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Research paper

Endogenous irrigation in arid Zimbabwe: farmer perceptions of livelihood benefits and barriers to scaling

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In Zimbabwe, farmer-led irrigation is far more widespread than planners and policy makers realise. Along the Shashani sand river, in the arid to semi-arid lands of south-western Zimbabwe, diverse farmer-initiated irrigation ventures exist. This qualitative case study focuses on bucket irrigation, in which very small vegetable fields of up to 450 m^2 are fenced by tree branches, and irrigated with water from scoop holes in sandy river beds. Farmers initiate and operate their fields with no external assistance. This study presents the benefits of bucket irrigation as an often-overlooked form of farmer-led irrigation development. Through this qualitative and strongly observational study, 26 bucket irrigation farmers and 4 non-irrigators were interviewed using semi-structured interviews where farmers' perceptions and experiences were captured. We investigate what drives and sustains bucket irrigation, its significance to rural livelihoods under harsh economic and climatic conditions, and the barriers towards scaling this type of farmer-led irrigation development. The results show that drivers for bucket irrigation stem from economic hardship and are gendered. Women are motivated to irrigate mainly by the need to produce vegetables for household consumption, whereas men pursue irrigation due to a lack of employment. Bucket irrigators experience enhanced food security, and have more secure income, contributing to improved wellbeing. Furthermore, despite the desire to scale, the farm size is mainly constrained by fencing and energy for transporting water, which is a result of a persistent lack of financial capital to invest in irrigation technologies. We conclude that bucket irrigation acts as an important livelihood strategy, and that it significantly enhances farmers' resilience to economic and climatic shocks. Bucket irrigation should not be overlooked in policies that advocate scaling of irrigation. Bucket irrigators have the potential to expand and benefit significantly if supported with innovative financial mechanisms that enable investments in the required technology and knowledge.

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INTRODUCTION

The rural poor in Sub-Saharan African countries base their livelihoods mostly on climate-sensitive rainfed agriculture (Burney and Naylor, 2012), and Zimbabwe is not an exception, with 70% of smallholder farmers residing in arid to semi-arid regions (World Food Programme, 2020). The reliance on agriculture by the rural population, for both household consumption and income generation, makes the agricultural sector crucial to Zimbabwe's food security and economy, despite the modest 15–20% contribution to the country's gross domestic product. This sector has been strongly affected by climate variability and change, particularly as a result of lengthy dry spells during the rainy season. Drought has been identified as the most critical climate-related danger in the country (World Food Programme, 2020). Irrigation development is a worthwhile investment towards the enhancement of the rural communities' adaptive capabilities. Nevertheless, irrigation development often requires significant investments in water storage, conveyance, and infield technologies, which remain unaffordable to many rural communities.

Sand river aquifers of ephemeral rivers form a significant source of water for irrigated horticultural production (Saveca et al., 2022). A sand river aquifer is a water source that is unconfined and comprised of layers of sand, silt, and clay that have been deposited by flowing water along a river channel, its banks, or floodplains (De Hamer et al., 2008). These seemingly dry river beds can store significant amounts of water, forming an important, easily-accessed nature-based water storage. These rivers particularly occur in arid to semi-arid regions where they are often the most prominent water source for rural populations, both for domestic and agricultural purposes (Masvopo, 2008; Mpala et al., 2016; Senzanje et al., 2008). In these regions, smallholder farmers take advantage of the water availability in ephemeral rivers and the relative low costs associated with abstracting water from these shallow sources (Duker et al., 2020). They may use fuel or solar pumps, or manual means such as buckets, to water their crops. The Shashani River in Zimbabwe is such an ephemeral river, where many smallholder farmers currently rely on manual means to irrigate their fields. These small farms are initiated by farmers without external support, where farmers exercise self-control to cultivate these small areas of land using tools and procedures that are locally available to them and can be considered a form of farmer-led irrigation development (Bryan and Lefore, 2021; Woodhouse et al., 2017). There is significant critique on donor investments that encourage collective irrigation schemes (Bjornlund et al., 2019; Harrison, 2018) and increasing advocacy for scaling farmer-led irrigation in Africa (Izzi et al., 2021).

According to the Oxford Dictionary, scaling means increasing something in size, number, or extent (Oxford Dictionary, 2023). However, for this study, we define scaling as having access to a pump for ease of water transportation, provision of fencing as well as increased area under irrigation. Small-scale irrigation is also often called distributed irrigation, small private irrigation, smallholder irrigation or farmer-led irrigation (Kay, 2001; Burney et al., 2013; De Fraiture and Giordano, 2014; Lefore et al., 2019). The growing interest towards promoting farmer-led irrigation initiatives in recent years can be attributed to its ability to address the long-term neglect and underinvestment by public agencies and also small-scale irrigation development has proved to be cost-effective compared to large-scale irrigation (You et al., 2011).

