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Title of Research Paper: Contribution of farmer perception and project implementation process towards adoption of rainwater harvesting tanks for food security in Bolero, Malawi

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Contribution of farmer perception and project implementation process towards adoption of rainwater harvesting tanks for food security in Bolero, Malawi

Abstract

This study explored the contribution of farmer perception and project implementation process to adoption of rainwater harvesting (RWH) tanks for food security in Bolero, Malawi.

Data was collected from 10 purposefully selected villages using semi-structured interviews, focus group discussions and direct observations involving 68 respondents comprising key informants, extension workers, project participants and non-participants. Data collected was analysed using descriptive content analysis.

Study results show that unsuitable aboveground RWH tank size was promoted for backyard irrigation. The 10m^3 tanks could not irrigate crops to maturity and farmers could not realize attractive benefits from produce. Results also reveal inappropriate approach use during technology introduction. Project introduction lacked publicity and community involvement in planning and participant selection. Participant selection was biased towards village heads hence RWH tanks were perceived as meant for village heads. The study concludes that RWH tank size and implementation approach created negative community perception towards RWH tank technology and thus low adoption.

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To enhance technology adoption, this study recommends improvement in tank size and implementation approach. Aboveground RWH tanks with capacity 30m^3 and above should be promoted in arid areas under high publicity and community involvement in decision making.

Contribution of farmer perception and project implementation process towards adoption of rainwater harvesting tanks for food security in Bolero, Malawi

1.0 Introduction

1.1 Background

Rainfall provides a major source of water to smallholder farmers for agriculture production. In recent years, Malawi has experienced erratic rainfall distribution in most parts of the country including Bolero, Malawi. Erratic rainfall through prolonged dryspells has led into crop failure and food insecurity among smallholder communities whose livelihood depend entirely on rainfed agriculture (Action Aid, 2006; Malawi Vulnerability Assessment Committee, 2014)

Rainwater harvesting (RWH) is a promising strategy to fight food insecurity in areas affected by prolonged dry spells in Africa including Malawi (Stringer et al., 2009). Hatibu and Mahoo (1999) define RWH as a method of collecting and storing rainwater for agriculture and other uses. RWH categories include in-situ RWH which promote infiltration of rainwater into the soil where it falls such as tie ridges and ex-situ RWH which collects runoff from catchments and stored in storage structures such as RWH tanks (Mogoi et al., 2009; Biazin et al., 2012).

Since 2006, the Malawi government and development agencies, following the Malawi Growth and Development Strategy which identifies agriculture and food security as a priority area, promoted RWH tanks across the country in areas affected by long dryspells and with limited access to conventional irrigation such as Bolero to allow vulnerable communities produce additional crop for food security through backyard irrigation (Rainwater Harvesting Association of Malawi (RHAM), 2013). The adoption and replication of these tanks among smallholder farmers however has remained low creating fears amongst development agencies over the sustainability of the technology (RHAM, 2013). Studies conducted in sub-Saharan Africa indicate that the low RWH tank technology uptake are due to farmers characteristics, socio-economic, technical and institutional factors (Ngigi, 2003; Mloza-Banda et al., 2006; Ahmed et al., 2013; Murgor et al., 2013) and based on some recommendations to explore the factors further, this study mainly focussed on socio-economic and institutional factors with particular attention to farmer perception and project implementation process.

1.2 Problem statement

Crop failure in Bolero is quite common and 87% of households experience food shortage due to frequent dryspells (Mataya et al., 2014). Despite huge investments by Malawi government and development agencies in RWH tanks to curb food insecurity through backyard irrigation, technology uptake remains very low (RHAM, 2013) yet farmers continue to face the risk of poor rainfed agricultural productivity. Studies have been done on RWH tank adoption with very few done in Malawi focusing mainly on identification of factors (Mloza-Banda et al., 2006; Murgor et al., 2013; Shikur & Beshah, 2013) with little attention placed on exploring how the factors affect technology adoption among smallholder farmers. Identified factors have included farmer characteristics, socio-economic, technical and institutional factors and key to these have been farmer perception and the implementation process. The studies have however not produced explicit information to explain and understand how the factors have contributed to adoption of RWH tank technologies to inform policy and practice.

1.3 The Purpose of the study

The purpose of the study was to explore how farmer perception and project implementation process contribute to adoption of rainwater harvesting tanks for food security in Bolero, Malawi.

1.4 Research questions

1. How was the RWH tank technology implemented in Bolero?

2. What is the perception of smallholder farmers towards RWH tanks in Bolero?

3. How do smallholder farmers describe their decision to adopt RWH tanks for food security in Bolero?

4. What strategies would enhance smallholder farmers' decision to adopt RWH tanks for food security in Bolero?

1.5 Significance of the research

This study was aimed at generating in-depth understanding on the contribution of farmer perception and project implementation process towards adoption of rainwater harvesting tank technologies for food security in Bolero, Malawi. The in-depth understanding will provide useful knowledge to policy-makers, development practitioners and the smallholder farmers for making informed decisions on best practices that could be employed to enhance mass adoption of the technologies. The information would provide a platform for effective policy development and engagement by concerned stakeholders to better deal with erratic and dry spells to address issues of food insecurity in dry areas like Bolero.

1.6 Layout of the paper

This paper has 5 sections. Section 1 provides the background to rainwater harvesting in Malawi and its relevance to food security, the problem statement, the purpose of the study and research questions. Section 2 reviews relevant literature to the study. Section 3 provides the methodology employed during the study. Section 4 presents the results of the study and section 5 presents discussions and conclusions on the study.

