In-situ water harvesting technologies in semi-arid southern Zimbabwe: Part I. The role of socio-economic factors on performance in Gwanda district

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ABSTRACT

Droughts and dry spells which have characterised the past decade in Zimbabwe have seen a marked increase in the promotion and use of *in-situ* water harvesting technologies(WHTs) as a drought mitigating strategy. A number of these technologies have been tried in recent years which include dead level contours with infiltration pits and deepened contours. However, although water harvesting is known to increase food security in drought prone areas, the role of socio-economic factors on their performance and scaling out is still not well understood. This study sought to investigate the socio-economic factors which influence the performance of these technologies as well as to identify key factors driving / hindering adoption. The study involved 14 key-informants interviews and questionnaire administration to a total of 55 respondent farmers practicing water harvesting. SPSS tools were used to analyse relationships between performance of WHTs and attributes such as labour, resources, gender, social status and education,

The results show a strong correlation between performance and resource status (p=0.004). For example within the wealthy category, 42.1% were successful, while 14.3% and 13.8% were average and poor performers respectively. Performance rating was also significantly correlated (p=0.007) to gender of household head e.g. within the most successful group 94.7 % were men compared to 5.3 % women. There was also a significant correlation between resource status and gender ($p=0.039$) such that within the wealthy category, **69.2**% of respondents were men compared to **30.8**% women. The majority of the key-informants (93%) alluded that the more labour resources at one's disposal, the higher their chances of success. This is so because WHTs are time-consuming and labour intensive. Social status, education level and number of years using water harvesting technologies did not have a significant bearing on performance. The most successful farmers had made modifications to their systems which included; plastering the bottom of pits, covering the pits to reduce evaporation and altering the depth of pits. The paper concludes that resource ownership could be a key factor in farmers' ability to scale out WHTs. Performance was significantly linked to resource status. Women headed households were performing rather poorly in WHTs suggesting the need for special attention to gender in the promotion of WHTs.

Keywords: *labour, performance, socio-economic, success, water harvesting technology*

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1. Introduction

Africa has, in the past been hit by a barrage of climate related natural disasters. These catastrophes have had adverse effects on communities, development efforts and national economies as well as on critical human, natural and other material resources. Zimbabwe has not been spared as evidenced by a marked increase in droughts and dry spells. For smallholder rain-fed systems, these occurrences have severely undermined food security and general livelihoods as the majority of rural populations derive their livelihoods from rain-fed agriculture (Makurira *et al*, 2007). The majority of affected small-scale farmers are located in less favoured agro-ecological conditions, with poor soils, and low and erratic rainfall where periodic droughts and dry spells result in complete crop failure, water scarcity and livestock deaths. In order to improve the effectiveness of crop production in these marginal rainfall regions, cultural practices which conserve and extend the period of water availability to the crop are essential (Gollifer, 1993; Twomlow and Bruneau, 2000).

In order to mitigate effects of droughts a number of in-situ water harvesting technologies (WHTs) have been introduced and are being implemented in many semi-arid areas of Zimbabwe. *In-situ* WHTs refers to all interventions that collect and conserve rainwater thereby prolonging the time of soil water availability to crops (Mupangwa, 2008). A range of *in-situ* WHTs exist and are currently being tested. These include infiltration pits (Maseko, 1995); cross-tied graded contours, deepened contours and fanya juus (Hagmann, 1994). Extensive research efforts have been done on *in-situ* WHTs in Zimbabwe and success stories have been documented (Nyagumbo, 1999; Twomlow *et al*., 2000; Rusike and Heinrich, 2002; Motsi *et al.*2004; Mugabe, 2004).

However, even though water harvesting is a proven technology to increase food security in drought prone areas (FAO/AGL, 2000; Mutekwa and Kusangaya, 2006), the conditions under which these technologies perform well has not been fully explored. This had led to indiscriminate recommendation of the water harvesting technologies without considering the prevailing socio-economic conditions of an area. It is hypothesised that social and economic aspects affect the performance of WHTs despite good techniques and design. Further research is thus needed to establish the key socio-economic conditions affecting the performance and scaling out of *in-situ* water harvesting technologies. This will help in refining recommendations for their use and improve farmers capacity to adapt to climate change.