In many Sub-Saharan African countries, small-scale irrigation is a crucial approach for raising agricultural productivity and generating income for rural farmers (Xie et al., 2014; Burney et al., 2010). Several studies have been conducted on farmer-led irrigation that improve food security, nutrition, and health outcomes through diversified production toward more nutritious crops like fruits and vegetables, increasing household financial resources, and expanding household accessibility to domestic water sources (Mekonnen et al., 2019; Xie et al., 2018; De Fraiture and Giordano, 2014; Van Koppen et al., 2014). Literature on small-scale or farmer-led irrigation focuses mainly on irrigation initiated, operated and maintained fully by farmers using irrigation technologies such as solar-powered or fuel pumps. Yet, little attention is given to the significance of farmers who use manual means to irrigate, and the role they could play for scaling farmer-led developments.

Literature close to the focus of this study points to 'home gardening', or African market gardening, as small traditional irrigation ventures (Maroyi, 2009; Merrey, 2014; Woltering et al., 2011). Individual farming families establish small irrigation plots at or near their homesteads, in their backyards, and make use of water from wells or wastewater from dishwashing or washing clothes. Besides growing vegetables, farmers also grow fruit trees in these garden settings. 'Gardening', as a farmer-led irrigation initiative, forms part of rural communities' subsistence livelihood strategies (Soleri and Cleveland, 1989). We, however, in this paper do not adopt the term 'home garden' as this has a focus on access and location but instead use 'bucket irrigation' as the focus is more on the practice/irrigation type used in these production systems.

In Zimbabwe, this form of irrigation is often called 'brushwood gardens', the name derived from the materials used to fence the fields. Inhabitants of the study area call them *ingadi* (in Ndebele) while elsewhere in Zimbabwe they are known as *mapindu* (in Shona), with both names seemingly derived from the English 'garden'. We use the word bucket irrigation because we focus on the irrigation practice rather than the home gardening aspect, which may have different meanings in different contexts and may delink from the larger irrigation context within which we view the practice.

The genesis of bucket irrigation along sand rivers is not explicitly elaborated in the literature, although there are observations in other parts of Matobo District (Ranger and Ranger, 1999). These studies have largely ignored the livelihood relevance and impact of such type of crop production. This paper assesses the role that bucket irrigation has played in the livelihoods of farmers of the Tshelanyemba community in Zimbabwe. We thereby investigate whether this type of irrigation can be a stepping stone towards more productive forms of farmer-led irrigation development. We examine farmers' motivation to engage in bucket irrigation and its impact on their livelihoods. The paper concludes with the aspirations of bucket irrigation farmers, as well as the challenges that hinder farmers from attaining such.

We first describe the study area and data collection methods, followed by a presentation of the findings, including the gendered motivations towards bucket irrigation, as well as the opportunities and challenges associated with it. Subsequently, the significance of bucket irrigation is presented according to the bucket irrigators' experiences and perceptions, followed by farmers' aspirations and the perceived barriers towards scaling. We conclude by presenting the discussion and conclusions.

METHODS

This section describes the study area, as well as the research approach and methods that were used in collecting data.

Area description

Zimbabwe is one of the poorest countries in the world (Cain, 2015), with Matabeleland South Province as one of the poorest provinces in the country (Ndhlovu, 2019). Within this province lies our study area, Matobo District, which has a 77.6% poverty prevalence (Zimbabwe National Statistics Agency, 2015). The focus of this study is the Shashani sand river, a tributary to the Shashe River which flows into the Limpopo River. The area experiences a unimodal rainfall pattern, characterised by low rainfall averaging 450 mm/year, falling between November and February (Mpala et al., 2016). The 206 km ephemeral river has an average width of 130 m and an average sand depth of 3 m (Mansell and Hussey, 2005). This sand river aquifer recharges primarily from flash floods experienced during the rainy season, creating an essential natural water storage facility, with the water being used for domestic purposes, livestock, as well as for irrigated agriculture.

The region's climatic conditions make rain-fed agriculture an unreliable venture (Mansell and Hussey, 2005; Mpala et al., 2016). Different types of irrigation have emerged along the Shashani River: bucket irrigation farms (individual farming households fetching water by hand or head with buckets from the river on very small portions of land, less than 0.1 ha); small community irrigation schemes (a group of irrigators jointly operating an irrigated area of 0.5 ha or less, either irrigating manually or with pumps); and 'individual irrigators' (irrigating plots that are larger than 0.1 ha with fuel or solar-powered pumps,). The area of study is a 7.2 km river stretch of the western part (right bank) of the Shashani River and the riparian community, within which our focus is the bucket irrigators (Fig. 1).

Research approach

To assess the role of bucket irrigation, both as a livelihood strategy and in relation to the recent farmer-led irrigation development (FLID) literature, a qualitative assessment was conducted. A strategy, in the words of Levine (2014), is a collection of best practices that people use to arrange themselves to achieve their life goals rather than merely a set of actions. Ellis (2000) contends that the adoption and development of livelihood strategies over time are influenced by household asset status, as affected by contextual factors as well as external trends or shocks.

