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Water supply system and the sustainability of smallholder irrigation in Zimbabwe

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Abstract

Irrigation agriculture is critical in enhancing food security especially in Africa where the carrying capacities for most rain-fed agricultural systems have been surpassed. As a result, smallholder irrigation schemes have been prioritized as a rural development model and have regained renewed attention from world and regional development bodies as a climate change adaptation measure. Unfortunately, there is hardly any case of successful smallholder irrigation scheme in Africa as the majority of them have been unreliable and contributing very little to the host countries and the livelihoods of the farmers. The factors leading to the unsustainability of the irrigation scheme are not fully understood. The major objective of the study was to assess the impact of water supply in the sustainability of smallholder irrigation schemes in the study area. The study targeted 8 irrigation schemes in Zimbabwe. A mixed research method was used and 316 randomly selected farmers were interviewed. Focus group discussion, key informant interviews and field observations were used to allow for triangulation of information. Unprecedented siltation of water bodies compounded with inequitable water sharing and poor catchment management was threatening the sustainability of smallholder irrigation schemes yet interventions in the schemes were not prioritizing sand abstraction water pumping system. The Zimbabwe National Water Authority (ZINWA) as the water governing body proved to be inefficient and detached from the farmers. Farmers could not understand why they were compelled to pay for the water as 70% of them rated its service as poor. A combination of farmers' low productivity levels, debilitating dependency syndrome, ZINWA's poor service culture and political interference in water governance was affecting farmers' ability and willingness to contribute towards water bills. There was poor in field water management and some schemes were poorly designed as there was no consultation of the local people on the designing of the pumping systems. The majority of the schemes were incurring frequent pump breakdowns and farmers had no reserved funds for repairs and replacement investment.

Keywords: Smallholder Irrigation Scheme; Siltation; Water Management; Replacement Investment

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1. Background

Globally, investments in irrigation have been an essential element in increasing food production to feed the ever-growing population (Mutambara et al., 2014). The World's irrigated land constitutes 19% of the land under cultivation and supplies 40% of the world's food requirements (Wiltshire et al., 2013). Irrigation is a possible adaptation strategy for agriculture to climate change and population pressure especially in Africa, where the population relying on farming has long surpassed the carrying capacity of many dryland agricultural systems (Kortenhorst et al., 2002; UNDP, 2012; Wiltshire et al., 2013; Maliwichi et al., 2012). Unfortunately, throughout Africa, there are hardly any cases of successful and sustainable farmer-managed smallholder irrigation schemes despite all efforts by different development agencies (World Bank, 2008). Irrigation development and rehabilitation interventions targeted towards the poor in the arid and semi-arid regions of Africa have not yielded expected results and the countries in these regions remain among the most disadvantaged in the world (Darkoh, 1992; Darkoh, 1998; Biggs et al., 2009; Magombeyi et al., 2012; UNDP, 2012). Most of the small-scale irrigation schemes have been associated with poor performance and little sustainability of the investment that seem to be locked in a 'build-neglect-rebuild syndrome', where the established scheme would have a time when they were neglected or non-functional and then get rehabilitated, only to be neglected again latter (Venot et al., 2013).

Small scale irrigation schemes have been prioritised as a rural development model by many developing countries in the past 5 decades, not only because they had higher returns on investment but also because they were found to be adaptable to the local farming systems (World Bank, 2008; Venot et al., 2013). Seventy percent of Zimbabwe's rural population live in Natural Regions III, IV and V where rainfall is erratic and unreliable, making rain-fed agriculture unreliable (FAO, 1997; Poulton et al., 2002). There is a direct positive correlation between Zimbabwe's agro ecological region and the prevalence of poverty in the country as shown in Table 1. (Poulton et al., 2002; Mutambara and Munodawafa, 2014). This correlation suggests that irrigation is the best way of alleviating poverty in the drought prone regions of Zimbabwe. Unfortunately, only 38% of Zimbabwe's smallholder irrigation schemes were functional in 2013, 40% in 2014 and 21% in 2015 (ZimVAC, 2013; 2014; 2015).

Table 1. Poverty prevalence in Zimbabwe by agro-ecological zone

Natural region	Prevalence of Poverty	Prevalence of extreme poverty
I	62.4	36.2
II	71.6	41.2
III	77.3	51.4
IV	81.6	57.2
V	79.5	55.7

(Poulton et al., 2002)

In the face of climate change and chronic poverty in developing countries, investment in irrigation agriculture is getting renewed attention from world and regional development bodies (UNCSD, 2012; NEPAD, 2008; UNDP, 2012; WFP, 2010). Yet, the factors that have been affecting the sustainability of irrigation schemes are not well understood (Manzungu and van der Zaag, 1996; Chancellor, 2004).

Although Asia has a lot of literature covering the water supply systems of irrigation scheme and how farmers have been responding to the changing demand in the water supply and how the government, the private sector and the individual farmers have been reforming the water and energy sector connected to the water supply system (Vermillion, 1997; Monari, 2002; Kadigi et al., 2012; Mukherji, 2012; Mukherji et al., 2012; Bryan, 2013; Falcon, 2013; Mundra and Garg, 2013), there is limited literature on the water supply system of smallholder irrigation schemes in Zimbabwe(Makurira and Mugumo, 2010). The majority of available literature on the water systems in Zimbabwe focused on the causes and effects of water related disputes and how they were resolved (Mombeshora, 2003; Svubure et al., 2010). As yet, no significantly known research has focused on the entire water supply system of smallholder irrigation schemes. The green fuel/ethanol plant along the Save catchment was the new establishment that was commissioned around 2012 and little has been done to study the downstream effects of such a giant water user on the smallholder irrigation schemes. Although siltation has been studied previously little was done to show the effects of the unprecedented siltation levels especially along the biggest river across Zimbabwe, such as Save River on the production systems of smallholder irrigation scheme (Morton, 2013; Ncube, 2013) and how the farmers and other stakeholders have been responding to such problems in the water supply system. Several reports have highlighted on the poor capacity of ZINWA and ZESA with regard to water supply in the urban areas (Svubure and Zawe, 2010; Mapira, 2011) but none of these has focused on the effects of the inefficiencies of these parastatals on the functionality of smallholder irrigation schemes. The water supply system for smallholder irrigation schemes is a dynamic sector and little research has been done to gain an understanding of the water challenges faced by the irrigation schemes in the light of the unprecedented siltation and changes in the water use patterns in Zimbabwe (Morton, 2013; Ncube, 2013).

The major objective of the study is to assess the impact of water supply in the sustainability of irrigation schemes in the study area. In order to meet this objective, the study had the following research questions:

- To what extent does the farmers' access to irrigation water affect the sustainability of irrigation schemes in the study area?
- Is the water supply adequate and reliable?
- What is the state of water source and irrigation water delivery system?
- To what extent are the irrigation schemes affected by the upstream competing water uses?

