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Irrigation and crop diversification in the 25 de Setembro irrigation scheme, Mozambique

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ABSTRACT

Crop diversification is one way of improving the profitability of small-scale irrigation schemes. The 25 de Setembro scheme is an ideal site to analyze diversification, as it is influenced by the markets in Maputo and South Africa. This study uses information gathered from observations, discussions with irrigators and an irrigator survey. Results identified seven irrigator types with different crop diversification strategies predominantly influenced by resource constraints. Most irrigators produce traditional crops, although there are opportunities for growing crops that are more profitable. Improved extension services, to identify cropping strategies that better align with market demand, would improve profitability.

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Mozambique; small-scale irrigation; crop diversification; market access; profitability

Introduction

Poverty in Mozambique is concentrated in rural areas, where the agricultural sector employs more than 80% of the labour force. Family farms dominate agriculture and mainly practise subsistence agriculture and dryland farming. Improving the productivity of small-scale farmers would increase agricultural output. However, to achieve this, some transformation of the sector is needed such as the adoption of strategies to create a more integrated agricultural sector focusing on job creation, food self-sufficiency and feedstock production for both domestic use and export (Sitóe, 2005).

In Mozambique, crop production is characterized by low productivity and limited intensification (Sitóe, 2010; Mosca, 2014). With the population increasing by 600,000 per year (UN, 2011; INE, 2010b) it is imperative to improve the productivity of the agricultural sector.

One key to improving productivity is irrigation, which is currently underdeveloped. Its potential is about 3 million hectares, but only 90,000 hectares are currently irrigated. Most of the systems use furrow or surface irrigation and were developed during the colonial period (mainly in the 1950s) in the southern region. Development ceased during the war of

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independence (1961–74) but resumed after 2001 with public funds and donations from development partners, which mainly resulted in the formation of small-scale irrigator associations and cooperatives with plot sizes ranging from 0.5 to 10 hectares. Still, large-scale commercial irrigation schemes and individual farms were also developed. In central and northern Mozambique the focus has been on new development, while in southern Mozambique it has been on rehabilitation of the existing schemes and other aspects such as value chain improvement.

Although farmers produce a variety of crops, about 80% grow maize, and 76% cassava. Both crops are mainly for subsistence (INE, 2010a; MINAG, 2010). Small-scale farmers, therefore, have little produce with which to raise revenue for farm inputs and other household expenses, such as health and education. As a result, households depend on diverse income sources including agriculture, forestry, livestock and off-farm work (Cunguara & Garrett, 2011).

Irrigation enables farmers to farm year-round and diversify their crops. This can increase food security and profitability by enabling farmers to grow a greater range and variety of commodities and benefit from seasonal price variations in the market. Diversification, both in agricultural production and income sources, reduces the risks associated with crop failure: diseases, pests, extreme climate events, fluctuating market demand and commodity prices (Cunguara & Garrett, 2011).

To improve the productivity and profitability of small-scale irrigated farms it is necessary to understand their reality, including the factors impeding their profitability and the context in which they operate with respect to socio-economic characteristics and government policies (Sitóe, 2005). This article aims to contribute to this understanding using the 25 de Setembro irrigation scheme (hereafter, the scheme) as a case study. It explores the potential to improve profitability through crop diversification, improved market access and extension services and how different farmer types adopt different strategies.

Irrigated agriculture in southern Mozambique

Maputo Province is in southern Mozambique; it includes the capital city and the population of the whole province is about 1.2 million inhabitants. The climate is semi-arid; the wet season occurs from October to March, with average yearly precipitation of 761 mm and evaporation of 1245 mm (FEWS NET, 2016). During the wet season, January–February is when precipitation is higher than evaporation. The beginning and the end of the wet season vary significantly from year to year, and the ability to predict this variability is still poor.

This variability means that rain-fed agriculture is associated with high risk. One way of managing and reducing this risk is to cultivate riparian land, which has better soil moisture and longer water retention. This practice extends the cropping season to July or August and enables the production of two crops. Another way of managing drought is the construction of irrigation systems. Of the 90,000 hectares of irrigated land in the country, 20,086 hectares is in southern Mozambique, and of this, close to 19% is located in Maputo Province.

Most schemes in southern Mozambique are small-scale, constructed by the government and managed by irrigators through associations or cooperatives. Associations aim to promote social, educational, cultural and political objectives to benefit certain groups; they are philanthropic in nature. Cooperatives are primarily facilitators of business operations (SEBRAE, 2015). In small-scale schemes, irrigators are responsible for maintenance of the infrastructure. Two types of large-scale schemes also exist, constructed by the government

or private companies. Private companies also manage the schemes constructed by the government and are responsible for maintenance of the infrastructure as well as water distribution. Farmers are responsible only for maintaining the canals that convey water to their plots and paying for water service.

The government provides extension officers to help irrigators improve their performance, and most are allocated to small-scale schemes. In emergency situations, the Ministry of Agriculture and Food Security provides inputs to farmers, both irrigators and rain-fed.

Traditionally, farms in Maputo Province produce maize, cowpea and groundnuts (Sitóe, 2005), mainly for subsistence. Farmers in Maputo Province wanting access to markets with better prices, mainly in Maputo City, face high transportation costs. The proximity of southern Mozambique to South Africa means that farmers may face labour constraints due to worker migration as well as unfair competition from imports, particularly of fresh produce, from neighbouring countries.

Study area, methodology and data collection

A number of schemes, both large and small, were considered in this study. In collaboration with the National Institute of Irrigation (www.inir.gov.mz), the 25 de Setembro scheme was selected based on its potential to improve or address agronomic practices, institutional capacity, market barriers and farming practices and factors such as site accessibility, research cost, crop diversity and the willingness to collaborate of the district authority. The scheme is in Boane District, 30 km south of Maputo City. Constructed in 1975, it consists of 1433 m of concrete canals and 2797 m of earthen canals supplying 38 hectares. After independence, in 1981, the scheme was transferred to the Cooperativa 25 de Setembro, which then had 56 members. The irrigators, all members of the cooperative, came from various parts of Mozambique. The number of irrigators has since declined to 38, with 22 being females and 16 males (Table 1).