Castleberry and Nolen (2018) emphasise that the major purpose of qualitative research is to better comprehend situations by recording individuals' unique viewpoints, which can be best understood within the context of their story and worldview. The bucket irrigation farmers were sampled using purposive and snowball sampling techniques. A total of 64 bucket-irrigated fields were identified along the river stretch during a baseline survey, where a snowball sampling technique was used. Four non-irrigators whose homesteads are close to the studied river stretch were also identified during the baseline study. These are farmers who have never engaged in bucket irrigation.

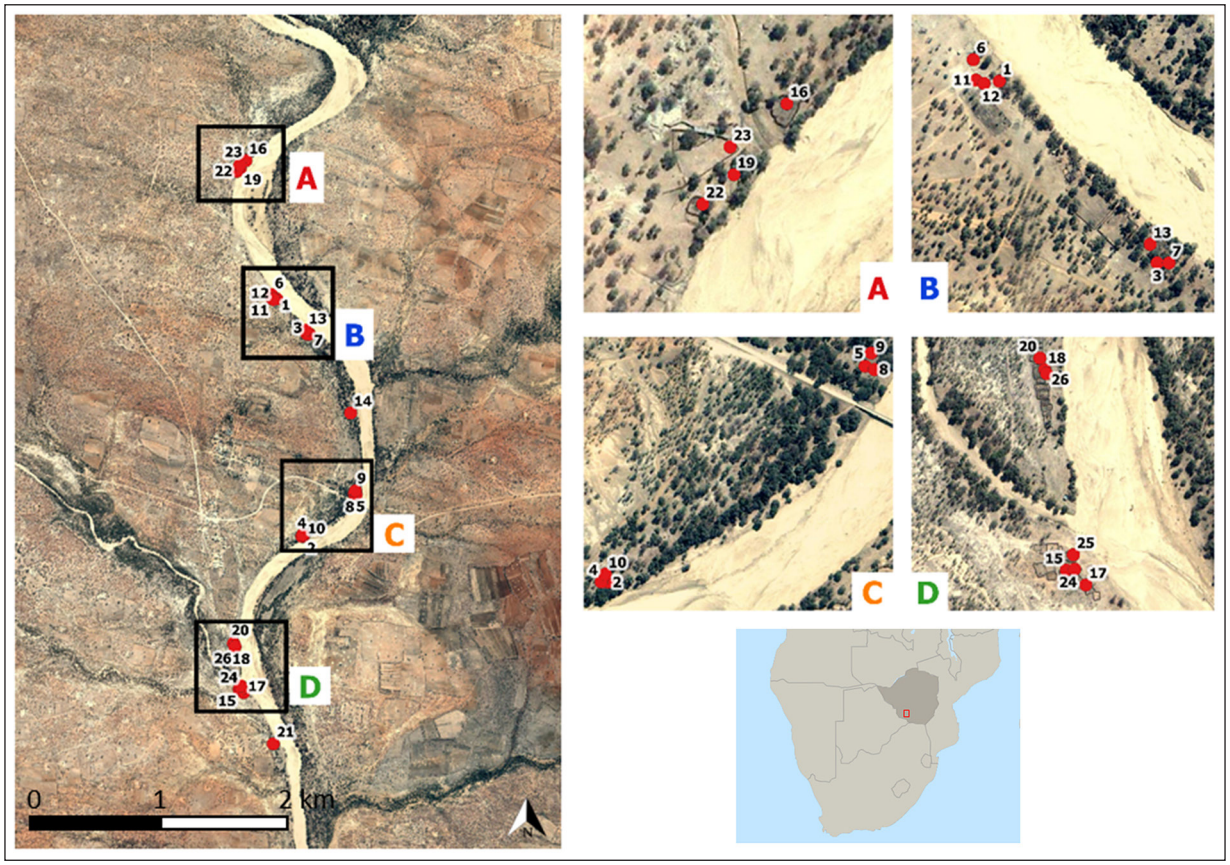

Figure 1. Location of 26 bucket irrigation fields along the Shashani River

Due to time constraints, as well as the dysfunction of most bucket irrigation fields during the first phase (rainy season), purposive sampling was done to select operational bucket irrigation fields, and 16 female bucket irrigators were identified and interviewed. During the dry season, 10 additional operational, bucket irrigation fields were identified, all farmed by male farmers who had been absent during the rainy season when they were concentrating on rainfed farming. Semi-structured interviews were conducted with the 26 bucket irrigators (16 female and 10 male), and the 4 non-irrigators. However, due to the study being a case study, with a small sample size, we cannot generalise the findings from this study.

