Unraveling decision-making in irrigated farming in Malawi

Using Q methodology to develop typologies on water transport technology adoption

Msc Research
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January 2020
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Abstract

Despite the strong emphasis on irrigation development in Southern Africa, different initiatives from technology developers, policy developers and development organizations to encourage water transport technology adoption have often been disappointing. The lack of long-term success can partly be contributed to a mismatch between farmer realities and technology packages, national irrigation management and development aid policies. In order to better design and promote adoption of water transport technology alternatives, it is important to create a clearer understanding of the full spectrum in which farmers operate and make farming and investment decisions. This study therefore analyses the diversity in decision-making variables influencing the adoption of water transport technologies, and considers the implications for policy & technology developers, researchers and development facilitators. Following the Q-methodology, four different factors of participants with respective sorting characteristics were identified. Thereafter the study reviews how conventional ways of grouping farmers in policy and development programs hold up against the statistically formed factors. The results show that the definitions used in the conventional way of grouping are inadequate in dealing with the subjectivity surrounding adoption of water transport technologies in Malawi. With this new appreciation for the heterogeneity of farmers comes an understanding that technologies, policies and programmes must move away from the traditional one-size-fits-all approaches to more targeted, tailor-made approaches that are more likely to facilitate efficient, sustainable and long-term uptake of water transport technologies. Policies and technology packages do not have to be tailor-made on individual scale, but should recognize the idea that there are many different kinds of farmers that base their decision-making on different variables. Recognizing this and translating it into contextualized support and technology packages can more effectively encourage uptake of water transport technology by farmers. Also, the study shows that Q-methodology can act as an useful tool to better understand farmer decision-making, feeding policy and technology discussions and development. The research seeks to contribute towards the understanding of farmer decision-making and improved action around implementation of water transport systems.

Keywords: Malawi, Q-methodology, Farmer decision-making, Farmer typology, Water transport technology adoption

Preface and Acknowledgements

My greatest appreciations are due to the farmers in Malawi who shared so much of their time and goodwill.

I wish to thank the organizations with which I have been able to work during the time period of this study. Without the support and facilitation of aQysta and Department of Agriculture & Irrigation in Malawi this research would not have been possible and I would like to express my sincere gratitude to these organizations and institutions and everybody who made this research possible. I would especially like to thank the extension officers who assisted in conducting the interviews and Q-sorts which formed an essential part of this study in Malawi.

Many thanks to my supervisors for their academic support which has been helpful in both shaping and developing this work.

Family and a number of friends in the Netherlands and Malawi have also played a great role in providing insights and creating opportunities for my general well-being and sustenance while I was conducting this study. Without mentioning their names individually, I want to thank them for the advice and care I have received from them.

Ruben van Dijk, January 2020

Abbreviations

CF	Commercial farmer
CFA	Centroid Factor Analysis
EX	Expert
FAO	Food and Agriculture Organization of the United Nations
GDP	Gross Domestic Product
GoM	Government of Malawi
HPP	Hydro-powered pumping
KADE	Ken-Q Analysis Desktop Edition
PCA	Principal Components Analysis
PCC	Pearson correlation coefficients
PSS	Product-service systems
NASFAM	National Smallholder Farmers Association of Malawi
NIP	National Irrigation Policy
NIMIF	National Irrigation Masterplan and Investment Framework
MIWD	Ministry of Irrigation and Water Development
RE	renewable energy
SF	Smallholder farmer
WTT	water transport technology

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1 Introduction

In many regions of Southern Africa the highly variable rain is insufficient or unreliable as a source of water for agricultural production, creating and emphasizing the need for irrigation (Burney & Naylor, 2012; De Fraiture & Wichelns, 2010). Especially in Malawi, where the agricultural sector employs about 80% of the workforce (NIMIF, 2015), irrigation provides technical means to increase agricultural production and productivity (NIP, 2016) and plays an important role to realize food security. That is why generally, most farmers within physical and economical reach of a water source have chosen, or have been encouraged by the Government of Malawi (GoM) or outreach programs, to irrigate their crops. Even though implementing stakeholders have ambitious aims, programs often focus on technical possibilities and performance potential, but long-term success rate is hampered by a lack of focus on the overall farm management contexts within which these must fit (van Dijk, 2017; Brodt et al., 2006). This study argues that, in order to better design and promote water transport technologies (WTT), we must first gain a clearer understanding of the full spectrum in which farmers operate and make farming and investment decisions.

An attempt to understand the diversity of farming decisions, or farmers styles, is not new. The concept of farming styles, developed to help understand diversity in farming communities, was originally developed by van der Ploeg (1985, 1994) in the late 1980s and early 1990s. Critical accounts to the concept of farming styles (Vanclay et al., 2006), however, argue that farming styles are more an intellectual than a social construction, because the qualitative methods used to identify farming styles are affected by the literacy skills of farmers, are susceptible to social desirability response bias and rely heavily on researcher assessments (Vanclay et al, 2006). In response, Fairweather & Klonsky (2009) suggested an alternative method that eliminates these problems and successfully identifies patterns of subjectivity. This method, called Q-methodology, rests on the expression of participant subjectivity rather than on methods that rely on researcher assessment. It is hypothesized that there is a substantial amount of heterogeneity among irrigating farmers in Malawi in terms of decision-making surrounding WTT and that with the help of the Q-methodology the sample can be differentiated into subgroups with their respective decision-making characteristics. Using the Q-methodology, this research studies the farmers and governmental extension officers using and advising on WTT to develop typologies of decision-making styles. Such ideas hold considerable implications for the design of outreach programs, technology and policies that aim to advance WTT adoption in Malawi.

The role of policy

Policies have a large role to play in farmer development. Given the substantial presence of farmers in Malawi, policies that directly or indirectly affect farmers have considerable effects on the social and economic trajectory of the country. Since there is a (inter)national wish (Burney & Naylor, 2012; NIMIF, 2015; NIP, 2016) from bilateral and international funders, donors and governments to develop agricultural irrigation, governments or independent organizations formulate policies to lay out basic principles, objectives and associated guidelines. These policies are often promoted by donors themselves to help them achieve their objectives more easily. While also making use of the agricultural and irrigation experts within the Ministry, governments are often informed by a wide range of professionals, consultants, engineers and development agencies to develop these policies. That is why policies often build around or run parallel to various studies. These stakeholders involved in the policy creation are inspired by their own ideals, context, paradigms and goals to work towards objectives such as realizing irrigation development potential, providing measurable development results and producing short-term success stories (van Dijk, 2017). That makes policy making, as discussed in Rap et al. (2013, p. 506), "*an interactive and ongoing process that is potentially self-reinforcing, but often fragile and reversible in practice. It is only by building a network of support and excluding opposition that a policy idea gathers momentum and is made to succeed*". The more policy stakeholders are aligned in a certain interpretation of policy, the more stable a policy becomes (Rap et al., 2013). The dominant policy narrative in turn results in development initiatives that build around it and are trying to influence irrigation practices, but also articulate international policy in order to assemble supporters and resources for current and future work in the development region. Without the mobilizing effects of national or international aid policy, it is very difficult to attract resources (Mosse, 2004). Policy developers in turn, are inclined *"to accept donors' agenda rather than risking the halting of donors' funding, as this funding is instrumental to reproduction of the irrigation agency's prominence in the national sphere"* (Suhardiman & Mollinga, 2012, p. 932). For irrigation development to achieve the intended success, however, this top-down approach, favoring administrative convenience (Kay, 2001), needs to be turned around. Therefore, it is important to investigate how we can contextualize policies to the heterogeneous conditions under which farmers cultivate and the dynamics of their environment.

The role of technology developers

The characteristics that define different farmers can have implications for farmers' technology adoption behaviour. Farmers with different farming orientations may have different interests in, or attitudes to, particular types of WTTs (Pereira et al., 2016). This makes it likely that not every farmer wants to adopt or transition to a certain technology when a technology seller uses only one approach. As Pannell et al., (2006) point out, if a technology is not 'adoptable', then communication and education activities will simply confirm a farmers' decision not to adopt. If technology developers, however, can understand how different farmers would react to different kinds of technologies, information or marketing approaches, they can tailor technologies, and their promotion, to the circumstances of the identified farmer to make a technology more 'adoptable'. Besides physically changing the characteristics of a technology, a helpful tool to achieve this is to design and offer different product-service systems (PSS) (Intriago Zambrano et al., 2019; Meier et al., 2010). These can help to develop the *best-fit* (Birner et al., 2009) possible for each farmer.

What is the *best-fit* is ultimately is up to the individual who ends up using the technology; the farmer. As said, the variables that influence farmer decision-making vary from place to place depending on a wide range of circumstances. Selection of the appropriate WTT, however, is for farmers key to the success or failure of their farm. Adoption of the wrong technology can as a consequence mean that the seeds of failure are already planted before an irrigation initiative has any chance of success (Kay, 2001). Since both technology developers, policy developers and development organizations have limited contextualized experience or practical technical knowledge to ensure selection of the best fitting technology, it's important that the different drivers influencing the adoption of WTT by farmers are properly understood (FAO, 2014a).

1.1 Background

Agriculture in Malawi

Malawi is a landlocked country between Mozambique, Zambia and Tanzania facing high climate variability and many agricultural challenges. Its economy is predominantly dependent on agriculture with the sector generally contributing more than a third of the Gross Domestic Product (GDP) (NIMIF, 2015), 40% in 2013 according to Harrison & Chiroro (2016), 90% of the total domestic exports (MIWD, 2008) and directly supporting over three quarters of the population (Harrison & Chiroro, 2016; NIMIF, 2015). With a fast expanding population, reaching 18.6 million in 2017 (Figure 1), this means that agriculture directly supports around 14 million people. Unfortunately, the production increase has failed to keep up with population growth, which has made the country to experience food shortages in times of poor rainfall (MIWD, 2008).

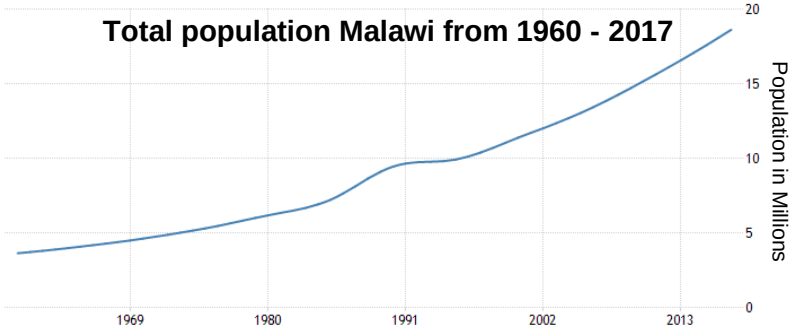

Figure 1 – Population growth in Malawi from 1960 (3.6 million people) till 2017 (18.6 million people), according to the latest census figures. Source: World Bank, 2019

Three-quarters of the total agricultural production is realized by smallholder farmers, of which most do not irrigate and rely on rain as a source of water (Harrison & Chiroro, 2016). The rainfed SF agricultural production, therefore determines the food security and socio-economic growth of the country to a large extent. This rainfed production is, however, highly uncertain. Given the large number of SFs in Malawi, intensification of their crop farming is key for local food security. However, smallholders appear to face many challenges linked to shortage of land, poor soil fertility, lack of investment capital, price fluctuations (Coulibaly et al., 2015), expensive labour, lack of extension services, expensive agricultural inputs, poor road infrastructure, poor market access and crop diseases. Also, weather events have burdened smallholder cultivation. Malawi has experienced unreliable rainfall, weather shocks and natural disasters over the last decades which are now worsened by climate change (IPCC, 2007). The country experienced extreme conditions during the dry spells and droughts of the 2000, 2001 2002, 2004 and 2005 season and the more recent 2015 and 2019 floods.

Since Malawi as a country lacks the financial resources to realize the aspired developments in the agriculture sector, it has turned to international donors to mobilize the necessary support. The fact that Official Development Assistance accounts for 23% of the gross national income (GNI) (GPEC, 2016), shows the enormous dependency and therefore

influences international aid organizations have on the development of agriculture in the country. This foreign development aid inflow started when the civil war in Mozambique began in 1977 and further increased when the one-party state regime, under leadership of president Hastings Banda, fell and the country became a multi-party democracy in 1994. Since then, after being informed by a wide range of professionals and consultants, the GoM and international donors have mainly focused on developing agriculture by establishing large smallholder irrigation schemes (SIS). Even though implementing stakeholders had ambitious aims, it is now widely accepted that these developmental efforts have often not delivered the intended result (Kay, 2001) and that the introduction of new WTTs for farmers has often failed. Too many cases have ended up underutilized or to not perform at all (Aliber & Hall, 2012).

Water transport technologies in Malawi

WTTs are at the heart of any irrigation system and farmers in Malawi are presented with a wide range of options. Decision-making around WTTs for irrigation in Malawi is especially interesting, because a large amount of irrigation technologies that farmers are using have been advocated, subsidized or handed out by the GoM and development organizations (Veldwisch et al., 2009; NIMIF, 2015; NIP, 2016). All technologies have different characteristics, which are likely to influence a farmers' decision-making process concerning adoption.

In gravity-fed irrigation systems (Figure 2, left picture) water is diverted from an upstream water source and is transported through a network of pipes, earthen or concrete canals. Some farmers construct gravity systems themselves by digging earthen canals. Although providing flexibility and low running cost, water losses in such a system can be considerable due to evaporation and seepage through the canal bottom. Moreover, if no water regulating structures are built, water distribution can be difficult to control, leading to possible canal breakages and further losses (Smith et al., 2014). Others have invested, or have received development aid, and have lined the canals in the system with an impermeable layer to improve water efficiency.

Figure 2 – Left: The lined gravity Chombi Irrigation Scheme in the Zomba District, Malawi. Right: A farmer shows the communities' motorized pump, pumping from the river in the background.

In some cases, the water source lies below the level of the irrigated fields. In that case other WTT must be used to supply water. Manual, or man-powered, WTTs provide relatively simple and accessible irrigation options that are understandable and widely practiced. These technologies for instance include the use of water cans or treadle pumps. These technologies need little investment, but are labour intensive and can provide water for only a relatively small area.

Other farmers have resorted to another WTT option; the use of non-manual powered water-pumping technologies to deliver water to fields. These technologies rely on the creation of a pressure difference within the pump system, so that the water moves from an area of high pressure to an area of low pressure. The global water-pumping irrigation industry is largely driven by the motorized water pump (Figure 2, right picture). These motorized pumps have increased performance compared to their manual counterparts. With higher lifting power and flowrates they enable farmers to irrigate more land, but also transport water further away. The pumps are fossil fuel-based and are therefore linked to pollution due to their emissions and noise. In addition, the initial investment and operation and maintenance costs are higher because of continuous use of expensive fuels (Aliyu et al., 2018; Chandel et al., 2015), often not

Figure 3 - Floating version of the Barsha Pump

available near rural irrigation sites, resulting in relatively high break-even yields (Mloza-Banda et al., 2010). This has caused these solutions to often be too expensive for many farmers (Burney & Naylor, 2012).

More environmentally sound, and at times less expensive alternatives, are pumping systems that make use of renewable energy (RE) sources such as solar power, wind power or hydropower (Gopal et al., 2013). Pressure-based hydro-powered pumping (HPP) technologies for instance, are systems that are driven by the energy contained in the water they lift. According to literature, HPP systems are regarded as more predictable, less maintenance-demanding and long lasting compared to their other RE-based counterparts (Fraenkel & Thake, 1986). One of these HPP technologies is the Barsha Pump developed by aQysta (Figure 3). The Barsha Pump is a water-wheel propelled pump that utilizes the energy of flowing rivers and canals to pump water.

1.2 Research Gaps

As pointed out, over the course of the last half a century many governments, national and international development organizations and NGO's have invested heavily in irrigation development and the implementation of new irrigation technologies (African Development Fund, 2006). All with roughly the same intention: combat the marginalization of the poor and develop rural areas. Investments started well in the first half of the 20th century, but the mistakes of focusing on technical possibilities and performance potential and overlooking social complexities, capacities and limitations (van Dijk, 2017), made in early development activities, are often still happening today (Veldwisch et al., 2009). Too many irrigation initiatives have ended up not delivering the intended result, to be underutilized or not perform at all (Aliber & Hall, 2012). A large contributing element to this is the mismatch between policies, development project strategies, farmer reality practices and implemented technologies. Developers and engineers have often assumed that the highest yields and greatest economic growth are the desired outcome (Strang, 2016). In the pursuit of a quick and measurable success story they have focussed on blanket, 'universal' strategies and technologies and have to a large extent ignored the complex, dynamic and diverse characteristics of farming.

There are, however, no specific studies that focused on understanding the variables that influence, directly and indirectly, the determinants of the adoption of WTTs for irrigation in Malawi. Understanding the determinants of farmers' technology decision-making sheds light on the dynamics of the farmers and is of fundamental importance to stakeholders such as technology developers and sellers, policy makers, agricultural scientists and irrigation officers. It can help to form an approach to assist in developing WTT for irrigation and can provide insight on how to introduce new technologies in societies by taking farmers' strategies in mind, to make use of their full potential in the future, in Malawi.

1.3 Research Objective

The objective of this research is to understand the decision-making variables for adopting WTT for irrigating farmers in Malawi and how these differ between automatically and predefined groups, to help decision-makers at national and project levels, policy developers, researchers and development facilitators better tailor differentiated approaches to supporting the WTT uptake by farmers in Malawi.

1.4 Research Question

In order to reach the objective mentioned above, the general research question (GRQ) is formulated as follows:

How do farmers in Malawi decide about water transport technologies?

In order to answer the GRQ the following sub research questions (SRQ) are formulated:

- SRQ1: Which decision-making variables play a role in the adoption of WTT of irrigating farmers in Malawi?
    - Which variables play a role according to literature, farmer interviews and experts' judgement?
- SRQ2: Which groups with differentiating decision-making characteristics can we distinguish with the help of the Q-methodology?
    - How does the consistency and interpretation of the factors transform when changing to different factor solutions?
- SRQ3: Which differentiating decision-making characteristics can we distinguish within subsets of participants that are homogenous according to certain background information and farmer definitions?

    - How are different subgroups defined in research and policy?
    - Do different predetermined subgroups have distinguishing decision-making characteristics?
    - How does the logic and rationale behind artificial predetermined subgroups that are homogenous according to certain background information compare and hold up to the groups identified with the help of the Q-methodology.
- SRQ4: What are the implications of the findings for policy developers, researchers, technology developers and development facilitators to more efficiently tailor and facilitate technology and support (services) surrounding WTTs for different farmer groups?

1.5 Reader's Guide

This thesis consists of 5 chapters. Chapter 2 introduces the theories and methods used in this research. The literature study and key informant interviews, used to develop the concourse and select the Q-set statements, are discussed and analyzed in Chapter 3. Chapter 3 also discusses the process of conducting the Q-sort. The results of the Q-sort exercise are presented in Chapter 4. Chapter 5 discusses the research findings and the consequent implications for policy developers, researchers and development facilitators.

2 Methodology

2.1 Methods used for Research

In order to respond to the themes embedded in the study and to gain in-depth insights into the cases at hand, the study uses a mixed-methods approach to answer the different sub-research questions. The combination of qualitative and quantitative methods, involving literature review, unstructured tape-recorded key informant interviews and Q-methodology, were chosen to explore the rationale behind certain farmers strategies and technology adoption decisions. The methods are explained below.

The thesis is written after three months of research fieldwork in Malawi during the agricultural dry season of 2019 (June-August). During the fieldwork there was collabouration with the developer of the Barsha Pump, aQysta, and governmental irrigation officers responsible for promoting and advising on irrigation activities in their respective districts.