2.0 Literature review

2.1 Theoretical concepts

Community participation and community development

Bamberger (1986) defined community participation as an active process whereby beneficiaries influence the direction and execution of development projects rather than merely receive a share of project benefits. Chambers (2004) referred to community development as economic growth aimed at responsible wellbeing for all by all.

Participation is widely used by development projects to involve the people in decision making in programmes that affect and benefit them (Bonye et al., 2013). True participation according to Ledwith (2011) is achieved through empowerment of people to engage in collective action for justice and democracy from a critical perspective. Zadeh and Ahmad (2010) argue that there can never be development without participation, because participation ensures that decisions affecting the community are taken by community members for collective ownership and transformation. The logic behind participation is that as development is people-centred, genuine development knowledge is people's knowledge and what counts is local rather than abstract expert knowledge (Pieterse, 2010). Believing in community participation creates the opportunity to believe in the power of solidarity. Joining together in solidarity facilitates community members' understanding that their individual problems have social causes and collective solutions (Tan, 2009). Well informed individuals about social issues are likely to engage in collective action (Fulbright-Anderson & Auspos, 2006) because they perceive that they are part of a greater unity, a more coherent whole rather than alienated fragments without the power to change the issues that are affecting their lives (Ledwith, 2011).

Adoption and diffusion of innovation

Rogers (1995) defines adoption as a decision to make full use of an innovation and rejection as a decision not to adopt an innovation. The perception of the community towards an innovation is critical in technology adoption. Govender and Govender (2014), argues that individuals have internal goals which they endeavour to achieve and keep their perceptions matching these reference conditions as they are subjected to an innovation. Rogers (1995) observes that innovations that are perceived by potential adopters as having greater relative advantage, compatibility with existing values and practices, trialability, observable results, and less complexity are adopted more rapidly than other innovations.

The adoption of a technology takes place through the innovation decision process and Rogers (1995) conceptualised a five stage process including 1) knowledge, 2) persuasion, 3) decision,

4) implementation, and 5) confirmation. Murray (2009) notes that each stage of the diffusion process requires unique strategies as the stages progress and thus in-depth research on the diffusion process will assist in translating research and innovations into good practice.

2.2 Empirical literature

Rainwater harvesting (RWH) for agricultural production is more suitable in arid and semiarid areas where annual rainfall average ranges from 200mm to 800mm (Ahmed et al., 2013). RWH is done to bridge crop growth during intra-seasonal dryspells to maintain or increase crop yields (Ngigi, 2003) and also to extend garden activities through irrigation to supplement rainfed produce (Woltersdorf et al., 2014). Implementation of RWH tank technologies have met adoption problems in many countries and research done has been seeking ways of improving adoption among the smallholder communities.

Hatibu and Mahoo (1999) reviewed major RWH technologies for improving crop production in Dodoma, Tanzania and observed that most RWH projects failed due to low acceptability by local farmers owing to lack of technical capacity, inappropriate approach with regard to farmers' socio-economic conditions and missing out on farmers' priorities. The study advises considering farmers' priorities in project designs and focussing on crops that can be sold for more cash because where clear benefits have been demonstrated, farmers undertake at their own initiative huge investment in RWH.

Ngigi (2003) assessed the potential of RWH technologies for improving food and water availability in semiarid regions of eastern Africa. Results indicated that ex-situ RWH technologies were less common in Sub-Saharan Africa due to relatively high investment costs although adoption is slowly picking up because of their contribution to food security. Ngigi (2003) however notes that each RWH technology has limited scope due to hydrological and sociological limitations. These limitations includes practised farming systems, economic environment, formal and informal institutions, land tenure, population pressure and social structures which must be considered when determining the potential of developing and up scaling ex situ RWH technologies.

Mloza- Banda et al. (2006) in Malawi evaluated factors affecting the performance and adoption of rooftop RWH tanks in orphan care centres using a questionnaire survey and focus group discussions. The study found that farmer participation and RWH tank utilization was based on perceived benefits although there was no uptake of the technology by community members other than those supported by projects due to affordability of the structures. The study recommended a cost sharing approach between development agencies and smallholder communities to enhance the adoption of the technology.

Kahinda et al. (2007) explores the state of RWH in South Africa using underground and above ground tanks and identifies challenges for sustainable implementation of the RWH pilot programme. Despite advantages of providing better quality water for drinking and other domestic uses right at the household, Kahinda et al. (2007) noted that the technologies are unaffordable by the rural population targeted. The RWH tanks lacked guidelines and operational procedures and that the designs did not include local community experiences. The study concludes that the sustainability of the technologies require close cooperation between the government, development agencies and rural households but also a clear legislation on RWH.

Sturm et al. (2009) examined if RWH techniques are technically and economically feasible as well as affordable for future users in Namibia. The roof catchment systems and the underground catchment systems were examined. The study concluded that roof RWH systems proved to be the most efficient option among the chosen alternatives and the tanks are affordable for private users, especially if options of microfinance are considered and recommended following up on underground catchment systems to gain technical and institutional experiences on adoption.

Murgor et al. (2013) using a field survey and structured interviews investigated factors influencing farmers' decisions to adopt RWH techniques in Keiyo district, Kenya and found that poor capital and human resource endowment, lack of access to credit, farmers perception, technical factors, lack of technical knowhow, level of education and involvement in social responsibilities as key factors affecting adoption decisions. The paper concluded by recommending strong awareness creation on technological benefits, consideration for inclusion of farmers' views in strategy development and implementation and the need for integrated water resources management and policy development on rainwater harvesting if rainwater harvesting structures could constitute a viable investment in semi-arid areas.