Water is extracted from the Umbelúzi River using a diesel pump, distributed by gravity through a canal system, and applied to the fields using furrow system. Currently, irrigators pay for pump fuel individually. A schedule is maintained in the cooperative's office, and members can book an available time. However, this is subject to constant negotiation as, at the time of writing, irrigators could receive water only every 15 days, on average. Irrigators can use the tractor and implements for fieldwork but have to pay a fee, mainly to cover the fuel cost. The cooperative also rents the tractor to neighbouring farmers at commercial rates. Irrigators can make their own decisions about what to plant and when, but have to report this to the cooperative's chief of production.

The cooperative has faced several difficulties, such as breakdown of the tractor and the pump, management issues, members leaving the scheme, non-payment of fees and the theft of chickens, which resulted in cessation of chicken production and distrust among members. Floods in 1984 destroyed much of the infrastructure, which was eventually repaired with support from Helvetas (a Swiss NGO) and the government. In 2015, the Japanese International Cooperation Agency donated a new tractor and two-ton truck.

Both men and women participate in the majority of farm work. However, the men are responsible for building, fetching water and supplementing household income by off-farm work, while the women are responsible for most domestic work.

Table 1. Farm and socio-demographic characteristics of 25 de Setembro.

Characteristics	25 de Setembro
Year established	1981
Number of irrigators	56
At establishment of scheme (1981)	38
At time of study (2015)	
Gender of household head	68%
Male	32%
Female	
Irrigators' mean age	57.0 (17.8)
Mean household size	6.8 (2.5)
Education	23%
No formal schooling	32%
Some primary school	5%
Completed primary school	27%
Some secondary school	5%
Completed secondary school	9%
Professional/college/trade	
Years of irrigating within the scheme	22.6 (10.4)
Irrigated area (ha)	38
Mean irrigated area (ha)	1.1 (0.5)
Main crop 1	Maize
Main crop 2	Cabbage
Main crop 3	Tomato/green beans
Legal structure	Cooperative is legally registered
Soils	Predominantly fertile
Rainfall	650–900 mm/y

Note: Figures in brackets are standard deviations.

This article reports on a range of data collected over a two-year period. First, a baseline survey was undertaken in July 2014 to elicit household information: demographics, farm characteristics, use of financial services, asset ownership and market conditions. The questionnaire was piloted, revised and then implemented by trained enumerators through face-to face interviews with 25 of the 38 households. Two short surveys of a panel of 20 randomly selected irrigators were undertaken, and two focus groups were held in January and July 2015 aiming to evaluate the progress of the project activities and the farmers' engagement, when possible with different farmers; however, the small number of households meant this was not always possible. Data collection also included observations by two project officers regularly visiting the scheme; reports from the meetings of the Agricultural Innovation Platform; and discussions with irrigators and scheme leaders.

The survey data were used to produce frequency tables and an index of asset ownership and to support the development of typologies. The qualitative data were used to support the discussion of the quantitative findings as well as the development of the typologies.

Results

The results are reported in five parts: (1) crop and income diversification; (2) factors influencing crop choice; (3) barriers to improving productivity and profitability; (4) farmer typologies; and (5) crop diversification strategies.

Crop and income diversification

Household income in the scheme relies on a diverse income stream: 32% of irrigators work off-farm, and 68% grow more than one crop (Figure 1). In total, 18 different crops are grown

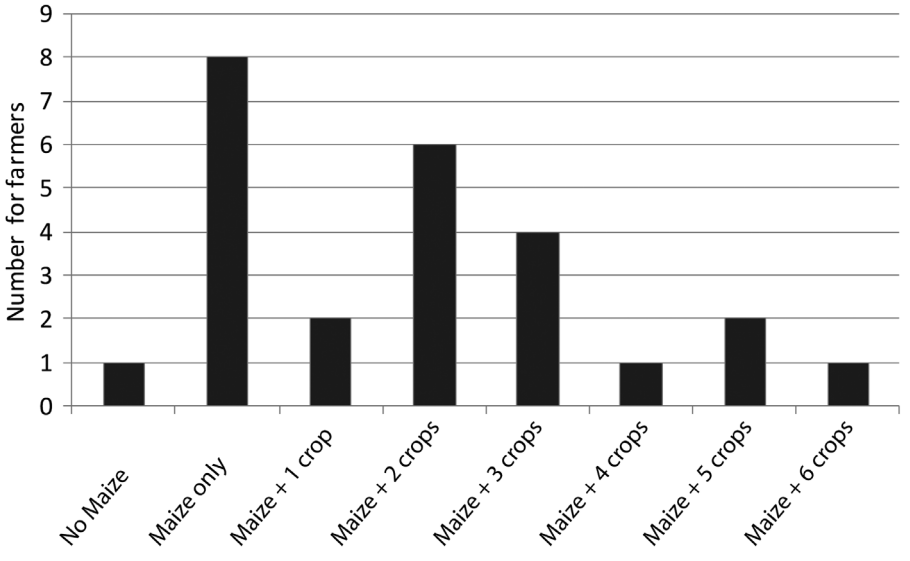

Figure 1. Crop diversification at 25 de Setembro (survey data).

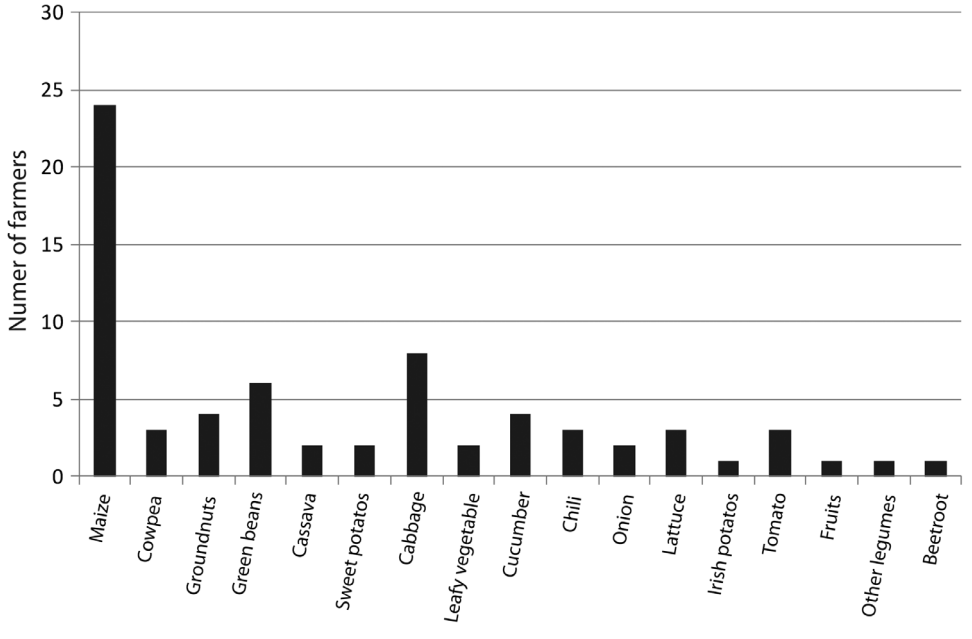

Figure 2. Frequency of crop production (survey data).