The use of in-depth semi-structured interviews as a data collection tool allowed for a comfortable discussion of farmers' perspectives, experiences, and life stories. Through capturing the experiences and perceptions of different bucket irrigation farmers, it was possible to assess and understand the driving motives of different farmers in irrigated crop production, as well as how engaging in bucket irrigation has contributed to the farmers' livelihoods over time, with access to vegetables and income generated before and after engaging in bucket irrigation used as the major livelihood indicators.

RESULTS

This section presents the findings, starting with a biophysical description of the bucket-irrigated fields as well as the social aspects. Opportunities and challenges faced by bucket irrigation farmers are presented, followed by the livelihood importance of bucket irrigation, and the barriers towards scaling.

Biophysical description of bucket-irrigated fields

Bucket irrigation is a traditional, endogenous practice that many rural women and few men engage in, taking advantage of the availability of water in the sand of streams and rivers. This type of irrigation can be traced back many years (one woman started her bucket irrigation field in 1973). The involvement of male farmers in bucket irrigation is believed to be more recent. One male farmer started in the year 2000, and the other male farmers in the survey started in 2014 or later. Results revealed that women started bucket irrigation as soon as they got married and had their own homes, with most men having to migrate to the cities in search of jobs as soon as they married, to be able to feed their families. The older men in bucket irrigation had back home when, due to their advancing age, they could not compete for work in industries. However, due to economic hardships being faced in the country and neighbouring states, young men nowadays decide to stay at home, hence end up engaging in bucket irrigation as one of their livelihood strategies.

These farms are small-scale with plot sizes of approximately 100 m^2 to 450 m^2. Most of these irrigation fields are fenced using branches of Mopane and/or Acacia tree species, while some are fenced using lines of barbed wire complemented by tree branches. The fencing is to prevent livestock from destroying crops. However, in most cases, it is not secure enough for small livestock like goats.

Bucket-irrigated fields along the Shashani sand river are mostly cultivated during the dry season. Most farmers partially abandon these irrigation plots during the rainy season to concentrate on rainfed farming, only to renew them during the dry season. The partial abandonment of irrigated fields during the rainy season can be attributed to the decreased need to produce vegetables in the rainy season as the need to work towards securing relish falls away in the rainy season because of the availability of wild vegetables. A relish is a seasoned and salted food serving made from vegetables, fruits or herbs to accompany a staple meal, and contributes to a more diverse diet. Additionally, the time required to walk to the rainfed fields, and then to the irrigated fields,

which are usually in opposite directions but both away from the homestead, also contributes to the partial abandonment of bucket irrigation fields during the rainy season.

During the rainy season, farmers dig shallow scoop holes in the riverbed. However, due to the gradually increasing depth of the water table during the dry season, farmers continuously have to dig the scoop holes deeper and some use tins without a bottom as casing to protect the scoop holes from caving in and filling up with sand when animals come nearby. These scoop holes are also covered on top with a big stone and/or tree branches to keep the animals away, while some farmers fence these scoop holes with tree branches. Usually, during the onset of the rainy season, the baseless tins are removed from the river and kept safe for use in the next dry season.

One scoop hole can be shared amongst 4 to 6 farmers who have their bucket irrigation fields clustered at one location. The clustering may be a result of soil types, as these fields are mainly established at anthills, which contain fertile soils, and also where the land can be worked flat. Besides water from these scoop holes being used for irrigation, people from the community also use it for domestic purposes, as well as for their livestock, where they fill containers for the livestock away from the scoop holes to avoid these caving in.

Bucket irrigation farmers highlighted that the river has never gone dry since 1947, even in the severest recent drought experienced in Zimbabwe and Southern Africa in 1992, as well as the recent drought experienced in Zimbabwe from 2015–2018, when some of the deep boreholes in the region dried up.

Bucket irrigation farmers use mostly 20-L buckets to access water from the river as well as to apply the water to the field. However, some use small containers to draw water from the 20-L bucket, especially when irrigating nurseries, while some use smaller containers to fetch water from the river due to old age and poor health statuses. Due to ageing, one elderly woman indicated that she had to reduce her irrigated field to only cater for two small beds, since she can no longer manage to carry a 20-L bucket on her head and now resorts to using a 5-L container.

Farmers carry the buckets by hand (men) or on the head (women) up the gentle slopes to the irrigation fields. The bucket irrigation plots are located close to the river, with some as close as 10 m (going against the legislative rule of Zimbabwe that forbids the practising of agricultural activities within 30 m from the highest flood level of any wetland and water body, be it a dam, lake, river). This in turn results in some irrigated fields being washed away in the event of larger flash floods that may occur once in 5 to 10 years. The location of the bucket-irrigated fields close to the river can be attributed to the intensive labour requirements associated with irrigating these fields, and farmers trying to cut the distance for ferrying the buckets.