Shikur and Beshah (2013) did a qualitative study to evaluate factors influencing the adoption of RWH techniques in Lanfuro Woreda, Ethiopia. The results indicated that educational level of household heads, water shortage experiences, farm size, technology awareness, institutional support, training and extension services, access to credit , farm income and household's age were factors that influenced household's decision to adopt RWH techniques. Shikur and Beshah (2013) however noted that perception and indigenous knowledge on rainwater harvesting practices needs to be exploited further to support adoption of RWH technologies.

Although literature has emphasized the importance of RWH technologies in addressing food insecurity in arid and semiarid areas, the study review has shown that implementation of those technologies has some adoption problems. The studies reviewed managed to identify factors affecting the adoption of the RWH tank technologies among the smallholder communities and key amongst them include farmer perception, approach to project implementation process, institutional and socioeconomic factors. The studies however have not provided the depth of knowledge required for understanding how the factors contribute to low adoption of RWH tank technologies. The study review has also shown that little attention has been placed on exploring factors affecting adoption of RWH tank technologies especially in Malawi to guide policy.

3.0 Research methodology

3.1 Study area

The study was done in Bolero Extension Planning Area (EPA), Rumphi district, in Northern Malawi. Bolero EPA headquarters lies on E0581360 and N8786019 and with an average altitude of 1,099m above sea level. The area has a total population of 58,550 people living in 112 villages (Rumphi Farm Input Subsidy Programme Database, 2012/2013).

Administratively, Bolero EPA is divided into 12 sections and has 11710 farm families whose livelihood depends on rainfed subsistence farming. Annual rainfall ranges from 600mm to 760mm and is unpredictable. Temperatures range from 22 to 35 degrees Celsius (Rumphi District Socio-Economic Profile, 2009). Maize is the main staple food crop grown followed by cassava and millet while tobacco is the main cash crop grown followed by groundnuts and beans (Mataya et al., 2014).

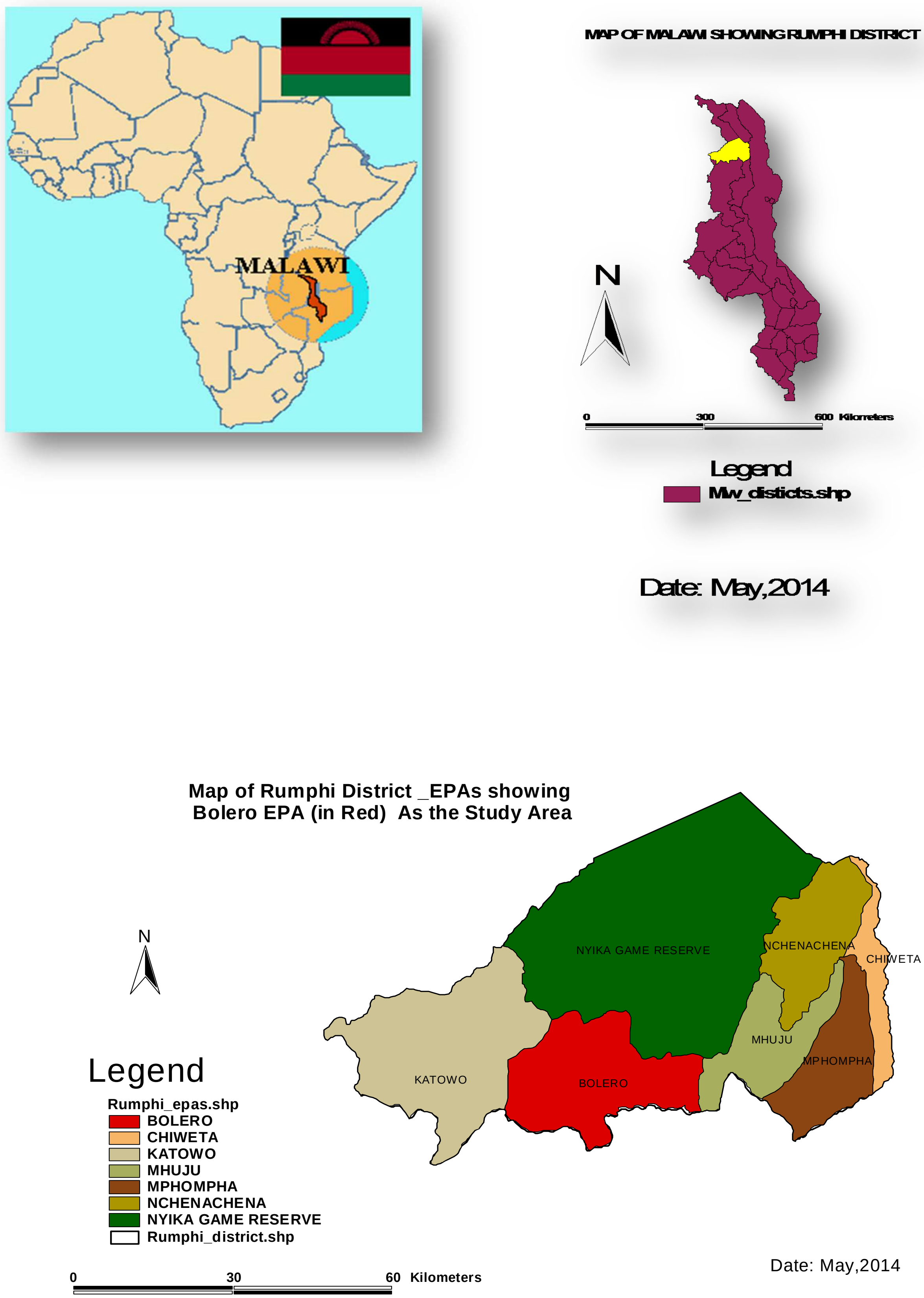

Figure 1: Map showing the study Area, Bolero

3.2 Study design

In order to collect in-depth information, qualitative methods were used in collecting primary data. Three methods were used in data collection including semi-structured household interviews, focus group discussions and direct participant observation. Obtaining data from different sources and using different methods helped in cross-checking results and increasing reliability of data (Berg, 2007).

