and knowledge of operation and maintenance, were required. They suggested:

- Appropriate and affordable technologies should be identified and promoted.
- Information about the quality of imported goods is available from the Tanzania Revenue Authority and should be shared more widely, i.e., with farmers and extension officers.
- Farmers should be trained in appropriate selection, use and maintenance of pumps.
- The capacity of pump dealers should be improved so they can offer advice to farmers.
- Agro-dealers should be encouraged to reach remote areas.
- A registry of information on different pump models should be available.
- To achieve maximum impact and adoption, the private sector should be targeted by the AgWater Solutions Project to demonstrate that there is huge demand for motorized pumps that could be tapped, if the private sector improved the information and services that they provide.
- Pump rental markets are emerging but options to improve them should be explored.

Source: FAO 2012b.

Conservation Agriculture[4]

The term 'conservation agriculture' (CA) covers a range of techniques used to increase yields by improving soil structure, conserving water and reducing the use of expensive inputs. Farmers using CA techniques have seen higher yields, environmental benefits and greater profits. Farmers are well aware of the value in using CA techniques but lack finances, knowledge and landownership rights.

Where the opportunity lies

Conservation agriculture makes it possible for farmers without direct access to surface water sources to increase yields by improving soil quality through moisture retention, nutrient capturing and preventing erosion (Table 4).

TABLE 4. Examples of CA techniques, what influences farmers' choice and constraints to adoption.

Examples of CA techniques	Factors that influence farmers' choice	Constraints to adoption
Terracing: sections of a hill are leveled or grassed to prevent rapid runoff, aiding water and nutrient conservation. **In-situ rainwater harvesting:** capturing water and conserving it in the soil. **Conservation tillage:** maintaining soil cover and rotating crops. ***Chololo* pits:** micro-catchments and water storage pits. **Trenches:** collect water and act as composting pits. **Cover cropping:** intercropping to reduce evaporation.	• Location and environmental conditions. Ability to conserve soil moisture, e.g., • terraces and conservation tillage in Arusha; pits in Dodoma. • Lower labor requirements were favored in Dodoma. • External support, e.g., subsidized inputs and training. • Gender and livelihood roles.	• Labor intensiveness. • Lack of training. • High capital costs. • Lack of landownership. • Delay in realizing returns (around 2 years).

Source: adapted from Tumbo et al. 2011.

The research

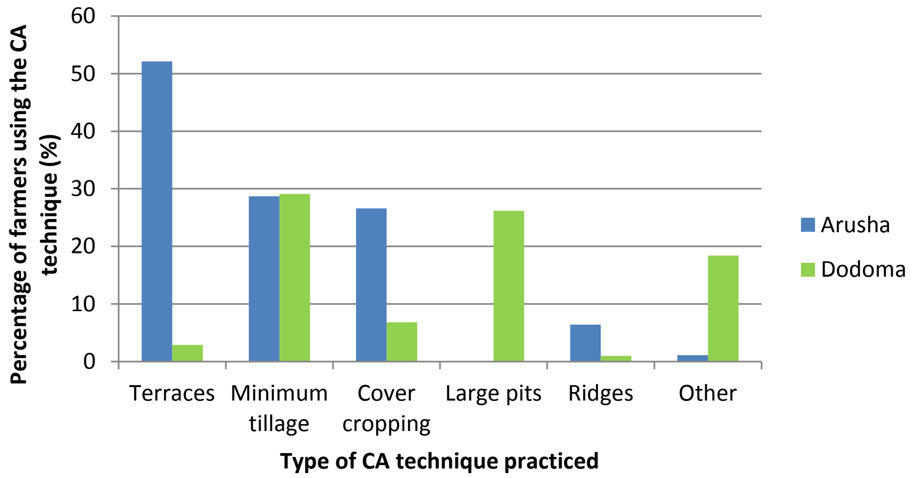
The AgWater Solutions Project team interviewed 200 farmers in eight villages in Tanzania. Villages were located in the Arumeru District, Arusha Region, and Chamwino and Dodoma districts, Dodoma Region. A variety of CA techniques are in use, especially terraces in Arusha and minimum tillage and *chololo* pits in Dodoma (Figure 9).

