An Evaluation of the Amalima Sub-Surface Tank Intervention

1. Introduction

1.1 Overview

In FY15, Amalima constructed six sub-surface tanks (SSTs) to capture surface runoff and minimize water loss in Tsholotsho District, an area characterised by marginal rainfall, and nonexistence of inland rivers and water bodies. SSTs were developed under Amalima Strategic Objective 1 that seeks to improve household access to and availability of food (IR 1.1.1 Access to water resources for agricultural production improved). SSTs were implemented in Ward 9 (Pondo) and Ward 22 (Mkhubazi) in Tsholotsho. A sub surface tank is a cone-shaped pit with a top diameter of 6 meters, a bottom diameter of 2 meters and a depth of 4 meters and a water holding capacity of $54m^3$. The pit is lined with a Butyl sheet measuring $50m^2$ to prevent water seepage. In addition, the pit is lined with sand cement sausages to prevent damage of the Butyl lining from UV rays, sharp stones, and rodents. The six subsurface tanks captured water received from the inflow of three rainfall seasons: 2015/2016, 2016/2017 and 2017/2018. This study sought to examine the performance, benefits, and challenges of the SSTs developed by Amalima in 2015 in Tsholotsho. The study found that one of the six tanks could not retain water for productive use and was not included in the data collection, and another retained approximately 75% of the water collected and was included to make a total of five functioning SSTs that were surveyed.

2. Research Objectives

The objective of the study was to evaluate the benefits of subsurface tanks as an investment for providing much-needed water to communities in water deficit areas of Tsholotsho district. The study was also aimed at providing information to 'Tell the Amalima story' on subsurface tank intervention. This included reporting successes, challenges and lessons learned. The lessons drawn from this study will serve to inform Amalima on the conditions, if any, under which SST technology might be successfully implemented.

3. Research Questions

The research questions were as follows:

- How were the sub-surface tanks managed, used and maintained?
- What were the tangible benefits of the sub-surface tanks for intended beneficiaries and the wider community in terms of food and income security?
- What were the costs and benefits of the sub surface tanks?
- How sustainable was the intervention?

4. Methodology

The study targeted all six subsurface tanks, although for the cost-benefit analysis the researchers used data from only the best managed SST (i.e. one with the longest crop production period in 2018), which presented the best possible scenario in managing production and sales from a SST. The approaches used to collect data were: review of farmer crop records (sales and expenditure), observation and measurement of the state of the tank and garden, and in-depth interviews with tank hosts and neighbours. To obtain records for the cost-benefit analysis, the researchers encouraged the SST farmers to keep records of production, sales, and expenses from the gardens for the 2018 crops. Data collection took place from February (when farmers planted their gardens) to September 2018 (when the last SST ran out of water). The research team periodically visited the farmers to check on the state of the gardens and to monitor and support record keeping. Farmer records were captured and analysed in Excel.

5. Key Findings

5.1 SST Ownership and Utilisation

SSTs were initially introduced as individual household assets and later changed to 'group' assets, allowing for each tank to be owned and utilised by a group of neighbouring households. In line with the Amalima group concept, this was done to spread the SST benefits to the wider community. Construction work on the SSTs was done in groups of three to eight neighbouring households. The results of the study showed that post-construction, the 'group approach' was minimal. Only one of the six SSTs had a functional 'group' (i.e. more than one household using the SST for watering the vegetable garden). The reasons for non-participation by neighbouring households were as follows:

- Some neighbours were near a water source and therefore did not need the water from the SST;
- Some households were lazy and not willing to undertake the amount of work a productive garden demands;
- Some neighbours were afraid of falling into the tank as they drew water since the tanks are not adequately protected or covered.

One farmer, who participated in the group work at two neighbours' SSTs (and went on to develop her own tank without Amalima support) mentioned that she was never a co-owner in the two SSTs. For her and her fellow group members, it was a learning experience that she was able to take and apply.

5.2 Technical Aspects

The process of tank construction involved an Amalima technician working with a group of SST beneficiaries, demonstrating the process from sitting, digging and construction. The technician then monitored and supported construction as beneficiary groups replicated the technology at the selected host homesteads. One participant though, ably constructed her own tank without direct Amalima support. The non-Amalima supported tank matched the Amalima tanks in shape and dimensions but excluded the Butyl sheet lining and concrete sausages. Instead it had a cement plaster on wire netting and a concrete floor (using a total of 14 bags of cement versus 25 bags on the Amalima SST). Other modifications included a much steeper finish around the rim including at the inlet, leaving no convenient standing room for fetching the water. The non-Amalima tank was effective in the first year only, after which the walls cracked significantly reducing the water holding to about 50 percent of the original capacity. The technical aspects were further aggravated by the lack of participation of government employees notably AGRITEX meaning no one could providing technical backstopping for replication or repair of the SSTs, should this be required.