Because of the different study locations in Malawi with different contexts and variables, this study was executed with the help of several data sources and methods of data collection. Using more than one methodology provides a better understanding of the multidimensional nature of farmer decision-making. In this way, the breadth of the study phenomena and validation of research findings are enhanced and the output of the research is more reliable (triangulation of methods). The main research method, however, is the Q-methodology, from now on referred to as Q, because it provides insight into individual viewpoints through systematic examination and understanding of an individuals' subjectivity concerning WTTs in a scientific way. The methodology groups participants according to their sorting of value and goal-related statements and thereby creates typologies that encapsulate the diversity of the participants (Pereira et al., 2016). While effectively determining the subjectivity of a participant, but also dealing with information statistically, it thereby combines the strengths of both quantitative and qualitative methods (Simons, 2013). Q, developed in the 1930s (Herrington & Coogan, 2011), has been used in social, political, psychologies and health studies, but its use has remained relatively limited in agricultural and environmental research. Over the last years, however, it has rapidly increased (Pereira et al., 2016; Zabala & Pascual, 2016).

In short, Q makes use if the following steps (Simons, 2013):

- **Concourse development**; forming a spectrum, as complete as possible, of items reflecting all possible opinions around the topic of concern.
- **Q-sorting identification**; selecting (the number of) statements that need to be involved to create a manageable and representative cross-section of the topic of concern.
- **Conducting the Q-sort**; participants are asked to rank the statements and this ranking is called the Q-sort.
- **Factor analysis**; all the Q-sorts collected are compared, grouped and summarized with the help of multivariate data-reduction techniques.
- **Factor interpretation**; the interpretation of factors is based on a combination of the relative item scores, qualitative data and the researcher's understanding of the case and of the participants views.

The steps mentioned are described in more detail for this study below.

Concourse development

As discussed by Simons (2013), the depth and breadth of the resources from which the concourse is developed provides a representation of all options related to, in this case, farmer WTT decision-making. The concourse is developed by gathering data from a number of sources:

- Related literature on farmer adoption of (irrigation) technologies and the impact of farmer strategies on technology decision-making
- Interviews with:
    - Farming Cooperatives,
    - Individual Farmers, and
    - Agricultural & Irrigation Experts

Interviews help to understand the choices that led to the current practises that are used in Malawi specifically and provide insight in what has changed since the introduction of different kind of technologies. Even though the interviews are essential for the development of the concourse of Q, they are also an important complement to Q. This way there is no reliance on one single method and there is a way to check alignment between the two methods.

The interviews were set up as semi-structured interviews, wherein depending on the role of the interviewee, specific questions could be asked. Some questions might be closed quantitative questions which can give more insight in the irrigation methods, the amount of land under irrigation, the size of the household and the number of households involved. The open questions yield more detailed qualitative data concerning the challenges, developments, external support the farmer has received and consequent decision-making. With a few questions in mind, the interviews were relaxed and left room to discuss topics that were important for the interviewee. This way, answers were raised which the interviewer could not have anticipated beforehand. The interviews were conducted amongst stakeholders with different levels of involvement in smallholder agriculture. With the help of purposeful selection it was attempted to cover all views and perceptions in the study area.

Another important method of data collection are observations of the physical reality at the time of the research. Through on the ground-level and aerial pictures more data and context on the size, performance and condition of the irrigation system were obtained. This presents an opportunity to look beyond the answers of the interview and see the environments in which the respondents are operating (Silverman, 2013).

As mentioned by Simons (2013), developing the concourse is one of the most time consuming aspects of Q. It should, however, not be rushed since the concourse determines the quality and reliability of the findings of the Q-sort and the identification of the resulting factors (Simons, 2013). The concourse development process is described in Chapter 3.

Q-sorting identification & Undertaking Q-sort

After the development of the concourse the statements were defined. The statements were presented as possible answers to an overarching umbrella question. It is important that the statements are reduced to a manageable amount so that participants stay involved and properly complete the Q-sort (Simons, 2013). Too many statements can become too difficult or time demanding, while too little statements can result in an unrepresentative statement set. The Q-sorting identification process is discussed in Chapter 3. After careful selection of the final set of statements, the Q-set, the Q-sort can be undertaken.

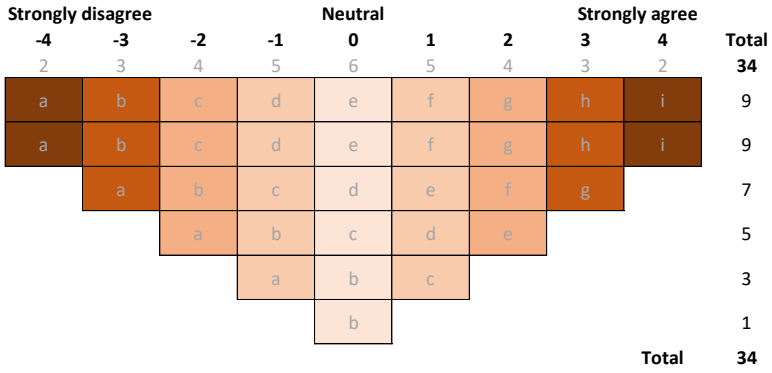

Figure 4 - Example of a Q-table

The Q-sort was performed by a wide variety of farmers using different WTTs for irrigation, using a Q-table as presented in Figure 4. Also irrigation experts were asked to perform the Q-sort. These experts often are an important source of information for farmers and can have influence on their respective decision-making, hence why they are interesting to include in this research. In Malawi, the most common source of irrigation support services are government extension officers. The experts were requested to perform the Q-sort in the perspective of a SF, but with their expert knowledge. The process of conducting the Q-sort is further described in Chapter 3.4.

Factor analysis

After undertaking the Q-sort exercise, the factor analysis can start to identify groups of farmers that sort the given statements in a comparable way. The process is visualized in Annex 1. The analysis is performed using KADE (Ken-Q Analysis Desktop Edition), a software package specifically made for the Q method. KADE provides a number of features currently not available in other open source packages for Q methodology and is especially attractive because it provides interactive visualization options. This makes it easier, after the program computes correlations between participants, to investigate the different analysis trajectories and interpret the data. It also present the opportunity to easily cluster groups of farmers and determine the different variables that influence their decision-making.

After organizing and loading the data, the Pearson correlation coefficients (PCC) are calculated. The PCC (Eq. 1) is used to measure the strength of a linear relationship between two variables, where the value 1 means a perfect positive correlation and the value -1 means a perfect negative correlation. The correlations calculated represent the covariance of the two variables divided by the product of their standard deviations. This explains the symmetry that can be found in

the resulting correlation tables. The PCC formula can be found below, where x and y are deviation scores around the mean of their respective scores in Q-sorts X and Y:

$$r_{xy} = \frac{\sum xy}{\sqrt{(\sum x^2)(\sum y^2)}} \qquad (Eq.\ 1)$$
$$where\ x = X - \bar{X}\ and\ y = Y - \bar{Y}$$

After calculating the correlation the Q-sorts are factor analyzed in order to show similar orders of ranking by different participants. The key determinants that help us understand the process of analysis in KADE are factors, factor loadings, Z-scores and factor scores. The processing is explained below with the help of these determinants.

Factors & Factor loading

Most of the scientific literature uses the term *"factor"* to indicate the weighted average Q-sort of a group of participants that responded similarly (Zabala & Pascual, 2016). In simple terms, a factor represents a group of participants that sorted the Q-sort puzzle similarly. These factors can either be automatically generated by the KADE software, by grouping Q-sorts that have high correlations based on *principal components analysis* (PCA) or *centroid factor analysis* (CFA). PCA is the mathematical standard factor analysis solution which seeks the least number of factors which can account for the variance of the Q-sorts. CFA allows researchers to manually rotate in accordance with researcher's research problem. The recommended and preferred option for most Q-methodologists is, however, the well-known techniques of PCA (Watts & Stenner, 2012), which is why it is also used in this research. Other important strengths of this approach are its reproducibility, ease of comparison across space and time, and the manageability, speed and accuracy with which datasets can be analyzed (Kostrowicki, 1977).

By choosing the PCA procedure, the analysis initially produces 8 unrotated factors, which is the maximum number of factors KADE can process. The explained variance of the respective unrotated factors is calculated using:

$$\%\ Explained\ Variance = 100 * \frac{Eigenvalue}{n} \qquad (Eq.\ 2)$$

, where *n* is the number of participants. *Eigenvalues* are calculated by taking the sum of the squares of the factor loadings (Herrington & Coogan, 2011; Brown, 1980).

The 8 emerged factors can be rotated analytically using *varimax*, or *judgmentally* with the help of two-dimensional plots. Both options are integrated in the KADE software. Factor rotation basically enables one to change the angle, or perspective, with which one looks at the factors (Brown, 1980). Not all 8 have to be taken into account during the rotation process. The researcher determines how many factors, with a maximum of 8, are to be included.

Judgmental rotation enables manual rotation in accordance with the researcher's research problem. It has been argued in literature that this way of rotating forces data to conform to a certain theory and might therefore loose its objective nature (Du Plessis, 2005; Brown, 1980). The *varimax* option seeks a rotational solution guided by statistical criteria (Brown, 1980). The method aims to distribute variance across the factors in such a way that each Q-sort has the highest degree of association with only one factor (Stricklin & Almeida, 2001). In this way it is realized to have the most amount of Q-sorts that significantly load on a factor. Because this research aims to take a holistic analysis trajectory the *varimax* option is used for the rotation process.

After the rotation a decision on the number of included factors must be made. There are no rules on how many factors should be formed, but in general the higher the number of factors included, the lower the number of participants who significantly load on these factors (Herrington & Coogan, 2011). In essence, the decision is a trade-off between extent of explained variance and a meaningful set of farmer types (Pereira et al., 2016). There are, however, several considerations that can help to make the decision. One of these considerations is the *eigenvalue* of the factor. If the *eigenvalue* is <1.0 the factor becomes non-interpretable and the chances are high that the participants have been grouped by chance (Flurey et al., 2016; Brown, 1980). Therefore in this research we consider factors with an eigenvalue >1.0.

Other considerations that can be taken into account are the *explained variance* (Eq. 2) and *composite reliability* (Eq. 3) of a factor, the number of distinguishing statements in a factor and the number of participants loading on a factor. In the

article by Huang et al. (2019) for instance the criterion to only include only those factors that have at least four significantly loading participants after rotation. This study uses the same minimum participant loading, which translates into a criterion for the composite reliability. The *composite reliability* of a factor *f* is calculated as:

$$r_f = \frac{0.8p}{1 + (p-1)0.8} \qquad (Eq.\ 3)$$

Where p is the number of *flagged* Q-sorts for the respective factor. The value 0.8 is the customary value used in Q-methodology for the average reliability coefficient, which is the expected correlation between two responses given by the same person (Zabala & Pascual, 2016). The composite reliability of a factor is therefore always the same or greater than the reliabilities of the participants composing it. The more participants define a factor, the higher the reliability. Simply said, the more persons who share a similar viewpoint, the more confidence we have in the scores of the items composing it (Brown, 1980). Therefore, this study uses the abovementioned criterion in which factors have to have at least four significantly loading participants after rotation. It is argued that if the composite reliability ≥ 0.94, the factor has a reasonable internal consistency (Ghazali et., 2018). If the value of the composite reliability < 0.94, the factor can be considered unreliable.

Another criterion that is often used is to seek a factor solution which retains at least 50% of the participants loading significantly and exclusively on a single factor (Hylton et al., 2018). In this study this is referred to as the *representativeness criterion*.

The final criterion is that of interpretability. The amount of chosen factors should be able to embrace the present variety and subjectivity, while still providing enough information to make a meaningful ontology. At this point, all factor solutions have explanation power and, therefore, all the factor solutions that pass the above mentioned criteria are analyzed and interpreted. This provides insight in what is lost and what is gained from going to another factor solution, which than ultimately determines which factor solution is the most interesting fit for the collected data.

After choosing the number of factors, the factor loading and *flagging* takes place. The factor loading is given by the correlation of each Q-sort with each formed factor and can range from −1 to +1. A Q-sort is most similar to the factor with which it has the highest loading (Zabala & Pascual, 2016). Although it may be that no Q-sort is the perfect representative of a factor, it is often the case that they correlate with one factor more than the others. In the *flagging process* the most representative Q-sorts for each factor are chosen according to the amount of loading and the loading of the same Q-sort for other factors. The auto-flag option in KADE provides the possibility to automatically flag Q-sorts. In this research we use the auto-flag option using the two standard criteria for automatic *flagging* used in Q analysis (Zabala, 2018):

1. Q-sorts which factor loading is higher than the threshold for p-value < 0.05, and
2. Q-sorts which square loading is higher than the sum of square loadings of the same Q-sort in all other factors.

The second criterion illustrates that when a Q-sort correlates well with multiple factors, this means that while reflecting the views of one factor, they also reflect some of the views of another factor. This is in accordance with *"the theoretical notion that people have a nuanced view that combines different elements of two or more discourses" (*Hermans et al., 2012, p. 78). A Q-sort showing similarities with more than one factor may therefore not be *flagged* to any factor.

Z-score & Factor Score

The Z-score and Factor score are important indicators that helps us to interpret the respective factors. The Z-scores indicate the relationship between statements and factors. The value tells us something about how much each factor agrees with a statement (Zabala & Pascual, 2016). The Z-score is a weighted average of the values that the Q-sorts participants in a certain factor give to a statement, and it is continuous. If the difference between the Z-scores of a statement in a certain factor solution is statistically significant, then what both factors think about that statement is distinguishing. When none of the differences between any of the factors are significant, then the statement is considered of consensus (Zabala, 2014).

Factor scores are integer normalized values, in our case -4 up to +4, based on Z-scores and they are used to reconstruct the Q-sort of a factor.

Factor interpretation

When examining the respective factor scores mentioned above in relation to the other statements within the factor, and by comparing this with the other factors, we can start interpreting the factors. It is the relative positions within the entire sort that describe the factor and not just the individual statements themselves. This factor interpretation process is described in Chapter 4.

When interpreting the factors it is important to reduce the distortion as a result of researcher's bias as much as possible, as this can affect the validity and reliability of findings. It can be tempting to give overly detailed factor descriptions, but if the respective factors scores do not allow for this, it should be avoided as it opens up the danger of imposing a certain view of the world on the factor.

2.2 Scientific relevance

This thesis is a multiple-case study in which an in-depth understanding of the decision-making variables for adopting WTT for irrigating farmers in Malawi is developed. The research environment is highly contextualized, but using the outcomes of the research and comparing them to other case studies has much scientific relevance. It can help us to understand the determinants of farmers' choices and give professionals and policy makers a better understanding on which sustainable strategies should be promoted as a step towards higher food security. It can also help technology developers, such as aQysta, with their future development plans and to better tailor their business models and technologies, including the services offered with it, to the context and demands of the farmers in Malawi.

Investing in irrigation development is a very important strategy in adapting to climate changes and reacting to the increasing food demand. Therefore, this study in Malawi can also be used as an instrumental case study, helping to gain more insight in how to think of different farmer choices and corresponding strategies or blockages. As put by Coulibaly et al. (2015, p.1621) *"it is important to document such strategies, to understand the determinants of farmers' choices and to identify policies that can promote sustainable coping strategies as a first step in the adoption of more robust adaptation strategies for future climate change"*. The knowledge gained from this research can help other cases to understand the dynamics of their situation and can help to form an approach to assist in developing irrigation systems. It gives insight in how to introduce new technologies in different kind of farmer societies in Malawi.

Besides that, some modern highly advanced interventions in agriculture and irrigation development projects can work to the detriment of smallholders. For instance, some locally inherent irrigation practices can be drastically altered with the introduction of highly advanced technologies, based on the claim that existing practices are *"old'*, *"inefficient"*, *"unsustainable"* or *"traditional"* (Kay, 2001). I am curious to find out what farmers themselves think about, and how they perceive, these differences in technologies.

3 Concourse & Q-set development

In order to conduct a Q-study it is of great importance to have a representative set of statements that are developed from the concourse that exists around the issue under consideration. Although the importance of the concourse development is thoroughly stressed in literature (Simons, 2013; Brown, 1993), many studies seem to develop the concourse purely based on literature. In the study by Pereira et al. (2016) for instance, 49 statements were developed to identify and group major values and goals amongst progressive and commercial-scale beef farmers in Brazil purely based on a literature study. The concourse, however, determines the quality and reliability of the findings of the Q-sort and the identification of the resulting factors. The better the resources from which the concourse is developed, the better it is able to provide a representation of options related to an individuals' subjectivity, in this case concerning adoption of WTTs. The concourse and Q-sort statements should therefore be developed by digging into multiple levels of information.

Hence, in this first part of the study, the focus is on unravelling the variables that play a role in farmers' decision-making and (non)investment choices for WTT. Firstly, an initial statement list was drawn from a literature-based exercise, which helped to establish the topics within the concourse. After this, individual interviews and focus sessions with a wide range of farmers as well as experts in Malawi were performed to gather more contextualized statements related to the topics within the concourse. Particular attention was paid to understand how the subjectivities surrounding different variables (finances, management, ownership, technology characteristics, etc.) ultimately shape the final decision to ensure the final Q-set would come closest to the actual expressions of the participants' viewpoints, while also ensuring simple, clear and concise formulation of the statements.

In the first section of this chapter discusses the literature on Q, farming decision-making and adoption of WTT, and how these helped to develop the first topics within the concourse. In the second section analyses the performed interviews to create the final Q-set presented in the last section.

3.1 Literature

The first step in developing the concourse was to identify variables that according to literature often have substantial, predictable and consistent influences on adoption of WTTs. This was done by extensive studying of existing articles on technology adoption (see below). Even though many of the articles were not specially focussed on the adoption of WTT in Malawi or other countries in the region, they prove useful to create an extensive set of variables.

First of all, it is widely recognised in scientific literature on agriculture and irrigation that decision-making concerning technology adoption depends on a wide range of personal, social, cultural and economic variables, as well as on characteristics of the innovation itself (Pannell et al., 2006). Amongst many others, the socioeconomic variables that influence decision-making include: age; marital status; number of children; education level; farming experience; time spent on farm; contribution to income; attitude; ownership of assets; farm size; family structure; social networks (Doss et al., 2014; Doss and Meinzen-Dick, 2015; Mutenje et al., 2016); access to markets (Matshe and Young, 2004); extension availability and quality (Wheeler et al., 2017). This list of variables shows the highly heterogeneous nature of farming and the complexity of influences on decision-making. They, however, have little to do with the irrigation technology of concern. Therefore information about these kind of variables has been gathered in interviews before and after the Q-sorting exercise as meta-data, or rather explanatory variables.

Decision-making influencing variables that do concern technology, however, are discussed in many papers (Burney & Naylor, 2012; Bolt & Fonseca, 2001; Hassan & Nhemachena, 2008; Pannell et al., 2006; Green et al., 1996) and show there are many different variables that are likely to influence a farmers' decision-making process concerning adopting a WTT for irrigation. These decisions are important for farmers as they may have considerable influence on financial spending, food availability, income generation, power relations and can be linked to social status and wealth (de Steenhuijsen Piters, 1995). An important variable influencing the decision-making for instance, is the relative advantage of a technology, which can, among many other things, depend on its risks, (operational) costs and performance (Kuehne et al., 2017). This relative advantage, however, depends on many different variables which can in turn differ between different farmers.

What is clear, however, is that when farmers are gathering information to decide whether to explicitly stick to their current technology, or to leave old and familiar practices behind and change towards new territories, with higher relative advantages, they are essentially in a process of learning (Pannell et al., 2006). In the case of a new technology for instance, uncertainty is likely to be high and familiarity low, but as farmers learn more about a technology, this might change. The more the farmers become familiar with a technology and are satisfied with its characteristics, the more they might be willing to contribute to obtaining such a technology themselves. The level of familiarity at which an individual or group, however, is comfortable enough to adopt a certain technology, can vary widely. Risk averse or risk taking behavior in individual and farmer group settings with respect to uncertainties surrounding technologies can considerably influence decision-making (Kay, 2001; Burney & Naylor, 2012; Kuehne et al., 2017).