Many farmers practice two or three techniques; more in the dryer Dodoma region. Poorer households in Arusha invest in fewer techniques. The CA techniques used also vary by gender, with men opting more for ridges and terraces and women opting for minimum tillage and cover cropping.

The use of CA techniques is largely influenced by outside agencies that come and train farmers. These subsequently spread from farmer to farmer: *"Our group started with 19 members and this is the third year that we are practicing CA … it has reached more than 50 households in the village."*

[4] This section is based on Tumbo et al. 2011; and AgWater Solutions Project 2012.

FIGURE 9. CA techniques practiced by the farmers interviewed in the Dodoma and Arusha regions.

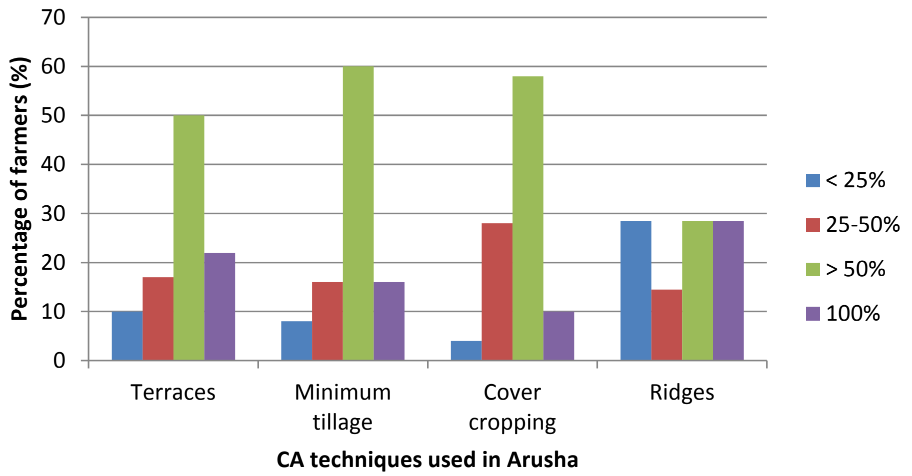


Source: Adapted from Tumbo et al. 2011.

The reasons given by farmers in Arusha for not adopting CA techniques were labor intensiveness, lack of training and high capital costs. In Dodoma, they cited absence of training, poverty and lack of landownership. The delay in realizing returns on investment, which is on average 2 years, also deters some farmers.

Those farmers that have adopted CA techniques have come to rely on them and believe that their crop yields would decline if they stopped using them. Some farmers estimate that the decline would be 50% or more (Figures 10 and 11).

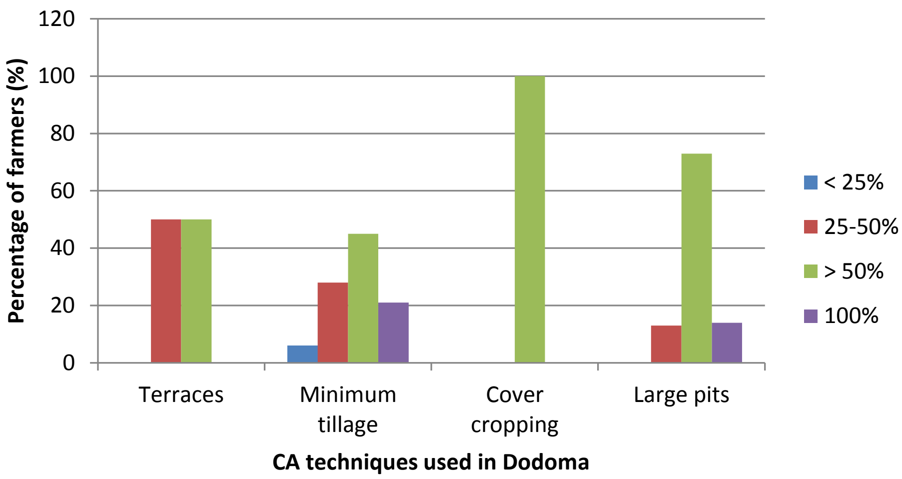
FIGURE 10. Yield loss predicted by farmers in Arusha if CA techniques were removed.



Source: Adapted from Tumbo et al. 2011.