(Figure 2). According to focus group discussions and the short surveys, the main advantage of diversification is to reduce the risks associated with market fluctuations, pests and diseases, post-harvest losses and climatic uncertainties. This confirms the findings of Cunguara and Garrett (2011).

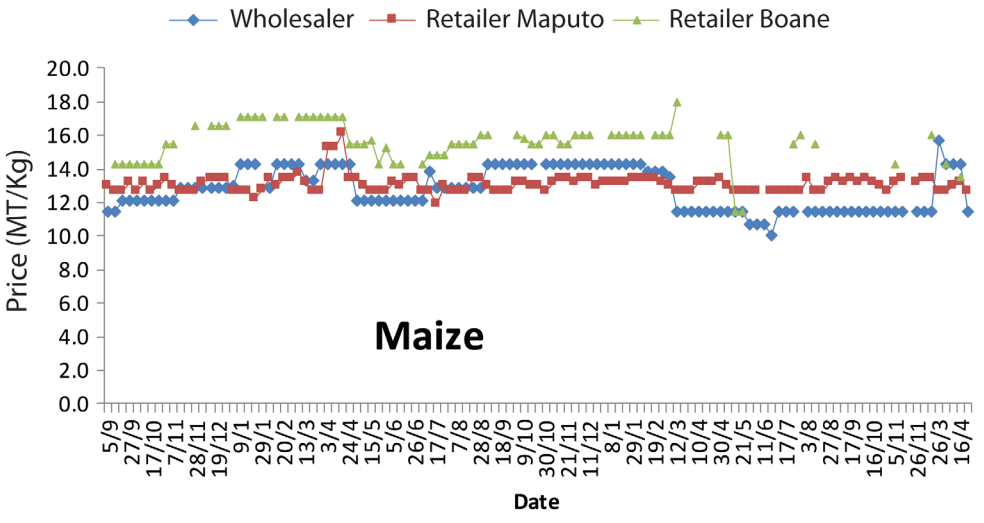

Figure 3a. Price variability for maize in wholesale and retail markets (SIMA, 2015).

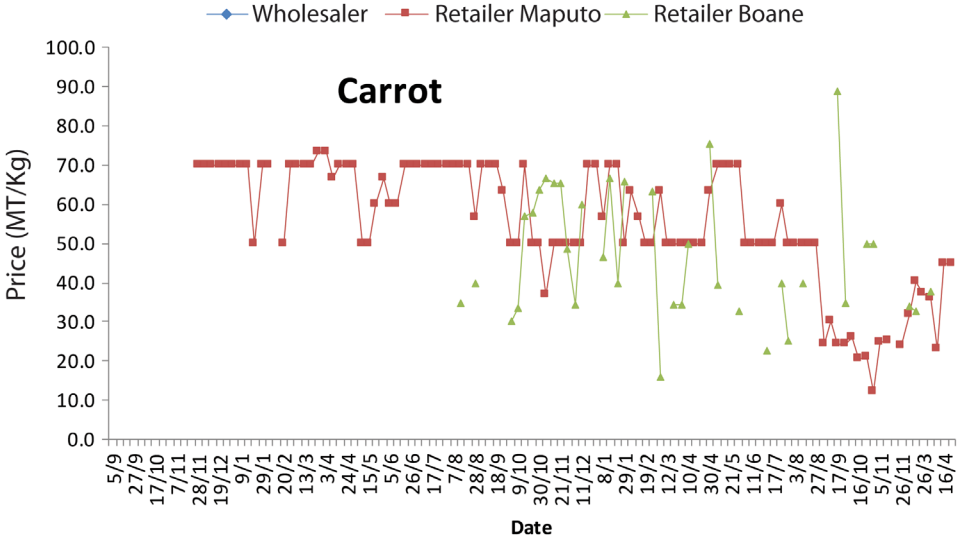

Figure 3b. Price variability for carrots in wholesale and retail markets (SIMA, 2015).

The most frequently grown crops are maize, cabbage and green beans (Figure 2), all of which are traditionally grown on rain-fed land (Bartecchi, 2011). Many families have to sell their crops immediately after harvest when prices are low because of their need for cash. Some of the vegetables, such as tomatoes, can only be stored for a limited period. Other vegetables, such as chillies, have a more limited use in traditional food systems and are grown for the Maputo market. Two types of diversification are evident among the irrigators: production of traditional crops – maize, cabbage and green beans – and production of non-traditional crops – tomatoes, chillies, cucumbers, onions, lettuce, potatoes and beetroot.

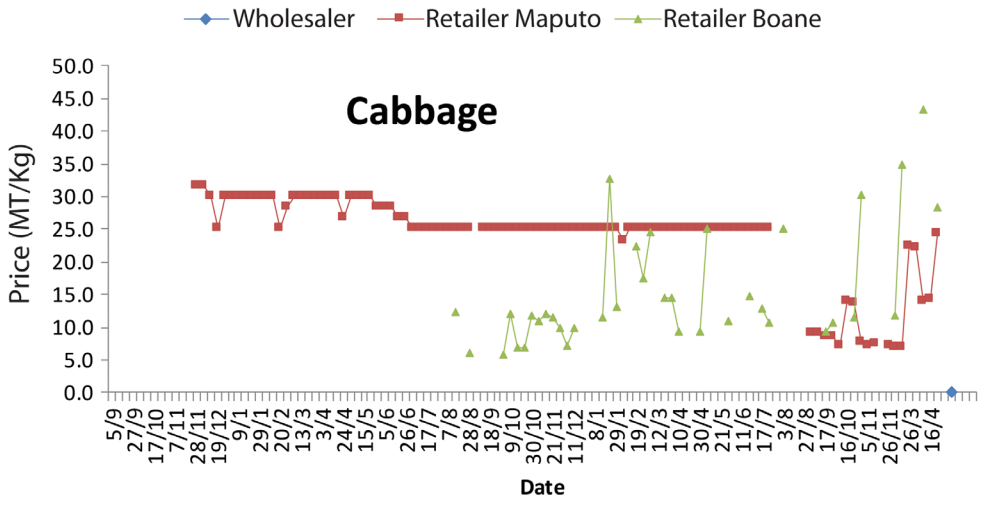

Figure 3c. Price variability for cabbages in wholesale and retail markets (SIMA, 2015).