Of course one needs to be aware of the existence of a technology. Information streams that provide technology insights can come from many sources such as radio, television, neighboring farmers, family, community members, extension officers and so on. Farmers must assess this incoming information with their objectives. When farmers have a strong orientation to a certain objective (e.g. profit, environmental sustainability or risk reduction) technologies that align with this orientation have greater appeal and higher potential adoption (Kuehne et al., 2017).

Also, it must be understood that farmers often undertake a variety of activities, not just one (Fresco, 1988). They can undertake a variety of cropping or livestock activities, but can also be engaged in other activities that generate alternative income. This can influence the amount of available resources, which can be financial capital (Bolt & Fonseca, 2001) but also labour and time, that farmers are willing to allocate towards their irrigation activities (Fresco, 1988), which can in turn influence their choice of technology. Farmers therefore consciously choose WTTs that *"fit"* their agro-socio-economic environment and satisfies their financial trade-offs.

Another variable that can influence farmers' decision-making is the management and working of the technology. The fact that management is a crucial variable, implies that technology can indeed make it possible to make management decisions relating to individual or group short or long term objectives (Fresco, 1988). Management variables can for instance involve the ease of operation, performance flexibility and maintenance necessities (Bolt & Fonseca, 2001).

The variables mentioned above show that the learning process is actually a very subjective process, in which an individual farmer's subjective perception about the new practice governs decisions. For several decades it was believed that if an irrigation technology would simply perform well and help farmers to produce more, they were likely adopt it. Goals among farmers, however, might vary widely and actual adoption is based more on perceptions and expectations rather than an objective truth. For instance, although it is generally known that farm management requires a long-term view, individual farmers might have short-term needs that govern their decisions. It is therefore a personal issue, and different farmers can think differently about whether a new practice is good, bad, or indifferent to their specific context. This partly explains why practices do not always, or usually do not get adopted by farmers.

In conclusion, the variables that influence subjective perceptions are vast and have been studied extensively by researchers, economists, social scientists and extension officers (Green et al., 1996; Hassan & Nhemachena, 2008; Pannell et al., 2006). Assessing the importance of the decision-making variables for farmers when adopting WTT using Q, however, has not been found. In order to group the Q-sort statements this study uses an adapted version of the broad sets of decision-making variables as described by Pannell et al. (2006):

1. the process of learning and experience,
2. the characteristics & circumstances of the farmer within their (social) environment, and
3. the characteristics of the practice.

3.2 Interviews

Once in Malawi the concourse was further developed with the help of qualitative unstructured tape-recorded key informant interviews. The goal of the interviews was to explore the diversity of decision-making variables to be found within the different sub groups and how these link to specific technology adoption behaviours. This was done by touching upon the themes embedded in the concourse that were already discovered in the literature study, but also by trying to explore new themes. The interviews were conducted by interviewing national and regional irrigation experts, often irrigation officers, and a wide variety of farmers. The 7 interviewed experts were often active in the research area or were performing extension services (Table 1). They were often also the ones that joined in the field when visiting the farmers and acted as an interpreter. In total 13 farmers or farmer groups were interviewed (Table 2). The judgements and insights from the interviewees were used to further develop the concourse, by carefully going through the interviews an extracting all possible statements.

#	Date	District	Organisation	Function
1	11-6-2019	Mwanza	Farmers Union of Malawi	Extension Officer Southern Region
2	11-6-2019	Mwanza	GoM - Department of Irrigation	Irrigation Extension Officers in Mwanza District
3	17-6-2019	National	GoM - Department of Agricultural Extension Services	Principle Extension Methodologist Officer
4	18-6-2019	National	GoM - Department of Irrigation	Deputy director
5	19-6-2019	Ntchisi	GoM - Department of Irrigation	Irrigation Extension Officer
6	19-6-2019	Ntchisi	GoM - Department of Irrigation	Intern Irrigation Extension Officer
7	27-6-2019	Zomba	GoM - Department of Irrigation	Chief Irrigation Officer

Table 1 - Overview of the interviews performed with experts. Interview transcripts can be found in Annex 3.

#	Date	District	Technology	Size cultivated area	Members
1	10-6-2019	Blantyre	Barsha pump	≈ 1 ha	1
2	11-6-2019	Mwanza	Barsha pump	10 hectares	45
3	11-6-2019	Mwanza	Treadle pump / Petrol pump	0.5 hectare	1
4	11-6-2019	Mwanza	Treadle pump / Solar pump	0.5 hectare	≈ 10
5	17-6-2019	Neno	Petrol pump / Barsha pump	4 ha (partly cultivated)	1
6	19-6-2019	Ntchisi	Barsha pump	≈ 1.5 ha	≈ 20
7	19-6-2019	Ntchisi	Petrol pump / Solar pump	≈ 4 ha	12
8	24-6-2019	Zomba	Gravity	20 hectares	200
9	24-6-2019	Zomba	Gravity	6 hectares	46
10	25-6-2019	Zomba	Petrol pump / Treadle pump / Solar pump	10 hectares	39
11	25-6-2019	Zomba	Watering can	2 hectares	7
12	25-6-2019	Zomba	Gravity	≈ 1 ha	25
13	25-6-2019	Zomba	Petrol pump	1 acre	12

Table 2 - Overview of the interviews performed with farmers. Interview transcripts can be found in Annex 2.

An analysis of the interviews is presented below. The interview transcripts can be found in Annex 2 and Annex 3 for the farmers and experts respectively.

Interview analysis

The interviews helped to further define and identify variables that have substantial influence on adoption of WTTs for irrigation. The most important variables are discussed below.

Finances

The most important variables identified by farmers, as well as experts, in the decision-making concerning WTT adoption were the initial and total investment and operational costs (Annex 3 – Interview 2, 4, 5, 6, 7). It was often the financial capacity, *"the financial muscle of the farmer"* (Annex 3 – Interview 7), that dictated the range of options that farmers were able to consider. If a technology is not affordable to a farmer, it is not even an option. That is why, if possible within their respective environment and topography, farmers opted for gravity systems (Annex 2 – Interview 2, 8, 9, 12; Annex 3 – Interview 2, 4); which according to them are the cheapest WTT. It must be noted that large gravity systems with lined canals actually have relatively high investment costs, but that the interviewed farmers received these lined canal systems from different development initiatives. They did, however, often start with the construction of gravity systems using earthen canals, dug by community members themselves, before receiving development aid. Farmers that draw from sources unsuitable for gravity irrigation, however, adopt other technologies that fit their budget. Some farmers even combined different kinds of technologies, such as Farmer 3 (Annex 2 – Interview 3), who used a cheap-to-run treadle pump in combination with and easy, quick but also expensive petrol pump.

Because investing a large amount of money in one go is difficult for many farmers, paying off technology in instalments was for many farmers an attractive proposition (Annex 2 – Interview 1, 5, 6, 10; Annex 3 – Interview 4). Paying for technologies by installments helps farmers to take into account a wider range of technology options. It also makes taking the step to commit to and invest in a technology easier. If technology needs to be paid off at once farmers need a long time to raise money and buy at a later stage (Annex 2 – Interview 5).

Information & advise

It also became clear that, as literature already suggested, decision-making around adoption of WTT is heavily influenced by information from different sources or people. Farmers became familiar with technologies through the radio, TV, fellow farmers or information from governmental extension officers. Exposure to technologies by physically seeing and trying, however, was most convincing to farmers (Annex 3 – Interview 7). More commercial and better educated (smallholder) farmers often had extra or alternative sources of information, namely their education and the internet. Other sources of information that were mentioned by farmers were Facebook (Annex 2 – Interview 1) and agricultural WhatsApp groups (Annex 2 – Interview 5). Advice and information from governmental extension officers was found to also influence WTT decision-making. As extension officers (Annex 3 – Interview 2) indicated in their interviews, farmers that are really willing to start irrigation come visit their office to ask for help: *"We have water, but we don't have expertise"*. When giving advice, extension officers use their expertise and knowledge of irrigation systems and existing technologies in mind. To contextualize and personalize advice for a specific farmer *"…we look at symptoms of course that indicate whether they can manage to buy. Next thing, we look at the source of water."* (Annex 3 – Interview 2). Also, extension officers actively demonstrate different WTT options to farmers during so called agricultural and irrigation fairs (Annex 3 – Interview 3, 7). These fairs enable farmers to become familiar with WTTs that they might not be familiar with. Especially farmers that have received relatively little education, live and farm in rural areas, have little other sources of information, or have received visits from extension officers, attach a lot of value to their advice (Annex 2 – Interview 3, 8, 10). Farmers that were well educated, well informed about different technology choices, or did not receive visits from extension officers (Annex 2 – Interview 1), however, mentioned that advice from extension officers was having little influence in their technology choice.

Ownership

Ownership of land also plays a role. A considerable amount of the farmers that were interviewed were not owners of the land they cultivated. They were leasing it or were given permission to cultivate it for the sake of "community development" (Annex 3 – Interview 4, 7). Often, there is an agreement between the land owners and the scheme users on how the parcels of land should be used. In some cases, the owners take back control of the land during the rainy season. Such a lack of ownership, authority and control over land can discourage farmers to invest in advantageous WTT for irrigation (Annex 3 – Interview 1, 4, 7).

Ownership of WTTs might also play a role. Farmer 3 pointed out that when group sizes get too big, an individual feeling of ownership might disappear, affecting proper farm and technology management (Annex 2 – Interview 3). This results

in a lack of feeling of self-empowerment that is required for farmers to make the decision to start or change their irrigation strategy (Bolt & Fonseca, 2001).

Market

Most farmers were growing crops to sell at the market, besides being used for home consumption. The crops being grown are often determined by the demand from the market (Annex 2 – Interview 3). In Malawi, however, it is not always easy to realize a good amount of money by selling your harvest at the market. Fluctuating prices and demand might endanger a safe sustainable irrigation system, because maintenance and running costs can all off a sudden become unaffordable. Having a safe stable market therefore, considerably reduces the risk for farmers to make technology investments. According to Expert 7, Chief Irrigation Officer of the Zomba district, (Annex 3 – Interview 7): *"The market is a harbor of how the farmers are going to realize income from their harvest. It is the core. ... So if this market is available, it is one of the most important things that can motivate and drive the farmers motive to actually continue farming."*

Performance

Often one of the underlying goals of the farmers choosing higher mechanisation levels or more advanced WTTs for their farm is to increase the land under irrigation, and ultimately the yields (Annex 2 – Interview 1, 2, 3, 7, 13). Whereas it seems that WTT does indeed have the ability to influence one's status in a community, most farmers mention they are purely interested in the way the technology transports water from the river to the garden (Annex 2 – Interview 1). Performance of different WTTs therefore, was indicated to have a considerable influence on farmers' decision-making. Water transport speed, pressure, volume, distance, time (Annex 2 – interview 3) are key variables. The value attached to these performance characteristics seem to vary noticeably per farmer. Some farmers, such as farmer 1 (Annex 2 – Interview 1), are looking for efficient and low cost technologies providing enough water over time: *"…I am not just looking at the pace with which I am pumping the water, I also look at the amount, the cost, that I am putting in. I am looking for something that needs little input, but gives much outcome."* Others are looking for technologies that pump high volumes of water in a short time (Annex 2 – Interview 3, 7, 10). For farmers that wanted to cultivate relatively far from their water source, WTTs such as the treadle pump or watering can have unfavourable characteristics. Water buckets or treadle pumps were often found to give too little water to cultivate and irrigate a satisfying area size. Also, many farmers indicated that adopting different and relatively more advanced WTTs was because manual technologies are labour intensive and "tiresome" (Annex 2 – Interview 1, 2, 3 …). Here, automatic WTT offers advantages, as mentioned by farmer 1 in using the Barsha pump: "*As I have said, with irrigation, you have somebody doing the job for you. If you have someone doing the job for you, it is so easy to expand*" (Annex 2 – Interview 1).

Environment

Technologies that have characteristics that are relatively environmentally friendly, such as the solar or the Barsha pump, were attractive to relatively richer and better educated farmers (Annex 2 – Interview 1, 5). Aspects like noise and air pollution were mentioned as contributing variables that influenced their decision-making. Changes in weather patterns were definitely said to have changed, sparking conscious technology adoption: *"Some of the effects of those things (petrol pumps) are air pollution and everything. Putting that into consideration I figured out that if I get some other means of pumping this water into the garden I will still be contributing to the problems that I am already facing"* (Annex 2 – Interview 1).

Although less educated and poorer farmers recognize the problem of changing weather patterns, environmental variables seem to be of little influence when deciding which technology to adopt. Advanced environmentally friendly pumps, however, often pump using free RE and require little to no operational cost, which to most farmers had a much higher influence on their decision compared to the effect of the technology on the environment (Annex 2 – Interview 1, 3, 5). Also, these advanced environmentally friendly technologies generally require a relatively high initial investment to adopt. Of course manual water transportation technologies, such as the watering cans or treadle pumps, also have environmentally friendly characteristics, but as indicated by farmers in the Matiti Irrigation Scheme *"The irrigation system doesn't depend on the environmental protection. It is just a bonus".* This standpoint towards adoption of certain WTT for environmental reasons, is common among most farmers according to the interviewed experts (Annex 3 – Interview 1, 5). They indicate that although most farmers think about the environment, most of all, they find it important to use a technology that helps them do their farming work the best they can (Annex 3 – Interview 2).

Ease of use
The ease of operation (Annex 2 – Interview 3) was a technology characteristic that especially individual farmers found important (Annex 2 – Interview 1, 3). Technologies that take permanent supervision or human input were found to be less attractive. Which system is easy to use and which one is not however, is open to interpretation. The farmers in the Matiti Irrigation Scheme (Annex 2 – Interview 9) for instance described their earthen canal gravity system as easy to use: *"… it is very easy to manoeuvre with the water. To channel the water. It doesn't take a lot of hassles to move the water around."*

Theft and vandalism were variables unidentified in the literature study, but some interviewed farmers indicated these to be of importance in their choice (Annex 2 – Interview 1). Technology that is difficult to move around and keep in a safe place can therefore be less desirable.

Water availability
Some farmers indicated that with their current WTT their respective water source was the limiting variable (Annex 2 – Interview 1, 2, 11). Although water sources often did not run dry, a reduction in water availability can spark conflict and a decrease in the irrigated area. Therefore, they indicated that efficient WTTs, or water storage solutions, that match water availability are of importance. Farmer 3 (Annex 2 – Interview 3) illustrates that even when water availability is not an issue, efficient water use is still important: *"I know the motorized pump is using a lot of water. Some of it is being thrown away".* Experts agree and mention that it is important for farmers to take their water source into account to make sure that the technology can be used sustainably and will not deplete its source or cause conflict with other water users (Annex 3 – Interview 3, 7).

Conclusions
It is clear that there are many variables that have an important role to play in the smallholder irrigation technology process. Exposing and familiarizing farmers to different kinds of technologies is critical in order for them to consider adoption. Information from irrigation officers, fellow farmers or other sources can help in this process, but the method that seems most convincing to farmers is to expose them to technologies by physically seeing them and trying them.

It is clear that most farmers want to grow and develop their farms and livelihoods and are willing to foster farm performance and reduce (labour) cost by using WTTs for irrigation. The low level of mechanisation and high dependence on manual labour, however, often compromises the ability to raise the cost of producing crops and undermines the profitability of the farming systems. The introduction of different irrigation systems does often result in increased crop yields, but is no assurance of improved food security and poverty reduction (Annex 2 - Interview 7, 8). The reason being is that some farmers do not produce enough to meet the increased production, running or maintenance costs, introduced by certain WTTs. Weak market links and constraints in accessing appropriate seed and fertiliser also contribute to the inability of farmers to fully utilize the increased production potential.

Even though smallholders often have similar clear goals, their decision to realize those goals are quite different. The statements as identified through literature and interviews can be found in Annex 2.

3.3 Final Q-set
From literature and interviews a list of 61 statements was drawn up (Annex 4). Literature suggests that a typical Q-sample involves 30 to 50 statements (Pereira et al., 2016). In this study the conscious decision was made to limit the number of statements because of time and understandability concerns. After all statements were assessed for duplication, statements that involved variables that could be answered with the help of some of the other statements were discarded. The final list involved 34 statements (Annex 5). The statements were categorized in three themes and subdivided in respective dimensions to ensure that all aspects are covered:

1. The characteristics of the WTT
   Subdivided across the dimensions:
   a. Financial aspects and affordability
   b. Management
   c. Technology characteristics
   d. Environment

2. Characteristics & circumstances of farmer within their (social) environment
   Subdivided across the dimensions:
   a. Community
   b. Ownership
   c. Agricultural extension services
   d. Company relationship

3. The process of learning and experience
   Subdivided across the dimensions:
   a. Familiarity
   b. Understandability

Some categories were represented more than others because of their relative importance and complexity, but during the Q-sample design it was believed to be more important to cover all dimensions rather than a balanced distribution of statements across the dimensions. It was ensured that the statements did not favour one aspect over another. The statements were rephrased to short and simple sentences and in such a way that participants could agree and disagree with statements. Afterwards, the statements were translated into Chichewa, the local Malawian language, and printed on chips (890 mm × 890 mm).

Q-sorting umbrella question

The umbrella question was formulated in first person perspective. This enabled the Q-sort attendee to feel empowered by the question. The question is clearly about the attendant as an individual, rather than just anyone. A more neutral, or third person, formulation might have introduced a certain amount of vagueness and could have negatively influenced the results.

The topic of the Q-sort was explicitly mentioned in the umbrella questions as *"farmer decision-making"*, to make sure the researcher's interest was immediately clear to the Q-sort participant. As an additional piece of information *"adopting WTT for irrigation"* was mentioned to further introduce the interest of the researcher.

The farmers that were undertaking the Q-sort were intentionally not exposed to other WTTs for irrigation that they were not familiar with, since the goal is to understand how farmers make decisions, including what they do not know, and address the reality as it is. Introducing the participants with unfamiliar technology before attending the Q-sort would give a distorted snapshot of their current subjectivity around WTTs for irrigation.

When farmers asked questions about irrigation technologies prior the interview or Q-sort, the decision was made to be as transparent as possible without showing any materials like movies, pictures or miniature models. In this way the interest and comment is appreciated, but isolates the subject and so avoids introducing new materials.

Umbrella question formulation:

What are the most important decision-making variables for me as a famer in adopting WTTs for irrigation?

An important assumption in this umbrella question is that the main use of the pump is irrigation. Their irrigation pump technology decision is not influenced by alternative uses of technology besides irrigation. Concerning the cases in Malawi this was found to be an acceptable assumption.

Shape Q-sort table

The participating farmers in the study are asked to rank and sort the statements in accordance with a predefined grid pattern (Figure 5). The shape of the Q-sort table mainly depends on the number of statements needed to embrace all the subjectivity. The table follows the shape of a normal distribution. This gives the farmers a chance to have a preference for extremes. Whether the statements under column "-4" or "+4" have one or two rows depends on the type of statements and the topics that are covered. Many topics might require more extremes and therefore more rows. To restrict the number of extreme options, however, forces the participant to really think about their opinion on the subject and sort it out.