3.3 Sampling methods and sample size

The research was purposefully conducted in 3 sections of Bolero EPA namely Mjuma, Bumba and Bata sections covering 10 villages. Purposeful sampling selects participants for a specific reason (Marvasti, 2004). The 3 sections were purposefully selected because more RWH tanks were implemented in these sections hence respondents knowledgeable on the research topic could easily be found. A stratified sample is used to ensure that certain segments of the identified population under examination are represented in the sample (Berg, 2007). In this case, participants and non-participants of RWH tanks were included in the study targeting both men and women. To reach saturation Hancock et al. (2009) recommends a total of 20 to 60 respondents or 4-10 focus group discussions depending on resources available. A total of 36 households were sampled for interviews from 10 villages comprising 18 participants and 18 non participants. Twelve of the participants selected implement household aboveground RWH tanks while the other 6 implement group RWH underground tanks (3 per group). Non adopters were selected randomly from a list of non- participating smallholder farmers in each of the targeted villages and proportional to adopters at the ratio of 1:1.

Due to the smallness of the sample, the study results cannot be generalised to the general population of Bolero and the aim was not generalisation but to sought understanding on the adoption of RWH tanks among the smallholder farmers in the study sites.

3.4 Data collection methods

Data collection was done using semi-structured household interviews, Focus Group Discussions (FGD) and direct participant observation. An interview guide (Appendix 1) was prepared and pretested prior to data collection to decide whether the interview questions were suitable for obtaining rich data for the proposed research questions (Elo et al., 2014).

Thirty six semi-structured household interviews were administered to gather information concerning the purpose and how the RWH tank projects were implemented in the study sites; the opinion of both participants and non-participants on RWH tanks implemented; the respondents opinion on adoption and factors contributing towards decisions to adopt the technologies; strategies that would enhance adoption and sustainability. The technique was chosen because it provides rich qualitative data related to experiences, opinions and values of the target population and allows access to the hidden perceptions of the respondents (Marvasti, 2004). Three project coordinators supporting RWH tank technologies in the study area were also interviewed for their experiences in supporting the technologies in the area.

Three FGDs attended by 29 respondents were administered to collect viewpoints from participants, nonparticipants and key informants in target sites on the implementation process and the adoption of the RWH tank technologies. Key informants included local leaders, lead farmers and extension workers in the study sites. Local leaders were selected for their local experiences in the study sites while lead farmers were selected for their role as local trainers alongside extension workers.

Note taking and audio voice recording accompanied FGDs and semi-structured interviews to allow data capture as respondents spoke. The direct observation method was used for collecting data on functionality and actual uses of the RWH tanks and photographs were taken.

Secondary data on past records of adoption of rainwater harvesting tanks was collected by reviewing recent literature from libraries, internet web sources and from development agencies.

3.5 Data analysis

Data analysis was done by using descriptive content analysis which involved establishing categories, systematic linkages between them and then counting frequencies of categories use in a particular item of text (Silverman, 2011). Considering the sample size of 36 respondents and 3 FGDs, data analysis was done manually (Finfgeld-Connett, 2014) with a focus on each question to look across all respondents and their answers to identify consistencies and differences (Taylor-Powell & Renner, 2003).

Data collected was inputted into word template and then reduced to only relevant data before coding (Namey et al., 2007). Coding of the findings was largely guided by the research topic, questions and the collected data sets (Finfgeld-Connett, 2014). By using cutting and sorting as a processing technique, data was placed into categories. Themes were then identified from categories by using repeating ideas (Ryan & Bernard 2003). The themes generated were later interpreted by looking at emerging trends within the responses of the participants in the study.

4.0 Results

This section presents findings from household interviews and focus group discussions (FGDs) with key informants. The results are presented based on the research questions and paragraphed based on themes that emerged during the analysis.

4.1 How was the RWH tank technology implemented in Bolero?

The study results show inappropriate approach to technology introduction to communities, biased project participant selection, inappropriate approach to technology financing and limited awareness creation as key issues emanating from the RWH tank technology implementation process and affected technology adoption.

Inappropriate approach to technology introduction: Results show 58% (N=36) of respondents indicating the technology was introduced through individual households, 28% indicated the technology was introduced through already existing groups while 14% of respondents indicated the technology was introduced through community meetings. All FGDs indicated community structures were not consulted during RWH tank technology introduction in study sites. Again 86% (N=36) indicated planning was done by development agencies, 8% indicated communities participated in planning and 6% indicated groups participated in planning. All three FGDs indicated programme planning was done by development agencies.

Biased project participant selection: Results show that 12 (N=18) participants were selected by agriculture extension workers for the sections and 6 were selected through existing groups. All the 12 participants selected by extension workers implemented household aboveground tanks of which 11 participants were village headmen and 1 participant was a village development committee leader. Six participants implemented group owned underground tanks. All the 18 participating households had prior experience in irrigation and belonged to existing groups previously supported by the agencies.

Inappropriate approach to technology financing: Results show that all construction materials including locally available materials such as sand, bricks and quarry stones for all RWH tanks (N=14) constructed in the study sites were wholly financed by the development agencies while project participants contributed food and accommodation for the builders. All skilled labourers were externally hired.