Table 2. Crop prices in wholesale and retail markets in Boane and Maputo (in Mozambican Metical, MT).

	Crop							
Market variables	Maize	Cowpea	Beans	Sweet potatoes	Potatoes	Cabbage	Carrots	Tomatoes
Wholesale market								
Number of observations[a]	115	116	117					
Mean price (MT)	12.78	19.19	38.90					
Coefficient of variation	10.0%	5.0%	18.6%					
Retail, Maputo								
Number	117	118	118	114	56	100	105	105
Mean price (MT)	13.09	21.21	45.72	14.48		23.90	55.47	30.14
Coefficient of variation	4%	8.5%	18.4%	20.1%	21.2%	27.6%	28.0%	17.4%
Retail, Boane								
Number	75	50	86	39	63	37	36	39
Mean price (MT)	15.63	38.13	62.08	25.92	26.92	15.48	46.57	26.26
Coefficient of variation	7.7%	20.8%	12.4%	54.9%	17.4%	58.3%	35.4%	23.9%
Relationship of retail market prices (BRP – MRP)								
Number[a]	75	50	86	73	31	36	36	39
% BRP<MRP[b]	1.0%	0.0%	0.0%	50.7%	8.0%	75.0%	55.6%	60.0%

[a]Number of price observations on which the mean (or % <0) is computed.
[b]Percentage of weeks during which the Boane retail price is lower than the Maputo retail price.
Sources: SIMA (2015) and survey data.

Factors influencing crop choice

Market segments and price fluctuations

To explore how crop price and price fluctuations influence cropping decisions and to identify potential cropping strategies, seasonal variations in crop price were analyzed for the wholesale market and the retail markets in Maputo City and Boane from September 2012 to May 2015. The analysis used weekly data from Sistema de Informação de Mercados Agrícolas (SIMA, 2015). Of the crops grown at the scheme, wholesale prices were available for three crops and retail prices for eight crops (Table 2).

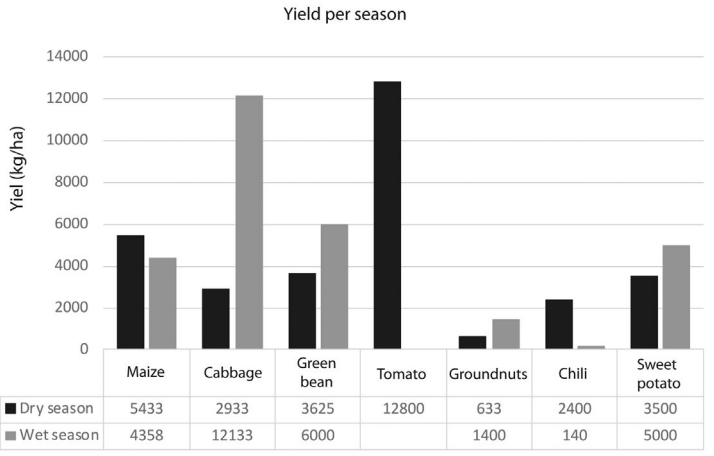

Figure 4. Total crop yield per season for 25 de Setembro scheme (SIMA (2015) and survey data).

Not surprisingly, vegetable prices fluctuate more than maize and other staple foods, such as cowpea in Maputo and beans in Boane. The retail price of vegetables tends to be more variable in Boane than in Maputo, with the exception of potatoes and beans. Potatoes are more often available at Boane than at Maputo, probably because potatoes are grown locally. Carrot and cabbage prices in Maputo were quite stable from 2012 to 2014 (Figure 3b and 3c). This may indicate that imports influence the price of these crops more than local production.

SIMA provides only consumer prices. The price paid to farmers will generally be lower, even though the higher prices for basic food in Boane suggest that there is a potential local demand. The analysis of the difference between retail prices in Boane and Maputo (Table 2) and the variability of price (Figure 3(a)–3(c)) identified three types of production scenarios:

(1) Traditional crops such as maize, cowpea, beans, cassava and groundnuts are the staple local foods. For these products, the Boane retail price predominantly remains above the Maputo retail price, except for a short period during the harvest of the rain-fed crops when prices in Boane plunge in response to high supply. However, this pattern is less clear with sweet potatoes, with occasional high weekly variation due to irregular local supply.

(2) Other products with local demand, mainly vegetables such as cabbage or tomatoes, have an unpredictable variation of price in the retail market at Boane and fluctuate with local supply.

(3) Products more connected to the Maputo market, such as potatoes, have unstable prices, which may indicate that local producers are failing to provide regular supply. The retail prices of these products are highly variable from week to week, even during the wet season, when production is much lower. During the main production season of traditional foods, the prices can fall below transportation costs, which occurs when other neighbouring areas supply the wholesale market.

The prices of local but less commonly produced crops are more stable due to the regularity of the imported supply. Hence, these products could provide an opportunity for local growers, as they are associated with less market risk.

Seasonal variability of yield

The risk of diseases and pest attacks increases in the wet season. Hence, the dry season presents an opportunity to minimize input costs and yield losses. This is particularly the case for tomatoes, which are only produced during the dry season (Figure 4).

Comparing the yield of major crops produced during the wet and dry seasons (Figure 4), the highest yields for maize (5432 kg/ha) and chilli (2400 kg/ha) are achieved during the dry season, when irrigation and soil moisture can be better managed to meet water requirements.

The highest yields of cabbage (12,133 kg/ha), green beans (6000 kg/ha) and sweet potato (5000 kg/ha) are obtained in the wet season, when these crops receive the highest prices due to lower supply. Hence, irrigators growing these crops on dry land during the wet season are increasing their productivity and should be more profitable. However, farmers said that to be successful they needed better technical skills and/or access to farm inputs, funding and labour.