2. Research objectives

The main objective of the study was to identify and evaluate the socio-economic factors which affect performance of *in-situ* water harvesting technologies.

The specific objectives of the study were as follows:

- To determine the socio-economic factors which influence performance of WHTs
- To explore preconditions for success in use of WHTs based on farmer's experiences

3. Methodology

3.1 Study area

The farmers targeted by the research were smallholder farmers involved in crop production using WHTs in Wards 17 and 18 of Gwanda District lying within the Mzingwane Catchment. Mzingwane catchment, which is part of the Limpopo river basin, is divided into four sub-catchments, namely, Shashe, Upper Mzingwane, Lower Mzingwane, and Mwenezi (Fig. 1). The rainfall is between 450 - 600 mm rainfall per year and this is subject to frequent seasonal droughts.

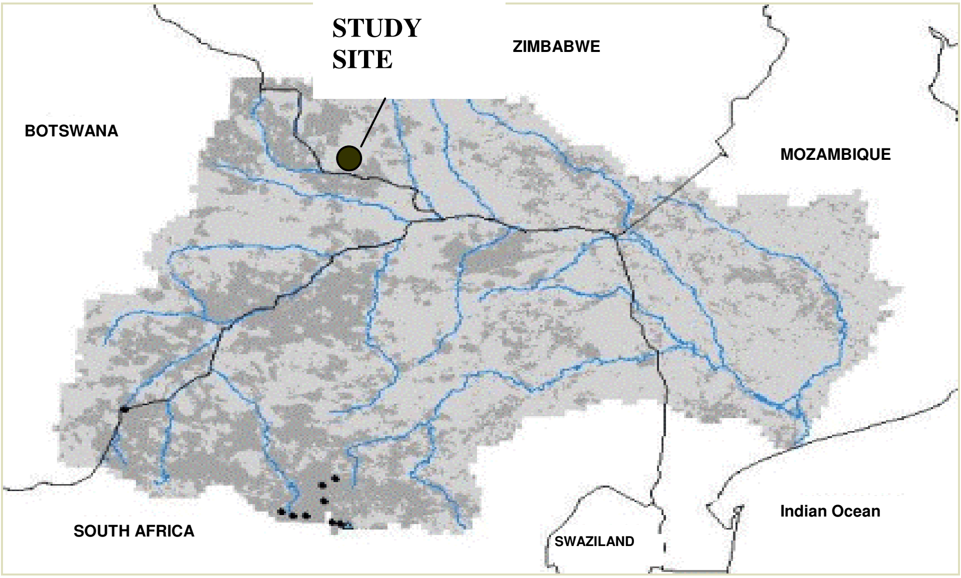

Fig. 1. Location of study site in the Mzingwane Catchment, Limpopo Basin

Gwanda because of its semi-aridity is flooded by numerous types of WHTs so as to overcome effects of seasonal droughts and ensure food security. These techniques include dead level contours with infiltration pits, conservation basins, contour strips, storage tanks, dam construction and ripping. A number of organisations mainly non-governmental organisations (NGOs) have been promoting the various technologies. Some of them are Practical Action, ICRISAT, ORAP, World Vision, and Agritex. Practical Action was more active in the visited wards. Although the programmes started as early as the pre-independence era (before 1980), intensive advocacy of the technologies started in earnest with coming of the new millennium.