2. Research methodology

An integrated research approach involving the use of quantitative and qualitative methods was used in this study. Questionnaire survey, key informant interviews, FGDs (Focus Group Discussions) and observations were employed to allow for triangulation of information. A commitment to inter-disciplinarity is often seen

as a necessary precondition for successful sustainability research, connecting people's time use patterns with their spatial and material footprints (Fahy and Rau, 2013).

Eight community small-scale irrigation schemes in the south-eastern low-veld and the Midlands province of Zimbabwe (Tsvovani, Dendere, and Rupangwana in Chiredzi district, Zuvarabuda and Vimbanayi in Chipinge district, Insukamini, Mutorahuku and Mambanjeni in Gweru district) were purposively selected for this study. The targeted irrigation schemes lie within the agro-ecological region V which receives very little rainfall (less than 400mm per year) and very high atmospheric temperatures, making the need for irrigation technology more critical in the area than any other region in Zimbabwe.

A simple random sampling method was used to select participating farmers through a self-weighting system or proportional representation whereby a scheme with more farmers had relatively more respondents that were selected for the questionnaire interview. Random samples were taken by assigning a number to each plot holder and using a random number table to generate the sample list. A total of 316 farmers were interviewed from the 8 irrigation schemes. Key informant interviews were conducted with the following stakeholders; 8 Irrigation Management Committees (IMC), 8 traditional leadership, 4 Agritex officers, 4 Department of Irrigation officers and 2 staff members from the Zimbabwe National Water authority (ZINWA). Eighty one (43 females and 38 males) farmers were interviewed in 8 Focus Group Discussions. Purposive sampling was used to determine the FGD participants. A farmer needed to be a member of the scheme in the 10 years preceding the day of the survey to participate in the FGDs. Field observations were carried out in the targeted irrigation schemes with the guidance of an observation checklist. Observations focused on the functionality of irrigation schemes, structures design system, land utilisation patterns, condition of distribution structures, erosion, siltation of rivers or water sources and canal, weed growth in the canal and on farm, water logging, irrigation practices and the state of perimeter fence.

Data from the questionnaire survey was processed in SPSS and was subjected to both descriptive and advanced statistical analysis. Qualitative data from FGDs and key informant interviews were analysed using the thematic framework analysis approach.

3. Research findings

3.1. Limited access to irrigation water

Over 77% of the farmers had periods of limited access to water and the differences by name of scheme was shown to be significant using Chi-square test (χ^2=1.027, df=7, p=0.000 with 100% of the farmers in Vimbanayi and Zuvarabuda (Figure 1.1) reporting that they had periods in the year when they had limited access to irrigation water.

The challenges farmers faced in accessing irrigation include siltation, selfish upstream users, pump breakdowns, poor water management, poor design of the water supply system and poor water system infrastructure as shown in Table .2. These challenges were discussed in depth in the subsequent section.

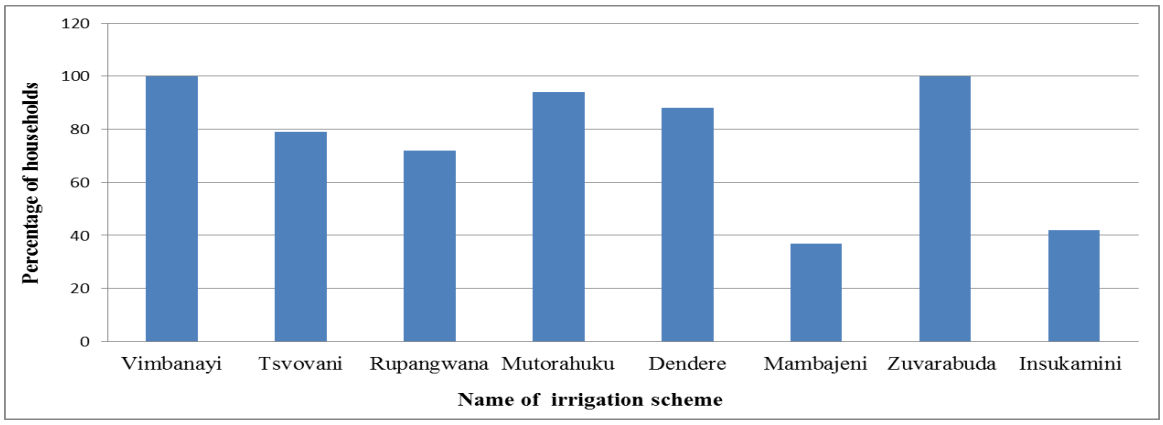

Figure 1. Percentage of farmers experiencing periods of limited access to irrigation water

Table 2. Percentage of farmers facing water supply challenges in the different irrigation schemes

Water supply challenges	Vimbanayi	Tsvovani	Rupangwana	Mutorahuku	Dendere	Mambanjeni	Zuvarabuda	Insuka mini	Total
Siltation of water source	93%	85%	88%	38%	94%	59%	97%	0%	70%
Damage of the delivery canal	0%	10%	0%	85%	0%	0%	0%	0%	11%
Lack of night water storage	17%	0%	13%	0%	19%	0%	0%	0%	6%
Low water level during critical times	42%	42%	0%	59%	41%	0%	61%	0%	31%
Selfish upstream water users	80%	83%	109 %	0%	94%	0%	73%	0%	56%
Poor water management	20%	75%	0%	68%	13%	0%	0%	5%	24%
Poor design	8%	42%	0%	0%	41%	50%	24%	0%	20%
Pump breakdown	37%	10%	0%	0%	56%	100%	39%	0%	29%

3.1.1. Siltation

Siltation of the water source was the major reason cited by 70% the respondents for having less water from the water source. All the schemes that had Save River as their water sources had problems of siltation. Field observations made during the survey and during the time when the researcher was working in the low veld of Chipinge and Chiredzi between 2008 and 2013 revealed that the problem of siltation was mainly felt during the dry season between September and December every year. The water would stop flowing; exposing the heaps of sand in the lower parts of Save River with a wide sea of sand platform dissected into tracks of shallow water strips running parallel each other as shown in Figure 2 and 3.

According to the farmers interviewed, in Chipinge and Chiredzi, water related conflicts tended to be more prevalent during the dry season as the normal watering schedule became difficult to maintain. One farmer in Rupangwana said: September to December is the time when people fight for water in the scheme as it will be difficult to maintain our normal irrigation schedule due to high temperatures and limited water in the river.