Market access

Irrigators seem to have poor access to market information. They have two main decisions to make: when to plant, which influences timing of selling; and where to sell. Irrigators usually sell their produce immediately after harvest: during February and March in the wet season and July to September in the dry season. Buyers often harvest the crops. Although the prices paid for commodities at the farm gate are lower, compared to those paid in Maputo City (Figure 5a and 5b), when the crops are collected by buyers the farmers do not have to pay harvest and transportation costs. At harvest times, prices are generally lower, as supply in the market is high (Figure 3a–3c); Figure 5), although there may be high weekly variations. For example, the price of tomatoes can reach 40 MT/kg in Maputo in the wet season and 28 MT/kg in the dry season. The difference is particularly high for some crops, such as cabbage, with a price of 15 MT/kg for large cabbages (4–5 kg) at plot level compared to 15–20 MT/kg at the market in Boane and 50 MT/kg in Maputo. However, for other crops, such as green maize, the difference is not significant.

Irrigators do not grow tomatoes in the wet season and do not benefit from the higher prices during that season. The price difference between the farm gate and Maputo is particularly high for cabbage in both dry and wet seasons. On the other hand, there is a very little difference in maize prices, which confirms the value of dry-season maize.

According to the baseline survey, only 27% of irrigators were aware of buyers who will pay a higher price than they were currently receiving. However, irrigators perceive that they are unable to sell to these buyers due to high transportation costs.

Technical skills and extension services

There has been no assessment of the technical skills of irrigators in the scheme. Observations and conversations at the plot level suggest that irrigators base their irrigation decisions on the appearance of plants and the soil surface. As a result, some farmers are likely to

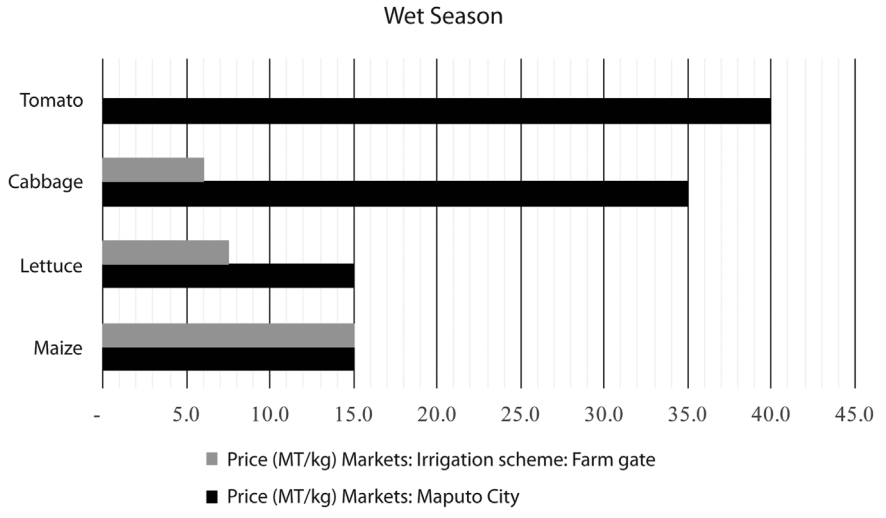

Figure 5a. Wet-season crop prices at 25 de Setembro's farm gate and Maputo City Market (SIMA (2015) and survey data).

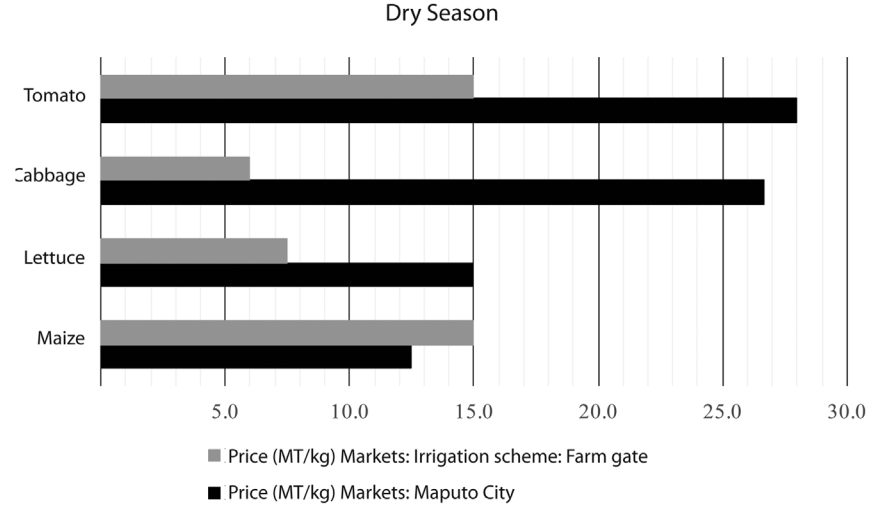

Figure 5b. Dry-season crop prices at 25 de Setembro's farm gate and Maputo City Market (SIMA (2015) and survey data).

over-irrigate, leading to nutrient leaching and reduced productivity, while others are likely to under-irrigate due to the high cost of fuel, resulting in yield losses.

Extension services are critical to provide crop management advice – such as the type, amount and relative importance of farm inputs, crop choices, irrigation scheduling and market options – and to improve agricultural and livestock practices. It is the responsibility of the government to ensure that extension officers are available free of charge and assist farmers where and when needed. However, due to the size of some regions, it is difficult to provide these services consistently across regions. The local authority has 12 extension officers to cover all the farmers in the district for rain-fed, irrigated and livestock advice.

Table 3. Main constraints on improving the viability of land.

Constraint	Irrigators experiencing constraint
Inputs (seeds and fertilizer)	84%
Implements and tools	64%
Access to functional markets	36%

Extension officers have little influence in the scheme. According to the short survey, only 28% of farmers have accessed an extension officer during the last two years. According to the baseline survey, 40% make their farming decisions based on their own experiences, conversations with other farmers and market observations. This suggests that extension officers are not present as frequently as they should be, and that consequently they are adding little to irrigators' knowledge and skills. Field observations suggest that the presence of extension officers is infrequent. One of the main reasons for this is poor salary and working conditions. The average salary for extension officers is USD 111 per month, while similarly skilled officers in the private and NGO sectors are paid approximately USD 1000 per month (MINAG, 2010). Consequently, the more experienced extension officers look for better conditions, contributing to high staff turnover (Eicher, 2002), which affects the efficiency and motivation of extension officers. Budgetary constraints further affect their ability to provide irrigators with appropriate services as officers lack access to transportation and ongoing training.