3.2 Data collection

The methods employed included a questionnaire survey; key informant interviews, focus group discussions and field observations. A questionnaire was administered to a total of 55 farmers from Ward 17 and ward 18. These respondent farmers were selected during two community meetings held in each ward. The farmers were put into three groups according to their performance (as evaluated by farmers themselves) with WHTs. It was from these groups that the 55 farmers were randomly selected. The aim of the meetings was to sensitise the community and create awareness about the study as well as to get their views and opinions on the various research questions. As a result the community were very active in the whole process. Key informant interviews were done with 14 informants identified from both wards and constituting kraal heads, councillors, WHT coordinators and extension agents. Direct observation was used as a crosscutting method throughout the fieldwork as it helped to capture some salient issues which did not necessarily feature during discussions.

3.3 Categorisation of farmers into resource categories

Respondents were classified into 3 resource categories (wealthy, medium rich and resource constrained) based on 3 criteria: range of implement types, livestock value, and land size. To calculate livestock value, market prices of livestock prevailing at the time of study were used in the formula;

$$\text{Livestock value} = (P_d*N_d+P_c*N_c+P_g*N_g+P_p*N_p)/(P_d+P_c+P_i+P_p)$$

Where;

P_d = price of donkeys ($300)
P_c= price of cattle ($250)
P_g=price of goats ($25)
P_p=price of poultry ($5)
N_c= number of cattle
N_d= number of donkeys
N_p= number of poultry
N_g= number of goats

Range of implement types referred to the number of different types of implements owned. The values from the 3 criteria were then used to classify the respondents into the 3 groups. Income and remittances could not be used due to economic challenges prevailing at the time of study

3.4 Data processing and analysis

The data collected was processed and managed using Microsoft Access database. Data summaries from the database were imported into Statistical Package for Social Scientists (SPSS) for statistical analysis. The following major analyses were carried out:

- General descriptive statistics including frequency tabulations and cross tabs mainly to ascertain the relationships between discrete variables such as resource status and performance level of farmers using WHTs.
- Comparison of means to find out the relationships between discrete and continuous variables.
- One-way analysis of variance for comparisons between groups on quantitative variables.

4. Results

4.1 Socio-economic characteristics of the sample

4.1.1. Education and average household size/age

The average age of the respondent farmers was 51 with the oldest respondent at 85 years and youngest being 31. The majority of the respondents were males (69%) and females were 31%. The average household size was 8 with average number of children (below 12 years) at 4. The majority of the respondents had complete primary education with the highest qualification being Ordinary level as shown in figure 1. Of the 14 key informants, four were women and 10 were men with ages ranging from 26 to over 56 years .The majority (80%) of the key informants fell in the over 56 years age group.