The main crops grown in bucket-irrigated fields are leafy vegetables for household consumption, mainly African kale, commonly known as chomolia in Zimbabwe, onions, tomatoes, and, to a lesser extent, carrots, pepper, butternuts, and green beans. Sometimes they grow green mealies (for maize cobs) towards and during the rainy season, intending to have them mature around the festive season. Some farmers also have fruit trees in their plots. Suckers from other farmers or previous seasons are used for the African kale, while for other crops farmers establish a nursery using seeds from the previous season and then transplant them to bigger beds. Farmers practise organic farming where organic materials such as manure and anthill soils are used to boost soil fertility, as well as organic pesticides, such as the use of ash to control vegetable lice. Inorganic fertilisers are hardly used by any of the farmers in the study sample due to the high costs involved.

Social aspects

Bucket irrigation is mainly done by family labour, with male bucket irrigation farmers indicating that their wives and children help in providing labour for cultivating, planting and irrigating the fields. The exception was one male farmer who indicated that he does not allow his wife to work in the irrigation field as he feels it is too much work for her. In contrast, all the interviewed women farmers indicated that the labour source for their irrigation fields was mainly from them, as well as their children, with their husbands not actively involved. Cultivation of the bucket irrigation fields is done manually using hoes, mattocks and gardening forks. An exception was one middle-aged woman, with her husband working in South Africa, who at the initiation stage of her bucket irrigation field, hired labour to fence the field. She exchanged a goat for the labour.

The main objective in engaging in irrigated crop production for the majority of the female bucket irrigation farmers was the need to produce vegetables for household consumption during the dry season when other relish options (indigenous vegetables from rainfed fields) are unavailable. However, three elderly women said that their motives were to produce vegetables for household consumption and to generate income through sales of excess produce. One of these women reflected on how her mother used to generate income, which she would use to buy school stationery for her and her siblings during their school days, from a bucket-irrigated field along a small stream near Plumtree town, and hence was motivated by such to start a bucket irrigation field when she got married. She acknowledged using the income generated from her bucket irrigation field to pay school fees and buy stationery.

The recent involvement of men in bucket irrigation is driven mostly by the economic situation prevailing in the country, and the failure of such farmers to get employment in Zimbabwean towns and cities, as well as in neighbouring Botswana and South Africa. This increased the need for these male farmers to engage in irrigation farming and concentrate on crop production beyond household consumption. Some male farmers established bigger irrigation plots compared to women's plots, and invest more time in the field. The majority of the farmers engage in irrigated crop production for subsistence, with the possibility of selling excess produce locally. For those few who engage more commercially, a nearby rural business centre is their marketplace.

Opportunities and challenges

Although in many arid to semi-arid regions water availability is the limiting factor towards irrigated crop production, the situation is different for bucket irrigation farmers along the Shashani sand river. The study did not analyse the potential to scale up irrigation in terms of assessing the capacity of the river to supply water for irrigation and other uses (including ecosystem services) for upstream to downstream users. However, hydrological studies in similar rivers in the river catchment (Love et al., 2011; Saveca et al., 2022) qualifies these rivers as reliable water sources. Additionally, bucket irrigation farmers acknowledged that, from their experience over the years, the sand river has proven to be a reliable water source despite frequent droughts and dry spells experienced during the rainy season, as well as prolonged droughts. The availability of water in the sand river increases farmers' opportunities to engage in irrigated crop production. Thus, the expansion of irrigated plots is not (yet) constrained by water. However, the expansion would require, next to labour and fencing material, a pump, as manually increasing the volume of irrigation water is not feasible – yet purchasing a pump remains out of reach of bucket irrigators. Although water availability is not (yet) a constraining factor for irrigated crop production along Shashani sand river, not all farmers who reside close to the river are engaging in bucket irrigation.

This type of irrigation is labour-intensive, at the initiation stage and during its operation. Fencing, which needs to be renewed annually, is another labour-intensive activity. Considering an estimated rate of evapotranspiration of 6 mm/day during the peak season, at least 600 L of water is needed per day for a 100 m^2 plot, equivalent to 30 buckets of 20 L per day, all transported manually.

Three-quarters of the interviewed farmers reside not more than 1.5 km from the river. The remaining quarter reside at a distance ranging from 1.6–4.5 km, except for one male farmer who resides approximately 10 km from the river. The long distances travelled by farmers on foot from their homesteads to the irrigated fields add to the labour intensity of this irrigation type, with only two (male) farmers using bicycles.