These findings are consistent with the work done by Eicher (2002), which covered three provinces and identified a link between low agricultural productivity and lack of adequate technical support from extension services as well as the extension techniques used. The link between extension services and agricultural research is weak, and officers' advice is not informed by the most recent research. Farmers' field schools are the method most commonly used for the transfer of technology. These schools use the 'training and visit' approach, which is 'top-down' and not oriented to the needs of farmers (DANIDA, 2002).

Despite the lack of extension services, the cooperative has received extensive support from the government and NGOs to improve agricultural practices. Examples are (1) the lining of 700 m of irrigation canal in 2007 by the aluminium smelter, Mozal; (2) equipment for processing of sweet potato into pulp from the International Potato Center in 2008; and (3) training in marketing under the Development Assistance for Private Sector Agriculture Initiative in 2009.

Barriers to improving productivity and profitability

With respect to the use of financial services, 36% of irrigators had no access to formal financial services, 52% had a bank account and 8% had a bank loan. One irrigator, in addition to a bank account and credit from the bank, also used telephone banking. Access to loans is a crucial issue in this scheme as the ability to purchase inputs (seeds and fertilizer) and implements are two of the main constraints, reported by 84% and 64% of irrigators, respectively (Table 3). Reflecting this, while all farmers claim to use some pesticides, not all use fertilizer.

According to Leonardo et al. (2015), labour is the most limiting factor for improved productivity in Mozambique; others disagree and find that productivity is constrained by

Table 4. Farmer types and their characteristics.

Farmer type	1	2a	2b	3a	3b	3c	4
Farmer label	Widowed farmer	Weekend farmer	Non-resident farmer	First- generation farmer	Second-generation farmer	New-generation farmer	Innovative market gardener
Number of farms	7	4	3	3	4	3	1
Farm numbers	407, 415, 410, 422n, 423, 413, 403	402, 414, 416, 411	408, 412, 404	406, 401, 424	418, 419, 425, 420	421, 405, 409	417
Resident of 25 de Setembro	Yes	No	No	Yes	Yes	Yes	Yes
Average age of household head	60.7 (15.0)	51.0 (20.6)	63.2 (16.8)	74.7(11.7)	57.5(9.3)	32.7(4.0)	54.0
Average irrigated area (ha)	0.86 (0.24)	1.00 (0)	1.38 (0.75)	1.67(0.29)	1.13(0.48)	1.17(0.76)	0.07
Area per full-time-equivalent family member (ha)	0.57 (0.25)	2.28 (1.18)	0.94 (0.67)	0.57 (0.24)	0.56(0.31)	0.83(0.29)	0.03
Average use of financial products (0–3 products)	0.4 (0.8)	1.3 (0.6)	0.5 (0.6)	0.7 (0.6)	1.0 (0.0)	0.7 (0.6)	3.0
Average estimated value of assets owned (scale of 1–5)	1.7 (0.9)	4.3 (1.5)	4.2 (1.0)	3.7 (1.1)	4.2 (1.5)	2.7 (0.6)	4.0

Note: Standard deviations in parentheses.
Source: survey data.

location and is context specific (Beekman, Veldwisch, & Bolding, 2014). This study concurs with the latter and finds that labour is a constraint only in some households, which affects crop choice or requires cash payments to hire non-family labour. In rain-fed systems, labour demand reflects the intensive manual work associated with land preparation. In the scheme, farmers use tractors for land preparation, and the critical labour issues are seeding, managing water, and notably weeding. Labour availability depends on family size, the age of the household head and the number of young people available. Discussions with irrigators suggest that young people prefer irregular but better-paid off-farm jobs, which takes them away from home and leaves the grandparents with the responsibility for their grandchildren and the farm. Domestic tasks reduce women's availability for farm work, especially those with younger children. Small farm households headed by widows are particularly likely to suffer from lack of labour and are often among the poorest (Cumbe, Lucas, & Matsinhe, 2009).

Farmer typologies

Following Landais (1998), this research adopts a functional farm typology to explore how resource access influences cropping strategies. Functional typology extends the categorization of farms beyond production factors and considers the dynamics of production, livelihood strategies and the history of the farm household. This study's typology is based on qualitative information gathered through project officers' weekly visits, focus groups and Agricultural Innovation Platform meetings; irrigators' access to key resources; and a consideration of the following variables from the baseline survey:

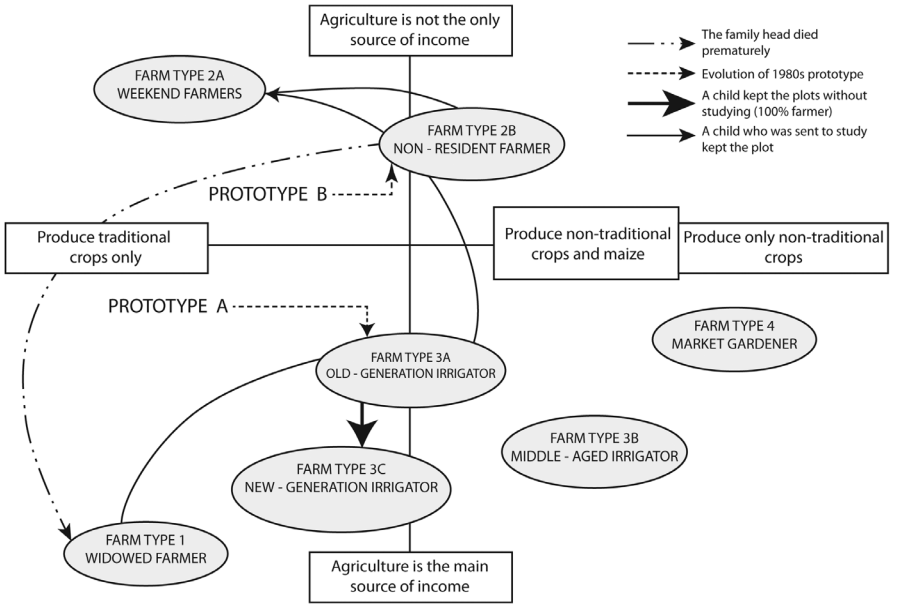

Figure 6. Farm typology and associated strategies.

Irrigated hectare per unit of family labour, computed by dividing the irrigated area by the household's full-time adult equivalent workforce (FTE). The composition of the household – with respect to gender, age and percentage of time spent on the farm – formed the basis for estimating the FTE.