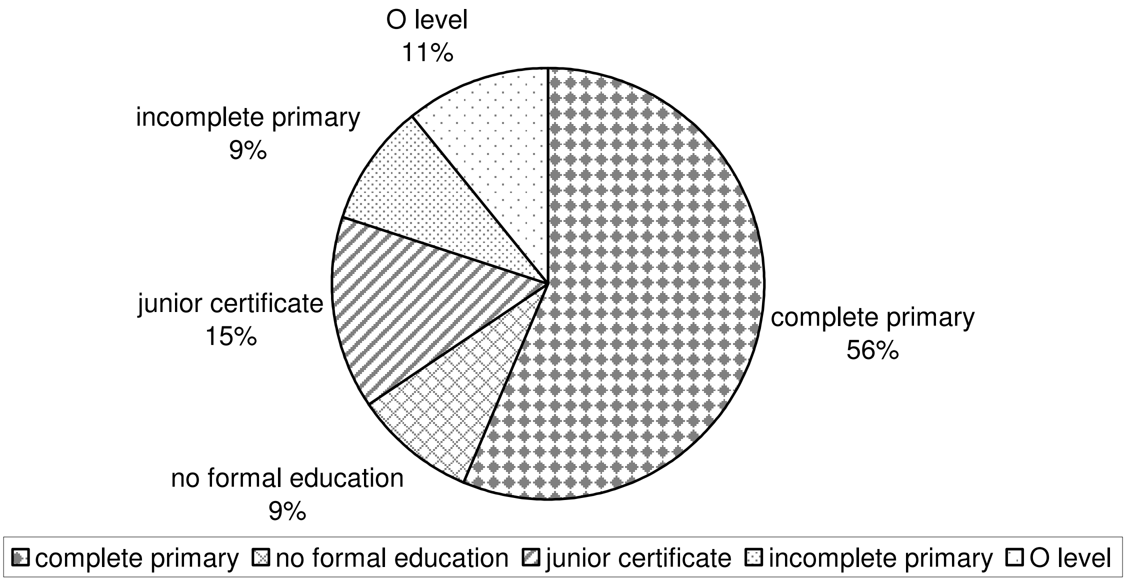

Fig. 1. Education level attained by respondents

4.1.2 Land ownership, tenure and tillage system

The average landholding size of respondents was 4.6ha with the smallest size of 1ha and biggest size of 6ha. It should however be noted that not all the area was under WHTs, as this increased with increase in land size as reported in Part I of this paper. When asked about the type of ownership of land, the majority (85.5%) indicated that their land was individually owned with the minority (14.5%) pointing out that their ownership type was collective. Collective ownership in this case referred to a situation where 2 or more farmers work together in one field when they are practicing WHTs. The main methods used to till the land were manual using hoes and animal traction using mainly donkeys and cattle (both ox and female cows are used). However, those using manual were few (23.6%) compared to those using animal traction (76.4%). Animals used for this purpose were either owned by the farmers (90 %), rented (7%) or borrowed (3%).

4.2. Influence of farmers' resource status on peer-rated performance in WHTs

Performance in water harvesting was found to be significantly correlated (p=0.004) to resource status with the wealthy farmers performing better than resource-constrained farmers as shown in Fig 2. Thus within the successful category, 42.1% were wealthy, while 42.1% and 15.8% were medium-rich and resource-constrained respectively. Within the average performance category, the majority were medium-rich (57.1%) compared to 28.6% and 14.3% resource constrained and wealthy farmers respectively. Within the poor performance category, the majority (51.7%) were resource constrained compared to 34.5% and 13.8% medium-rich and wealthy farmers respectively.

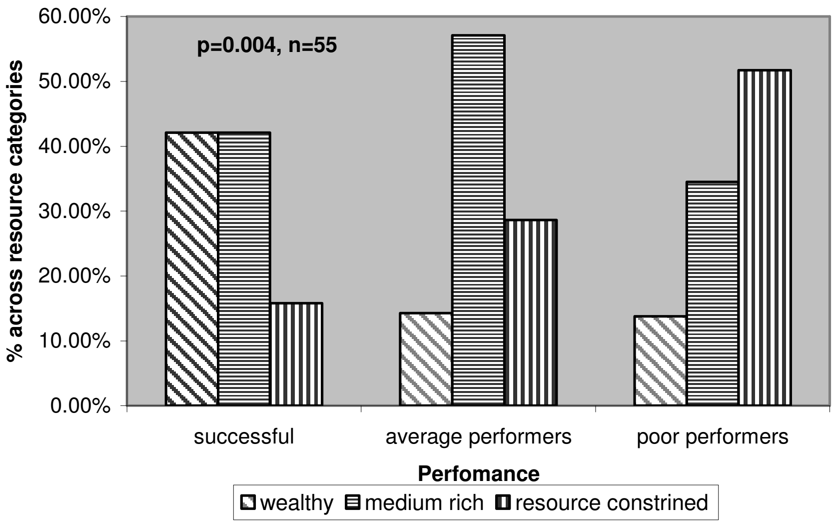

Fig. 2. Influence of resource status on farmers' peer-rated performance in WHTs

The same trend was noted when analysing constitution of farmers by resource status within each performance category as shown in Table 1.

Table 1. Variation of Performance within each Resource Category

Resource Category	% Within Performance Category		
	Successful	**Average**	**Poor**
Wealthy	61.5	7.7	30.8
Medium-rich	36.4	18.2	45.5
Resource constrained	15.0	10.0	75.0

Table 1 shows that the majority of wealthy farmers are also successful (61.5%), compared to 7.7% and 30.0% average and poor performers respectively. In the resource constrained category, the majority (75.0%) were poor performers, while 15% and 10% were successful and average performers.