Strongly disagree				Neutral				Strongly agree	
-4	**-3**	**-2**	**-1**	**0**	**1**	**2**	**3**	**4**	**Total**
2	3	4	5	6	5	4	3	2	**34**
a	b	c	d	e	f	g	h	i	9
a	b	c	d	e	f	g	h	i	9
	a	b	c	d	e	f	g		7
		a	b	c	d	e			5
			a	b	c				3
				b					1
								Total	**34**

Figure 5 - Shape of the Q-sort table with 34 statements

3.4 Conducting the Q-sort

The Q-sort was conducted by 58 individuals consisting of experts and a wide range of farming individuals and cooperatives. Most of the farmers that were initially interviewed during the concourse development were revisited for the Q-sorting exercise, because the extensive qualitative background data could help explain their sorting decisions. Also, the interviewees expressed their interest in how their interview information had translated itself into a puzzle exercise.

The 9 experts that participated in Q-sort were most of the time active as governmental irrigation officers responsible for promoting and supervising irrigation activities in a respective district.

The participating farmers ranged from poorly educated farmers operating on farms of around 0.1 hectare, to well-educated farmers operating commercially on areas up to 5 hectares. Besides some groups seemingly similar, this did not necessarily mean they used the same WTTs. Special attention was paid to make sure the pool of participants formed a reasonable representation of the diversity of farmers and WTTs in Malawi to make sure no group or technology was underrepresented.

Before performing the exercise, participants were instructed how the sorting should be performed. If participants felt the statement aligned with their opinion they were asked to place the statement more to the right (positive) side of the grid, while if they disagreed more to the left (negative) side. The more detailed instructions, provided in English and Chichewa, that were developed for the participants can be found in Annex 6. It must be noted that most of the instruction was done verbally, because of participants with illiteracy problems. Also it was found that verbally explaining the puzzle often went a lot faster compared to participants reading the instructions.

Figure 6 – Above: A finished Q-sort. Below: A finished Q-sort with the chips turned around, exposing the statement numbers.

In order to make it easier and more understandable for the farmers and experts performing the Q-sorting exercise, they were advised to first form three piles of statements: those they agreed with, those they disagreed with and those that they felt fairly neutral about. In practice, however, participants decided to place the chips where they initially thought it should be, instead of making piles, after which they shuffled the statements around on the go. The participants performed the exercise in groups or individually and were encouraged to shuffle statements around until satisfied with their sorting. After the sorting (Figure 6), the participants explained their respective choices in a tape-recorded interview. The time needed to complete the Q-sort ranged considerably between participants, but generally the exercise took 20-40 minutes after the explanation.

Often, the poorly educated farmers were not able to understand English, or were illiterate, and had to be supported by fellow farmers or a local irrigation extension officer. When visiting a large cooperative, special attention was taken to make sure that illiterate and literate participants were grouped together.

Especially when the Q-sort was performed in a group, there was a lot of discussion between participants. Also, in particular the experts and commercially-minded participants were very interested in the puzzle and asked for a picture after finishing the Q-sort. Their reasoning was that the decision-making analysis that they were having to make while making the Q-sort might be valuable and help them in the future.

Some participants raised the issue of a lack of space under the strongly agree side of the spectrum (+3, +4) of the Q-sort. This issue seemed to be more apparent amongst the poorer and less educated SFs compared to the other participants. As a consequence these participants needed some extra time to properly order the chips in this side of the spectrum.

4 Results

In total 58 Q-sorts were conducted. The participants included 49 farmers and 9 experts. Out of the 58 Q-sorts, 26 were performed by one or more males, 12 by one or more females and 20 in mixed groups of male and female. All the Q-sorts can be found in Annex 7. The collected Q-sorts were structured in a two-dimensional matrix. Next, the Q-sorts were correlated. The correlation tables for all participants can be found in Annex 8.

4.1 Q-sort grouping

To understand the influence of the different groups of participants on the formed typology, the Q-sorts were analyzed using all participants, only farming participants and only experts respectively. The results show that, depending on the factor solution, the exclusion of certain subgroups do influence the ultimate factor typology. The effect of the removal of the 9 experts for instance, largely depends on the chosen factor solution. In the 2-factor solution for instance, the differences between the sorting behavior of the respective factors of all participants compared to only the farming participants are minimal. The removal of the 9 expert participants hardly influenced the factor scores. This is understandable because of the relatively large amount of participants defining the factors. In the case of the 4-factor solution, however, we find that the removal of the experts has made more difference. Where some factors have stayed relatively similar in participants and typology, others have been reshuffled and consequently have a slightly different typology. The respective results for the analysis with only farming or expert participants can be found in Annex 9 & 10 respectively. After the above mentioned analysis, it was concluded and recognized that exclusion of different participants has a definite influence on the ultimate typology of the resulting factors.

In the analysis below all 58 Q-sort participants are included, which presents the opportunity to study if distinguishment within subsets of participants, that are homogenous according to certain background information and definitions, can be found. In the following section, the choices that were made to determine the most interesting factor solution are discussed.

Factor analysis

When including all 58 Q-sorts the 8 unrotated factors accounted for 70% of the total variance (Table 3). Looking at the statistical data (Table 3), the first factor explained the greatest part of the variation as it accounts for ~38% of the variability in the data. An amount more than 12 times greater than factor 8.

	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Factor 7	Factor 8
Eigenvalues	22.0063	3.7314	3.2316	2.6998	2.608	2.508	2.1518	1.9425
% Explained Variance	38	6	6	5	4	4	4	3
Cumulative % Expln Var	38	44	50	55	59	63	67	70

Table 3 – The 8 unrotated factors of all 58 Q-sort participants after PCA with their respective eigenvalues and explained variance %.

After the factors were rotated using the *varimax* method their respective relevance was assed. The first step in this process was applying the *eigenvalue* criterion. With all *eigenvalues* above the criterion of unity (Table 3 & Figure 7), no factors could be discarded. The number of factors to include therefore needs to be based on the explained variance of the factor, composite reliability and the number of distinguishing statements. In order to compare the statistical data for the different amounts of factors, the case of 2, 3, 4, 5, 6, 7 and 8 factors were generated. The Q-sorts were loaded to the factor using the automatic *flagging* process using a 5% significance level ($P < 0.05$). The statistical data is presented in Figure 8.

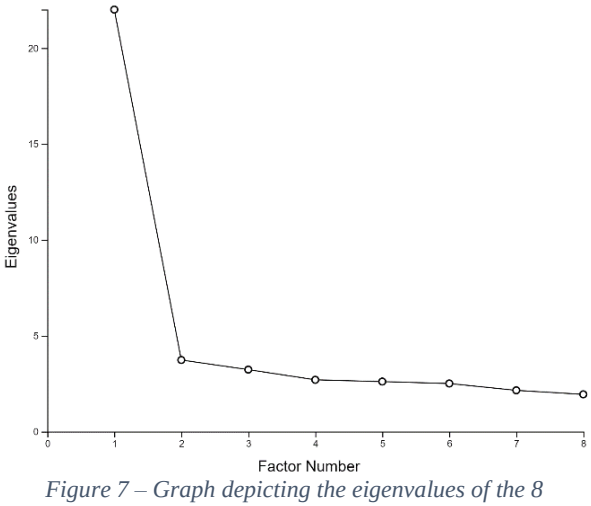

Figure 7 – Graph depicting the eigenvalues of the 8 unrotated factors of all 58 Q-sort participants after PCA.

When looking at representative scores in Table 4, one can see that as the number of factors increases, the number of unflagged Q-

sorts increases. All factors, however, still load more than 50% of the participants, which gives us no grounds to discard factors based on the *representativeness criterion.*

As a consequence of the decrease in the number of respondents loading significantly on a factor, however, the composite reliability (Eq.3) decreases. This is also evidenced by the slightly increasing standard errors of the factor Z-scores. This is understandable since the more factors there are, the more possibility there is that part of the pattern of an individual's sorting of the statements is similar to another factor (Herrington & Coogan, 2011). It is also clear that as the number of factors increases, the amount of distinguishing statement (P ≤ 0.05) decreases.

All participants	flagged	unflagged	flagged %
2 factors	55	3	95
3 factors	48	10	83
4 factors	43	15	74
5 factors	41	17	71
6 factors	31	27	53
7 factors	32	26	55
8 factors	30	28	52

Table 4 – Factor solution representative scores; the respective flagged to unflagged ratio of the respective factor solutions.

On the basis of the composite reliability criterion we can discard the option of the 6-, 7- and 8-factor solution, because they show results of unreliable composite reliability values of < 0.94. Another reason to reject the 6-, 7- and 8-factor solution is their low number of distinguishing statements.

2 FACTORS	factor 1	factor 2
# Participants defining Factor	32	22
Composite Reliability	0.992	0.989
Distinguishing Statements (P ≤ 0.05)	25	25

4 FACTORS	factor 1	factor 2	factor 3	factor 4
# Participants defining Factor	12	11	9	11
Composite Reliability	0.98	0.978	0.973	0.978
Distinguishing Statements (P ≤ 0.05)	8	11	13	9

3 FACTORS	factor 1	factor 2	factor 3
# Participants defining Factor	21	15	12
Composite Reliability	0.988	0.984	0.98
Distinguishing Statements (P ≤ 0.05)	14	15	14

5 FACTORS	factor 1	factor 2	factor 3	factor 4	factor 5
# Participants defining Factor	10	11	7	4	9
Composite Reliability	0.976	0.978	0.966	0.941	0.973
Distinguishing Statements (P ≤ 0.05)	5	7	6	7	4

6 FACTORS	factor 1	factor 2	factor 3	factor 4	factor 5	factor 6
# Participants defining Factor	9	7	5	2	7	1
Composite Reliability	0.973	0.966	0.952	0.889	0.966	0.8
Distinguishing Statements (P ≤ 0.05)	0	2	5	5	1	7

7 FACTORS	factor 1	factor 2	factor 3	factor 4	factor 5	factor 6	factor 7
# Participants defining Factor	8	5	4	2	7	1	5
Composite Reliability	0.970	0.952	0.941	0.889	0.966	0.800	0.952
Distinguishing Statements (P ≤ 0.05)	1	2	5	3	2	5	1

8 FACTORS	factor 1	factor 2	factor 3	factor 4	factor 5	factor 6	factor 7	factor 8
# Participants defining Factor	6	5	3	2	7	1	4	2
Composite Reliability	0.96	0.952	0.923	0.889	0.966	0.8	0.941	0.889
Distinguishing Statements (P ≤ 0.05)	0	3	2	2	2	2	0	1

Figure 8 - Factor Characteristics of the respecitve 2, 3, 4, 5, 6, 7 & 8 number of factor solution cases.

Therefore, based on the rules of statistics and criteria brought forward in other Q-methodology studies, we can go forward with the analysis of 2-, 3- , 4- and 5 factor solutions. From this point, choosing the amount of factors to be analyzed is a trade-off between extent of explained variance and a meaningful set of farmer types (Pereira et al., 2016). In an exploratory journey, which can be found in Annex 11, it was investigated which factor solution is the most interesting fit for the data. In summary it was found that although the 2-factor solution has the highest representative score (81%), it does not embrace the complexity represented in the group of participants. This is supported by the fact that the 2-factor solution represents 44% of the total variance. Also, when looking at the factor visualizations for the 2-factor solution (Annex 11.2), we find that all statements are either significantly distinct or of consensus, indicating that significance is easily reached and that there is more variety to this group of participants than a 2-factor solution can display. The 5-factor solution on the other hand, embraces a lot more of the variety, 59% of the total variance, but was found to give too little distinguishment between the different groups (Annex 11.5). This is mostly due to the low number of participants that significantly load on the factors. As a result, it becomes difficult to pinpoint and understand the sorting behavior of a respective factor.

The 3- and 4-factor solution were found to both give enough explained variance and distinguishing statements for analysis and are therefore discussed in further detail below.

Factor interpretation

3-factor solution

In this analysis three factors were kept in rotation, accounting for 50% of the total variance. 48 of the 58 participants (83% of the sample) were automatically *flagged* to the factor with which they had significant loading. The remaining 10 participants were disregarded for this part of the analysis because they loaded insignificantly or loaded significantly on more than one factor (multiple loaders). For each factor, a factor matrix, factor visualization and a list of distinguishing statements can be found in Annex 11.3 & 11.4. Detailed accounts of all three factors are presented below. These were composed by examining the sorting of statements in relation to the other statements within the factor and by comparing this with the other factors (Table 5). It is the relative positions within the entire sort that describe the factor and not just the individual statements themselves. From the three factors, each of which can be considered as a synthetic representative farmer according to their key sorting behavior, a brief participant typology was created (Table 6).

3-Factor Solution
Factor 1
Characteristics: follower, dependent, team player
The participants in this factor prefer WTTs that give high volumes of water. If this means that a WTT is relatively more expensive to run, this is accepted. External support or advice is hugely appreciated because of lack of knowledge about the technologies or low financial capabilities.
Factor 2
Characteristics: individual farmer, risk taker, cost-effective decision maker, long-term thinker
The participants in this factor have profit maximization as a primary objective. In order to realize this they are looking for a technology that is affordable and labour saving, but also offers low running cost, in order to expand their farm. In their decision-making process they pay special attention to the gross margin and cost of production. If this means they have to invest in more expensive technology, but ultimately safe on running cost, this is accepted. Since these farmers often operate individually, it is important that the technology is easy to individually operate.
Factor 3
Characteristics: risk averse, environmentally aware
For the participants in factor 3 it is very important to minimize risk. Therefore they have a strong preference for proven, familiar, understandable technologies that are hard to vandalize or steal. Diagnosis of the environment and assessment of available water resources for irrigation are taken into account to make sure the WTT fits their specific situation.

Table 6 - A brief summary of the three factors

Factor 1

21 participants loaded significantly on factor 1. The participants of factor 1 seem to be heavily influenced by variables involving external support. This support can involve finances and help with farming inputs, but also knowledge about irrigation management, local markets or the different WTT options. The decision-making process for instance is heavily impacted by the advice given by governmental extension officers. Also, statement 29 was often associated with external support from development organizations and the disagreeing sorting behavior of factor 1 can be interpreted as another expression of the request to be supported by external organizations:

27	I prefer a technology that has been advocated by the extension officers.	**3**
28	I need external support after implementation.	**2**
29	I prefer if the company representatives are Malawian.	**-4**

As a supplement to the statements mentioned above, from the statements on the right can be concluded that the participants are financially limited in their adoption of WTTs. More advanced and more expensive technologies might therefore be difficult to attain. Paying for technologies by installments and in a group, however, helps to open a wider range of technology options:

8	I prefer to use and pay for a technology with a group of farmers instead of individually.	**2**
2	I want overall affordable costs.	**2**
1	I prefer paying through installments over time.	**1**

Theme Q statement	Factor scores		
The characteristics of the WTT	F1	F2	F3
Financial aspects and affordability			
1. I prefer paying through installments over time.	1	0	3
2. I want overall affordable costs.	2	4	2
3. I don't mind paying fuel to keep the technology working.	0	-3	-2
4. I am happy with my current pumping method. I don't want to invest.	-1	-1	-2
5. I prefer to wait for someone to give me an irrigation technology.	-2	-2	-1
6. It is too expensive. I don't want to invest.	-3	-2	-3
7. I have other farming limitations. I don't want to invest.	-2	-3	-3
8. I prefer to use and pay for a technology with a group of farmers instead of individually.	2	1	0
9. I prefer to adopt a more expensive technology but safe on running cost.	-1	2	-1
Management			
10. I find easy individual operation important.	1	3	1
11. I find easy maneuverability important.	-1	0	0
12. I find it important that the technology is hard to vandalize or steal.	-1	-1	3
Technology characteristics			
13. I want to be able to maintain the technology myself.	2	2	1
14. I want it to be cheap to maintain the technology.	0	4	0
15. I want my irrigation technology to give me a better status in my community.	0	-2	-1
16. I prefer a technology that works automatically without human power.	-2	2	-2
17. I prefer a technology that can give me a high volume of water.	4	1	0
18. I prefer a technology that can give me a high pressure.	3	1	-2
19. I want the technology to enable me to grow crops that I can sell at the market.	4	3	4
20. I want the technology to enable me to grow crops that I can eat.	3	2	2
21. I prefer a technology that uses water efficiently.	1	3	0
Environment			
22. I don't mind watering the crops myself without the use of a technology.	-2	-4	-4
23. My water availability and water source determine my technology choice.	1	1	4
Characteristics & circumstances of farmer within their (social) environment			
Community			
24. I want support from my community and family.	-3	-1	-1
Ownership			
25. I don't own the land on which I farm. I don't want to invest.	-4	-4	-4
26. I can't expand my farm. I don't want to invest.	-3	-3	-3
Agricultural extension services			
27. I prefer a technology that has been advocated by the extension officers.	3	1	1
Company relationship			
28. I need external support after implementation.	2	0	0
29. I prefer if the company representatives are Malawian.	-4	-1	-1
The process of learning and experience			
Familiarity			
30. I want to hear about the technology before I adopt it.	0	0	3
31. I want to have seen the technology before I adopt it.	0	-2	2
32. I want to try out the technology before I adopt it.	-1	-1	1
33. I want a technology that other farmers have used successfully before I adopt it.	0	0	1
Understandability			
34. I prefer technology that I can understand.	1	0	2

Table 5 - Raw scores of statements for the 3-factor solution.

The highest sorting of statement 3, compared to factor 2 and 3, indicates that if WTTs are relatively cheaper to obtain, higher running cost are accepted:

3	I don't mind paying fuel to keep the technology working.	**0**

Although the participants of factor 1 have a preference for adopting technologies in a group, support from their respective communities and families is not an important decision-making variable in the decision-making process:

24	I want support from my community and family.	**-3**

The sorting behavior of factor 1 seems to express a stronger focus on high volumes of water compared to the efficient use of water. This means that the participants of factor 1 experience water more as an abundant recourse to be utilized rather than a scarce resource that needs to be used efficiently:

17	I prefer a technology that can give me a high volume of water.	**4**
18	I prefer a technology that can give me a high pressure.	**3**
21	I prefer a technology that uses water efficiently.	**1**

Factor 2

15 participants loaded significantly on factor 2. The cost effectiveness of the WTT is something that the participants in factor 2 value relatively much. In financial terms this does not just involve the size of the initial investment, but also the long-term maintenance and running cost of the WTT:

2	I want overall affordable costs.	**4**
14	I want it to be cheap to maintain the technology.	**4**
21	I prefer a technology that uses water efficiently.	**3**
9	I prefer to adopt a more expensive technology but safe on running cost.	**2**

An important variable of the cost-effectiveness of a technology that drives the decision-making of the participants in factor 2 is their ease of use and labour saving ability. The ability of the WTT to work automatically is therefore strongly preferred. Unlike when using watering cans were one has to walk up and down to the water source, these technologies require little human effort or attention when pumping water. This enables the farmers to focus on other activities such as working on the crops or expanding the farm:

10	I find easy individual operation important.	**3**
16	I prefer a technology that works automatically without human power.	**2**

The participants in factor 2 attach relatively little value to the familiarity, understandability or status of a technology. As long as the WTT satisfies their most important decision-making variables, they are confident enough to adopt:

34	I prefer technology that I can understand.	**0**
30	I want to hear about the technology before I adopt it.	**0**
31	I want to have seen the technology before I adopt it.	**-2**
15	I want my irrigation technology to give me a better status in my community.	**-2**

Also, the participants in factor 2 attach significant little value, relatively to the other factors, to external support. This can be support in terms of advice, farm inputs or financial tools to help obtain WTTs. Paying for technologies in installments for instance, is not of huge importance to the participants in factor 2. This could suggest they have enough financial resources themselves to pay for the technology:

27	I prefer a technology that has been advocated by the extension officers.	**1**
1	I prefer paying through installments over time.	**0**
28	I need external support after implementation.	**0**
29	I prefer if the company representatives are Malawian.	**-1**

Factor 3

12 participants loaded significantly on factor 3. The participants in this factor express high value to the notion that different physical situations influence the suitability of a WTT, and they are determined to find the best technology fit with theirs:

23	My water availability and water source determine my technology choice.	**4**

The sorting behavior of factor 3 also shows that its participants are significantly more risk-averse when choosing WTT for irrigation. This is expressed in the relatively high valued importance of familiarity and understandability, but also in the preference for technologies that are hard to vandalize or steal:

30	I want to hear about the technology before I adopt it.	**3**
12	I find it important that the technology is hard to vandalize or steal.	**3**
34	I prefer technology that I can understand.	**2**
31	I want to have seen the technology before I adopt it.	**2**
33	I want a technology that other farmers have used successfully before I adopt it.	**1**
32	I want to try out the technology before I adopt it.	**1**

Besides the risk-averse sorting behavior mentioned above, the participants of factor 3 also express financially risk-averse behavior. Paying in installments reduces the initial financial risk and helps to open a wider range of technology options:

1	I prefer paying through installments over time.	**3**

Consensus

Besides statements that distinguished the Q-sort participants into three factors, there are also statements that participants agree on. This happens when similar sorting of some statements, which in the Q-methodology is called *consensus*, appears. It means that there is no significant difference between the factors. In the midst of all the subjectivity between participants, it can be especially interesting to discover statements that people have agreement on. The consensus statements are colored green in the factor visualizations (Annex 11.3).