Capacity to hire non-family labour and purchase farm inputs, estimated using two proxies: (a) the value of a household's assets based on their second-hand value (assets were reported in the baseline survey), rated on a scale from 1 to 5; and (b) use of formal financial products, rated on a scale from 0 to 3 products.

Size of the irrigated area.

Residence status: non-resident if at least the household head is living and working off-farm. This reflects a household's access to off-farm income, which influences the ability to hire labour and buy inputs as well as the household's commitment to the farm.

Age of the household head. This reflects the level of irrigation experience.

Housing condition was not considered since farmers are provided housing through the scheme.

Seven types of farmers were identified (Table 4), and elements of farm development and family history help explain how they evolved (Figure 6). Considering that plots were allocated in 1981, the first-generation farmers now cohabit with the younger generations taking over the farm. Further, some of those who took over the farm 30 years ago have moved away and now farm the plot more or less remotely. Given the small number of farmers per type, the quantitative indicators should be interpreted with caution.

Originally, there appear to have been two types of farmers: resident farmers, only engaging in farming, and non-resident farmers, engaging in off-farm work and residing outside the scheme. The resident farmers seem to have evolved into five different types: widowed (1), first-generation (3a), second-generation (3b), new-generation (3c) and innovative market

gardener (4). There are two types of non-resident farmers: weekend farmers (2a) and non-resident household head (2b).

Widowed farmers have: (a) the lowest asset value and use of financial products; (b) similar access to family labour as the first- and second-generation farmers (0.57 ha/FTE); and (c) the smallest irrigated area, apart from the innovative market gardener. Their livelihoods depend on subsistence agriculture and include rain-fed crops.

Both types of non-resident farmers have an urban lifestyle. The weekend farmers spend most of their time in the city for their off-farm work. The heads of households are relatively young, with the highest value of assets and the second-highest use of financial products. They have a relatively small irrigated farm (1.0 ha) and a limited family workforce (2.28 ha/FTE). In the non-resident household head type, the household head lives in the city, but the family works on the farm. They have the second-largest irrigated area, the second-highest area per unit of family labour (0.94 ha/FTE), the second-highest age, and high asset values. However, they use few financial resources.

The first-generation farmers have the highest average age and control the largest irrigated command area. They have a family workforce (0.57 ha/FTE) that is similar to the widowed and second-generation farmers, limited use of financial resources and moderate value of assets. The second-generation farmers are somewhat younger, their irrigated area is relatively small, and they have similar availability of family labour (0.56 ha/FTE). The value of their assets is high, and their use of financial resources is good. The new-generation farmers are the youngest. They have a relatively small irrigated area (similar to second-generation) but lower availability of family labour (0.83 ha/FTE), which probably reflects the household's having school-age children. These farmers have limited use of financial resources, and the value of their assets is low. Compared to the two other resident groups, the new-generation farmers have recently taken over the farm and have not yet accumulated assets.

The last type, the innovative market gardener, is unique. This farmer is a middle-aged woman with a very small farm (0.07 ha), very good access to financial products and high-value assets. The intensive nature of production is supported by the lowest ratio of irrigated area to family workforce (0.03 ha/FTE).

Crop diversification strategies

The different farmer types follow different diversification strategies (Tables 5 and 6). The two non-resident types have opposing strategies. The weekend farmers grow only maize and are the only group with no diversification. Maize is an easy-to-manage but water-intensive crop that is suited to distant management with minimum family labour. The non-resident household head type has the highest level of diversification: an average of 5.33 crops in addition to maize, and an average of 2.67 non-traditional crops. This diversification probably reflects their access to off-farm income as well as family labour. Among the resident farmers, the older first-generation farmers mainly diversify by growing a mix of traditional crops, which are easier to manage, have less market risk and are grown on dry land. The younger, second-generation farmers diversify by growing traditional and non-traditional crops, with some success, as they have accumulated more wealth over time than first-generation farmers. They have been able to produce and market their crops profitably despite the high price volatility.

Table 5. Crops grown by irrigators in addition to maize.

Farmer type	1	2a	2b	3a	3b	3c	4
Farmer label	Widowed farmer	Weekend farmer	Non-resident farmer	First-generation farmer	Second-generation farmer	New-generation farmer	Innovative market gardener
Number of farms	7	4	3	3	4	3	1
Average number of traditional crops grown in addition to maize	1.14	0.00	5.33	2.67	1.25	2.33	4.00
Average number of non-traditional crops grown	0.89	0.00	2.67	1.00	1.25	1.33	4.00

Source: survey data.

The diversification strategy of the widowed farmers appears to be a simplified version of the first- and second-generation farmers. Four out of seven of these farmers combine maize production with one or two traditional or non-traditional crops.

The innovative market gardener has a completely different diversification strategy: attempting to maximize profit from a small area by only producing non-traditional crops. This cropping pattern is similar to that used by peri-urban horticultural producers in Maputo's greenbelt.

The preference for traditional crops can stem from experience with the cropping techniques; a desire to produce a crop that contributes to both home consumption and cash income; or the need to have access to a more secure market, even if profits are limited. Non-traditional crops have a higher risk in terms of productivity and the market, but can be more profitable.

Discussion

Cairns, Tschirley, and Cachomba (2013) identified four groups of horticultural producers in a sample of 616 farmers from the periphery of Maputo and the districts of Boane and Moamba. Amongst the producers, 38% had access to irrigation, and their farms ranged from small, less intensified farms (median size 0.17 hectares) to larger and more intensified horticultural farms using irrigation on 1-hectare plots. Their typology complements this analysis, which has differentiated farmers into seven types in terms of size, resource access, overall livelihood strategy and elements of pathway development.

Within the scheme, agricultural diversification strategies vary. Options include the use of different combinations of traditional crops (maize, cowpea, beans and groundnuts) and non-traditional crops (such as tomatoes, cabbages, chillies and onions). Maize, produced as monoculture or as part of diversification, is the main crop and can be produced year-round under irrigation. The seven farmer types follow different diversification strategies. The widowed farmer is most affected by limited access to land, labour and purchasing power.

Table 6. Diversification of crops by farmer type.