4.3 Influence of gender on peer-rated performance in WHTs

Pearson chi-square test showed a significant correlation (p=0.007) between gender and farmers' performance with WHT with men performing better than women as shown in Fig 3.

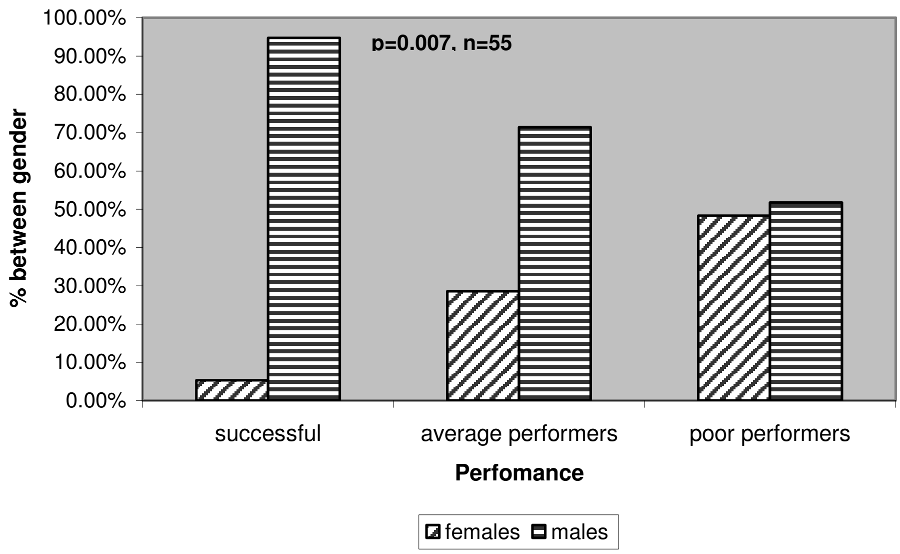

Fig. 3. Relationship between gender and performance

Fig 3 shows that within the successful category, there were more men (94.7%) compared to women (5.3%). In the average performance category, the same trend was observed with 71.4% men and 28.6% women while in the poor performance category 51.7% were men compared to 48.3% women. Further analysis was done in order to get variation of performance levels within each gender category. The results are shown in Table 2. Table 2 shows that within each gender category the majority of women (82.4%) were poor performers while 5.9% successful and 11.7% average performers. On the other hand, majority of men (47.5%) were in the successful compared to 13.1% and 39.5% who were average and poor performers respectively.

Table 2. Influence of gender on farmers' performance with WHTs

Gender	**% Within Performance Categories (n=55)**		
	Successful	**Average**	**Poor**
Females	5.90%	11.70%	82.40%
Males	47.40%	13.10%	39.50%

4.4 Relationship between gender and resource status

Upon realising that female-headed households performed poorly than their male counterparts, there was need to ascertain if resource endowment had anything to do with this status quo. The results showed a significant Pearson correlation (*p=0.039)* between resource status and gender with the majority of men being more resource endowed compared to women as shown in Fig. 4.