Out of all statements in the 2-factor solution, there were 9 out of 34 statements which were sorted significantly similar by all participants (Table 6). There was a strong consensus against the notion that investment in pumping technology for irrigation is entirely blocked by financial, farm size or ownership limitations. There was also significant consensus in favor of edible crops that can be sold to the market:

Consensus statements		F1	F2	F3
20	I want the technology to enable me to grow crops that I can eat.	**3**	**2**	**2**
13	I want to be able to maintain the technology myself.	**2**	**2**	**1**
11	I find easy maneuverability important.	**-1**	**0**	**0**
4	I am happy with my current pumping method. I don't want to invest.	**-1**	**-1**	**-2**
7	I have other farming limitations. I don't want to invest.	**-2**	**-3**	**-3**
6	It is too expensive. I don't want to invest.	**-3**	**-2**	**-3**
26	I can't expand my farm. I don't want to invest.	**-3**	**-3**	**-3**
22	I don’t mind watering the crops myself without the use of a technology.	**-2**	**-4**	**-4**
25	I don't own the land on which I farm. I don't want to invest.	**-4**	**-4**	**-4**

Table 6 - Raw scores of consensus statements for the 3-factor solution.

Gender distribution

The gender distribution in the three respective factors is presented below in Table 7. Some Q-sorts were performed in mixed groups of male and female, which were classified as ‘Mixed’. The table present the number and percentage of male, female and in mixed groups performed Q-sorts in the respective factors. Because the total number of males, females and in mixed groups performed Q-sorts was uneven, the last column presents the normalized percentages relative to sample size distribution.

	# Male	# Female	# Mixed	# Total	% Male	% Female	% Mixed	Normalized Male %	Normalized Female %	Normalized Mixed %
Factor 1	5	4	12	21	24	19	24	17	30	53
Factor 2	10	4	1	15	67	27	0	50	43	7
Factor 3	7	2	3	12	58	17	0	46	28	26

Table 7 - Gender distribution in the 3-factor solution.

4-factor solution

In this analysis four factors were kept in rotation, accounting for 55% of the total variance. 43 of the 58 participants (74% of the sample) were automatically *flagged* to the factor with which they had significant loading. The remaining 15 participants were disregarded for this part of the analysis because they loaded insignificant or loaded significantly on more than one factor (multiple loaders). For each factor, a factor matrix, factor visualization and a list of distinguishing statements can be found in Annex 11.4. Detailed accounts of all four factors are presented below. These were composed by examining the sorting of statements in relation to the other statements within the factor and by comparing this with the other factors (Table 8). It is the relative positions within the entire sort that describe the factor and not just the individual statements themselves. From the four factors, each of which can be considered as a synthetic representative farmer according to their key sorting behavior, a brief participant typology was created (Table 9).

4-Factor Solution
Factor 1
Characteristics: dependent, team player, water volume seeker
The participants in this factor prefer to adopt WTTs in a group and prefer WTTs that provide high volume of water. If this means that a WTT is relatively more expensive to run, this is accepted. External support or advice is hugely appreciated because of lack of knowledge about WTTs or low financial capabilities.
Factor 2
Characteristics: individual farmer, risk taker, cost-effective decision maker, long-term thinker
The participants in factor 2 have profit maximization and farm expansion as primary objective. Therefore, they are looking for a technology that is affordable and labour saving, but also offers low running cost. In their decision-making process they pay special attention to gross margin and cost of production. Since these farmers often operate individually, it is important that the technology is easy to individually operate.
Factor 3
Characteristics: attach strong value to individuality & independency, risk averse, environmentally aware
For the participants in factor 3 it is very important to minimize risk. Therefore they have a strong preference for proven, familiar, understandable technologies that are hard to vandalize or steal. Diagnosis of the environment and assessment of available water resources for irrigation are taken into account to make sure the WTT fits their specific situation.
Factor 4
Characteristics: dependent, resource constrained, team player
The participants in factor 4 prefer to adopt affordable WTTs, that have low running cost, in a group. In order to obtain a WTT external support or advice is hugely appreciated. Paying for technologies by installments and using it in a group helps to invest in technology options. Easy maneuverability helps to share the technology with other farmers in the group.

Table 9 - A brief summary of the four factors

Factor 1

12 participants loaded significantly on factor 1. The sorting behavior of factor 1 seems to express a stronger focus on high volumes of water compared to the efficient use of water. Statement 18 was often associated with the use of petrol water pumps. From the respective sorting of statement 18 and statement 3, we can conclude that the participants in factor 1 have a strong preference for the performance characteristics of the petrol pump technology:

17	I prefer a technology that can give me a high volume of water.	**4**
18	I prefer a technology that can give me a high pressure.	**3**
3	I don't mind paying fuel to keep the technology working.	**2**
21	I prefer a technology that uses water efficiently.	**-1**

The participants of factor 1 seem to be somewhat influenced by variables involving external support. This support can involve finances and help with farming inputs, but also knowledge about irrigation management, local markets or the different WTT options. The decision-making process for instance is heavily impacted by the advice given by governmental extension officers. Also, statement 29 was often associated with external support from development organizations and the disagreeing sorting behavior of factor 1 can be interpreted as another expression of the request to be supported by external organizations:

27	I prefer a technology that has been advocated by the extension officers.	**3**
29	I prefer if the company representatives are Malawian.	**-4**

Theme Q statement	Factor scores			
The characteristics of the WTT	F1	F2	F3	F4
Financial aspects and affordability				
1. I prefer paying through installments over time.	0	0	2	3
2. I want overall affordable costs.	1	4	2	2
3. I don't mind paying fuel to keep the technology working.	2	-4	-1	-2
4. I am happy with my current pumping method. I don't want to invest.	-1	-1	-2	-2
5. I prefer to wait for someone to give me an irrigation technology.	-2	-2	-1	-1
6. It is too expensive. I don't want to invest.	-3	-3	-4	-3
7. I have other farming limitations. I don't want to invest.	-3	-3	-2	-2
8. I prefer to use and pay for a technology with a group of farmers instead of individually.	2	0	0	2
9. I prefer to adopt a more expensive technology but safe on running cost.	1	1	0	-1
Management				
10. I find easy individual operation important.	1	3	1	0
11. I find easy maneuverability important.	-2	0	0	2
12. I find it important that the technology is hard to vandalize or steal.	0	-1	4	1
Technology characteristics				
13. I want to be able to maintain the technology myself.	3	2	2	1
14. I want it to be cheap to maintain the technology.	0	4	1	0
15. I want my irrigation technology to give me a better status in my community.	-1	-2	-1	-1
16. I prefer a technology that works automatically without human power.	-1	2	-1	-3
17. I prefer a technology that can give me a high volume of water.	4	1	0	0
18. I prefer a technology that can give me a high pressure.	3	1	-3	-1
19. I want the technology to enable me to grow crops that I can sell at the market.	4	3	3	3
20. I want the technology to enable me to grow crops that I can eat.	2	2	1	4
21. I prefer a technology that uses water efficiently.	-1	3	0	1
Environment				
22. I don't mind watering the crops myself without the use of a technology.	-3	-3	-3	-4
23. My water availability and water source determine my technology choice.	0	1	4	2
Characteristics & circumstances of farmer within their (social) environment				
Community				
24. I want support from my community and family.	-2	-1	-2	-3
Ownership				
25. I don't own the land on which I farm. I don't want to invest.	-4	-4	-4	-4
26. I can't expand my farm. I don't want to invest.	-2	-2	-3	-2
Agricultural extension services				
27. I prefer a technology that has been advocated by the extension officers.	3	2	0	3
Company relationship				
28. I need external support after implementation.	0	0	-1	4
29. I prefer if the company representatives are Malawian.	-4	-1	-2	-1
The process of learning and experience				
Familiarity				
30. I want to hear about the technology before I adopt it.	2	0	3	1
31. I want to have seen the technology before I adopt it.	1	-2	2	0
32. I want to try out the technology before I adopt it.	-1	-1	1	0
33. I want a technology that other farmers have used successfully before I adopt it.	0	1	1	0
Understandability				
34. I prefer technology that I can understand.	1	0	3	1

Table 8 - Raw scores of statements for the 4-factor solution.

Paying and using a technology in a group, however, makes it easier to invest and helps to open a wider range of technology options:

8	I prefer to use and pay for a technology with a group of farmers instead of individually.	**2**

Factor 2

11 participants loaded significantly on factor 2. The cost effectiveness of the WTT is something that the participants in factor 2 value relatively much. In their decision-making process they pay special attention to the gross margin and cost of production. In financial terms this does not just involve the size of the initial investment, but also the long-term maintenance and running cost of the WTT:

2	I want overall affordable costs.	**4**
14	I want it to be cheap to maintain the technology.	**4**
21	I prefer a technology that uses water efficiently.	**3**
9	I prefer to adopt a more expensive technology but safe on running cost.	**1**
3	I don't mind paying fuel to keep the technology working.	**-4**

Paying for technologies in installments, however, is not of huge importance to the participants in factor 2. This could suggest they have enough financial resources themselves to pay for the technology:

1	I prefer paying through installments over time.	**0**

An important variable of the cost-effectiveness of a technology that drives the decision-making of the participants in factor 2 is their ease of use and labour saving ability. The ability of the WTT to work automatically is therefore strongly preferred. Unlike when using watering cans were one has to walk up and down to the water source, these technologies require little human effort or attention when pumping water. This enables the farmers to focus on other activities such as working on the crops or expanding the farm:

10	I find easy individual operation important.	**3**
16	I prefer a technology that works automatically without human power.	**2**

The participants in factor 2 attach relatively little value to the familiarity, understandability, safety or status of a technology. As long as the WTT satisfies their most important decision-making variables, they are confident enough to adopt:

34	I prefer technology that I can understand.	**0**
30	I want to hear about the technology before I adopt it.	**0**
12	I find it important that the technology is hard to vandalize or steal.	**-1**
31	I want to have seen the technology before I adopt it.	**-2**
15	I want my irrigation technology to give me a better status in my community.	**-2**

Factor 3

9 participants loaded significantly on factor 3. The participants in this factor express high value to the notion that different physical situations influence the suitability of a WTT, and they are determined to find the best technology fit with theirs:

23	My water availability and water source determine my technology choice.	**4**

Also, the participants in factor 2 attach significant little, relatively to the other factors, value to external support. This can be support in terms of advice, farm inputs or financial tools to help obtain WTTs:

27	I prefer a technology that has been advocated by the extension officers.	**0**
28	I need external support after implementation.	**-1**

The sorting behavior of factor 3 also shows that its participants are significantly more risk-averse when choosing WTT for irrigation. This is expressed in the relatively high valued importance of familiarity and understandability, but also in the preference for technologies that are hard to vandalize or steal:

12	I find it important that the technology is hard to vandalize or steal.	**4**
30	I want to hear about the technology before I adopt it.	**3**
34	I prefer technology that I can understand.	**3**
31	I want to have seen the technology before I adopt it.	**2**
32	I want to try out the technology before I adopt it.	**1**

Besides the risk-averse sorting behavior mentioned above, the participants of factor 3 also express financially risk-averse behavior. Paying in installments reduces the initial financial risk and helps to open a wider range of technology options:

1	I prefer paying through installments over time.	**2**

Factor 4

11 participants loaded significantly on factor 4. The participants of factor 4 seem to be heavily influenced by variables involving external support. This support can involve finances and help with farming inputs, but also knowledge about irrigation management, local markets or the different WTT options. The decision-making process for instance is heavily impacted by the advice given by governmental extension officers:

28	I need external support after implementation.	**4**
27	I prefer a technology that has been advocated by the extension officers.	**3**

From the statements on the right can be concluded that the participants are financially limited in their adoption of WTTs. Paying for technologies by installments and in a group, however, helps to open a wider range of technology options. Easy maneuverability helps to share the technology with other farmers in the group:

1	I prefer paying through installments over time.	**3**
8	I prefer to use and pay for a technology with a group of farmers instead of individually.	**2**
11	I find easy maneuverability important.	**2**

Although financially limited, from the statements on the right we can conclude that the participants of factor 4 do want to develop their farm. Although they do not want to water the crops themselves without the use of a technology, a technology that pumps automatically without human power or input is also not preferred. The problem with some of the available WTTs, however, is that they might come with higher running cost, which the farmers do not want to accept or cannot afford:

9	I prefer to adopt a more expensive technology but safe on running cost.	**-1**
3	I don't mind paying fuel to keep the technology working.	**-2**
16	I prefer a technology that works automatically without human power.	**-3**

Also, factor 4 is the only factor that gives higher value to the cultivation of food for eating compared to producing food to sell at the market. This indicates that the participants produce more for subsistence rather than for commercial purposes:

19	I want the technology to enable me to grow crops that I can sell at the market.	**3**
20	I want the technology to enable me to grow crops that I can eat.	**4**

Consensus

Besides statements that distinguished the Q-sort participants into four factors, there are also statements that participants agree on. This happens when similar sorting of some statements, which in the Q-methodology is called *consensus*, appears. It means that there is no significant difference between the factors. In the midst of all the subjectivity between participants, it can be especially interesting to discover statements that people have agreement on. The consensus statements are colored green in the factor visualizations (Annex 11.4).

Out of all statements in the 4-factor solution there were 4 out of 34 statements which were sorted significantly similar by all participants (Table 10). There was a strong consensus in favor of the need to invest in WTT, and against the notion that investment in pumping technology for irrigation is entirely blocked by farm size or ownership limitations or other farming limitations:

Consensus statements		F1	F2	F3	F4
4	I am happy with my current pumping method. I don't want to invest.	-1	-1	-2	-2
7	I have other farming limitations. I don't want to invest.	-3	-3	-2	-2
22	I don’t mind watering the crops myself without the use of a technology.	-3	-3	-3	-4
25	I don't own the land on which I farm. I don't want to invest.	-4	-4	-4	-4

Table 10 - Raw scores of consensus statements for the 4-factor solution.

Gender distribution

The gender distribution in the three respective factors is presented below in Table 11. Some Q-sorts were performed in mixed groups of male and female, which were classified as ‘Mixed’. The table present the number and percentage of male, female and in mixed groups performed Q-sorts in the respective factors. Because the total number of males, females and in mixed groups performed Q-sorts was uneven, the last column presents the normalized percentages relative to sample size distribution.

	# Male	# Female	# Mixed	# Total	% Male	% Female	% Mixed	Normalized Male %	Normalized Female %	Normalized Mixed %
Factor 1	4	4	4	12	33	33	33	22	49	29
Factor 2	7	4	0	11	64	36	0	45	55	0
Factor 3	8	1	0	9	89	11	0	79	21	0
Factor 4	3	1	7	11	27	9	64	21	15	64

Table 11 - Gender distribution in the 4-factor solution.

Difference between 3- and 4 factor solution

It is interesting to see how the consistency of the factors transform when changing from the 3- to the 4 factor solution. Which other subjectivities are embraced when space is created for an extra factor, or which subjectivities are neglected when leaving less space? Does the consistency of all factors change or does one factor split into others? When investigating the automatic *flagging* of the participants for the 3- and 4-factor solution (Annex 11.3 & Annex 11.4), we find several noticeable differences and similarities. An overview of the exact changes can be found in Table 12 below.

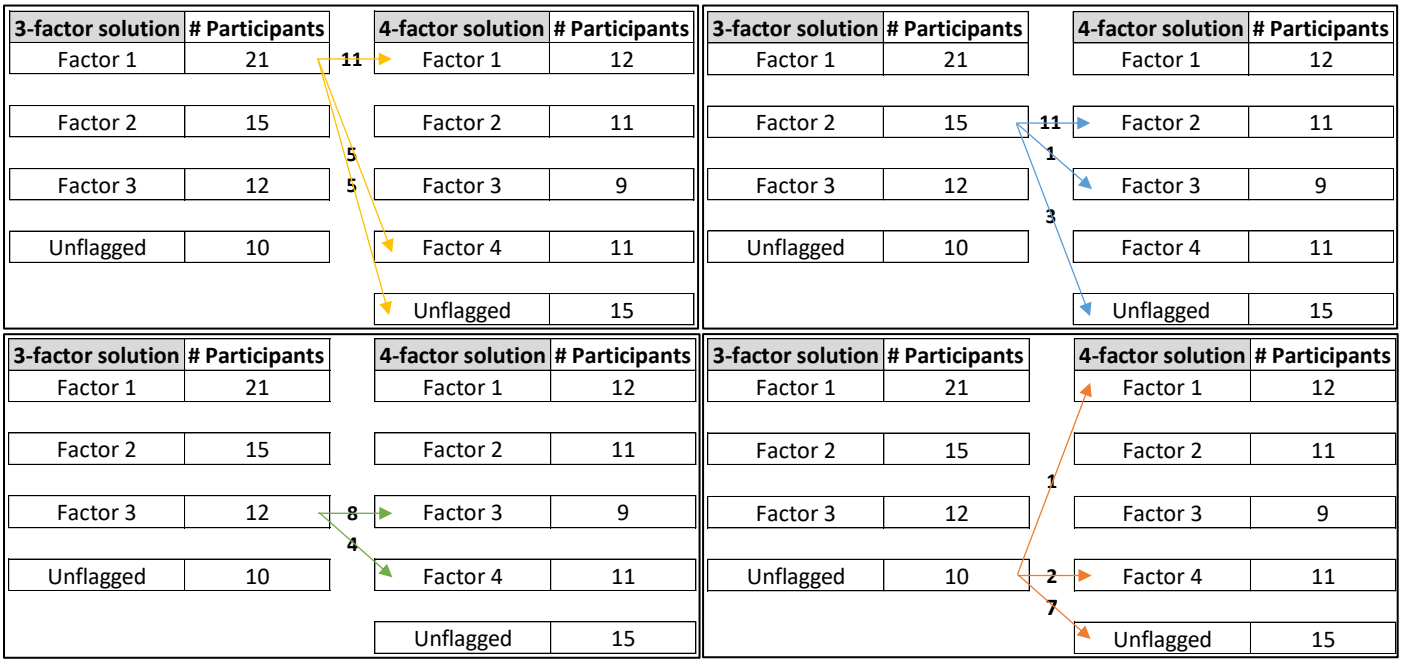

Table 12 - Split up of factor 1, 2 and 3 when changing from a 3- to a 4-factor solution.