***Limited awareness creation about the RWH tank technology*:** Results show 94% (N=36) of respondents indicated not being aware about the technology prior to introduction to the community while 6% reported being aware. Most non-project participants (83% N=18) and most FGD members indicated not being aware about the purpose and uses of the technology in the study sites despite seeing them.

4.2 What is the perception of smallholder farmers towards the implementation of RWH tanks in Bolero?

The attitude of the respondents towards the usefulness of the RWH tank technologies on food security, their willingness to invest and means of investing in the technologies were explored.

Respondents were asked to rate the usefulness of the RWH tanks on their contribution to food security on a scale of 1-3 where 1=not useful, 2= useful and 3= very useful. The results are presented in table 1 below. The table shows more respondents indicating that the RWH tanks are useful to the community with average rating of 2.

Table 1: Rating of RWH tanks

Rating	Participants (N=18)	Non Participants (N=18)	Total respondents (N=36)
Very useful	7	4	11
Useful	9	5	14
Not useful	2	9	11
Average rating	**2.3**	**1.7**	**2**

On willingness to invest in the RWH tank technology, 69% (N=36) of respondents indicated willingness to invest in the technology and 31% indicated not willing. Out of those showing willingness, 60% (N=25) indicated would invest in the RWH tank technology through cost sharing with development agencies, 32% indicated would invest in the technology if provided with full support on construction materials while 8% indicated would invest in the technology by themselves.

4.3 How do smallholder farmers describe their decision to adopt the RWH tank technology for food security in Bolero?

Results show factors which motivated smallholder farmers' decision to participate in RWH tank projects and also factors which limited their participation and uptake of the technology.

For participating farmers (N=18), 89% mentioned participating in RWH tank projects because of their experience with water shortage in the area for domestic use, livestock drinking and perceived earnings from irrigation activities while 11% mentioned participating due to desire for new experience. The study shows 14 pilot RWH tanks constructed in the sampled villages between 2006 and 2012 to which the 18 smallholder farmers participated. Two types of RWH tanks are promoted. The 10 cubic meter (m^3) aboveground RWH tanks promoted at household level and the $50m^3$ underground RWH tanks promoted at group level. At the time of the study, 8 RWH tanks were functional and utilized, 2 were broken down and needed spare parts while 4 were non-functional due to cracks. For the 8 functional RWH tanks, observations showed the tanks are used for domestic purposes, livestock drinking, backyard irrigation and tree nursery as presented in figure 2 below. The figure shows that a large number of RWH tanks are used for domestic purposes while backyard irrigation has the least number of RWH tanks used for that purpose.

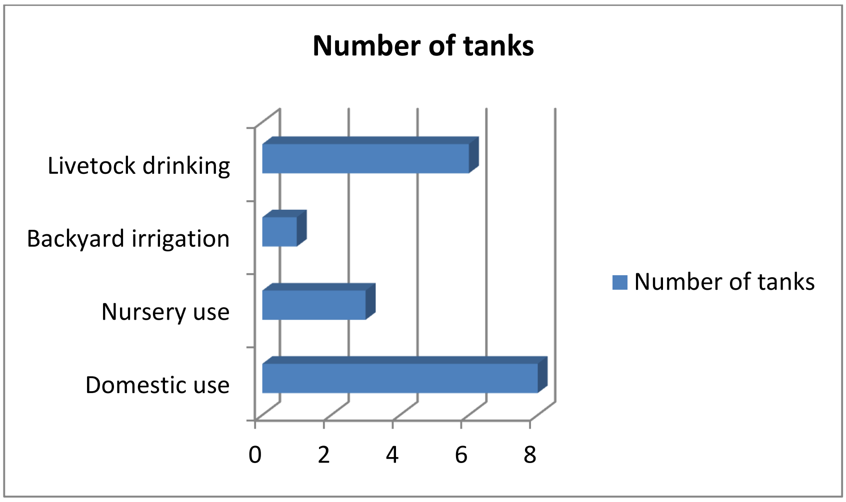

Figure 2: Uses of the RWH tanks (N=8)

The results also show that women use the RWH tanks mostly for domestic purposes while men use the RWH tanks mostly for livestock drinking, tree nursery works and backyard irrigation.

Figure 3: Domestic use of a RWH tank (Source: author, January 2015)

For non-functional RWH tanks, direct observations showed that most of the tanks are neglected as shown in figure 4 below.

Figure 4: A neglected underground tank (Source: Author, January 2015)

Factors which hindered uptake and adoption of RWH tanks by smallholder farmers for food security were listed and presented in table 2 below and ranked according to priority.

The table shows that unattractive monetary benefits ranked as the most important factor in limiting adoption of the technology followed by RWH tank size while fear of mosquitos/ disease ranked as the least important.

Table 2: Factors hindering the uptake and adoption of RWH tank technology

Factor	**Rank**
Unattractive monetary benefits	1[1]
Small RWH tank size	2
Inappropriate approach to technology introduction	3
Lack of awareness on the technology	4
High construction cost	5
Limited access to training and extension service	6
High labour demand	7
Fear of mosquitos/ malaria disease	8

4.4 What strategies would enhance smallholder farmers' decision to adopt RWH tanks in Bolero?

A number of strategies were identified that would help enhance adoption of the RWH tanks as in the table below ranked based on priority:

[1] 1= highest priority

Table 3: Key strategies for enhancing farmers' decision to adopt RWH tank technologies

Strategy suggested	**Rank**
Promote appropriate RWH tanks sizes for backyard gardening depending on area specific rainfall and rainwater catchment area.	1[2]
Enhance community participation in programme planning and implementation to include farmer needs and aspirations in technology implementation	2
Enhance publicity of the RWH tank technologies to create awareness to a wider society and attract donor support.	3
Develop and enhance a proper funding mechanism that will match community needs and farmer resource base.	4
Enhance training and extension service delivery to enhance management and utilization of RWH tanks on backyard irrigation.	5

The table shows promoting appropriate RWH tank sizes for backyard irrigation as strategy with highest priority followed by enhancing community participation in programme planning while training and extension delivery was ranked as least priority.