In low rainfall years, conservation agriculture can be particularly helpful in protecting crops. A study during 2007-2008, a year with below average rainfall (630 mm), found a significant difference in yield between conventional tillage (1.7 t/ha) and conservation tillage (3.8 t/ha) (Mkoga et al. 2010). Benefits are found to be greatest when combined with fertilizer application (Rockström et al. 2010).

FIGURE 11. Yield loss predicted by farmers in Dodoma if CA techniques were removed.



Source: Adapted from Tumbo et al. 2011.

Where to invest

The AgWater Solutions Project study found that there are several techniques suitable for further adoption in Tanzania. Combinations of these techniques produce the best results (Box 4). Many of the techniques produced yields that were twice the average for the study area, but yields of sorghum, groundnuts and lablab were low across all the CA techniques studied. Farmers should be provided with several CA options so they can select the most appropriate for their needs, e.g., soil type and the labor available.

Box 4. Recommended CA techniques and benefits.

- Terraces: maximum maize and cassava yield; maize yields of 1.3 t/ha were reported, which is high for the area.
- Large pits and ridges: yields of beans were 1.5 t/ha, which is high for the area; maize yields were 1 t/ha, twice the typical maize yield in the study areas.
- Terraces and minimum tillage: cassava on terraces and minimum tillage (0.5 t/ha).
- In-situ rainwater harvesting and storage.
- Management of strategic watersheds.
- Soil moisture conservation, e.g., through cover crops.
- Optimization of water infiltration and retention – tillage and crop choice.

Incentives

The right incentives, such as training and supporting farmers through the two-year payback period, will promote adoption of CA techniques.

Training

Since farmers adopt CA techniques after being trained, the spread of CA could be increased if there were more trainers. Investments should be made in the training of trainers (e.g., NGOs, suppliers, extension agents) in the use of CA techniques and their benefits. Trainers should be given good quality materials and training packs. Demonstration plots and exchange visits should be included in farmer training programs.

Farmer groups

Farmers report that CA techniques spread when farmers see other farmers getting good results. Forming farmer groups to enhance information exchange could speed up this process. Some of these farmers could also be registered as trainers.

Who benefits and where

The AgWater Solutions Project mapped two CA techniques: in-situ rainwater harvesting and terracing.

In-situ rainwater harvesting

Using the biophysical criteria of topography (slope steepness) and aridity index, combined with livelihood-based demand, the AgWater Solutions Project estimated that, at a 50% adoption rate, in-situ rainwater harvesting could benefit up to 317,000 to 1,447,000 households (nearly a quarter of all rural households) (Figure 12).

The potential application area is up to 2.6 Mha (9% of the total agricultural land area).

Taking river basin hydrology, environmental constraints, yield improvements, costs of the investment and price impacts of expanding crop production into account, the estimated potential population reached through in-situ rainwater harvesting is over 100 million people (IFPRI 2012c).

Terracing

Using the biophysical criteria of topography (slope steepness) and aridity index, combined with livelihood-based demand, the AgWater Solutions Project estimated that, at a 50% adoption rate, terracing could benefit up to 314,000 households (approximately 5% of rural households) (Figure 13).