Figure 2. Save River with a small stream navigating through heaps of sand deposits near Rupangwana irrigation scheme

Figure3. Save River- a week after the onset of rains in November 2014 showing high level of siltation

In Rupangwana, the farmers reported that they would concentrate on 2 blocks during the dry season and get back to their fields when the water situation normalised after the onset of the rainy season. This strategy involved each farmer cultivating less than 0.1 hectare during the period of limited access to water. In Dendere, the night storage was *2500 cubic metres and the 75 hectare scheme was divided into 5 blocks but only 4 blocks were used as the fifth one could not be used due to water shortage. Each farmer was allocated a 0.1 hectare field in each block to make sure that some farmers were not disadvantaged as some blocks were not accessing adequate water.*

Farmers from Chiredzi and Chipinge felt that the silts that were sucked by the water pump were affecting the normal functionality of the schemes. In Dendere one IMC committee member said:

> *"We started experiencing more frequent pump breakdown the time when we started having a lot of silts on our side of the river and when we took out pump for service, the mechanic said that the sand was damaging the pump's impeller as it was increasing the pumping load of the pump".*

It was also confirmed by farmers in Tsvovani irrigation scheme, that before a new set of pumps was bought, more pump breakdowns were experienced during the dry season when the water discharge was low and sand would be closer to the pumps. Siltation also added the scope of work for the farmers as it required backbreaking scooping. In the case of Tsvovani, the sand that was sucked in by the pumps was deposited in the main delivery canal or the first reservoir and the farmers would scoop both ends, the suction point at the river and from the delivery canals. If allowed to accumulate in the canals, the silts from Save River would not only lead to the siltation of night storage dams but would also reduce the water holding capacity of the delivery canals leading to water spillage. In Zuvarabuda, the farmers had the extra responsibility of diverting the water that was usually prevented from flowing along the Chipinge bank side by the silts so that the water would flow near the suction point of the pump for the scheme. Each time the farmers were irrigating, they

would use their shovels to direct the water to their pumping pool, scooping sand in the process. One farmer said:

> *"Tinombobvisa zvedu ivhu nemafoshoro asi ibasa rinoda dozer kuti mvura iuye kuside kwedu, mavhu acho awandisa" (Although we do scooping using our own shovel, the work requires some earth moving machinery like dozers to direct the water to the side of the pump as the mass of sand to be moved is just too much).*

3.1.2. Technical challenges on dams

Farmers for Mutorahuku irrigation scheme reported that the scheme was severely affected by the reduction in the water level as it reduced the pressure needed to allow the syphoning system to suck water from the dam following vandalism of the original system that used to drain water from underneath. Initially, the system was designed in such a manner that an underground pipe would drain water from the bottom of the dam to the delivery canal. In the 2005 drought, the water level for the dam was so low that the whole dam was reduced to a small pool around the suction point. The illegal fish mongers who were taking advantage of the reduced dam water level to fish in the dam blocked the suction pipe to prevent fish from hiding in the pipe. By the time they learnt about the blockage, it was already too late to rectify it as the suction point was at the deepest end of the dam, making it inaccessible. The service of sea divers was needed to remove the stones that closed pipe. However, ZINWA reportedly, could not enlist the service of sea divers due to financial constraints.

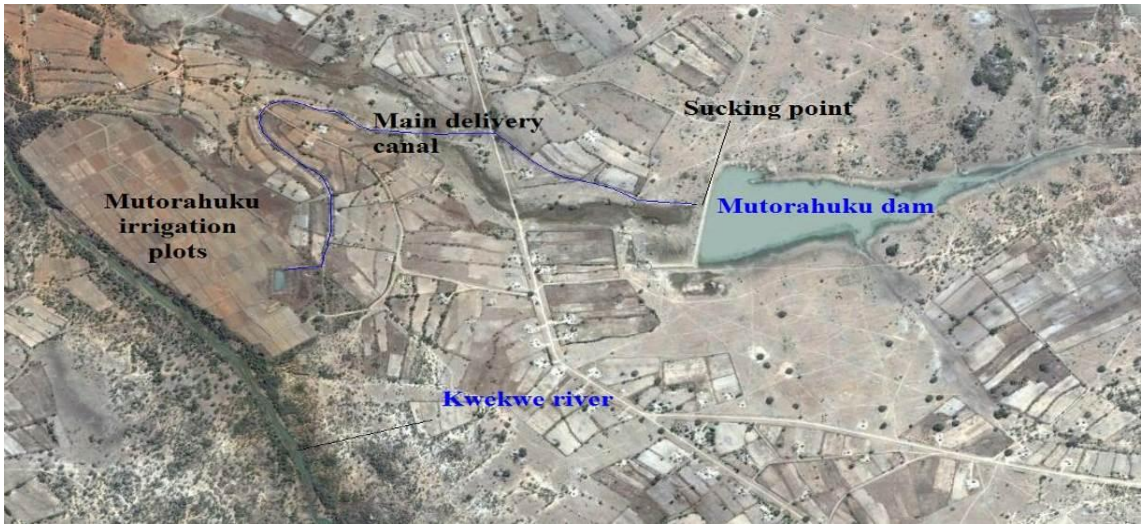

Figure 4. Mutorahuku irrigation scheme-showing the gravity powered system from the dam to the irrigation plots

The farmers were told that sea divers were very expensive to hire. Instead, they inserted a syphonage system (see Figure 4 and 5) that played a similar role but only when the dam level was above 70%. Consequently, the system only works until August every year when the dam level would still be high. The moment the water level fell below 70% full, the reduced volume of water from the dam would not give the needed pressure build-up to force the water to be siphoned through the pipe. The poor water abstraction at Mutorahuku was preventing farmers from growing wheat in winter as the water supply could not irrigate the crop to maturity, considering that the dam would be below 70% full by August every year, when the wheat crop would still be in its late vegetative stage.

Figure 5. The syphoning system of water abstraction at Mutorahuku dam in September 2014

At Insukamini, farmers get their water from Insukamini Dam through gravity. The dam was constructed across Ngamo River, and was believed to be so big that, even if the catchment of the dam failed to receive any single drop of rain in 5 years, farmers would continue to irrigate in the scheme. Unfortunately, one of the dam's outlet pipes developed a small leak by the end of 2013, which was manageable in the first few days. With time, the leak grew bigger and became unmanageable (See position of the leakage in Figure 6). By the time of the survey, the ZINWA official based on the site indicated that the water that was coming out of the leaking pipe was more than what the farmers were using in the irrigation scheme.

The farmers' fear was that, at that rate of water loss, the water in the dam would be finished before their crops reached maturity stage during the last week of November 2014. Unfortunately, ZINWA was taking time to rectify the problem, to tame the unaccounted for water losses and the ever increasing pipe leak which the ZINWA official based at the dam and the farmers believed could threaten the dam wall. As was the case with Mutorahuku, sea divers were needed to search for the rod that was used to close the gate valve located at the deepest inner side of the dam. It was a very dangerous spot and only sea divers could assist. Farmers were told that ZINWA had no money to enlist the service of sea divers. Since the leaking started, engineers from ZINWA never visited the site to weigh different options of solving the problem or to share with the farmers what they should brace for in the face of the new challenge. Farmers were never made aware of the estimated cost of hiring sea divers. For farmers who have been paying their water bills for almost 2 decades,

they could not understand why ZINWA was failing to secure money to stop the leaking dam. This possibly explains why 74% of the farmers felt ZINWA's service was poor.