5.0 Discussions and conclusions

This section discusses key issues presented in the study results with a focus on research questions and their implication to policy. The section also draws conclusion based on the findings and discussions made.

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[2] Strategy with highest priority

5.1 How was the RWH tank technology implemented in Bolero?

The results show that the project implementation process was marred by inappropriate approach to project introduction, biased project participant selection, inappropriate technology financing and poor publicity to create awareness.

Inappropriate approach to technology introduction: The introduction of the RWH tank technology to communities lacked community involvement as the technology was directly introduced to selected individual households and a few to already existing groups. Again the revelation that development agencies exclusively planned for the implementation of the technology means that project participants passively participated in implementing the technology as local knowledge and aspirations were not included in the implementation plans. This top-down approach utilized by development agencies is widely criticized for ignoring the involvement and participation of the poor in interventions that affect their livelihood and also for demarcating between traditional cultures and modern cultures (Escobar, 2007). Matunhu (2011) notes that where participation is ignored strategies fail to construct adequate community commitment on development interventions. Lack of community participation during project planning can explain the absence of commitment project participants have on maintaining non-functional RWH tanks in Bolero suggesting lack of ownership over the technology. To enhance project performance and technology adoption, development agencies should consider community involvement during project planning and introduction to include local knowledge and experiences and encourage active participation in the implementation process.

Biased project participant selection: Results reveal that development agencies did not consider community participation as a strategy for selecting project participants instead opted to directly select individual participants through extension workers based on previous experience in irrigation activities, past affiliation to supporting agencies and community leadership positions. This approach excluded smallholder farmers who did not meet the criteria despite having the need and will to participate. The exclusion created a negative perception towards the RWH tank projects as most project non-participants believed that development is biased towards those who are already in development projects and could not be selected by extension workers because they were not known to them. The exclusive selection of village heads as project participants for almost all aboveground tanks was viewed by project non-participants and FGDs as inappropriate as the tanks were alleged by the communities as a technology meant for village heads only. This perception may have contributed to low technology uptake in study communities. To minimise bias, development agencies should consider community involvement through open forums as appropriate strategy for project participant selection.

Inappropriate approach to technology financing: The study results show that construction costs for the RWH tanks were exclusively financed by development agencies because the tanks were introduced to communities as demonstrations. This approach was inappropriate because it created participant dependency on project financiers and lack of ownership for the RWH tanks due to limited contribution from participants. The revelation can explain the non-functional RWH tanks awaiting support from development agencies to repair them. Since RWH tanks were introduced as demonstrations, the approach to financing too was part of the demonstrations suggesting that the technology can only be financed by development agencies as the implementation process lacked a replication plan. The use of skilled labour from outside study communities did not build the capacity of local artisans in the communities to construct the RWH tanks in case of technology replication and repair. Mathur et al. (n.d.) reports of a successful RWH jar programme in Thailand where locally trained village artisans provided skilled labour to interested project beneficiaries who had contributed 25% towards construction materials in addition to provision of locally available materials.

Limited awareness creation about the RWH tank technology**:** Most respondents indicated the technology was new and were not aware about the purpose and uses of the technology in the study sites despite seeing them suggesting that limited awareness about RWH tanks was created during the implementation process as communities lacked knowledge about the technology. Although coordinators indicated RWH tanks were introduced as demonstrations, the study reveals lack of effort to support demonstrations with publicity to expose the importance of the technology to the communities. Jean-Charles (2007) in Mali reported that it is difficult for a community to support a technology they do not understand or have not seen before because the risk of implementing it is too high. Access to technical information and potential benefits will allow farmers assess the technology for adoption hence the need to enforce publicity during technology introduction and implementation.

5.2 What is the perception of smallholder farmers towards the implementation of RWH tanks for food security in Bolero?

The perception of smallholder farmers in the study sites is that RWH tanks are useful and could contribute towards food security through irrigated cropping. This is a positive attitude towards the technology also as supported by the high number of respondents (69% N=36) willing to invest in the RWH tanks because of their experience with water shortage. Smallholder farmers however had negative perception towards the approaches used by development agencies in introducing the technology to the communities and thus affected the technology adoption process. He et al. (2007) found that the likelihood of adoption for farmers with positive attitude towards a RWH technology is higher than farmers with negative attitude. This study recommends community involvement during technology introduction and planning for any future efforts in RWH tank technology transfer to minimise negative perceptions towards the implementation process of the technology.

5.3 How do smallholder farmers describe their decision to adopt RWH tanks for food security in Bolero?

The results show unattractive monetary benefits, tank size, construction cost and access to training and extension services as most important factors in influencing farmers' decision to adopt RWH tank technologies in Bolero.

***Unattractive monetary benefits*:** The monetary benefits earned from backyard irrigated cropping were perceived unattractive to entice smallholder farmers to invest in RWH tanks for irrigation in study sites. The crops grown through backyard irrigation such as leafy vegetables were considered of low value due to low pricing thus did not provide attractive earnings to the participating farmers. On average, the participating farmers who grew leafy vegetables using underground tanks over 30 square meters (m^{2}) irrigation plots earned 6 Euros (€[3]) per cropping. Revenues of 108 € from 20m^2 irrigation plots for tomato were reported in Namibia under the pilot garden RWH tank project using household aboveground tanks and 258€ over a 48 m^2 plot using underground tanks (Woltersdorf et al., 2014). This is suggesting that future implementation of RWH tanks for irrigation purposes should be accompanied by high value crops for sale which would provide more monetary benefits to farmers for household maize[4] purchases for food and thus attract more farmers to adopt the technology for food security.