5.3 Benefits of the STT on Owner and Wider Community

Where sub-surface tanks stored water effectively, beneficiaries expressed happiness with easy access to water in their backyards. They indicated that their lives had improved and were better off compared to before they had the SSTs. Farmers mentioned that the SST water was used from the month of February, when nearby open water pans ran dry. The water was used to water backyard vegetable gardens and fruit trees, supplementary watering of dryland crops, water goats and calves, brick making and domestic use. Most farmers mentioned that livestock watering using SST was a last resort when water pans became dry and boreholes broken down. Farmers indicated that they were able to water livestock while preparing to find a solution for water shortages. As such, SSTs were a temporary measure for livestock watering. Farmers mentioned having increased production of vegetables and fruits using the SSTs and that they could produce up to the month of September. The produce was sold locally in cash and kind, thus contributing to nutrition security. The SST were said to be particularly useful in times of peak water shortage (June to November). Using the available water, farmers realised increased incomes. Farmers mentioned investments in retail stock, purchase of construction material, purchase of farming equipment and paying for casual labour for dryland crop production. The farmers did not keep historical records of their crop enterprises, so it was not possible to verify these reports.

5.4 Challenges Encountered with SSTs

5.4.1 Tank leakages

The six tanks were sited appropriately at waterways and have effectively captured surface run-off for the past three rainy seasons. Four of the six tanks held water effectively and according to design. In two cases which are detailed in Table 1 below, the tanks leaked due to construction defects.

Table 1: Defects of two tanks that were assessed

Tank Name	Assessment of the Tank Defects
Vusanani Tank Ward: 9	• There is seepage at the top quarter of the tank due to unsecured/unfused overlap of the PVC canvass. • The reason for leakage is that at construction an additional PVC lining was laid on top of the main PVC lining to accommodate the pit which was dug slightly bigger than the required size. • The main PVC sheet covered up to 3.3 meters of the 4-meter pit and an additional sheet of 1m was overlaid. The leakage is a result of water permeating between the PVC sheets. • The tank holds $34m^3$ instead of the design 54 m^3
Makhelwane Ward: 22	• Water loss is occurring at the base of the tank. The tank can hold water for 3 weeks after it has filled. • Water loss is as a result of a tear on the PVC sheet at the base of the tank which possibly occurred while laying the sand cement sausages at the base of the tank.

5.4.2 Poor soil quality

The use of locally available materials to construct the SST was efficient as it saved on cost and time. However, care and attention were not always taken during site selection to ensure that the selected sites had the right soil qualities. At one of the tanks (Zenzeleni tank) the soil is predominantly sodic and does not have good compacting properties. The cement sausage mix that was constructed from this soil showed signs of erosion around the rim and at the entrance to the tank. This had the potential of reducing the tank's lifespan.

5.4.3 Water extraction challenges

According to tank beneficiaries, the final product (SST) fell short of what was initially promised early in the project, due to a compromise between ease of use and safety. Beneficiaries expected a pump for easy water extraction. However, the pump was not supplied as this was never part of Amalima's plan. This left farmers to abstract water with a bucket tied to rope. Though the rope and bucket are a simple, low cost technology, it posed a danger of damaging the tank as the bucket hit, weakened and dislodged the concrete sausages.

When the water went below the one metre level, extraction with a rope and bucket system proved very difficult. The farmers would improvise by placing a homemade wooden ladder to reach the lower water level. This proved especially difficult for young children and women.

5.4.4 Small water holding capacity of tanks

The beneficiaries felt the water holding capacity of the SSTs was too small to meet their cropping requirements. Across the SSTs the water from the 2017/18 rainy season lasted sometime between June and September. Where the water lasted up to September, the farmer watered a 130m^2 garden and 70 potato plants planted in bags for efficient utilisation of water. The tank was also covered with a canvas sheet to minimize evaporation throughout the season. While the SSTs generally did not hold enough water to take most horticultural crops to maturity, there is evidence that a modest eight-month cropping calendar took place especially where the water was protected from excessive evaporation.

5.4.5 Safety concerns

The SSTs are located approximately 100m from the homesteads, which lessens the danger of children accidentally falling into the reservoir, they however still pose a danger as they are not adequately secured in most cases. Only one homestead had a lockable gate restricting access to the reservoir.

5.5 Cost Benefit Analysis

The Shalom SST was used for the cost-benefit analysis. The SST was selected as it supported all the planted crops to maturity in 2018, the study period thus presenting the best possible scenario in managing production and sales from an SST. The data in Table 2 shows a Gross Margin of US$239 over 6 months producing a combination of vegetables on 130 square meters of land. The farmer estimated that she spent on average, one hour per day in the garden for about 20 days in a month during the six months of garden cropping. Her next best form of employment is petty trade. Considering that gardening took a very small fraction of the farmer's time, allowing her to do other activities, over the period, the Gross Margin was a bonus to the farmer. The garden, therefore, has no significant opportunity cost attached to it.