The first notable difference between the 3- and 4-factor solution is the higher number of unflagged Q-sorts; 10 and 15 participants respectively. This can be explained by the fact that with more factors there is more chance a Q-sort participant can share its sorting behavior with more than one factor, increasing the likeliness of not being *flagged*. Increasing the amount of factors from 3 to 4, however, resulted in the *flagging* of 3 participants that were previously unflagged in the 3-factor solution. Other participants, however, changed from being flagged in the 3-factor solution to being unflagged in the 4-factor solution. The changes in the consistency of the respective factors for the two different factor solutions (Table 13) can roughly be summarized as follows:

- Factor 1 in the 3-factor solution split up in factor 1 & 4 in the 4-factor solution.
- The consistency of factor 2 in the 3-factor solution stayed roughly the same in the 4-factor solution
- Factor 3 in the 3-factor solution split up in factor 3 & 4 in the 4-factor solution.

	4-factor solution
3-factor solution	Factor 1 → Factor 1 & 4
	Factor 2 → Factor 2
	Factor 3 → Factor 3 & 4

Table 13 - Comprehendible overview of the changes when moving from a 3- to a 4-factor solution.

Although the above illustrated consistency differences between the factors in the 3-factor solution and 4-factor solution are clear, it is still difficult to understand exactly which changes occur and which subjectivities are embraced when space is created for an extra factor. Therefore, to fully understand the differences between a 3- and 4-factor solution, three different visualizations were developed using the concept of Q mapping, introduced by Yoshizawa et al., (2016). Q mapping transforms participants' individual Q scores into distances represented in two-dimensional space, in order to illustrate the relative positioning and partitioning of perspectives. Because it was impossible to do this for all 34 statements, representing 34 dimensions, this was done by grouping similarly themed statements together. The three themes and corresponding statements are presented below in Table 14.

Cost-effectiveness
2. I want overall affordable costs.
3. I don't mind paying fuel to keep the technology working (inversed).
9. I prefer to adopt a more expensive technology but safe on running cost.
14. I want it to be cheap to maintain the technology.
21. I prefer a technology that uses water efficiently.
Support
27. I prefer a technology that has been advocated by the extension officers.
28. I need external support after implementation.
29. I prefer if the company representatives are Malawian.
Risk
12. I find it important that the technology is hard to vandalize or steal.
30. I want to hear about the technology before I adopt it.
31. I want to have seen the technology before I adopt it.
32. I want to try out the technology before I adopt it.
33. I want a technology that other farmers have used successfully before I adopt it.
34. I prefer technology that I can understand.

Table 14 –Themes and their corresponding statements.

It must be noted that the themes mentioned above were chosen, because they were recognized as important variables differentiating the different factors. Multiple other themes underlying differences in decision-making could have been chosen. Also, the scores belonging to statement 3 had to be inversed, because of a difference in formulation.

For each theme, the individual scores of the underlying statements for each participant were averaged. When plotting two different average values of a theme in a graph, with the horizontal and vertical axis each represent a theme, each data point corresponds to an individual participant. The perspectives for each factor is captured by drawing a circle around the respective factor data points. Each factor circle is based on the linear trendline going through the points of the respective factor and represents an aggregate factor perspective.

In Figure 9 below, the horizontal axis ranges from ‘independent’, where the participants attach strong value to individuality and independency, to ‘support seeker’ where participants appreciate external support or advice. The vertical axis spreads from ‘risk averse’ to ‘risk taker’, depending on how much value participants attached to familiarity and understandability.

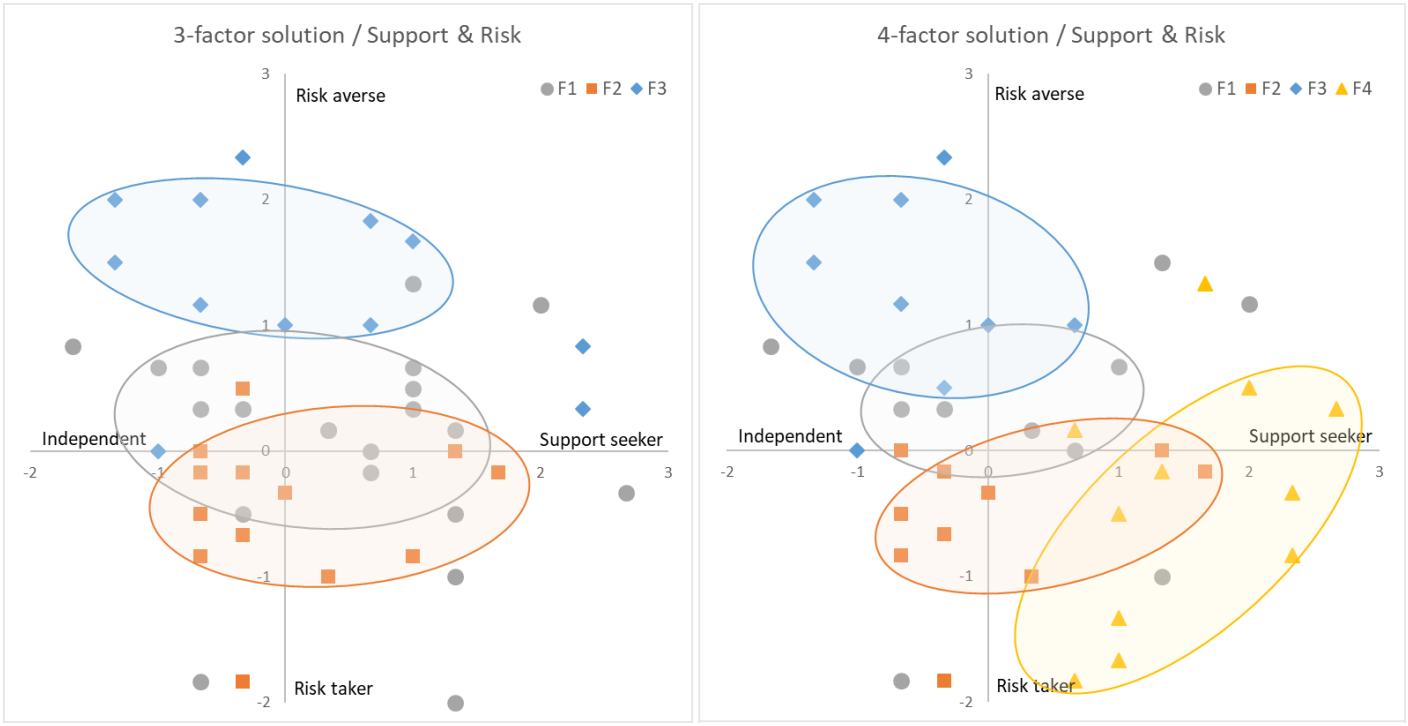

Figure 9 – Q map plotting the themes ‘Risk’ and ‘Support’ for the 3- and 4-factor solution respectively.

Figure 10 – Q map plotting the themes 'Support' and 'Cost effectiveness' for the 3- and 4-factor solution respectively.

In the Figure 10 above, the horizontal axis has stayed the same, representing the 'Support' theme, but the vertical axis now represents the 'Cost effectiveness' theme, showing how much value is attached to variables such as maintenance, profit maximization and cost of production.

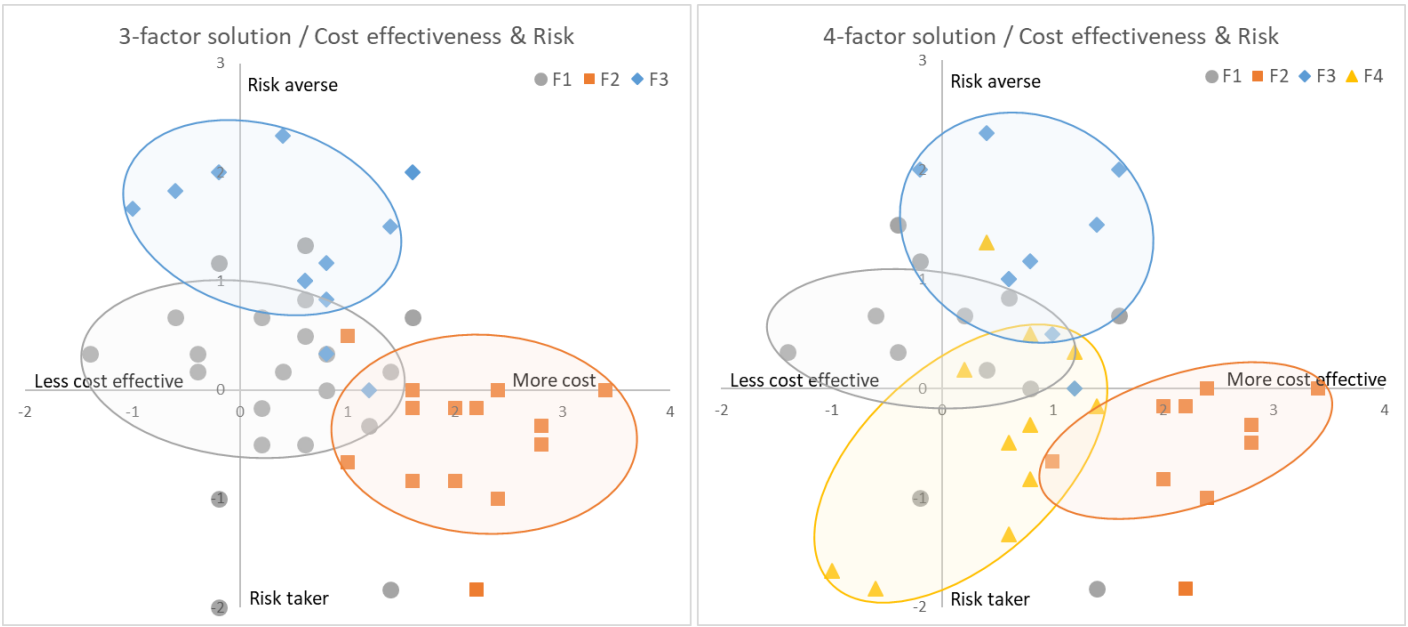

Figure 11 – Q map plotting the themes 'Cost effectiveness' and 'Support' for the 3- and 4-factor solution respectively.

In Figure 11 above, the horizontal axis represents 'Cost effectiveness'. The vertical axis represents 'Risk'.

The factor circles in Figure 9, 10 and 11 above can be interpreted using the concept of a Venn diagram. The factor circles show parts that overlap, while other parts do not overlap. This visually represents the similarities and differences between the decision-making of the participants in different factors. Factor circles that show an overlap illustrate that participants of different factors can share similar perspectives on a decision-making theme. It also shows there are inter-factor relationships.

Although even within a factor participants' two-dimensional positions show a clear variance with some even plotting outside the factor circle, it is clear that each factor circle occupies a certain region in the graph. This region represents a distinctive way of decision-making. However, not all the regions in the graphs are represented.

When comparing the graphs of 3- and 4-factor solution we find that some points disappear, some new ones appear and some change color. This represents the factor consistency changes illustrated in Table 10. What also becomes visible when comparing the two factor solutions, however, is that the factor circles change shape and direction. What a generated factor can encapsulate therefore, is clearly dynamic and depends on the chosen factor solution. Areas earlier unrepresented in the 3-factor solution, are represented when an extra factor is introduced in the 4-factor solution.

It is also clear that the introduction of an extra factor results in more overlap of the factor circles. This coincides with the finding that when the number of factors increases, the number of unflagged Q-sorts also increases. Indeed with more factor, there is a higher chance that an individual's Q-sort correlates, or in the case of the figures above overlaps, with multiple factors and may not be *flagged* at all.

Although when changing from a 3- to a 4-factor solution, the factors consistency (Table 10) initially seemed to largely stay the same, the figures above illustrate that some important changes occur and as a results also the interpretation of the factors do change. The changes to the interpretation the factors that come with moving from a 3- to a 4-factor solution are discussed below.

Factor 1
11 of the 12 participants of factor 1 in the 4-factor solution were part of factor 1 in the 3-factor solution. One would therefore expect the detailed accounts of factor 1 to be similar for the 3- and 4-factor solution. There are, however, considerable differences. The preference for high volume WTTs, that are not necessarily efficient and use fuel, is expressed even clearer. Also the importance of familiarity is sorted as being more important, while external support is less highly ranked. These changes indicate that the 10 participants that moved to factor 4 or became unflagged suppressed the expression of these variables.

Factor 2
The 11 participants of factor 2 in the 4-factor solution were all part of factor 2 in the 3-factor solution. Hence, the detailed accounts of factor 2 is almost the same for the 3- and 4-factor solution. While in both factor solutions the importance of low running cost was clearly expressed, in factor 2 of the 4-factor solution it is even clearer that a technology that uses fuel is not preferred. Also more value is given to individuality and technologies that have been advocated by extension officers or fellow farmers.

Factor 3
Factor 3 in the 4-factor solution also hardly changed in consistency since 8 out of its 9 participants were part of factor 3 in the 3-factor solution. The factor in the 4-factor solution expresses even more value to safety and familiarity, a little more value to maintenance variables, and less value to external support compared to in the 3-factor solution.

Factor 4
The newly created factor 4 receives participants from factor 1, 3 and the unflagged group respectively. The new group of participants attaches less value to performance indicators compared to their originating factors. They express more value to the affordability of the WTT and external support, but do not want to have a technology with high running costs. Paying for fuel to run the technology for instance, is not preferred. Paying for a more expensive technology and saving on running cost is difficult because of financial limitations. Manual technologies and paying in installments is therefore preferred. Also the factor is the only factor, in the 3- or 4-factor solution, that gives higher value to the cultivation of food for eating compared to producing food to sell at the market. This indicates that the participants produce more for subsistence rather than for commercial purposes.

Conclusion

After analyzing the 3- and 4-factor solutions, we can draw several conclusions. It is clear that, although some factors stayed relatively similar in loading participants, others have been reshuffled and consequently have a different typology. When the consistency of a factor stays the same, however, its relative position with respect to other changing factor can still develop. Moving from the 3- to the 4-factor solution therefore most certainly has an influence on the factor consistency and their respective expression of subjectivity.

It is clear that the amount of significant consensus statements decreases when the amount of factors increases. This shows that when creating an extra factor, there is indeed more room for distinguishment, resulting in less consensus between the different factors. Four consensus statements were the same for the 3- and 4-factor solution, showing a strong consensus in favor of the need to invest in WTT, and against the notion that investment in WTT is entirely blocked by farm size or other farming limitations.

Although the 3- and 4-factor solution were found to both give enough distinguishing statements for analysis, it was found that a 4-factor solution was the most interesting fit for the data. Although a ‘perfect fit’, does not exist, the 4-factor solution is able to embrace more variety and subjectivity, while still providing enough information to make a meaningful ontology.

Successfully exploring the ability to create different numbers of factors that represent a certain way of decision-making also showed that different decision-making styles interact with each other and that it is possible to transform from one to the other or share views with multiple styles. Farming participants indicated that they were, or have been, in a transition from subsistence to commercial farming and that this also brought a change in the respective importance of different decision-making variables.

4.2 Predefined grouping

An alternative to automatic *flagging* is to identify certain typologies manually and group farmers manually. This analysis trajectory can be used to illustrate the variance in decision-making between predefined groups of people. A practical way of grouping farmers is to artificially stratify farmers into subsets that are homogenous according to certain background information and farmer definitions. This is for instance often used in policies to make them tangible and implementable.

Factor analysis

The participants in this study can be categorized in smallholder farmer, commercial farmer and expert. In order to group Q-sort participants under these different predetermined factors, we need to define their respective typologies. These are discussed below.

All participants were predetermined to be smallholder farmers, commercial farmers or experts. Even the Q-sorts that showed insignificant loading to their predetermined factor or showed sorting similarities with more than one factor, were labeled to their respective group. The results can be found in Annex 12.

Factor 1 – Smallholder Farmer (SF)

The definition of who and what a SF is, is not as clear cut as it may seem. In order to avoid ambiguity and confusion, it is important to properly describe the definition SF. The terms *"smallholders"*, or small-scale farmers, resource-poor farmers, food-deficit farmers, land-reform beneficiaries and emerging farmers are widely used (DAFF, 2012; Machethe et al., 2004; Botha and Treurnich, 1997; The Farmer Support Services Working Group, 1997; Catling and Saaiman, 1996; Van Zyl et al., 1991; Eicher, 1990; Fanadzo et al. 2010) and the assumption is that there is a common understanding, especially in academic research and development literature, of what this incurs. Definitions, however, are often lacking or inconsistent and vary across different authors (Annex 13). Some have tended to emphasize the lack of land size, others have pointed to the low productivity levels, and yet others have pointed out the limited resource levels of the sector (Annex 13). Too many, however, have neglected to clarify their used definition of a SF at all. The nature of SFS is highly heterogeneous (Machethe et al., 2004), which explains the diversity in the different definitions found in literature. SFs are generally known for practicing indigenous farm knowledge with less farm assets, resources, arable land, labour and a weak developed link to the larger economic system (Fanadzo et al., 2010), yet, the context in which the smallholder finds itself, is determining its definition till a great extent. By context I mean to refer to country, crops that are being grown and the climate (DAFF, 2012).

There are, however, certain criteria that are often used to classify farmers as smallholders or not, namely land size, (purpose of) production, labour resources and income level (Fanadzo et al. 2010; FAO, 2015a). Although this is widely recognized, farm size data is often used to classify farmers in statistics, economic analysis, policies and development programs, because of its relative availability and ease to measure and access (FAO, 2014b). Farm size is considered to explain differences in technical efficiency, land productivity and income and is commonly highlighted as a major influence on decision-making behaviour (Lund & Price, 1998; Katongo, 1986; Lowder et al., 2016; Rose et al., 2018). The most common definition (FAO, 2015a; Thapa, 2009), also used in the World Bank's Rural Development Strategy (World Bank, 2003) therefore defines smallholders as farmers *"with a low asset base and operating in less than 2 hectares of cropland"*. What a small or big farm size is, however, is still relative to its context. Across different countries the distribution of farm sizes depends on a number of agroecological and demographic conditions and economic and technological factors (FAO, 2015b). This context is embraced in the FAO study *"The economic lives of smallholder farmers"* (2015), where SFs are identified using the middle-sized farm threshold. This threshold is determined by ordering farms in different countries from smallest to largest and choosing the farm size at the middle as the threshold to identify smallholders. Using FAO *Smallholder Farmers' Data Portrait* dataset for Malawi from 2011, this median is calculated to be 0.91 hectares (FAO, 2018). Therefore, for this study the following definition is chosen:

Smallholders in Malawi are farmers that manage a maximum farm size of 0.91 hectares, being the weighted median threshold of operated land identified at national level.

Factor 2 – Commercial Farmer (CF)

What a CF defines is less controversial, but is also not without discussion. Also in this case, literature often lacks to explain what is meant by CF (Pereira et al., 2016), but often seems to assume it is the inverse of what is understood to be a SF. Although some stakeholders merely characterize CF as farmers farming mostly for business rather than subsistence (FAO, 2014c), the group is most often illustrated as being modern, efficient and oriented towards profit, market, and high productivity levels. Also they are often portrayed to have sufficient resource levels and to farm on a large piece of land using more advanced technologies (Kirsten & Van Zyl, 1998). By making use of this larger farm size, CFs make use of economies of scale with advantages in terms of finance, technology, and logistics (Eastwood et al., 2010). It is argued that because larger farms are more capital-intensive, it is easier to adopt more expensive advanced technologies (Poulton et al., 2010). Just like in the case of SFs, however, the easy and more tangible determinant of land size is often used to classify a farmer as a CF. With the common definition of SFs farming on land below 2 hectares, CFs are often defined as farming on more than 2 hectares. But since it is acknowledged that farm sizes depend on a number of agroecological, demographic, economic and technological factors, which vary across countries (FAO, 2015b), this study uses the middle-sized farm threshold for Malawi calculated by the FAO. As a result, CFs in Malawi are defined as:

Commercial farmers in Malawi are farmers that manage a farm size larger than 0.91 hectares, being the weighted median threshold of operated land identified at national level.