Figure 6. Insukamini leaking dam wall

Investigations by the researcher on the cost and procedure of getting the sea divers further exposed ZINWA's appalling lack of service delivery culture and commitment. The sea divers were found at the Police's Sub Aqua unit based at the Zimbabwe Republic Police Morris Depot in Harare. One needs to pay US$500 consultation fee and pay their subsistence allowance of $100 per day for every member of the team, which for a team of 5 divers could cost $500 per day. If the job takes 2 days, the service requester would just pay the subsistence allowance for the divers, giving a cumulative total of $1500. ZINWA's claim that they could not afford the service of the sea divers raised 2 issues. One being that they never bothered to inquire about the cost in the first place as it was cheaper than the syphoning system they introduced at Mutorahuku. The other issue is that ZINWA was so detached from the problems of the farmers that they never bothered to weigh the cost and benefits of the new system at Mutorahuku.

3.1.3. Competition with upstream water users

The Save River siltation, causing water shortage in smallholder irrigation scheme on the lower Save catchment during the period between August and December, was exacerbated by the fact that Macdom Sugar Estate, which feed into the Chisumbanje Ethanol plant usually block the whole river during the same period, to create a dam around their pump house (See picture in Figure 1.7 and 1.8). The water would only escape the barricades as seepage underneath the sand. The blocking of the whole river was done at the expense of the smallholder community irrigation schemes downstream at a time when the temperatures would be very high and the need for irrigation would be very critical in the schemes. Farmers in all the schemes expressed

that reduced water discharge became more serious from the time Macdom resumed agricultural operations in 2009.

What disappointed farmers most about the water sharing violation by Macdom was the fact that ZINWA was not doing anything about the monopolisation of Macdom over the river water, although they had water permits allowing them to access water freely from the Save River. ZINWA had assured them access to irrigation water throughout the year even during the years of drought as ZINWA would open water from Osborne Dam in the upper Save Catchment. Contrary to their expectations, the water permits were not adding any value as they did not experience any improvement in water access after obtaining the water permits and paying up their water bills. Although several complaints were sent to ZINWA over this mal-practice by Macdom, nothing was done. The failure by ZINWA to enforce such a critical section of the Water Act, in the eyes of the smallholder farmers, showed that it could not support its founding principles. After failing to act decisively on Macdom to share the water equitably, ZINWA was pressing harder on the smallholder farmers to pay their monthly water bills, yet the farmers would have struggled through scooping to access the water. One farmer in Rupangwana said:

> *"Iyo mvura yatinenge tatambudzikira tichibvisira mavhu, ndiyo yavanouyira pano kuti pengera kuti tibhadhare. Apa vanorega ve Macdom vachitora mvura yese, dei vachichi piwa mari yacho ne Macdom yacho iyoyo" (we struggle to get our water through scooping and ZINWA comes hard on us to pay for the very water that we struggled to get. If they give priority to Macdom, why don't they get all the money from Macdom?).*

We struggle to get our water through scooping and ZINWA comes hard on us to pay for the very water that we struggled to get. If they give priority to Macdom, why don't they get all the money from Macdom?

Figure7. The Save River completely blocked to create a pool around the Macdom estate pump house

Figure 8. The Save River completely blocked at the Macdom pump house a week after the onset of the rainy season in November 2014

3.1.4. Poor infield water management practices

Poor infield water management in the schemes was threatening their sustainability. For schemes like Insukamini, farmers started experiencing water shortages when the government extended the scheme using funds from the European Union. The extension of the scheme was done without the consultation of the farmers which in turn reinforced the farmers' perception that the scheme belonged to the Government. It was also done without due consideration of the water supply needs especially the enlargement of the main delivery canal from Insukamini dam.

In Tsvovani, the in-field earth canals were in poor working conditions causing a lot of the pumped water to be wasted before getting into the field. The scheme was operating on earth canals since 1984, which were initially rammed but the canals were no longer in good shape. Some parts of the canal system had become so shallow, due to the accumulation of sediments, that the water could no longer take one direction causing leakages all over. Some parts were engulfed by grass that was curtailing the smooth movement of water as shown in Figure 9.

Figure 1. Shallow and grass choked canals at Tsvovani irrigation scheme

Consequently, some fields in the south eastern part of the scheme were failing to access water at all while water was taking a very long time to reach other parts, which challenged the water sharing system amongst the farmers. The poor state of earth canals was therefore causing water logging on some parts of the plots while other parts were completely dry. The farmers were not able to upgrade the earth canals into concrete canals as they were heavily saddled by water and electricity bills. Only those farmers whose plots were being affected by the siltation of the earth canal felt the urgency of repairing or clearing the canal while those served with concrete canals were not worried about the problem. However, the poor flow of water was affecting every farmer, as it was contributing to high electricity bills to the scheme.

In Vimbanayi and Mutorahuku, field observations indicated that the embankments of the canals were so heavily eroded that it was a matter of time before they could collapse as shown in Figure 10. Some of the eroded canals had already started leaking. This level of neglect of the critical infrastructure in the schemes raised questions on the commitment of the farmers to the irrigation schemes. The filling of embankments did not require any special resource but importation of sand from one part of the scheme or just outside the scheme to the canal bank using wheelbarrows or buckets.

Figure 2. Eroded canal embankments in Vimbanayi and Mutorahuku irrigation schemes

3.1.5. Inability to pump during the rainy season

The researcher' experience along the lower Save river and farmers' reports confirmed that, in a normal or above normal rainy season, the Save River would be flooded from late December up to February. Because their plinths for the pumps were built on the river bank (Figure 11), they would be completely covered by water. In order to save the pump, farmers in Vimbanayi and Zuvarabuda would remove the pump and keep it outside the water until the floods subsided to safe levels.

Figure 3. Pump plinth for Vimbanayi and Zuvarabuda constructed near the bank of Save River

The pumping unit at Zuvarabuda and Vimbanayi were mounted on wheels to allow the farmers to drag the pump off the river before the pump was inundated with the floods. This was an effective way of protecting the pump from the floods but the process was not thought through to cater for irrigation needs during flood times. Reportedly, the flooding of Save River was highly unpredictable because the water that floods this part of the river usually come from the high rainfall receiving areas on the upper course of the Save river. The floods usually happen when the area, being a low rainfall area, would be completely dry and their crops in the scheme are in critical need for water. Farmers indicated that if they were consulted by the engineer on the maximum extent of the flood under normal and extreme flood conditions, they would have helped to site the plinth using their local knowledge about the flooding pattern of the river. Considering that these schemes would have experienced water shortages between September and December due to the combination of siltation and the poor water sharing system with Macdom Sugarcane Estate, the farmers in these two schemes would only be left with 6 months or two cropping cycle of effective irrigation of their plots. Considering the poor level of productivity of the schemes, these two cropping cycles could do little to leverage the continued existence of the scheme in the face of high electricity and water bills.