Table 2: Gross Margin Analysis at current management levels

CROP	AREA PLANTED M^2	TOTAL VARIABLE COST (US$)	TOTAL HARVEST (KG)	QUANTITY SOLD IN CASH (KG)	VALUE OF SALES (US$)	GROSS INCOME (US$)	GROSS MARGIN (US$)
Tomato	78	$14.91	176.50	165.50	$160.00	$170.63	$155.72
Leafy vegetables	21	$0.30	20	0	$0	$20.00	$19.70
Spinach	7.80	$0.00	13	6.00	$6.00	$13.00	$13.00
Green pepper	11.40	$0.00	18	12.00	$12.00	$18.00	$18.00
Sugar beans	13.20	$0.00	11.5	6.50	$13.00	$23.00	$23.00
Potatoes	0	$3.25	13	11.00	$11.00	$13.00	$9.75
Total	131.40	$18.16	240.50	194.50	$202.00	$257.63	$239.17

The SST is, however, a questionable undertaking from an investment perspective, since the financial benefits at US$239 over (about) 6 months are very insignificant at both the household and community level. Limitations are related to the small tank water holding capacity, coupled with low productivity per crop due to minimal soil fertility improvement and minimal and delayed pest and disease control. Table 3 below shows potential productivity under near-optimal conditions of soil fertility and pest and disease management. The table shows that the SSTs' performance is still far below optimum.

Table 3: Gross Margin Analysis at near optimum management levels

CROP	AREA PLANTED (M^2)	TOTAL HARVEST (KG)	POTENTIAL (T/HA)	GROSS INCOME (US$)
Tomato	78	312	40	$301.60
Leafy vegetables	21	63	30	$63.00
Spinach	7.80	23.40	30	$23.40
Green pepper	11.40	13.68	12	$13.70
Sugar beans	13.20	4	2	$8.00
Potatoes	0	13	30	$0
				$409.70

Amalima's investment of US$2,250 per tank (albeit with a 10-year life span) is very high compared to US$239 return to (often) one family (per year). The same amount (US$13,500 for 6 tanks) could have been spent on drilling and equipping a community/group borehole that can irrigate up to 5,000 square meters (0.5ha), servicing over 30 farmers. As noted above, SSTs have several uses which were not included in the benefits calculation. The researchers believe that even with the mentioned social benefits change the SST remains a poor investment.

6. Recommendations

6.1 Importance of Doing a Preliminary Economic Analysis before Implementation

It is important to do a Preliminary Economic Analysis of the SST technology before implementation to justify the investment so that clear benefits are known. The current calculations reveal that this might not be a viable intervention. As such it might be important to revise the design to allow for a cheaper version of the SST.

6.2 Availability of Technical Backstopping should be Ensured at the Onset

It is difficult to have the SST at the community level considering its capacity and the need for constant repairs. It is important to relook at the technical viability of the SST technology. While it is easy to monitor quality construction, the linkages with existing government structures are important to ensure that there is technical backstopping and support to the farmers beyond the project life. The technology is best applied at household level with very few benefits that can flow to the rest of the community.

6.3 The SST Needs to be Constantly Repaired and Maintained to Ensure Longevity

SST beneficiaries routinely carryout basic maintenance on SSTs in terms of desilting of the tanks and silt traps. SST beneficiaries, however, do not undertake repairs to SST infrastructure or replace components such as torn PVC canvas due to SST beneficiaries' low income that make SST repair an unviable and low priority undertaking.

6.4 The Right Locally Available Material Should be Used in the Construction of the SST

While the use of locally available material is important, factors such as availability of compact soils and coarse sediment should be considered in the siting of the SSTs as these are key determinants to quality structures and determine tank durability and life span.

6.5 Safety and Ease of Use Should be Considered in the Design of an SST

It is important that the SST is redesigned to cater for issues that seem to have been overlooked in the initial design, such as safety, security and the ease of drawing water, so that it is user friendly to households and communities.

7. Conclusion

While the SST is a good intervention that is able to store runoff water, which can support a decent horticulture crop giving a reasonable return to a farmer, there are several questions surrounding its viability as a cost-effective intervention. The major questions arise from the ability of farmers to undertake repairs and increase the longevity of the tanks. This is premised on the lack of integration of this technology with government structures. Of concern again is the safety of the tank for both people and livestock. Lastly, there are concerns about its suitability as a community intervention compared to a household level intervention. These concerns build some consensus towards a redesign of the SST technology . It is likely that rainfall patterns are going to be characterised by short and huge downpours, making it prudent to capture as much runoff water as possible in an environment of sandy soils that have very poor water holding capacities.