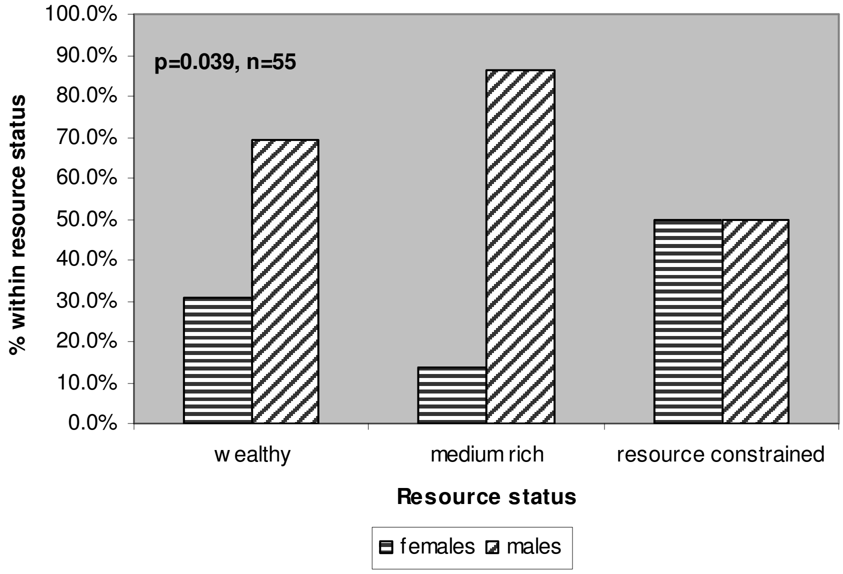

Fig. 4. Relationship between gender and resource status

Fig 4 shows that within the wealthy category, the majority (69.2%) of respondents were men compared to 30.8% women. In the medium rich category, the majority (86.4 %) were men compared to 13.6% women. However, in the resource constrained category there was an equal proportion (50%) of men and women. Results further reveal that within each gender category, more women were resource constrained compared to men as shown in Table 3.

Table 3. Distribution of gender in resource categories

Gender	% Within Each Resource Category (n=55)		
	Wealthy	**Medium-rich**	**Resource constrained**
Females	23.50%	17.60%	58.90%
Males	23.70%	50.00%	26.30%

Table 3 shows that within each sex category most women (58.90%) were resource constrained compared to 23.5% who were wealthy and 17.6% who were medium-rich. For men, the majority (50%) were in the medium rich category compared to 23.7% in the wealthy and (26.3%) in the resource constrained categories. This shows that most of the women were resource constrained whereas most of the men were medium-rich.

4.5 Influence of experience (number of years using WHTs) on peer-rated performance on WHTs

Results showed no significant difference in mean years of experience across performance ratings even though data tended to show a decline in performance with decrease in number of years a farmer has been practising WHTs as shown in Fig. 5. Increasing experience also tended to reflect improved performance.

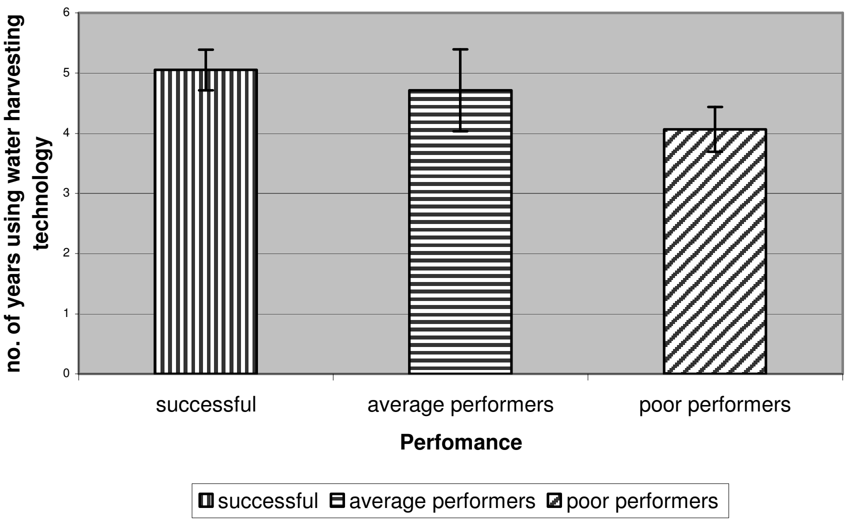

Fig 5. Influence of experience on peer-rated performance on WHTs

4.6. Influence of labour on peer-rated performance on WHTs

Using family size as a proxy for available family labour, and taking into account that family labour is often complemented by hired labour and through labour exchange, the study found no significant difference between labour numbers and performance despite the fact that the majority (93%) of the farmers felt labour was a key factor for success. Average labour per household was 6.3.