Theoretically, the land along the sand river, where bucket irrigation farms are established, is meant for livestock grazing. In practice, however, farmers seek verbal permission from village heads to cultivate the land. Additionally, it is illegal to grow crops within 30 m from the river bed; hence, for these reasons, it makes it difficult to make a case of law when a neighbour's livestock strays into the irrigation fields. Fencing with tree branches remains insecure, as livestock, especially goats, often find their way inside. Bucket irrigation farmers complain about cows and goats destroying their irrigated fields, especially during the dry season when even livestock from further away come to drink water from the Shashani River. One of the bucket irrigation farmers narrated how she left home on an ordinary day to pick vegetables from her field, only to find the irrigated field destroyed by livestock. Despite residing relatively close to the river, on average 0.6 km, 4 farmers who never engaged in bucket irrigation cited lack of branches for fencing as well as cows and goats being likely to destroy irrigated fields due to poor fencing as the discouraging factors for them to establish bucket-irrigated fields.

Importance of bucket irrigation to farmers

Vegetables may be accessed by buying from neighbours with bucket irrigation fields, or by having one's own irrigation field. Having to buy these vegetables or, worse, having to do without them, were the experiences faced by the majority of interviewees before they started bucket irrigation along Shashani sand river. Due to a lack of money, with a bundle of chomolia costing 18–20 ZAR (equivalent to 1 USD), all 26 farmers interviewed had to rely on dried indigenous vegetables (*ulude*, *idelele*, *imbue*, *indumba*, among others), acquired during the rainy season. Farmers reflected on how they would consume these indigenous vegetables without tomatoes and/or cooking oil, due to lack of cash to procure vegetables as well as cooking oil. One middle-aged single mother reflected on having to go to bed hungry, despite having maize meal to cook *sadza/Isitshwala* (maize porridge) because of the absence of relish. She added, '*…Ngangihlupeka emoyeni ukuba lempuphu koda abantwana belala bengadlanga ngenxa youswelakala kwesitshebo*' ('It was stressful to have maize meal, yet see my children going to bed hungry because of lack of relish.').

Some farmers would afford the vegetables sometimes, but not daily, as most had no stable source of income. Most farmers described the hardships they had to endure to access vegetables, with some having to do piece jobs like irrigating and weeding on irrigation fields of others to earn a bundle of vegetables for household consumption. Most farmers described life before establishing bucket irrigation farms as 'hard', *"Kadhe siphila nzima…"*. The majority of farmers reflected on having to miss a meal because of lack of vegetables. Dried cowpea leaves and Mopane worms had become sources of relish and protein for many, although these were seasonal and could not be sustained throughout the year. This left a gap, especially during the dry season. Despite people pursuing different livelihood strategies, farmers along the studied river stretch struggled to raise money for everyday essential supplies for their households before they started engaging in bucket irrigation. The majority reflected on how difficult it was to get hold of as little as 20 ZAR (equivalent to 1 USD). Lack of income resulted in farmers lacking other small but critical household essentials such as salt, sugar and matches. Four of the farmers interviewed acknowledged living from borrowed money or foodstuffs or both, obtained from neighbours. One of the farmers reflected on this matter when she said, *"khadhe sidhubeka kubi, ubani ozokunika icent, ngani"* (no matter how I would wish to get money, no one would give it to me for free).

Interviewed female farmers indicated that before engaging in bucket irrigation, meeting with other women was mainly during funerals. This lack of socialising and networking among women gave rise to stress and depression.

Although all the farmers practising bucket irrigation knew about farming through their rainfed fields, they indicated that they lacked knowledge of irrigated crop production when they started bucket irrigation. Farmers said they lacked knowledge on aspects such as types of vegetables to grow in irrigated fields, how to grow them, and when. This they learnt over time from experience and each other. For male farmers, lack of income was emphasised as their major challenge before engaging in bucket irrigation. Lack of relish was a major concern for female farmers as the role to provide relish is perceived to be women's responsibility. The interviewed farmers emphasised that bucket irrigation has played a crucial role in their well-being, quality of life as well as social life.

The availability of vegetables was not taken for granted by women farmers. "…Having vegetables from my own irrigation plot is such a relief, I know if I go to the field I will not come back empty-handed," said one middle-aged female farmer. The women farmers acknowledged that the generation of cash from the sales of produce also enabled the procurement of other household essentials like sugar, salt and detergents. Male farmers indicated that vegetables from the irrigated fields lessened the burden on their wives' shoulders. Access to basic vegetables contributes to an improved state of health as perceived by the farmers, due to the nutritious contribution of such vegetables.

Three of the interviewed women farmers highlighted that, in addition to acquiring vegetables for household consumption, they also manage to sell excess produce to neighbours. This generates income that they then use to buy small, yet critical, household essentials. All male farmers interviewed indicated earning income from the sales of produce, with some significant enough to buy small livestock. Most young male farmers indicated that they were managing to buy clothes from the income they earn from their bucket-irrigated fields.

Out of the six female farmers who were engaging in piece jobs before accessing water from Shashani sand river for irrigated crop production, two indicated that they were no longer pursuing piece jobs. They highlighted that the piece jobs they used to engage in were in exchange for vegetables for household consumption and this was no longer relevant since they were now producing their own vegetables. However, the other four continued with piece jobs because their fields were too small in relation to their family sizes to produce excess produce for sale. One of the interviewed female farmers indicated that, due to Covid-19 restrictions, her husband who used to send remittances for the past 2 years was not able to do so and reflected on how the income generated from the bucket-irrigated fields has helped her sustain her family.