Tank size: The study reveals that the 10 cubic-meter (m^3) aboveground RWH tanks promoted were small in size and could not store enough water to irrigate a crop to maturity. Crops dried before maturity meaning the intended benefits from crop produce could not be realised. The drying of crops was not experienced by farmers who implemented 50m^3 underground tanks for

[3] Euro equivalent to Malawi Kwacha was 501 at the time of study.

[4] Maize has remained the main staple food for Malawians hence food security has mainly been defined in terms of access to maize (Malawi Growth and Development strategy II, 2011-2016).

irrigation. The results also show multiple uses of the stored water with women using the stored water mainly for domestic purposes due to recurrent water scarcity problem in the area which means that the water available for irrigation was reduced hence a contribution to the drying of crops. These results suggest that for backyard irrigation to be a success, larger aboveground RWH tanks should be considered. Bancy et al. (2005) reports of up to $40m^3$ household aboveground tanks and 100-$150m^3$ institutional aboveground tanks in rural Kenya used for backyard gardening. Considering that tank size depends on annual rainfall and roof catchment area (Mathur et al., n.d.) Bolero with 600- 760mm of rainfall and average roof catchment of $60m^2$ for interviewed households, 32 – $40m^3$ tanks could be constructed to irrigate 25-30 m^2 area based on average crop water requirement of $1.2m^3$ per $1m^2$ area (Sturm et al.,2009).

High construction costs: The construction of the storage tank represents the biggest capital investment of the RWH tank (Vilane & Mwendera, 2011; Aheeyar & Ariyananda, 2014). Study respondents indicated that it was difficult for them to afford to invest in the RWH tank technology considering their limited sources of income for their livelihood. This supports the findings of Moges et al. (2011) in Ethiopia who found that the high cost of investment in RWH technologies affects smallholder farmers' decisions to adopt the technologies. This suggests that for smallholder farmers to adopt the RWH tanks, support on construction materials should be made available on cost sharing learning from Malik et al. (2014) in India who reported on how government subsidies successfully supported construction of RWH ponds for irrigation.

Access to training and extension services: Results reveal 72% (N=18) of participating farmers not trained in RWH tank technology as testified by respondent 6 (21 January 2015) "*Since I was selected, there was no training to show me how the tank works or how to establish and irrigate* *the vegetable garden. I used common sense*". The limited training and extension service delivery explains why farmers were not able to properly manage the tanks and irrigation plots and eventually neglected the technology thereby creating negative perceptions in communities where the technology failed. Awulachew et al. (2005) also reported of negative perceptions in beneficiary communities where RWH schemes failed in Ethiopia due to poor training delivery. Gebregziabher et al. (2013) also found that access to extension and training services contribute positively to RWH technology adoption as farmers are better informed hence a better chance for technology adoption. Thus to enhance RWH tank technology adoption, development agencies should upscale their effort in training and extension service delivery to improve farmers knowledge and skills on tank operation and irrigation management.

5.4 What strategies would enhance smallholder farmers' decision to adopt rainwater harvesting tanks in Bolero?

A number of strategies are suggested that would enhance RWH tank technology adoption.

- **Enhance community involvement during project introduction and planning.**

Community involvement during project introduction and their participation in planning will enable development agencies include farmers' needs and local knowledge in the development plans and the implementation process. Bamberger (1986) reported that community participation can ensure a projects social acceptability and increase the likelihood of beneficiary participation in project implementation. This will generate project ownership by the community and high commitment in programme implementation. Woltersdorf et al. (2014) used a participatory approach in implementing a pilot garden irrigation project using RWH tanks in Namibia and achieved high commitment from farmers. Community involvement will also minimise biases and negative perceptions on participant selection during project introduction. Engaging community structures such as village development committees would be instrumental in supporting programme monitoring to enhance adoption of the technologies.

- **Promote appropriate RWH tank sizes for backyard irrigation**

Rainwater harvesting tank size was identified as a limiting factor towards technology adoption as stored water could not irrigate a crop to maturity. The study recommends increasing the tank size as a viable option. A $30m^3$ aboveground tank is widely used for backyard irrigation in most parts of Africa with success (Woltersdorf et al., 2014). Another option is to start the backyard gardening towards the end of the rainy season and finalise cropping using irrigation from stored water. The perception of the farmers is that the cropping has to be done using stored water in the dry season hence have not used the approach. This was also reported by Malik et al. (2014) in Madhya Pradesh, India where farmers did the cropping only in dry season due to perception.

- **Enhance training and extension service delivery to promote technology adoption**

Training and extension will provide knowledge and technical knowhow on management of the RWH tanks as well as management of irrigation plots. Many studies (Malesu et al., 2006; Meijer et al., 2014) have recommended enhancing training and extension services to promote adoption of the RWH technologies. Training of extension workers at all levels on RWH tanks will enhance their skills in providing extension services to farmers. This may include training lead farmers who are local extension agents at village level (Masangano and Mthinda, 2012) but also local artisans at village level who can professionally construct the RWH tanks and provide backup services in case of repair and maintenance. Following the Malawi government new extension policy, smallholder farmers have to be allowed to determine the training information required based on their needs and in a language they can easily understand.

- **Develop and enhance proper funding mechanism that will match community needs and farmer resource base**.