4.7 Influence of farmer innovativeness on peer-rated performance on WHTs

Innovativeness as measured by type of modifications done to WHTs was observed in fields of the most successful farmers. While the majority of farmers (70%) did not do any modifications to their fields, some of successful farmers (30%) had made some modifications to their systems.The modifications included: plastering the bottom of pits, covering the pits to reduce evaporation, altering the depth etc. as shown in Fig 6.

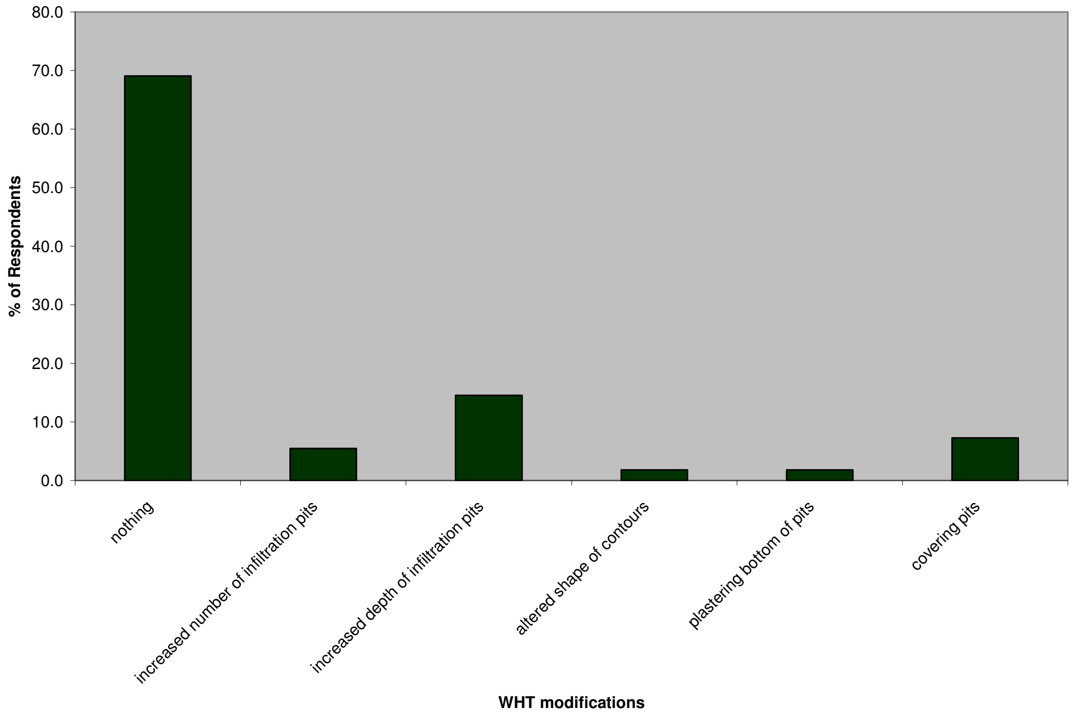

Fig. 6. Variation of modifications made to WHTs by successful farmers

4.8 Influence of social status and education level on peer-rated performance on WHTs

Education and social status did not have any bearing on performance as the wards have recorded success across different education levels and social divide. Key informants elaborated that ordinary farmers with no position in society can do well than those with influential positions and vice-versa.

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5. Discussion

A number of challenges were met during the execution of study which could have affected outcome of results. It should be noted that even though the farmers interviewed can all be viewed as poor farmers, there was however need to categorise them into the 3 resource categories so as to be able to explain the differences in their performances. Remittances and other financial income was deliberately left out in the categorisation of farmers into resources categories because of the complexity of calculating the income due to the different currencies used at the time as well as the hyperinflationary environment. Even though yield was a better indicator for performance there were a number of challenges which made it scientifically unsound to use yield figures. For instance, the farmers did not record their yield as a result figures given were not reliable. In addition yield was given for different seasons making a comparative analysis difficult.