	Widowed Farmers							Weekend Farmers			Non-resident Farmers				First Generation Farmers			Second Generation Farmer			New generation Farmers				IMG	Total number of households growing the crop
Crops	407	415	410	422	423	403	413	402	414	416	411	412	408	404	406	401	424	418	419	425	420	421	405	409	417	
Traditional crops:																										
Maize	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		24
Cowpea			X		X						X					X										4
Groundnut											X	X					X							X		4
Green beans											X	X			X	X	X							X		6
Cassava														X										X		2
Sweet potatoes													X	X												2
Non-traditional crops:																										
Cabbage			X	X	X		X					X	X	X								X				8
Leafy vegetables														X			X									2
Cucumber											X			X	X						X			X		5
Chilli															X			X	X							3
Onion													X												X	2
Lettuce													X											X	X	3
Potatoes			X																							1
Tomato																					X	X			X	3
Fruits																		X								1
Other legumes																									X	1
Beetroot							X																			1
Total irrigated area (ha)	0.5	1.0	1.0	1.0	1.0	1.0	0.5	1.0	1.0	1.0	2.5	1.0	1.0	1.0	1.5	1.5	2.0	1.5	1.5	0.5	1.0	2.0	1.0	0.5	0.7	

Source: survey data.

The markets for maize and beans are steady throughout the year, with very little variability in demand or price. Therefore, many irrigators sow small areas with these crops, which they harvest up to three times a year to provide an important source of income. The results of this study show that the widowed farmers and the new-generation farmers use maize and beans as cash crops. Traditional crops, such as beans and peanuts, may provide the same price stability due to the high demand in the Maputo and local markets. However, to confirm this, further market analysis is required. Irrigators could benefit from these stable markets, but profit might be limited.

Non-traditional crops have a greater risk due to high price volatility and susceptibility of the crops to pests and diseases, especially during the wet season. However, profitability might be higher if their harvest is better-timed and appropriate agricultural and water management practices are used. For instance, improving the timing of access to the Maputo market for cabbages would make this crop 32% more profitable compared to lettuce, cucumbers and chillies (Sitóe, 2010). However, the cost of inputs per hectare is very high when growing cabbages during the wet season (Cairns et al., 2013), and achieving this requires good farm management skills. Because of this, few farmers produce vegetables in the wet season. In the scheme, only the second- and new-generation farmers do so.

Farmers are mainly producing non-traditional crops on small areas during the dry season; supply in the market is therefore very high, which results in lower prices. The short shelf life of these crops also results in high price variability. Only a few farmers have the skills and financial capacity to grow non-traditional crops during the wet season, and therefore local producers are unable to supply the market year-round. Improving farm management skills and access to input finance would enable production of non-traditional crops during the wet season. This would allow farmers to supply the retail sector all year, which is a precondition for competing with South African producers in the Maputo market. Management skills could involve staking tomatoes and applying appropriate pesticides, highlighting the critical role of extension officers and/or the ability of farmers to purchase inputs. But the challenge for local producers to access the Maputo retail market is more complex than supplying year-round. The low prices of imported South African produce make it very difficult for local producers to compete without some kind of market protection, such as limits on importation of some commodities. This would be difficult now that the Southern Region of Africa intends to become an open market.

Not all irrigators can benefit from growing non-traditional crops during the wet season. Limited technical knowledge, access to inputs such as seeds and fertilizer, and information are likely to persist as challenges. Widowed farmers could produce green beans in small areas and mix them with other crops to generate cash and contribute to the family diet. This strategy could also apply to the first- and second-generation farmers.

Weekend farmers produce only maize throughout the year, probably because this crop is easier to manage and because they usually sell it fresh, which fits with these farmers' high levels of absence from the farm and their reliance on hired labour. The proximity to South Africa may contribute to labour shortages in southern Mozambique and may increase the cost of labour. For these irrigators, the dry season could provide an opportunity to produce crops that are more profitable or improve their family's diet.

Irrigators have difficulty gaining access to market information, which can also be infrequent and inaccurate. This presents an opportunity where extension officers can contribute to increasing profitability. Nevertheless, the small number of extension officers is a problem,

which is a result of low salaries and poor working conditions (Sitóe, 2010). Improving extension services could make a significant difference if used strategically in areas such as information provision, organizing market access, crop management practices for the wet season and improving access to and use of inputs. Most households have a cellphone, and extension services could use this technology to disseminate information widely. Although the scheme has benefited from training in the past, it is difficult to see the results among the irrigators or the extension workers. There has been an absence of extension projects directed to irrigation. In the future, such projects should clearly be targeted at techniques adapted to the local conditions and actively involve the extension officers to ensure longevity and sustainability.

Collaboration with other irrigator associations and partners, such as NGOs, could help resolve vegetable storage issues and extend the period over which products can be sold, to achieve higher prices. The study also emphasizes the need to increase the support provided to women to raise their participation in the cooperative's administration and reduce their time in the field, releasing them for other jobs, including alternative income generation. This is a long process because it requires changing long-standing cultural traditions.

The scheme has provided irrigators access to a steady water supply and the use of a tractor and implements at low cost. When this article was written, a significant proportion of the canals remained unlined, which was causing water losses, long delays in transporting water to fields and increased pumping costs, and limiting water delivery to every 15 days. However, the baseline survey suggests that these issues are less constraining than access to inputs, transport, markets and extension services.

Conclusion

Irrigator households pursue different cropping strategies depending on their access to financial and human resources, level of knowledge and skills, and dependence on agriculture as a source of income. Cropping strategies range from total reliance on traditional crops to a focus solely on non-traditional crops. Resource-poor households focus on traditional crops, as they are simpler to grow, are associated with lower production risk and price volatility and can provide both food and cash income. Resource-rich households have the resources and a greater ability to manage the challenges of producing higher-value crops, including production risks and price volatility. The amount of time that an irrigator and farm household can spend at the scheme and work in the field also influences the choice of cropping strategies. Based on resource constraints, current market conditions and price volatility, the irrigators' cropping strategies appear to be rational.

While water supply reliability was not raised as an issue in the baseline survey, focus group discussions clearly indicated that it is an issue. Subsequent to this study, the remaining earthen canals were lined, which has significantly increased the speed and volume of water delivery. Consequently, field officers are currently working with scheme management to increase the available irrigation slots so farmers can irrigate once a week.

However, while these strategies are important, they will not maximize the profitability of farm households and the viability of the scheme. Given the market condition and price volatility of some crops, such as tomatoes and cabbages, simply increasing the productivity of these crops will not necessarily increase profitability. Strategies and policies need to be

developed to better integrate each of the farmer types into the market and the value chain and thus improve access to inputs, transport and extension services.

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