In Mambanjeni, the pump house was constructed near the bank of the Gweru river (see Figure 12) which usually got inundated with water every year and the farmers indicated that if they were involved in the siting of the pump house, they would have helped to avoid this design error to save the pump as all community members were aware of the extent of the flood of the river in a normal rain season.

3.1.6. Pump breakdown

Pump breakdown was a major problem in the history of all the pumped schemes although their severity differed across the schemes in the 10 years preceding the survey. Vimbanayi and Zuvarabuda had almost similar experiences in pump breakdowns and how the problems were fixed. Their pumps were washed away by the cyclone and flood of the year 2000 and they were only fixed between 2008 and 2010 by Mercy Corps (NGO). At the time of the survey, moderate pump breakdowns were reported in Dendere, Vimbanayi and Zuvarabuda and Rupangwana. Tsvovani had never experienced any breakdown since the pump was fixed in 2009 by an NGO called Parsel while Mambanjeni was under breakdown by the time of the survey.

For Dendere, the long history of breakdowns (since 1997) and how the farmers tried to fix the problem on their own explained how the number of farmers was reduced from 90 to around 50. In Dendere, farmers who participated in the FGDs recounted farmers' participation in the establishment and rehabilitation of the scheme which made them more committed to their scheme than the other schemes. During the year when they were handed over the scheme by of RED Barna (an NGO that helped to establish the scheme), they experienced a pump break down. The farmers had to contribute US$500 for the repair of the pump and those who failed to contribute towards the repair of the pump lost their membership to the scheme. This saw the scheme membership dropping from 96 farmers to 54 farmers. After frequent breakdowns, farmers resolved to buy two new sets of pumps in 2007, with each farmer contributing 100 Rands. The membership shrunk further to the current number of 38 farmers in 2007 after the other members failed to raise the 100 Rands needed for the replacement of the old pumps. The plots sizes were originally 0.18ha but had since increased to at least 0.4ha.

Figure 4. Plinth and pump house at Mambanjeni built on the river bank

In Tsvovani, the sand abstraction pumping system that was damaged by the cyclone and floods in 2000 was never repaired. What was left of it got vandalised during the 7 years of disrepair (between 2002 and 2009), to the extent that by the time of the survey, there was nothing left but a few remnants dumped outside the pump house as shown in Figure 1.13. In Rupangwana, when the sand abstraction system was damaged, ZINWA as the hitherto custodian of the pumps collected the pumps and its accessories for repair in Mutare in 2003. They never returned the pump. Reports of water pumps being taken away from the schemes by ZINWA or ZINWA related officials were not uncommon in schemes previously run by ZINWA. At St Joseph Irrigation scheme 20km from Dendere along Save River, the Chiredzi side, farmers lost their pumps under similar circumstances in 2004. In Rupangwna, a robust pump was allegedly stolen by ZINWA officials during the time when the Department of Water was transitioning to ZINWA.

Figure 5. Part of the remains of the sand abstraction system equipment at Tsvovan

3.1.7. Challenges in pump repair

All the 8 schemes had no member in their respective schemes that could repair pumps in case of breakdown, and mechanics for the repairs were only found in the towns of Chiredzi, Gweru, Bulawayo and Harare. The spare parts were either obtainable in Chiredzi or in Harare (about 600 kilometres away). The long distances travelled made these spare parts very expensive due to transport costs and the time to travel also increased the down-time periods of the pumps.

Only 31% of the farmers reported that they were contributing towards pump repair (Figure 5.14). The difference by sex of the number of farmers who were contributing towards pump repair was not statistically significant (χ^2=0.122, df=1, p=0.727).

The only reason farmers gave for not contributing towards repair was lack of money due to poor productivity levels. Sugar bean was the major cash crop for the scheme and the revenue received from the quantity of beans sold was regressed against the amount contributed towards pump repairs. Those producing more beans in the schemes were contributing more towards repairs as the regression analysis shows a positive linear relationship between the quantities of beans sold and the amount contributed towards pump repair R^2 = . 0.304, F=137.13 = 42.64, p< .001.

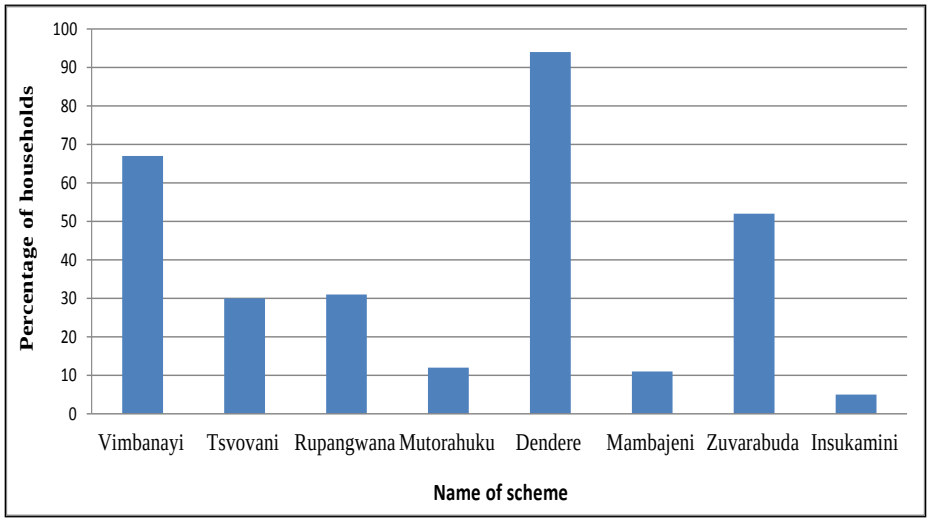

Figure 6. Percentage of farmers contributing towards pump repairs

The Pearson's correlation also shows that there was a strong positive correlation between the quantities of sugar beans sold and amount contributed towards scheme repairs (r = .0.55, df=1 p =.001). This finding suggests that those who were selling more had a greater incentive to contribute towards pump repair than who were selling less. The Chi square tests revealed that there was a significant difference between farmers with different ownership perception of their irrigation schemes and the amount they were contributing towards scheme repair (χ^2= 217.22, df=1, p=0.000). Those who felt did not own the irrigation plot were contributing less money towards repairs, suggesting that, insecure land tenure was removing the incentive to contribute towards repairs of the scheme.