However, be that as it may, results from this study suggest that socio-economic factors affect performance of farmers with WHTs. Researchers and development operators often fail to perceive the whole picture, and tend to overlook the inner household context and/or external environmental factors that influence the performance of such innovations.

5.1 Wealth

Wealth status was shown to contribute to success or failure in use of WHT. Those farmers who were resource endowed performed better than farmers who did not have as much resources. This could be because for WHTs to be implemented farmers need draft power, implements and capacity to buy inputs. These findings support earlier observations by Perret and Stevens (2004) who noted that farmers who possess a higher quantity and quality of endowments will place a higher future value on medium- and long-term benefits produced by investment in conservation technologies. This observation could explain the differences in performances across different resource categories. Interesting to note also is the fact that, more medium –rich farmers performed better than wealthy and poor farmers. The reason for this could be that the medium-rich category is usually comprised of farmers who are innovative, dynamic and willing to capitalise on every opportunity which might arise in the community to better their lives. They have nothing to lose unlike wealthy farmers who tend to have pride at stake such that they do not attend most community meetings and they feel they have everything. As for the poor farmers , lack of resources to implement new technologies and their risk averseness tends to limit their capacity to succeed with new technologies.

5.2 Gender

The results show that gender balance determines to a larger extent how farmers perform with WHTs. Women performed poorly with WHTs mainly because most of these women are single parents as a result of either death of husband, divorced or never married. This status puts women at a precarious position because they do not have the much needed resources to successfully implement WHTs as their male counterparts. Boyd *et al* (2000) noted that female-headed households tend to have less family labour and participate less in labour exchange, a factor which could explain their poor performance. In addition Semgalawe (1998), found that female-headed households tend to have limited access to information and land ownership. Resources aside, there are some households where women who are staying with their husbands implement WHTs alone without their husbands even though they are present. In such households, women pointed out during focus group discussion they face a lot of challenges. The most important one was because of the nature of the task (labour intensive, tiresome) these women would be found wanting when they become intimate with their husbands because they will be tired. So in order not to compromise their marriages they tend to reduce their effort in WHTs.

5.3 Labour

The study found out that labour numbers did not have any significant effect on performance. The reasons as articulated by farmers was that, even though labour is very crucial since the task is so labour intensive (Boyd etal, 2000; Perret and Stevens, 2006), the number of persons in each household does not necessarily translate to available labour. The logic behind this was that people need to be cooperative in order to be successful. A household might have many people who are able to work in the field but as long as they do not unite to achieve a common goal then a household with fewer united labour people might be more successful than the one with more people. This finding may also be explained by the long term nature of investments in water harvesting technologies, implying that cross-sectional data are not the best approach to analysing this factor. As pointed out by farmers they employed collective action and reciprocal arrangements to overcome household labour shortages when they were digging the dead level contours.

5.4 Education

Study results showed no significant correlation between education level and performance with WHTs meaning that a farmer's education status did not influence his/her performance with WHTs. These findings were different from what was found by Boyd et al (2000) who found that those with education up to primary or 'O'-level were most likely to practice and perform better with soil and water conservation techniques whilst those with no education were less likely to practice suggesting that some education is an important prerequisite. Differences between these two sets of results might be because in this study the technology was promoted across all farmers and used practical demonstrations to show farmers how to implement the technology thus nullifying the need for education or literacy.

6. Conclusions

This study highlighted that socio-economic factors play an important role in determining farmers' performance with water harvesting technologies. There is need to consider the inner household context if these technologies are to be successful. Overall the results from the study suggest that resource ownership could be a key factor in farmer's ability to scale out WHTs. Performance was found to be significantly linked to resource status. Women headed households were performing rather poorly in WHTs suggesting the need for special attention to gender in the promotion of WHTs. The influence of labour on performance was not apparent from the study which might have been to do with limitations of the methodology used in the study.

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