Some male farmers said that there was no longer a need to go abroad searching for employment opportunities as irrigated crop

production was a full-time job. *"Imali isemhlabathini, ayikho eGoli kembe eBotswana."* (Money is in the soil and not in foreign countries like South Africa or Botswana.)

Access and use of Shashani sand river for irrigated crop production has enhanced networking and socialising during the time that farmers are irrigating their fields. The interviewed women farmers stated that meeting other women during the time they irrigated acts as a means of relieving stress. It was discovered that the farmers who, despite residing close to the river, do not own bucket-irrigated fields along the river had other means of securing their livelihoods, with receiving remittances from family members being the common source.

Scaling aspirations: limitations and anticipated livelihoods

All interviewed bucket irrigation farmers acknowledge the need to continue engaging in irrigated crop production, and the majority (85%) of the farmers aspire to expand irrigated farming, either through scaling the existing fields or through establishing new irrigated plots close to homesteads (Table 1). How they want to expand is influenced by the distance of their homesteads from the river where irrigation plots are established, age, as well as health issues.

Almost half of the interviewed bucket irrigators (46%) want to expand the current field, while a few (12%) want to establish a new farm near their homestead. Also, 27% acknowledged having mixed aspirations of both scaling their existing bucket irrigation plots along the sand river, as well as establishing irrigated fields close to homesteads. Their priority, finance permitting, would be to have irrigation plots close to homesteads. However, lack of a reliable water source close to farmers' homesteads makes the aspiration of scaling existing irrigation plots along Shashani sand river more practical.

The aspiration to scale up (self-scale) fields includes securing a pump, fencing and expanding their irrigated fields. However, we did not see evidence of self-scaling. Farmers remain where they started (with the oldest bucket irrigated field for this study established in 1973), operating using buckets, and this can be attributed to the fact that the small irrigated fields have no capacity to generate significant amounts of money that can be channelled to scaling. In the absence of significant amounts of income generated from the small irrigated fields, self-scaling of these bucket irrigated fields remains a dream. Additionally, the high levels of poverty being experienced by rural farmers cannot be overlooked, with the small amounts generated from bucket irrigation being used to secure other essential household supplies rather than being saved towards scaling of these fields.

Although a few bucket irrigation farmers do have livestock that could act as capital towards procuring irrigation equipment, they are reluctant to sell livestock, indicating that these are meant for emergencies. With the value of one cow selling at approximately 350 USD, irrigation expansion for a smallholder farmer could mean selling at least two but probably three cows to purchase a solar-powered pump and sufficient fencing materials for a 2 000 m^2 plot. Livestock is thus seen as an essential life insurance in an uncertain (biophysical and socio-economic) environment, and, apparently, irrigation development is considered a less secure option than maintaining livestock.

These farmers indicated that if financial assistance could be availed to them in the form of a loan, they will welcome it as they believe they will be able to pay it back from the sales of produce from the expanded irrigated fields.

Those not willing to expand irrigated farming (15%), all elderly women, indicated that although they aspire to have a mechanical way of transporting water, as well as fencing their existing irrigated fields along the sand river, they do not aspire to expand their irrigated fields. Due to their old age and health issues, they indicated that they are failing to manage and operate their small irrigated fields.

A minority of farmers (13% of the female farmers and 10% of the male irrigators) stated that they aspire to start bigger irrigation plots at their homesteads (and not the existing fields). These farmers reflected on how they spent half of the time they could channel towards production walking to and from the irrigated fields. Starting irrigation plots close to homesteads would mean drilling boreholes and pumping the water for irrigation of these plots. These farmers lack the finance to expand their bucket-irrigated fields along the sand river, let alone drill a borehole and pump groundwater close to their homesteads. Thus, most of the farmers' aspirations remain a dream in the absence of external financial assistance.

Three young farmers (one female and two males) who jointly operate a bucket-irrigated field that they inherited from their parents indicated that they aspire to expand the field and continue operating it on a collective basis. The efforts by their father to sell a cow towards expanding his irrigated field were not fruitful as he could not find a buyer. The two male young farmers highlighted that once they get married, they would want to have independent irrigation plots.

Bucket irrigation farmers indicated that they foresee improved livelihoods for their families if they manage to expand their irrigated fields. They reflected that the market was not a problem as local people are always in need of vegetables. Scaling, according to these farmers, would mean shifting from producing mainly for household consumption to a business venture and focusing on high-value horticultural crops, as well as producing grains. Some farmers indicated that if they had a pump and fencing materials, an irrigated plot of 1 000 to 2 000 m^2 would be feasible and have the capability of transforming their livelihoods through both increased access to nutritious diets, as well as increased income.