It was also observed in the field that some of the pumps in the smallholder irrigations had outlived their design life and had become obsolete. Interviews with Department of Irrigation (DOI) officials hinted that if the farmers were made to invest in the replacement of these pumps in the preceding 2 decades, farmers could have bought new pumps on their own to replace old ones, instead of relying on Government or NGOs. Owing to the fact that the companies that used to deal in water pumps had closed down in the face of hyper-inflation and the country's economic melt-down, the DOI officials said that they were assisting individual farmers in buying new water pumps from South Africa where they were much cheaper than in Zimbabwe. For example officials from the DOI revealed that, whereas big pumps cost US$9000 in South Africa they cost between US$16000 and US$20000 in Zimbabwe. Unfortunately, it was also reported by DOI officials that these irrigation equipment (including irrigation pipes and drip lines) were still attracting import duty and taxes at borders making these critical equipment very expensive and unaffordable for most of the smallholder farmers in Zimbabwe.

3.1.8. Poor service provision by ZINWA

All the 8 irrigation schemes had water permits although they reported that their level of engagement with ZINWA was not adding any value to their operations as it was not translating into improved access to water.

The service ZINWA was offering was rated poor by 70% of the farmers (Figure 15) and the difference in the farmers' rating across the 8 schemes was found to be statistically significant (χ^2=1.174, df=21, p=0.000). Mambanjeni had the highest proportion of farmers (91%) who rated the service poor, while Mutorahuku had the lowest proportion of farmers (26%) who rated ZINWA services poor. There was a significant difference on the amount contributed toward water bill and among farmers with different perceptions about the ZINWA service (χ^2=162.48, df =9, p=0.000) with those who rated it poor having the highest proportion of farmers who were not contributing anything towards water bills.

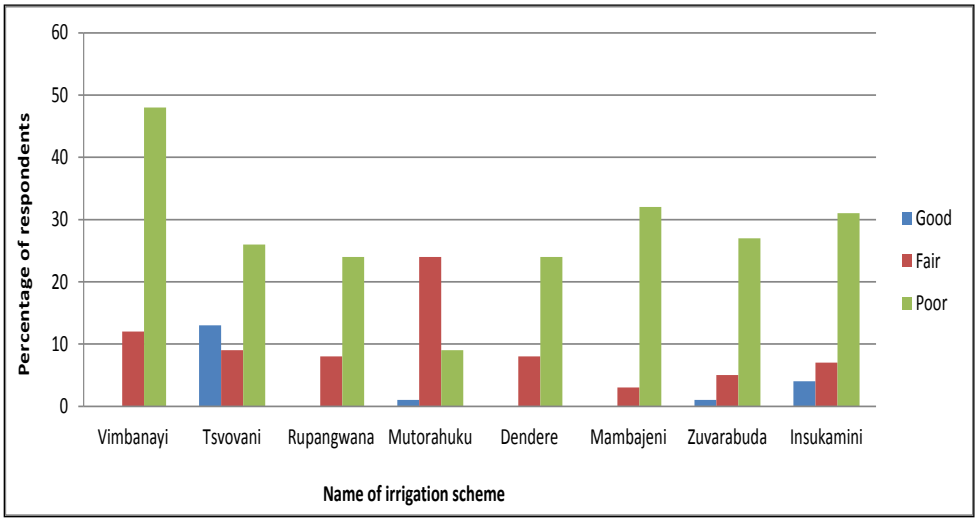

Figure 7. Farmers' rating of ZINWA service

This pattern suggests that farmers were resisting payment towards water bill due to poor service. Key informant interviews with officials from ZINWA confirmed that the organisation was getting resistance from farmers. One engineer from the Save catchment revealed that ZINWA was owed over US$35 million dollars by irrigating farmers across the country excluding those farmers who were irrigating illegally without the water permits. Farmers across the 8 schemes reported that they were no longer committed to clear off their arrears with ZINWA but were just paying enough money to prevent them from getting disconnected to water supply as they were not satisfied with the service from ZINWA.

3.1.9. Unjustified water charges

Farmers across the 8 schemes could not understand why they were compelled to pay for water irrigation from rivers and dam when there was no materiality in the service being offered by ZINWA. Unlike the farmers in Gweru district where ZINWA was actively involved in pump repair (at Mambanjeni), managing and running the gravity powered water system at Insukamini and Mutorahuku, farmers in Chiredzi and Chipinge could not understand why they were asked to pay ZINWA. They were extracting their water from the Save River and felt there was no apparent value addition in the involvement of ZINWA in their water supply system. One farmer from Zuvarabuda said; *"Ndinorwadziwa ne ZINWA, Mari yatinobhadharandeyei"* (I

am particularly pained by the money that we pay to ZINWA, what is it for?). The farmers that participated in the FGDs confirmed that they were not getting any service from ZINWA. They felt ZINWA's work was merely travelling to the scheme to collect their money every month and to disconnect the water supply if farmers failed to pay. If asked to attend to a pump breakdown or for any technical assistance, ZINWA would, according to the interviewed farmers, charge the farmer for both the mileage and for the repairs, making their service more expensive than that of private mechanics in Chiredzi.

The justification that farmers were given by ZINWA for paying for water was that it was their legal obligation by virtue of The Water Act and The ZINWA Act as bulk users of water. Failure of which could attract a fine or imprisonment. The Water Act (Chapter 20:24), Sections 34 and 39, and The ZINWA Act (Chapter 20:25) Section 30, made it clear that anyone using water for commercial purposes should do so in terms of a permit issued by the relevant Catchment Council or an agreement entered into with ZINWA, and should pay (ZINWA, 2014).

The justification given by ZINWA officials was that the government had invested in dams and was set to recover some money from the investment in keeping with the 'User Pays Principle'. The Government was also expecting ZINWA to be independent in covering some of its running cost and not to depend on the fiscus. Also the dams from which some of the schemes were getting their water were managed by ZINWA and the operational costs and personnel costs attached to it had to be paid by the users as the Government was incrementally failing to cushion ZINWA.

3.1.10. Overcharging of farmers by ZINWA

Although the ZINWA Act requires that irrigating farmers have meters or other measuring devices at their points of abstraction for both billing and statistical reasons, none of the 8 schemes had meters to quantify the water used and charged for by each. The bill was therefore based on the projected water use per hectare and the pumping capacity of the pumps. For schemes like Dendere where the pumps were mal-functional, farmers felt these estimates were not a true reflection of the water consumption of the schemes. Also, crops at different stages of growth have different water requirements and the use of estimates was not smart enough to reflect such fluctuations in water demand. When the Save River was flooded and during times when farmers used less water due to low river discharge, ZINWA would continue to charge the same flat rate. That partly explains why farmers felt the ZINWA billing system was not fair.

In Insukamini, it was reported that ZINWA overcharged farmers during the early days of the introduction of multiple currencies in 2011/2012. The error emanated from the use of a much bigger hectarage than what the farmers were cultivating. By the time of the survey, Insukamini farmers owed ZINWA US$10 000. All the farmers were paying between US200 and US$400 per month towards the water bill. The error was never rectified and the farmers were struggling to service the debt with their own production. Farmers consulted the ZINWA office to get clarification over bills but no feedback was obtained. Each time they visited ZINWA they would meet a different person who knew nothing about previous reports on the matter. The catchment staff, based in Bulawayo (over 200 kilometres away), never visited farmers to talk about their problems and the person they usually met was the official responsible for collection of monthly payments towards the bill

and who, when asked about the problem, always said; *''ini ndavinga mari handina hurukuru, kana muchida hurukuru endai kwaBulawayo''* (I have just come to collect money and if you have queries regarding the bill you should visit the catchment office in Bulawayo).