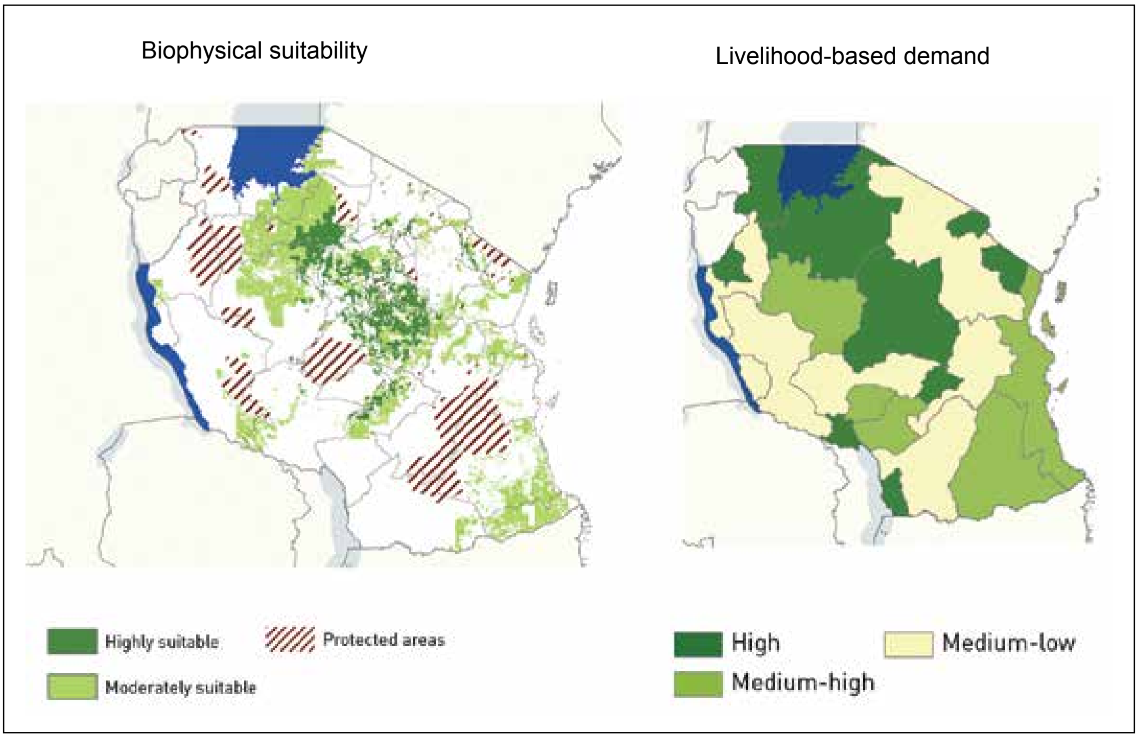
The potential application area is up to half a million hectares (2% of the total agricultural land area).

Stakeholder recommendations.

- Water storage systems or communal groundwater should be encouraged in drier parts of the country like the Dodoma Region.
- The benefits of low- and no-tillage farming need to be clearer because the government has tried its best to provide power tillers to farmer groups and the campaign is still ongoing.

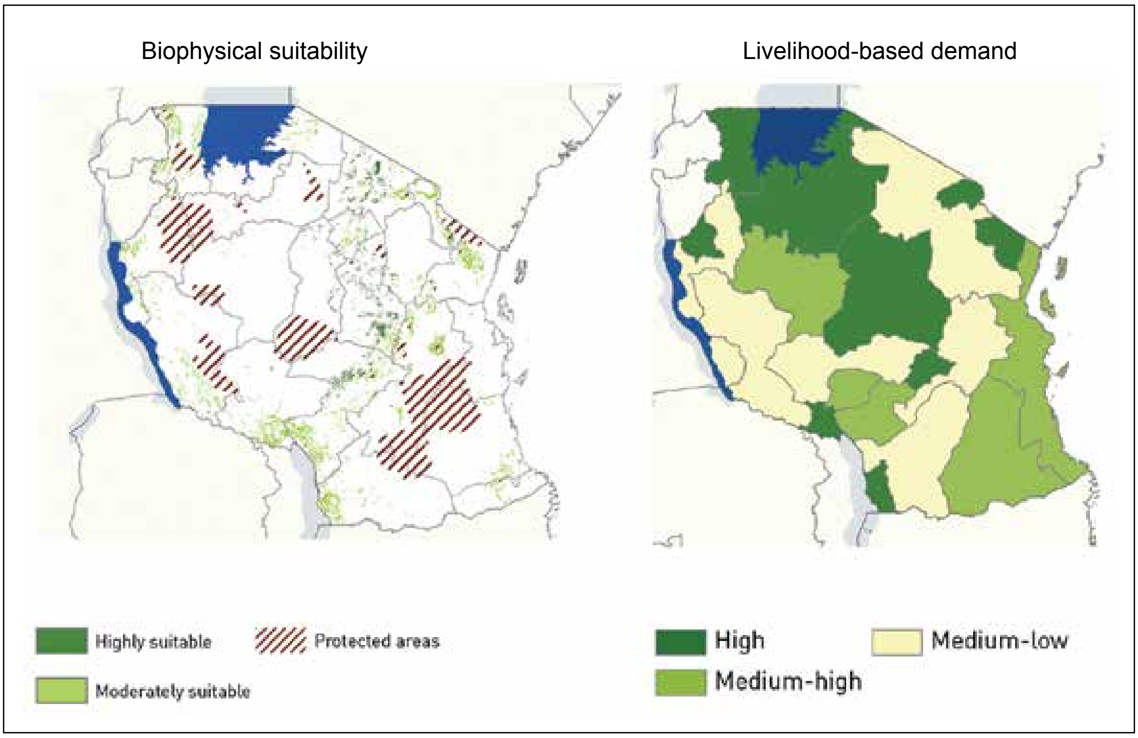
Source: Adapted from FAO 2012b.