Table 1. Bucket irrigation farmers' aspirations

Aspirations	Total (*n* = 26)	Male (*n* = 10)	Female (*n* = 16)
Continue with irrigated crop production	26 (100%)	10 (100%)	16 (100%)
Willing to expand irrigated farming through:			
Expand existing irrigated field only	12 (46%)	6 (60%)	6 (38%)
Establish irrigated field close to homestead only	3 (12%)	1 (10%)	2 (13%)
Expand existing field and establish one near homestead	7 (27%)	3 (30%)	4 (25%)
Not willing to expand irrigated farming	4 (15%)	0 (0%)	4 (25%)

DISCUSSION

Although there is not much literature on how access to water from sand river aquifers for irrigated crop production contributes to the livelihoods of different farmers, studies by Mpala et al. (2016) and Senzanje et al. (2008) indicate that rural communities in Sub-Saharan Africa have benefitted from sand rivers for centuries by using the water for domestic and livestock purposes. Moreover, communities currently access water from sand rivers for irrigation purposes (Karimba et al., 2022; Love et al., 2011). Results from this study show that people from Tshelanyemba community access water from Shashani sand river for domestic use, livestock as well as irrigation of small fields. The existence of the sand river cushions farmers from risks of water shortage as the river is perceived to be a reliable water source.

Tijani and Kone (2020) argue that women form the backbone of agriculture, as well as everyday family subsistence. In the case of Tshelanyemba, these small bucket-irrigated vegetable fields have played a significant role in providing relish in the form of vegetables, thereby relieving stress, especially for women, who are seen as having a duty to provide food of sufficient quantity and quality for their families (cf. Marsh, 1998). Irrigated crop production thus is an important tool for women's empowerment and improving nutrition (Chazovachii, 2012; Merrey, 2024). Results from this study show that through the provision of vegetables for household consumption, women gained self-esteem, while earning income from sales of vegetables increased their economic independence, confidence, and dignity. Furthermore, women bucket irrigation farmers indicated improved networks were made possible through bucket irrigation. The bucket irrigation provides space for socialisation away from the household and for sharing ideas in public spaces. Farmers perceive this as contributing to stress relief and mental health.

Having highlighted the benefits of bucket irrigation, it nevertheless remains a relatively modest venture, constrained as it is by the labour requirements for irrigating the plots manually using buckets. The livelihood benefits from these irrigated fields are thus mostly limited to the availability of vegetables for household consumption with little income generated. Byan and Mekonnen (2023) argue that there is a greater potential for enhanced income and improved productivity for farmers who utilise any form of pump for irrigation, since this enables irrigation of a larger piece of land compared to the manual means.

Expanding these irrigated fields is a necessity to achieve increased production and income. A pump and fencing materials are the most constraining elements for smallholder farmers to expand their bucket irrigation fields, not water. Scaling these irrigated fields is a necessity to support increased production and income. Irrigation developments that are scaled from an endogenous technology, i.e., bucket irrigation, has the advantage that it is built on traditional and indigenous tried and tested knowledge and practices. This may, however, require irrigation experts to train farmers on irrigation technologies such as solar-powered irrigation systems (Woltering et al., 2019). The findings have shown that poverty and lack of cash remain the major barrier for smallholders to expand their irrigation fields. Farmers are reluctant to give up their household insurance (livestock), perhaps compounded by the prestige value attached to it, without the security of getting that money back within a foreseeable time.

CONCLUSIONS

Bucket irrigation is a tried-and-tested example of a sustainable farmer-led horticultural production system practised as a complementary livelihood strategy by mostly women in an arid to semi-arid region of Zimbabwe. Its sustainability can be attributed to its self-regulating ability based on limiting factors such as labour, which determines the area under irrigation and the water used as well as its endogenous nature. Yet, its importance is recognised more from farmers' experiences and perceptions than from measured quantities. Despite being practiced over small areas, bucket irrigation significantly contributes to farmers' livelihoods, mainly through the provision of vegetables, and generates small, yet significant, income.

Farmers fail to expand their fields mainly due to lack of financial capital to purchase a pump and fencing materials. Although there is a great willingness by farmers to expand, lack of finance remains the major stumbling block, and they are reluctant to sell livestock, being their only insurance asset. Though the expectation would be to see these small bucket-irrigated fields self-scaling, there was no evidence of such in the absence of external financial assistance. There is a need for external developmental agencies to consider assisting these farmers on their terms, in the form of (low-interest) loans. Given the observed motivation and dedication of bucket irrigators under difficult conditions, it is likely that they can substantially benefit from support in accessing a pump. This will likely, if provided with a pump, result in enhanced production thereby enabling farmers to pay back loans on payment terms. This, in our opinion, will enhance and strengthen the sustainability of irrigation development with minimal dependence on external agencies, while retaining its farmer-inspired character.

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