3.1.11. Political interference

ZINWA officials indicated that the institution's operations in dealing with all categories of farmers were affected by political interference. Without necessarily referring to smallholder farmers, they indicated that defaulters of payments for water permits were usually protected against disconnection by politicians, with indications that although they use disconnection as a strategy to force farmers to pay, an order by a politician to stop the process usually frustrates the efforts. They also highlighted that most ministers and high-ranking officials owed ZINWA millions of dollars and the institution could not do anything to them. The zenith of political interference was demonstrated in July 2013 when the Government ordered ZINWA and ZESA to cancel all the debts owed by rural and urban residents.

3.1.12. Rigidities in operations of ZINWA

ZINWA was using catchment boundaries rather than the political boundaries respected by other institutions. For some water users, this system of defining jurisdictional areas was proving to be very costly as that would entail travelling very long distances to get a service that could be offered by the same organisation closer by, but belonging to a different catchment. For example, although closer to the Sanyati catchment (20 kilometres in Gweru), Mambanjeni and Insukamini Irrigation schemes were working with ZINWA Gwayi Catchment with offices Bulawayo in Bulawayo, over 200 kilometres away. Such rigid adherence to catchment boundaries was expensive to both the farmers and ZINWA itself and one would wonder why ZINWA could not make a discretional decision to allow users closer to a ZINWA office to use it even if it did not belong to that catchment. That possibly explains why Mambanjeni had the highest proportion of farmers who rated the service of ZINWA as poor. Mutorahuku is in the same district as Mambanjeni which was serviced by the Sanyati catchment in Gweru and had the lowest proportion of farmers who felt ZINWA's service was poor.

ZINWA officials reported that the underlying factors against non-payment of water rates was that the farmers were still not self-sufficient and were not operating as commercial farmers but as communal subsistence farmers. One ZINWA official said:

> *"We have fewer problems in servicing estates like Ratings and Macdom sugar estates that feed into the green fuel Ethanol plant at Chisumbanje in Chipinge, than smallholder irrigation schemes. Therefore, the solution for the low production levels and non-payment of rate lies in the commercialization of the schemes".*

One ZINWA official from Manicaland Province revealed that Matanuska Banana company was sub-contracting farmers in Tanganda irrigation schemes to grow bananas under contract farming arrangements. It was working very well. It guaranteed farmers with a steady flow of income and the private company was also benefiting from the arrangement. With the land reforms and the fluidity of the land ownership structure

in Zimbabwe, the former white commercial farmers in the farming industry survive better by partnering with the smallholder farmers under such arrangements like contract farming. ZINWA's experience with farmers under such partnership revealed that they were paying their water rates more consistently without any serious follow ups than those who were not under contract farming.

4. Discussion of research findings

All the irrigation schemes along the Save River were threatened by siltation which was preventing water from flowing on the surface between September and November every year. Farmers had to scoop the sand around the pump suction point to create a pool from which to access irrigation water. In Zimbabwe research has focused on the causes of siltation with Morton (2013) and Ncube (2013) highlighting how illegal mining by gold panners and Chinese mining companies in Matabeleland South were causing siltation of Insiza River and Umzingwane River. Siltation has reduced water holding capacity of Insiza, Inyankuni Lower NcemaUmzingwane and Upper by also most 40% due to rampant siltation (Morton, 2013; Ncube, 2013). In 5 out of the 8 irrigation schemes siltation was shown to be restricting the quantities of water available for irrigation and the scooping of sand was over burdening the already over-burdened farmers. The farmers' experience were similar to what farmers in Koraro village in Ethiopia have been experiencing since 2000, when the rivers' surface flow became seasonal due to both high siltation level and reduced rainfall, forcing farmers to scoop sand or digging holes in the dry riverbed (Ngigi, 2014).

It can be deduced from the effects of siltation in the irrigation schemes that the future generation will not enjoy the same access to water as the current generation due to poor land use and mining practices with the catchment areas of the respective water source. In keeping with the concept of natural stock of capital that underpins sustainable development, sustainability of irrigation schemes can only be ascertained if the natural capital/stock, (water resource) remained intact, suggesting that their future will remain hopeless in the face of the unprecedented siltation. The WCED (1987) states that sustainable development happens when exploitation of resources, the direction of investments and institutional change are all in harmony and enhance the potential to meet the current and future human needs and aspiration.

Farmers who participated in this study linked the siltation of water bodies to the economic hardships affecting the country as people began turning to gold panning in large numbers in the early 1990s when the country was hit by poor harvests due to droughts and high level of unemployment following the country's Economic Structural Adjustment Programme (ESAP) and its economic meltdown in the 10 years preceding 2009. The link between Zimbabwe' economic meltdown and siltation of rivers was consistent with the SLF understanding of the non-linearity nature of factors that affect livelihood strategies and the SLF assertion that sustainability was constrained by the environment of structures and processes (Davies, 1997). The 2010 report on climate change attributed the change in water discharge to low average rainfall and high evapotranspiration rate from the ever increasing high temperatures (IPCC, 2014).

The problem of siltation in the irrigation schemes along Save River was exacerbated by the inequitable water uses between the upstream giant sugar plantation and the smallholder irrigation schemes in the

downstream as the plantation would completely block river to create a big pool around their pumps at the expense of the smallholder farmers. ZINWA's failure to effect an equitable water sharing mechanism among the different farmers did not only compromise the sustainability of the irrigation schemes as it did not only affect the cropping cycles of the schemes but also the willingness of the farmers to contribute towards water bills which in turn was critical to sustainable of ZINWA as the organisation relied on what the farmers were paying to finance its operation. The concept of equity that underpins the concept of sustainable development was premised on the realisation that the unjust society or practices are unlikely to be sustainable in environment or economic terms in the long run (Agyeman et al., 2002). In trying to explain the poor state of irrigation farming in Sub Saharan Africa, Barker and Molle (2004) indicated that there has been a serious lag in the development of appropriate institutions to deal with the equitable allocation of water among competing users and strategically integrate the management of different stakeholders to satisfy the different needs of smallholder farmers.