FIGURE 12. Potential for in-situ rainwater harvesting to improve livelihoods in Tanzania.



Source: Adapted from FAO 2012a.

FIGURE 13. Potential for terracing to improve livelihoods in Tanzania.



Source: Adapted from FAO 2012a.

SUPPORT MEASURES

Many of the AWM techniques and technologies reviewed require support measures to ensure they address the challenges identified by the project. Suggestions were raised by the case studies and discussed extensively with local stakeholders. In Tanzania, the stakeholders highlighted two key measures: capacity building and improving access to rural finance (Table 5).

TABLE 5. Stakeholder recommendations for AWM support measures.

Crosscutting issue	Action
Capacity building	• Increase knowledge of more efficient water application technologies such as drip irrigation. • Provide training to improve marketing and post-harvest processes.
Improve access to rural finance for AWM	• Improve farmers' business skills so that financial institutions have more confidence in lending to them. • Government credit assurance could be given to existing SACCOs to allow for more flexible loans and other micro-finance options that suit farmer' needs. • Tax exemptions could be considered on agricultural technologies such as motor pumps. This could be a short-term measure so as not to stifle production within Tanzania.

Source: FAO 2012b.

SOCIAL AND ENVIRONMENTAL IMPACT: ANTICIPATING THE CONSEQUENCES[5]

An AWM solution that benefits one farmer may negatively impact someone else or the environment, for example, by diverting water from ponds used for fisheries or livestock or lowering the water table. For any AWM solution to be sustainable, the negative impacts have to be anticipated and minimized as much as possible. AWM solutions may also have unexpected benefits.

The possible and probable impacts of interventions were reviewed through studies in the Mkindo watershed. These studies showed that while expansion of most AWM options will have some negative impacts on water quantity and quality, overall they have positive implications for poverty reduction and gender equity.

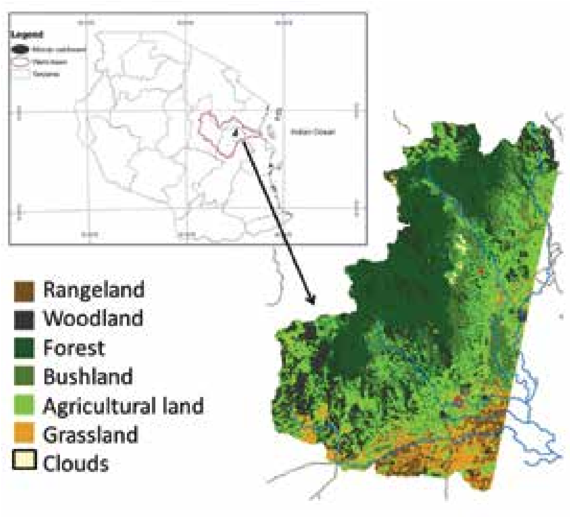
Mkindo Watershed

The Mkindo watershed in the east of Tanzania covers just over 900 square kilometers (km^2) of mountains, wetlands and agro-pastoral lowlands (Figure 14). Two rivers feed the wetland which has been gradually cleared for agriculture, mainly paddy. A wide range of AWM options are used in the watershed, including gravity-fed furrow systems, unlined canals, supplemental irrigation from rivers, manual irrigation with buckets and motorized pumps. Some commercial growers use sprinklers and operate contract farming systems with smallholder farmers.

One-quarter of the people in Mkindo live below the poverty line. Rice yields in the main irrigation scheme are twice those of rainfed farms. Livestock owners are the least secure.

[5] Based on SEI 2012.

FIGURE 14. Mkindo watershed.



Source: SEI 2012.