Factor 3 – Expert (EX)

Agriculture or irrigation experts are often an important source of information for farmers and can have considerable influence on farmer decision-making (Wheeler et al., 2017). In this study EXs are defined as:

Experts are individuals that perform, and are educated to perform, agricultural or irrigation support services.

Factor interpretation

In this analysis 58 of the 58 participants were *labeled* to one of the three predefined factors; smallholder farmer (SF), commercial farmer (CF) or expert (EX). For each factor, a factor matrix, factor visualization and a list of distinguishing statements can be found in Annex 12. Detailed accounts of all three predetermined factors are presented below. These were composed by examining the sorting of statements in relation to the other statements within the factor and by comparing this with the other factors (Table 15). It is the relative positions within the entire sort that describe the factor and not just the individual statements themselves. From the three factors, each of which can be considered as a synthetic representative farmer according to their key sorting behavior, a brief participant typology was created (Table 16).

Predetermined 3-Factor Solution
Factor 1 – Labeled SF
Characteristics: dependent, team player, water volume seeker
The participants in this factor prefer WTTs that are relatively affordable and realize high volumes of water, in order to grow more crops for the market. If this means that a WTT is relatively more expensive to run, this is accepted. External support or advice is hugely appreciated because of lack of knowledge about the technologies or low financial capabilities.
Factor 2 – Labeled CF
Characteristics: individual farmer, cost-effective decision maker
The participants in this factor are looking for an automatic technology that is affordable and labour saving, but also offers low running cost and cheap maintenance. In their decision-making process they pay special attention to the gross margin and cost of production.
Factor 3 – Labeled EX
Characteristics: risk averse, environmentally aware
For the participants in factor 3 it is very important to minimize risk. Therefore they have a strong preference for proven, familiar and understandable technologies. They pay special attention that this technology fits their specific situation and topography.

Table 16 - A brief summary of the three factors

Theme Q statement	Factor scores		
The characteristics of the WTT	SF	CF	EX
Financial aspects and affordability			
1. I prefer paying through installments over time.	1	0	3
2. I want overall affordable costs.	2	3	3
3. I don't mind paying fuel to keep the technology working.	0	-4	-1
4. I am happy with my current pumping method. I don't want to invest.	-1	-2	-2
5. I prefer to wait for someone to give me an irrigation technology.	-2	-2	-1
6. It is too expensive. I don't want to invest.	-3	-3	-3
7. I have other farming limitations. I don't want to invest.	-2	-2	-2
8. I prefer to use and pay for a technology with a group of farmers instead of individually.	2	-1	1
9. I prefer to adopt a more expensive technology but safe on running cost.	-1	3	0
Management			
10. I find easy individual operation important.	1	2	1
11. I find easy maneuverability important.	0	-3	0
12. I find it important that the technology is hard to vandalize or steal.	-1	0	2
Technology characteristics			
13. I want to be able to maintain the technology myself.	2	1	1
14. I want it to be cheap to maintain the technology.	1	4	0
15. I want my irrigation technology to give me a better status in my community.	0	-2	-3
16. I prefer a technology that works automatically without human power.	-2	4	-1
17. I prefer a technology that can give me a high volume of water.	4	2	0
18. I prefer a technology that can give me a high pressure.	2	-1	-2
19. I want the technology to enable me to grow crops that I can sell at the market.	4	1	4
20. I want the technology to enable me to grow crops that I can eat.	3	3	3
21. I prefer a technology that uses water efficiently.	1	2	0
Environment			
22. I don't mind watering the crops myself without the use of a technology.	-3	-3	-4
23. My water availability and water source determine my technology choice.	1	2	4
Characteristics & circumstances of farmer within their (social) environment			
Community			
24. I want support from my community and family.	-2	0	-1
Ownership			
25. I don't own the land on which I farm. I don't want to invest.	-4	-4	-4
26. I can't expand my farm. I don't want to invest.	-4	-1	-3
Agricultural extension services			
27. I prefer a technology that has been advocated by the extension officers.	3	1	2
Company relationship			
28. I need external support after implementation.	3	1	-1
29. I prefer if the company representatives are Malawian.	-3	-1	-2
The process of learning and experience			
Familiarity			
30. I want to hear about the technology before I adopt it.	0	1	1
31. I want to have seen the technology before I adopt it.	-1	-1	2
32. I want to try out the technology before I adopt it.	-1	0	0
33. I want a technology that other farmers have used successfully before I adopt it.	0	0	1
Understandability			
34. I prefer technology that I can understand.	0	0	2

Table 15 - Raw scores of statements for the 4-factor solution.

Factor 1 – Labeled SF

41 Q-sorts participants were labeled to be SFs. The SF participants of factor 1 seem to be heavily influenced by variables involving external support. This support can involve finances and help with farming inputs, but also knowledge about irrigation management, local markets or the different WTT options. The decision-making process for instance is heavily impacted by the advice given by governmental extension officers. Also, statement 29 was often associated with external support from development organizations and the disagreeing sorting behavior of factor 1 can be interpreted as another expression of the request to be supported by external organizations:

27	I prefer a technology that has been advocated by the extension officers.	**3**
28	I need external support after implementation.	**3**
29	I prefer if the company representatives are Malawian.	**-3**

The labeled SFs in factor 1 seem to express a stronger focus on high water volumes and pressure compared to the other factors. Statement 18 was often associated with the use of petrol pumps. From respective sorting of statement 18 and statement 3, we can conclude that the participants in factor 1 have a strong preference for the performance characteristics of the petrol pump technology:

17	I prefer a technology that can give me a high volume of water.	**4**
18	I prefer a technology that can give me a high pressure.	**2**
3	I don't mind paying fuel to keep the technology working.	**0**

From the respective sorting of statements 9 and 16 we can conclude that the labeled SFs attach little value to the characteristics of more expensive and advanced automatic technologies with low running cost:

9	I prefer to adopt a more expensive technology but safe on running cost.	**-1**
16	I prefer a technology that works automatically without human power.	**-2**

Paying and using a technology in a group, however, makes it easier to invest and helps to open a wider range of technology options. The labeled SFs adopting and using technology in a group, however, find group and community status, the extent to which members of a group are respected and admired by others in the community, more important compared to the other factors. Support from the community and family, however, is values the least compared to the other factors:

8	I prefer to use and pay for a technology with a group of farmers instead of individually.	**2**
15	I want my irrigation technology to give me a better status in my community.	**0**
24	I want support from my community and family.	**-2**

The labeled SF participants attach relatively little value to the familiarity and understandability of a technology, continually scoring lowest compared to the other factors for the statements on the right. As long as the WTT satisfies their most important decision-making variables, they are confident enough to adopt:

30	I want to hear about the technology before I adopt it.	**0**
33	I want a technology that other farmers have used successfully before I adopt it.	**0**
34	I prefer technology that I can understand.	**0**
31	I want to have seen the technology before I adopt it.	**-1**
32	I want to try out the technology before I adopt it.	**-1**

Factor 2 – Labeled CF

8 Q-sorts participants were labeled to be CFs. The cost effectiveness of the WTT is something that the participants in factor 2 value relatively much. In financial terms this does not just involve the size of the initial investment, but also the long-term maintenance and running cost of the WTT:

14	I want it to be cheap to maintain the technology.	**4**
9	I prefer to adopt a more expensive technology but safe on running cost.	**3**
21	I prefer a technology that uses water efficiently.	**2**
3	I don't mind paying fuel to keep the technology working.	**-4**

An important variable of the cost-effectiveness of a technology that drives the decision-making of the participants in factor 2 is their ease of use and labour saving ability. The ability of the WTT to work automatically is therefore strongly preferred. Unlike when using watering cans were one has to walk up and down to the water source, these technologies require little human effort or attention when pumping water. This enables the farmers to focus on other activities such as working on the crops or expanding the farm:

10	I find easy individual operation important.	**2**
16	I prefer a technology that works automatically without human power.	**4**

From the respective sorting of statement 8 and 10 we can conclude that the CF prefer individual adoption and use of WTT:

10	I find easy individual operation important.	**2**
8	I prefer to use and pay for a technology with a group of farmers instead of individually.	**-1**

Interestingly, the CF attached relatively low value to the notion of adoption of WTTs that enable them to grow crops that can be sold on the market. This doesn't necessarily mean they don't find this important, rather it shows that other variables are of more importance in their respective decision-making:

19	I want the technology to enable me to grow crops that I can sell at the market.	**1**

Factor 3 – Labeled EX

9 Q-sort participants were labeled to be EXs. The experts express high value to the notion that different physical situations influence the suitability of a WTT, and they are determined to find the best technology fit with theirs:

23	My water availability and water source determine my technology choice.	**4**

Also, the experts in factor 3 attached a lot of value to the notion of paying in installments:

1	I prefer paying through installments over time.	**3**

From respective sorting of the experts we can conclude that the they attach relatively low value to WTT indicators:

17	I prefer a technology that can give me a high volume of water.	**0**
21	I prefer a technology that uses water efficiently.	**0**
18	I prefer a technology that can give me a high pressure.	**-2**

The sorting behavior of the experts in factor 3 also shows that they attach significantly more value to avoiding risks, when choosing WTT for irrigation. This is expressed in the relatively high valued importance of familiarity and understandability, but also in the preference for technologies that are hard to vandalize or steal:

12	I find it important that the technology is hard to vandalize or steal.	**2**
34	I prefer technology that I can understand.	**2**
31	I want to have seen the technology before I adopt it.	**2**
30	I want to hear about the technology before I adopt it.	**1**
32	I want to try out the technology before I adopt it.	**0**

Interestingly, the experts attached relatively little value to the notion of support after implementation relative to the other factors:

28	I need external support after implementation.	**-1**

Consensus

Besides statements that distinguished the three factors, there are also statements that participants agree on. This happens when similar sorting of some statements, which in the Q-methodology is called *consensus*, appears. It means that there is no significant difference between the factors. In the midst of all the subjectivity between participants, it can be especially interesting to discover statements that people have agreement on. The consensus statements are colored green in the factor visualizations (Annex 12).

Out of all statements in the predetermined 3-factor solution there were 8 out of 34 statements which were sorted significantly similar by all participants (Table 17). There was a strong consensus in favor of the need to invest in affordable and easy to maintain WTT, and against the notion that investment in WTT is entirely blocked by farm size or other farming limitations.

Consensus statements		SF	CF	EX
20	I want the technology to enable me to grow crops that I can eat.	**3**	**3**	**3**
2	I want overall affordable costs.	**2**	**3**	**3**
13	I want to be able to maintain the technology myself.	**2**	**1**	**1**
30	I want to hear about the technology before I adopt it.	**0**	**1**	**1**
33	I want a technology that other farmers have used successfully before I adopt it.	**0**	**0**	**1**
4	I am happy with my current pumping method. I don't want to invest.	**-1**	**-2**	**-2**
6	It is too expensive. I don't want to invest.	**-3**	**-3**	**-3**
25	I don't own the land on which I farm. I don't want to invest.	**-4**	**-4**	**-4**

Table 17 - Raw scores of consensus statements for the predetermined 3-factor solution.

4.3 Comparison of the predetermined and automatic 4-factor solution

Comparing the predefined analysis trajectory with the automatic 4-factor solution can give us insight in whether our determined groups definitions actually have similar sorting behavior. In Table 18 below we compare the predetermined labeling with the automatic 4-factor solution:

		Automatic labeling - 4 factor solution					
		Factor 1	Factor 2	Factor 3	Factor 4	Unflagged	**Total**
Predetermined labeling - 3 factors	Labeled SF	10	8	1	11	11	**41**
	Labeled CF	1	3	4	0	0	**8**
	Labeled EX	1	0	4	0	4	**9**
	Total	**12**	**11**	**9**	**11**	**15**	

Table 18 – Overview of the predetermined 3 group labeling and automatic 4-factor solution

When we compare the statistical data of the two analysis trajectories below in Table 19, we find higher Mean Standard Deviation (STD) for the raw factor scores for the predefined grouping compared to the automatic 4-factor solution. We also find higher factor score correlations compared to the automatic 3-factor solution. This indicates that the factors are in fact more similar and as Brown (1996) emphasizes, factors should not be highly correlated because the higher factors are correlated, the fewer distinctions there will be between the different factors known as distinguishing statements. These differences are not surprising, because the PCA method mathematically seeks for the least number of factors which can account for the most amount of variance of the Q-sorts. The comparison, however, illustrates that the predetermined labeling indeed does not embrace the variety as well as the automatic *flagging* alternative.

		Predetermined labeling - 3 factors				**Automatic flagging - 4 factor solution**			
		Factor 1	Factor 2	Factor 3		Factor 1	Factor 2	Factor 3	Factor 4
# Participants defining Factor		41	8	9		12	11	9	11
Mean STD for RAW factor scores		1.73	1.63	1.52		1.53	1.58	1.58	1.53
Factor score correlations	Labeled SF	-	0.60	0.70	Factor 1	-	0.54	0.58	0.61
	Labeled CF	0.60	-	0.65	Factor 2	0.54	-	0.59	0.52
	Labeled EX	0.70	0.65	-	Factor 3	0.58	0.59	-	0.67
					Factor 4	0.61	0.52	0.67	-
Average Factor score correlations				**0.65**					**0.58**

Table 19 – Statistical comparison between the predetermined labeling 3-factor solution and the automatic flagging 4-factor solution.

A similar comparison was made between the predefined analysis trajectory with the automatic 3-factor solution. The results, which can be found in Annex 14, show similar results.

Conclusion & Discussion

Although we can see patterns, it is clear from the results that the predefined groups did not sort the statements in one characteristic way. This in turn means they had different drivers that guide their adoption of WTTs. The group showing the greatest variety in sorting behavior is the SF group. This group of participants automatically *flagged* to all four different factors. This indicates that SFs, all farming on a relatively small farm, base their WTT decision-making on different variables. Some SF participants are actually highly correlated with factor 2 and 3, factors that host the majority of CFs and represent a way of sorting more closely aligned with commercial and independent objectives. The results show that although facing disadvantages, be it because of small farm size, inherited inequalities, economic isolation, lack of access to credit, agricultural inputs, transport, storage, knowledge and markets, some of the SFs most certainly do not only base decision-making on farming for subsistence, like often suggested in literature and policies (Rockstrom, 2000). Some of the labeled SFs who were using relatively less advanced technologies, such as the watering cans or treadle pump, still made decisions based on completely different variables than their other labeled SF counterparts (Example 1). Other SFs were using more advanced technologies. Some invested individually or as a group to acquire these WTTs (Example 2). Others were supported by development initiatives to acquire WTTs. While the lack of access to formal bigger markets was clearly an issue, many SFs sold their cultivated cash crops to informal and seasonal local markets. In many cases the smallholders would transport their yield to local market or sell at the farm gate. Whereas literature and policies illustrate that SFs need heavy external support and are otherwise stagnant and destined to decline (Collier & Dercon, 2014), this analysis shows that some SFs are willing and able to make substantial investments in WTTs for irrigated agriculture, and make these decisions based on a wide spectrum of variables. Although possibly facing other constraints in their ability to undertake more profitable farming activities in the agricultural sector, the lack of land does not have to be the governing variable in their decision-making process.

Example 1

Farmer 5 (Annex 7 - Q-sort 5) – factor 2

Farmer 5 is the chairman of the Kachere Cooperative in Rumphi. The 300 members of the Kachere Cooperative farm on around 35 hectares. The irrigation scheme was started in 2003, because the community was receiving low amounts of rains per year. Between 2007 – 2010 they were supported by a German development initiative, which helped to establish an gravity irrigation scheme.

Because the rising interest in irrigation, the cooperative decided to purchase 2 Barsha pumps. Motorized pumps were considered to be expensive in the long run, whereas the Barsha pump can be bought for once and for all.

Example 2

Farmer 50 (Annex 7 - Q-sort 50) – factor 2

Farmer 50 farms on 1 acre of land. She is therefore labeled a SF. She has, however, been able to purchase a petrol pump, which she uses to irrigate her land, were she grows a wide variety of crops. She has constructed a subsurface piping system to do so.

Also the predefined CFs loaded on different factors. Interestingly none of the labeled CFs loaded on factor 4, and only 1 on factor 1, the two factors with most of the SFs. The CFs, however, dispersed evenly over factor 2 and 3. This illustrates that indeed most CFs make technology adoption decisions based on other variables than most SFs. Where CFs, however, are often also portrayed as one homogeneous group being very market and growth orientated, this analysis shows that CFs can have significant differences in the variables influencing decision-making. Factor 2 is guided mostly by the cost-effectiveness and the labour saving ability of the technology, whereas the CFs in factor 3 are mostly driven by understandability, risk aversion, environment and topography. When studying the background information of the CFs in factor 2 and 3, we find that most of the CFs in factor 3 have been well educated, have other sources of income besides farming and have employees that work on the farm. These could be explanatory variables that could help us understand why the respective sorting of CFs in factor 3 is more dependent on other variables such as long-term sustainability. CFs in factor 2 on the other hand seem to be more financially limited and focused on profit maximization. This could also explain why more SFs loaded on factor 2 compared to factor 3. In this research, however, extensive studying of the participant background variables was beyond the scope.

Interestingly, in the predefined group of which one might also expect consistent sorting behavior, the experts educated to perform support services, almost half of the expert participants ended up in the unflagged group of participants. This means they loaded insignificantly on one single factor or shared significant sorting behaviors with multiple factors. When studying the factor matrix in Annex 12, we can conclude it is mostly the latter reason. The other half of the expert participants mostly loaded on factor 3; a factor characterized by risk-averse behavior and with strong preference for proven, familiar and understandable technologies that fit well in their respective environment.

5 Discussion & Conclusion

5.1 Discussion

The findings of this study suggest that the decision-making variables surrounding the adoption of WTTs in Malawi is highly diverse. With the help of Q-methodology, four participant types, driven by different distinguishing variables, were identified. Successfully exploring the ability to create factors, using different factor-solutions that represent a certain way of decision-making, also showed that different decision-making styles interact with each other and that it is possible to be transformed from one to the other or share views with multiple styles in the analysis.

Besides unraveling decision-making typologies in irrigated farming in Malawi, the study also drew a comparison between the groups identified with the help of the Q-methodology and artificial predetermined subgroups that are homogenous according to certain background information. Through this analysis it has become clear that the sorting behavior of farmers is highly contextualized and cannot be pinpointed purely by looking at farm size. The results indicate that farm size might have an influence, but that it is not the only explanatory variable to explain farmer's decision-making. While in literature farm size is often highlighted as the most important smallholder farmer characteristic, it is clear that this variable does not seem to address the heterogeneity that characterizes farmers in Malawi. The FAO itself encourages this single-variable perception by developing a systematic and standardized dataset on the profile of smallholder farmers, the *Smallholder Farmers' Data Portrait* (FAO, 2018), and defines a smallholder as a household that manages a farm size below a certain threshold. This perception and definition of smallholder farming, however, can be seen as dated. As can be concluded from my results, the definition of what a smallholder is goes far beyond farming size, and if one compresses the meaning of a farmer down into one word that stands for multiple characteristics, what characteristics are included in a particular user-case becomes very important. Especially when these definitions take center stage in the formation of policies, technologies and development projects. It clear that when using this definition, one can be a labelled 'smallholder farmer' and yet have similar decision-making patterns as a labelled 'commercial farmer' or an 'expert'. Being a smallholder does not necessarily mean that one is only providing for household food security. Smallholders can and have developed themselves, with or without external support, to be competitive in the (local) market. They do not necessarily need to be poor farmers who are waiting for handouts. Among the participating farmers there are many cases in which smallholders or smallholder cooperatives have formed themselves to create large and meaningful entities for the local market and are competitive with commercial farmers. The term smallholder can therefore be misleading, as it almost labels itself as insignificant. As can be seen in Malawi, smallholder farmers can have enormous impact on the agricultural production of an area. It is therefore important to realize that they can also be seen and valued as being the nursery from which successful commercial farmers can develop (Aliber & Hall, 2012).