The research study found out that in almost all irrigation schemes ZINWA could not respond to pump breakdowns, failed to avail sufficient quantities of irrigation water throughout the year yet it continued to levy farmers consistently even during the months when farmers had limited access to irrigation water and its officials were reportedly stealing from the irrigation schemes. Farmers also blamed ZINWA for failing to fix the gravity powered water extraction system that was vandalised by fish mongers at Mutorahuku dam and for failing to attend to the leaking Insukamini dam. The institution was also blamed for running a rigid service regime at the expense of the poor farmers. The concept of sustainable development calls for the identification and removal of such accumulated rigidities and impediments as well as the enhancement of the lost renewal capacities in institution to enhance sustainable development (Rigby and Caceres, 2001). The weak response to water breakdowns was contrary to the experiences of farmers in most Asian countries where, when a dam appeared to be leaking, the operating authority was usually under enormous pressure to repair the leak to save farmers from losses and the lives of the people in the downstream (Moore, 2011; International Atomic Energy Agency, 2014).

The fact that farmers were not happy with the service they were getting from ZINWA and yet were compelled to pay and, at times, short-changed, and also lacked the capacity to engage ZINWA and other related stakeholders such as Macdom to hold them accountable, mirrored the problems of insecure water rights which were reported in Philippines, Turkey, Mexico, Colombia and Argentina during the 1980s. The problems in these countries were attributed to farmers' lack of capacity and mechanisms for reliable legal and technical support services and for lobbying in governmental water policy forums (Moigne and Easter, 1992). It can be deduced from the above discussion that ZINWA failed to embrace the basic tenet of sustainable development, the concept of intra-generational equity (fairness in allocation of resources between competing interests), to enhance sustainability of both their business and that of the smallholder farmer (Agyeman et al., 2002). Contrary to the experiences in these schemes, it was revealed that Chile had an effective law enforcement mechanism that protected users from detrimental third party effects, part of which was an independent judiciary system that was monitoring water sharing among different users and reprimanding inefficient water authorities (Moigne and Easter, 1992).

The current research discovered that the absence of this link between payment and performance possibly explains why 7 out of the 8 schemes had outstanding ZINWA bills. Although there was no known research in Zimbabwe on the link between performance of service provision and farmers' willingness to pay utility bill, a number of researches in Asia predicted a high defaulting rate on water bill where farmers lacked the incentive to pay due to lack of a sustainable link between payment and performance (Barker and Molle, 2004; World Bank, 2008; Kadigi at al., 2012). In Morocco, increased water charges have been accompanied by improved service, hence greater willingness to pay on the part of the farmers (Kadigi at al., 2012).

It was also revealed that the farmers were not taking proactive measures in maintaining proper infield water management practices like maintaining infield canals in good working condition although the activity did not require any monetary commitments. Good stewardship of limited resources, ability to maintain wellness of infrastructure and ability to take responsibility and ownership enhances the sustainability potential of interventions (Grant, 2010). Poor production levels were also shown as the major threat to the sustainability of the smallholder irrigation schemes as there was a correlation between high levels production and demonstrated willingness to contribute towards electricity and water bills. This correlation attests to the inter-linkages of different systems connected to smallholder irrigation scheme as the production system affected the water supply system which in turn was affected by the input, output and financial markets as well as the ineffectiveness of the IMC and poor quality of institutional service delivery.

It was revealed that ZINWA was riding on the law to bill and to enforce payment by farmers, yet its engagement with farmers lacked materiality. The concept of social sustainability, inclusion and participation of multiple perspectives, hinted that for development initiatives and engagements to be sustainable, they need not be prescribed by law but that all players and agents must contribute to it and derive value from it (Phuhlisani Solutions, 2009; Rogers et al. 2013). The way the smallholder farmers across the 8 irrigation schemes were enduring the poor services from ZINWA confirms SLA's assertion that the main problem the poor farmers face is that the processes and structures which frame their livelihood strategies may constrain them unless the state adopts pro-poor policies (Carney, 2012).The sustainable development concept, as a discourse of ethics advocated for sustainable ways of doing business by organisations and governments (Jabareen, 2012). Therefore, the failure by ZINWA to professionally deliver some value into their service to the farmers predicted unsustainability, not only of the smallholder irrigation schemes but also of their business with and cash-inflows from the farmers.

Researches in Latin America confirmed similar inefficiencies with parastatals for several decades, where the providers of water and electricity were so poor that their services were deteriorating by the day and the poor farmers suffered most (Ferrand et al., 2004). Unlike the case with Zimbabwe where the water and electricity service provision has remained in the hands of parastatals, the provision of these services in Latin America, were handed over to private companies following some dramatic reforms, resulting in improved water and electricity supply to the poor smallholder farmers (Ferrand et al., 2004).

The sand abstraction water pumping systems that could have guaranteed continuous water pumping was not given priority by the development agencies that developed and rehabilitated irrigation schemes along the Save River. In the eyes the unprecedented siltation, the water supply systems of the smallholder irrigation

schemes would not be resilient to the increasing siltation of the Save river. The fact that the irrigation schemes were affected by floods and reduced river discharge was also a strong indicator of the fact that climate change adaptation was not streamlined in the rehabilitation of the irrigation schemes (Downing et al., 1994; Brown and Lall,2006; Brown, 2012).

The failure by Engineers to consult locals in the siting of the pump plinth affirms the sustainable development concept of eco-form which asserts that sustainability can only be achieved where planning was done at the local level involving the intended beneficiaries (Grant, 2010). It is only through high level of local community participation that intended beneficiaries share ideas and use their indigenous knowledge to sustain their own projects such as the community irrigation scheme (Carney, 2005; Ofosu, 2011; Nyong et al., 2013). Ostrom (1994), in her study of the community smallholder irrigation schemes in Asia concluded that where community members were actively involved and the traditional management system embraced, most of the schemes were free from threat of inundation and flooding.

5. Conclusion

Unprecedented siltation of water bodies compounded with inequitable water sharing and poor catchment management were conspiring to frustrate the sustainability of smallholder irrigation schemes yet interventions in the schemes were not prioritizing sand abstraction water pumping system. The Zimbabwe National Water Authority (ZINWA) as the water governing body proved to be inefficient and its engagement of farmers as its major client was very poor. Farmers could not understand why they were compelled to pay water bills to ZINWA as they could not find the link between the water charges and the quality of the service they were getting. A combination of farmers' low productivity levels, debilitating dependency syndrome, ZINWA's poor service culture and political interference in water governance was affecting farmers' ability and willingness to contribute towards water bills. There was poor in-field water management and some schemes were poorly designed as there was no consultation of the local people on the designing of the pumping systems. The majority of the schemes were incurring frequent pump breakdowns and farmers had no reserved funds for pump repair and replacement investment.

6. Recommendations

- Smallholder irrigation schemes need to invest in sand abstraction water pumping system to adapt to the unprecedented levels of siltation in Save river
- The Government need to improve the service culture of the water governing bodies and each irrigation scheme should have a replacement investment fund to allow for continuity of operations in irrigation schemes without reliance on external aid.

- ZINWA should work hand in hand with the Environmental Management Agency to reduce river siltation by curbing gold panning along river catchments and stream-bank cultivation. It should also invest in ways of de-silting water bodies or sand abstraction methods of abstracting water.

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