Equity

Access to water and the way it is managed are not always equitable and there are often tensions between users (de Bruin et al. 2012). In the dry season in Mkindo and many other river basins, water scarcity forces livestock owners to move their herds to the nearest available water source, resulting in tension with farmers. Based on a review of several possible AWM interventions, it was found that combining the expansion of irrigation schemes with purpose-constructed livestock watering ponds would be a catalyst for food production, jobs, improved livestock products and sustainable resource management (Table 6). Conflicts can be avoided by involving livestock owners and farmers in planning and strengthening watershed management (Cinderby et al. 2011). There are currently no organizations to coordinate watershed level management.

TABLE 6. Social and environmental impacts.

Technology	Social impacts			Environmental impacts		
	Equity	Gender	Poverty reduction	Water quality	Water quantity	Natural resources
Gravity-based furrow system for paddy rice production	+ /-	-	+	-	-	-
Diesel pumps irrigating from rivers	+ / -	+	+	-	-	-
Livestock watering ponds	+	+	+	NA	+	+
Livestock watering canals	-	+	+	NA	NA	-
Large-scale irrigation for cash crop production	-	NA	Unclear	-	-	-

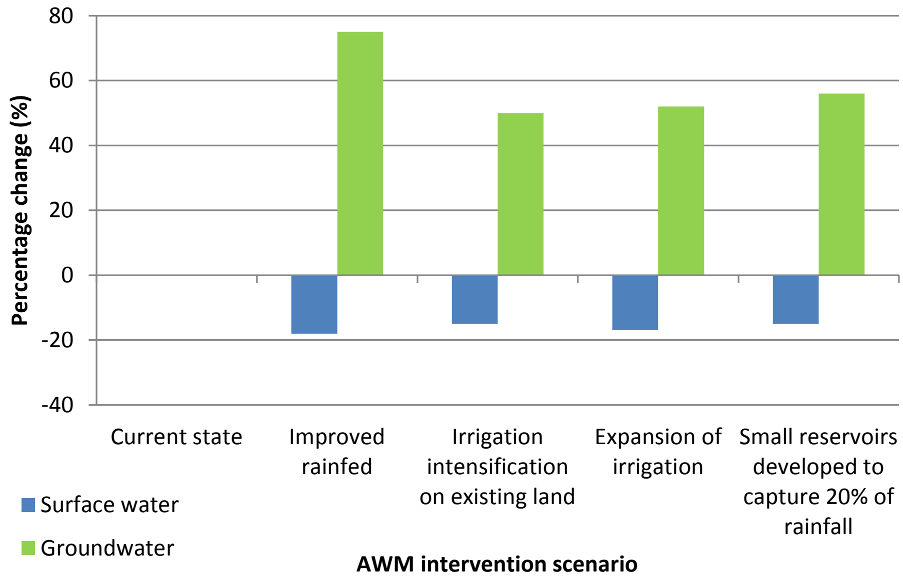
Source: SEI 2012.

Notes: + (positive impact); - (negative impact); NA (no specific impact); Unclear (there could be no impact or the impact could be positive or negative).

Hydrologic and Yield Impacts

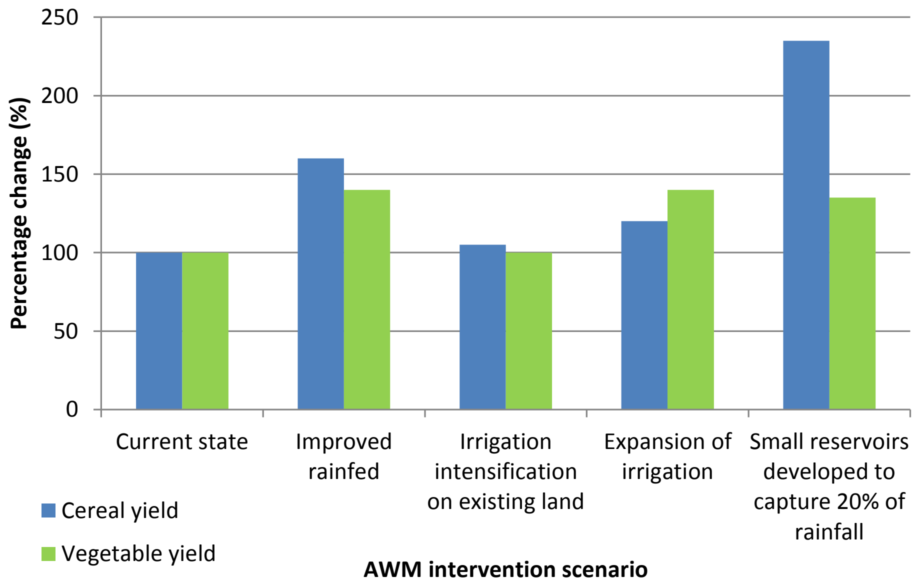
The impact of AWM interventions on hydrology was considered based on improving rainfed agriculture, intensification on existing land, expanding the irrigated area and developing small reservoirs that capture 20% of the rainfall (Kongo 2012). Crop intensification would decrease surface water availability by 14-18% and increase groundwater availability by 50-75%. Yields could increase by as much as 135% for rice and maize, and up to 40% for vegetables. Small reservoirs would increase crop production the most (Figures 15 and 16).