Focus group discussions recommended a cost sharing scheme as a means to support smallholder farmers construct RWH tank for food security just as is the case with conventional irrigation schemes as the main challenge for farmers is the financing of construction materials for works. This was also recommended through consultation with farmers by Mloza-Banda et al. (2006). The aim of cost sharing is to create ownership and commitment from interested beneficiaries.

- **Enhance publicity for the RWH tank technology**

New technologies such as RWH tanks should be accompanied by extensive publicity to create awareness of the technology to potential adopters. Publicity can be through media, on-farm demonstrations and exposure visits to raise awareness on observable benefits. The use of radio is quite crucial in reaching out to communities because of its wide availability in households (African Technology Policy Studies Network, ATPS, 2013). Farmer to farmer contact is also crucial in publicising a technology. Studies have shown that farmers tend to adopt innovations learned from a family member or fellow farmer more frequently than those introduced by other sources (Sturdy et al., 2008).

5. 5 Conclusion

This study was undertaken to explore how farmer perception and project implementation process contribute to adoption of RWH tanks for food security in Bolero, Malawi.

The main findings show that the aboveground RWH tank size implemented in Bolero was not suitable for backyard irrigation to contribute to food security. This is because the $10m^3$ tank size promoted was small and could not store adequate water to irrigate a crop to maturity. While the $50m^3$ underground tanks stored adequate water to irrigate a crop to maturity, the vegetable crops grown were of low value and sales were perceived unattractive to entice farmers to invest in the technology for irrigation purposes. The study reveals that the approach used by development agencies during technology introduction was inappropriate as the process had limited consultation and community involvement in planning. This is likely to have contributed to poor choice of crops, unsuitable tank size, biased project participant selection, limited awareness creation and inappropriate approach to technology financing since local knowledge was not included in project planning. The approaches used negatively affected community perception hence low adoption.

Future efforts in promoting RWH tanks for backyard irrigation should consider improvement in aboveground RWH tank size and better approach in technology introduction to communities to enhance adoption. Development agencies should consider promoting $30\text{-}40m^3$ aboveground tanks for household irrigation where applicable by targeting communities experiencing water shortages for irrigation and use of high value crops to improve on monetary benefits for accessing food supply in times of scarcity. The study strongly recommends community involvement during project introduction and planning so that local knowledge and aspirations are included in the implementation process and make the technology a success.

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APPENDICES

Appendix 1: Interview guide for house hold interviews and focus group discussions.

Date ………/………/………..   Respondent ID number………………………

Identification details

District………………….EPA……………………..Section…………………..Village…………..
.

1. Gender of respondent……………… Is respondent HH head…………………Y/N

2. Age of respondent…………… Education of respondent…(primary, secondary, tertiary)

3. Number of household members ……Male HH members …….Female HH members……

4. Total land holding size (acres) ……….. Total arable land size (Acres) ………………

5. Total rainfed area cultivated (Acres) ………………………………………..

6. Main crops grown under rain fed cropping

   1………… 2…………. 3………… 4……………… ……

7. Total irrigated area cultivated………………………………………………………….

8. Main crops grown under irrigated cropping 1……………2…………….3……………

9. House measurements……….length (m)………Width (m)……….area……….M2

1 Why and How were rainwater harvesting tank projects implemented among the smallholder farmers in Bolero?

a) Who introduced the Rain Water Harvesting (RWH) tank (s) in your community and under whose idea? When was the RWH introduced to you?

b) How was the RWH tank technology introduced to the community?

c) What was the purpose and main objectives for introducing the RWH tanks to your household/ community? Were the objectives appealing to you? Why?

d) Who decided upon the objectives/uses of the RWH tanks introduced to your household/ community? Were the objectives achieved? explain

e) Who selected your household to be a beneficiary of the RWH tank project?

f) What criteria did they use in selecting beneficiaries for the RWH tanks? Do you see the criteria used as justified? How?

g) Is the RWH tank operational? Has there been any damage to the tank? If yes who maintained it? How was the cost for maintaining it met?

h) What support were you given in the process of constructing the RWH tank and who provided that support? What was your contribution?

i) What support were you given in operating/using the tank? Who provided the support? What was your contribution?

j) What trainings were you given on RWH tank project? Who provided the trainings?

k) What is the tank mainly used for now? If not in use, explain. If main use has changed, why?

l) Who is benefitting from the RWH tanks?

m) Do extension workers visit you? If yes, what do they mainly advise when they visit you?

n) What have you experienced using the RWH tank for the set objectives

2 What is the perception of smallholder farmers and development agencies towards rainwater harvesting tank projects in Bolero?

a. What can you say about climate change in your area?
b. What can you say about RWH tanks being an adaptive strategy to effects of climate change and support to food and nutrition security?
c. Considering the set objectives for the current RWH tanks, what would you say about investing in such RWH tank?

3 How can smallholder farmers describe their decision to adopt rainwater harvesting tanks in Bolero?

a. Have you been involved in any form of RWH as a source of water before? If yes, what have you been using to collect rainwater and what did you use the water for? How has that helped you in taking part in the RWH tank project?
b. What motivated you to participate in the implementation of the RWH tank project?
c. What expectations and /or fears did you have on the RWH tank project at your household/ community?
d. What economic benefits have you realised from implementing the RWH tank
e. Has there been replication of the RWH tanks in the area? If no, how do you explain that?
f. What would you need to encourage or promote your participation in RWH tank project?

4 What strategies would enhance smallholder farmer adoption of rainwater harvesting tanks?

a. What are the key challenges that you faced during the implementation of the RWH tanks at your household / community?

b. In your view, what are the root causes of such challenges?
c. How were these challenges resolved or how can they be dealt with?
d. What have you learned from the RWH tank technologies implemented in Bolero?
e. What can you say about the implementation of the RWH tank technology in your community?