FIGURE 15. Potential impact of AWM options on the water balance of the Mkindo Basin.



Source: SEI 2012.

FIGURE 16. Potential impact of AWM options on crop yields in the Mkindo watershed.



Source: SEI 2012.

Accelerating AWM Adoption

Local informal village committees play an important role in water management, but are fragmented and not officially recognized (Stein et al. 2011). If they could be brought into the formal governance system it could improve AWM and the benefits that accrue to community members. Potentially, this could be achieved through the WUAs being established by the Wami River Basin Authority.

Improving relations between village institutions and higher levels of government will increase the opportunity for negotiating the multiple uses of land and water and the potential negative impacts of interventions.

Linking AWM with Other Interventions

A combination of different AWM solutions and social and institutional improvements will result in the greatest positive impact on livelihoods. Existing micro-finance initiatives can be supported to reach more households. Training farmers to use improved agricultural practices has improved yields without farmers having to invest in new technologies.

Mkindo farmers and local experts suggest:

- Multiple AWM solutions for rainfed and irrigated agriculture, and livestock.
- Access to credit and training.
- Involvement in planning and governance.

CONCLUSIONS[6]

Agricultural productivity can be improved through investments in infrastructure, financing and training. Combinations of AWM options will offer the greatest benefits, for example, a system to improve community managed river diversions could require the following components:

- Expand and develop water management infrastructure at the farm level by providing external support for major infrastructural work such as the construction of reservoirs, main canals and off-takes.
- Provide training and extension services to improve on-farm management practices and the business skills of farmers, such as bookkeeping and marketing.
- Improve access to financing options such as micro-credit facilities to enable investment in improved technologies and practices.
- Promote the combined use of proven technologies such as small diesel/electric pumps and conservation agriculture.
- Support marketing, post-harvest storage and processing of agricultural products.

[6] All figures provided in this section assume that 50% of the total potential users adopt the AWM option. All figures are taken from FAO 2012a.

However, there are challenges in managing the changes equitably and limiting the negative social and environmental impacts. Strengthening local institutions and linking them with formal institutions is likely to improve negotiation, planning and the positive outcomes of AWM interventions. Investing in a mix of AWM solutions will avoid conflict and marginalization of vulnerable groups.

To recap, if all the farmers in Tanzania – for whom water is a limiting factor for agriculture – were to adopt some form of AWM option, around 17 million people could benefit. Some of the AWM options that could be implemented to achieve this are:

- **Communal irrigation schemes** which could benefit up to 509,000 households irrigating 1.6% of the total agricultural land. The investment cost could be as much as USD 2,162 million. Interventions need to include improvements to physical infrastructure and training for farmers, especially in marketing and business aspects.
- **Motor pumps** could benefit up to 781,000 households irrigating 2% of the total land area. The total investment cost could be around USD 312 million. Increasing access to pumps will require greater information, more local sales points and finances. Irrigation service providers may offer a solution for some smallholders.
- **Conservation agriculture** in the form of **in-situ rainwater harvesting** could benefit up to 1.4 million households irrigating 9% of the total land area. The investment cost could be as much as USD 536 million.
- **Terracing** could benefit up to 314,000 households irrigating 2% of the total land area. The total investment cost could be up to USD 349 million. To expand conservation agriculture, farmers need confidence in the techniques. This can be achieved by providing demonstrations and training. Higher yields and greater incomes will require extension services. Financing may also be required as returns on investment can take a few years.

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