Hence, the definition of 'smallholder farmer' used in policy should be expanded beyond the strict focus on farm size to reflect the idea that they are not a homogeneous group, but rather a diverse set of farmers with varying characteristics. As other studies suggest, there could be alternative underpinning reasons for differences in decision-making (Pannell et al., 2006; Doss et al., 2014; Doss and Meinzen-Dick, 2015; Mutenje et al., 2016; Matshe and Young, 2004; Wheeler et al., 2017). As Winnie Byanyima for instance pointed out in her speech for the IFAD Governing Council in 2015, women often hold completely different investment priorities than men. They often value time saving technologies, while men are more likely to value technologies that increase productivity. While no clear reason to suggest this can be found in the gender distribution of the 3-factor solution, the gender distribution in the 4-factor solution shows that indeed the normalized female percentage in factor 2, the factor characterizing cost-effective and labour saving technologies, is higher compared to that of males. Males on the other hand load considerably more on factor 3, characterized by independent and risk averse decision-making. While this research is not focused on the impact of gender aspects on farmer decision-making in Malawi, we should not assume that men and women have the same technology preferences. The results indeed suggest there is an influence of the different investment priorities between men and women, which is aligned with research such as "G*ender aspects of small-scale private irrigation in Africa"* (van Koppen et al., 2013). Understanding the exact variables that distinguish decision-making for different genders could be very worthwhile to study in future Q-research. Extensive studying of further participant background variables was beyond the scope of this research. It could be a valuable addition for further research to explore underpinning reasons, other than land size, why certain farmers sorted differently than others. Explanatory background variables could be characteristics such as household composition, age, education level, experience, alternative sources of income and labour resources..

The results also show that when performing the Q-sorting analysis using predefined grouping, one can be tempted to fall back into certain prejudices; a traditional way of thinking in which certain characteristics are forced upon an individual or group. Choosing this analysis trajectory in essence destroys the goal of the Q-methodology, namely to consider the gathered data in terms of the participants' whole pattern of responses. Predefined grouping would mean looking for patterns among people, but in the actual case it is the *"people and not tests that are the variables"* (Herrington & Coogan, 2011, p. 24). Imposing a label to a participant therefore denies them to be correlated with persons, or aspects of persons from another group. As mentioned by Herrington & Coogan (2011), the meaning of the factors must be attributed *a posteriori* through interpretation rather than through an *a priori* postulation. By no means are the four Q-sort factors a perfect representation of participants' subjectivity around the adoption of WTTs. The comparison, however, shows that the Q-sort grouping, designed to embrace most of the variance in a given number of factors, shows different sorting patterns compared to traditional, though currently existing, predetermined ways of grouping. The fact that the predefined groups give considerably different typologies compared to the current existing ideas about this group of participants illustrates that we need to be careful with how we (pre)define people. Where literature and policies for instance illustrate that smallholder farmers in Malawi need heavy external support and are otherwise stagnant and destined to decline (Collier & Dercon, 2014), the results show there were actually many smallholder individuals or cooperatives that have been able to make the leap from subsistence to commercial farming, or at least commercial decision-making, and have been able to make substantial investments in productive assets in agriculture. These individual or collective initiatives show motivation and willingness to outgrow a smallholder's current situation.

This suggest that farmer technology decision-making is part of a social dynamic system that is influenced by many variables. This in itself is in contrast with the traditional thinking of straight-lined technological transfer from governments, development organizations and technology sellers, that was, and often still is, apparent in developing countries and also in Malawi. While other possible variables of influence to the decision-making process such as uncertainty, capital, (running) cost, performance, and so on, are abundantly discussed and recognized in literature, they are rarely translated into policies.

First understanding and afterwards alleviating the specific constraints in which the farmers work can have much longer benefits compared to implementing and promoting blanket, 'universal' strategies and technologies. Instead of a convenient standardized one-size-fits-all imposing approach in which we believe we know what farmers need and want, we need to transition to an approach based on the actual farmer reality. It is time for governments, organizations, technology developers and the research community to adapt their investments, innovations, technologies and policies to the different farmer types that are found in their working areas. Together they should help different farmer groups remove obstacles in the way of technology adoption, such as assisting them to manage or avoid risk or increase adoption opportunities through different kinds of financial structures. Adapting these measures to each country's context and respective farmers, can play a critical but varying role in bringing down barriers for farmers to efficiently uptake WTT for irrigation. This idea is described by Garb and Friedlander (2014) who argued that we should replace the metaphor 'technology transfer', often used in policies and development programs, with 'technology translation'.

Although this research focused more on decision-making rather than farming styles in general, some of the fundamental features of the different decision-making styles revealed in this study show resemblance with farming styles identified in other Q studies performed in different parts of the world. Where, however, many other studies have named their respective factors (Table 20) according to their respective key characteristics (Brodt et al., 2006; Fairweather & Keating, 1994; Burton & Wilson, 2006; Pereira et al., 2016; Walter, 1997), this research has deliberately not given the factors a name. As discussed above, a lot of complexities are reflected in the formed participants types themselves and these should therefore be interpreted with caution. Interpretation of the participants types is performed by the researcher and requires analytical skills. The interpretation might therefore be distorted by bias, affecting the validity and reliability of findings. To avoid such occurrences, the factors were purposely not given a name to acknowledge their multidimensional characters. It is believed that this multidimensional character, inherent to the concourse and the resulting statements, should not be summarized into one orientation.

The described orientation of *Production Maximiser* (Brodt et al., 2006), *Agricultural Producer* (Burton & Wilson, 2006), *Dedicated Producer* (Fairweather & Keating, 1994) and *Professional farmer* (Pereira et al., 2016) however, show resemblance with factor 1 identified in this research. These participants attach relatively high value to financial stability and high yields, accepting the environmental consequences of farming. If a decision benefitting agricultural production is relatively more expensive to run, this is accepted.

Brodt et al. (2006)	Burton & Wilson (2006)	Fairweather & Keating (1994)	Pereira et al. (2016)	Walter (1997)
Environmental Steward	Conservationist	Environmentalist	Committed Environmentalist	Stewards
Production Maximiser	Agricultural Producer	Dedicated Producer	Professional farmer	Manager
Networking Entrepreneur	Diversifier	Flexible Strategist	Aspirant Top farmer	Conservative
-	Agribusiness Person	-	Profit Maximiser	Agrarian

Table 20 – Factor names found literature according to their respective key characteristic.

Factor 2 identified in our research shows affinity with the farming styles *Profit Maximiser* (Brodt et al., 2006) and *Agribusiness Person* (Burton & Wilson, 2006). The participants in these styles have profit maximization as a primary objective.

The identified characteristics of factor 3 showed resemblance with the *Conservative* farming style (Walter, 1997). The participants in this farming style have as main goal the long-term preservation of their farm business and hence, show signs of risk averse decision-making behavior.

Despite some similar characteristics with the farmer types discussed in other studies, differences were also found. None of factors in this research had considerable resemblance with the *Environmental Steward* (Brodt et al., 2006), *Environmentalist* (Fairweather & Keating, 1994), *Committed Environmentalist* (Pereira et al., 2016) and *Conservationist* (Burton & Wilson, 2006). Where participants in these identified farming styles placed higher value on environmental protection than on productivity and production, and were willing to sacrifice income to be more environmentally friendly, this was hardly visible in our identified factors. WTTs using RE were often preferred because of their low operational cost, rather than their environmentally friendly characteristics. A possible explanation for this could be that compared to the countries where the abovementioned research took place, the concept of environmental protection in Malawi might be relatively less familiar or unattractive (Younis, 2015). In Malawi, immediate needs might outweigh the delayed environmental and financial benefits of WTTs using RE.

Factor 4 identified in this research was found to have some resemblance with the farming style *Agrarian* (Walter, 1997), which values the rural life style and community participation, but no resemblance with the other farming styles below. The participants attached high value to external help, cooperative payments and ease of use, a characteristic unidentified in other research. A possible reason for this could be that the participants in this factor were often resource constraint to a much larger extent than the farmers in the other studies.

The abovementioned comparisons suggest that although studies are performed in different countries with completely different context, decision-making can be driven by similar goals and values.

Despite any restrictions in this Q-study and the methodological limitations of Q-methodology for extrapolation however, our findings also reinforce other studies that identified different farmer types within what might, in other contexts, be considered relatively homogeneous groups (Brodt et al., 2006; Pereira et al., 2016; Vander Vennet et al., 2016).

Limitations of the findings

A key strength of the Q-methodology is that it captures the subjective decision-making behavior of the participant and that this is achieved independently of any researcher judgement. As discussed and illustrated, the trade-off between explained variance and a representative typology, however, is a process of selection and choosing a certain factor solution can considerably influence the resulting participant typologies. By no means therefore, are the resulting Q-sort factors in this study a perfect representation of the participant subjectivity around the adoption of WTTs in Malawi. There are many alternative ways of analysis, of which many can be found in the Annex (9, 10, 11, 12), but the presented comparison shows that the automatic Q-sort grouping gives different sorting patterns and resulting typologies compared to predetermined traditional ways of grouping.

In this study certain aspects that underlie the ability of Q to embrace decision-making subjectivity could have been compromised. Other Q studies, for instance, have used larger Q-sets (Dziopa and Ahern, 2009; Ellis et al., 2007; Leggette & Redwine, 2016; Pereira et al., 2016) ranging up to 140 statements. Yet again other studies have used as few as 18 statements (Taylor et al., 1994). One of the founders of Q suggested that the main goal in selecting the Q-sort statements is to provide a representative cross-section that, as good as possible, reflects the larger process being modelled (Brown, 1993). What actually is *"a representative cross-section",* however, if possible at all, remains up to the researcher. What is for certain, is that a constraint is put on the participant in terms of the statements provided. As

argued by Fairweather & Klonsy (2009, p. 192) however, *"all research brings some frame to the enquiry even if it is completely quantitative"*, but in this study extensive time and resources were spend on developing the Q-set to be as representative as possible. Even still, it is likely that certain decision-making variables of influence were missed or not adequately represented. To test this and to gain further insight into drivers of WTT adoption, therefore, other statements should be incorporated in future research. For this study it still holds that once the Q-set statements were prepared, the researcher had no active influence on how they were sorted.

The statements themselves, as part of the Q-set, are all individual means to help organize the diversity of the participants. The designer of the statements, the researcher, has formulated the statements with a certain idea and interpretation in mind, but the actual judge or evaluator of the statements is the participant. Flaws in the statement formulation or translation might therefore have influenced the interpretation and consequently the sorting of a respective statement. This is especially difficult in Malawi, where the local language of Chichewa is a language in which the context of words and sentences are of great importance. Single words can have multiple meanings depending on the context they are placed in. A Q-sort participant may therefore have interpreted a statement in a certain way, where another participant interpreted it differently. An example of this issue was statement 29, *"I prefer if the company representatives are Malawian"*. This statement was imagined to test whether participants preferred technologies or companies that are located in Malawi compared to from other countries. The statement, however, was often associated with external support from development organizations. Fortunately this was recognized for this specific statement, but a misinterpretation might have occurred for other statements as well. Although this imperfect situation, it is believed that the interpretation of the statements has not greatly influenced the result of this research. It is, however, advised to double check statement interpretation in future research. Improved formulation, and hence the anticipated interpretation, could have given a fuller explanation of the generated factors.

Some statements, being the consensus statements, were mostly sorted in a particular way, independent of the chosen factor solution and resulting factors. Although this being interesting in its own right, it may also reflect limitations of the chosen statement or statement formulation.

The sample size of this study is within the suggested range by Brown (1980) and Simons (2013), and is actually larger compared to many other Q-studies (Ellis et al., 2007; Leggette & Redwine, 2016; Pereira et al., 2016). Especially in the comparison between the smallholder farmers, commercial farmers and experts, however, the commercial farmers and experts were relatively underrepresented compared to the smallholder participants. A larger set of commercial farmer and expert participants might therefore improve the representativeness of their respective factors. Identifying and working with large sample sizes, however, can be expensive and time consuming.

Also external factors can have influenced the sorting behavior of participants. Although explicitly mentioning I am a student and explaining the purpose of my visit, some farmers might have identified my presence in the field with potential donor assistance, and this, undoubtedly, influenced their sorting behavior. Farmers might have adjusted their sorting to ways of which they think is acceptable to avoid criticism. During most of the field visits also a governmental irrigation extension officer was present which might have also increased the likelihood of high sorting of support and extension service variables. This may have limited the ability to capture and represent all subjectivity.

All these complexities are reflected in the formed participants types themselves, which should therefore be interpreted with caution. Interpretation of the participants types is performed by the researcher and requires analytical skills. The interpretation might therefore be distorted by bias, affecting the validity and reliability of findings. To avoid such occurrences, the factors were purposely not given a name, so often done in other research (Brodt et al., 2006; Fairweather & Keating, 1994; Burton & Wilson, 2006; Pereira et al., 2016), to acknowledge their multidimensional characters. Further potential pre-existing assumptions were kept at bay by continuous re-evaluation, analysis of the data in many different possible ways (Annex 9, 10, 11, 12) and by interpretation checking of an independent person several times during the study.

Finally, this study is representative for Malawi but cannot be extrapolated to other countries in the region, let alone the world. In order to draw more widespread conclusion the study should be reproduced in other neighboring countries. It must be noted that willingness to conduct the Q-sort exercise was high in Malawi. This might not necessarily be the case in other countries.

5.2 Conclusion

The results of this study show that there is considerable diversity in the decision-making variables driving WTT adoption in Malawi, as shown by the four synthesized participant types identified in this study using Q-methodology. Furthermore, it shows the notion of farming is not rooted in the variable of land size, that is so dominant in policy formation. In fact the results show that land size could be considered a poor measure to predict farmer decision-making and that the relationship between farm size and decision-making is more complex than what is traditionally believed. The often perceived homogenous groups of smallholders, commercial farmers and experts actually showed variety in their respective decision-making variables around the adoption of WTT. Therefore, if one compresses the meaning of a farmer down into one word that stands for multiple characteristics, what characteristics are included becomes very important. Especially when these definitions take center stage in policies, technologies and development projects.

5.3 Implications

The results of this study also imply a need and opportunity to rethink the fundamental approach of development programs and technology sellers encouraging adoption of WTT. The results reinforce the necessity of a change in paradigm that emphasizes on technology itself, to one that emphasizes on the different beneficiaries and their preferred behaviors. Improving technology adoption is not only about overcoming technical problems, it is also about looking at the social design of ensuring that technologies become part of a long-term, rather than a short-term, success story. It follows that in order to be truly successful, policy makers, technology developers, development programs and research seeking to sustainably encourage WTT adoption must take into account the opportunities and constraints identified across locally generated farm types and tailor their policies, technologies, product-service systems and development strategies accordingly. Therefore, in this final section, the implications of this research for policy design and technology development and adoption are discussed. It is recognized that it is challenging, if not impossible, to fully capture the diversity and heterogeneity of farming systems. Standardization is, therefore, unavoidable and beneficial, reducing confusion and increasing simplification, unification, coordination and optimization. It helps to create a common international language and guides aid initiatives. This, however, does not mean that standardization is not a process of evolution. It should be possible to design standardization, policy and technology in relation to type-specific farm characteristics (Kuivanen et al., 2016). The Q-methodology was effective in capturing the diverse decision-making variables amongst the participants and with this newly generated appreciation for the heterogeneity of farmers comes an understanding that technologies, policies and programmes should move away from the traditional one-size-fits-all approaches to more targeted, tailor-made approaches that are more likely to facilitate the sustainable and efficient uptake of WTTs.

Policy design

Often, policy does not address the heterogeneity that characterizes farmers (FAO, 2014b), and a stronger focus on unravelling this heterogeneity is necessary to effectively support and encourage the uptake of WTT by farmers. As we have seen, a Q-study provides an opportunity to start understanding farmer decision-making. It can act as an useful policy tool to start understanding the perspectives of different groups of farmers and to get a grip on the drivers behind technology adoptions, ultimately feeding policy discussions and creation to support water management resource structures. A number of key (and often interlinked) interventions that can help to do this are discussed below:

Develop policies that acknowledge different farm-types

It is clear that politics, policies, development donors, NGO's and even the academic world discussed have an important role to play in the farmer development process. The effectiveness of policies that have tried to encourage effective WTT uptake and promote development projects have often disappointed. A possible contributing element to this could be the mismatch between policies, and hence project strategies, and farmer realities. Even though, especially local, professionals have a good understanding of farmer dynamics, realities and needs, this understanding does not translate into matched policies, development strategies, programs and projects from both governments and development agencies. Policy making stakeholders have to develop effective and transparent policy arrangements to guide contextualized and sustainable technology information spreading so that farmers and development organizations can make informed and contextually relevant decisions about these technologies. Organizations influencing policy making, such as the FAO and the World Bank, have to recognize that they have a major responsibility in policy development. When they themselves acknowledge and stress the huge variety among farmers, also producing documentation where the notion of what a farmer is compressed into one word that stands for only one of the characteristics of influence is

hugely contradictory. In fact, producing inconsistent documentation about this topic discourages the change towards more representative policy guidelines.

Also local experts, with great local understanding, NGO's and the academic world could gain from integrating broader concerns into their work. As argued in van Vuren et al. (2009, p. 165) it is important that these professionals "*stick their necks out and organize responsible and respectful interactions, see opportunities, arrange connections, and simultaneously reinterpret their own routines".* Collectively they can have great influence on the dominant policy narrative and therefore irrigation technology implementations.

Improve technology familiarization through extension services

From this study, an important finding is that many farmers who are interested in adopting WTT need information about the advantages and disadvantages of different available technology options. Although governmental extension services already play an important role in this process, informing and demonstrating technology to farmers in Malawi is falling short. There is too little focus on, or resources for, familiarizing farmers with the wide range of technology options and their respective characteristics, but rather on presenting one single technology that is perceived the best. It must be noted that providing this wide range of technology options is difficult. Often technology is not available for the extension officer to demonstrate (Annex 3 – Interview 3). If anything, governmental extension officers can only demonstrate technology if within their respective district there's a farmer who has that technology and is willing to share his experiences. Even then, this provides information about only a single technology instead of presenting a range of options. Improving irrigation extension and advisory services so that irrigators are familiarized with an appropriate and accessible range of technologies therefore is important and policy-makers have direct influence on the characteristics of advisory and informing extension services since they are publicly financed. To enhance technology adaption, policies can promote training and other education schemes tailored to the technical needs and goals of farmers. These trainings must be backed by national research on farmer typologies and executed by extension systems.

Encourage public-private-partnerships

Also, the governmental extension services can be enhanced by establishing partnerships with WTT developers and sellers in the private sector. When joining forces, the necessary capacity is available to successfully carry out practical farmers training and demonstration programmes. However, without support from extension services, it is difficult for WTT sellers to reach or organize the farmers, provide the WTT and the basic education needed to enable the farmers to make an informed choice. Therefore, an incentive to work together with governmental extension services must be established. At the same time, this can build capacity among policy-planners and governmental extension officers to identify ways of providing technology advisory services that are adopted to the specific conditions of a certain group of farmers.

Generate farmer value chains

Also, as became clear from the interviews (Annex 2), many farmers are dealing with unstable markets and price fluctuations when trying to sell their produce. Linking farmers to (local) agri-food value chains that offer reasonable prices and stable demands could be an important component to relieve further farmer uncertainty. For both policy and technology sellers this is an opportunity, although it is recognized that such coordination mechanisms is difficult and require strong institutional capacity. Other farmer type-specific strategies for technology developers and sellers are discussed below.

Technology developers & sellers

For technology developers and sellers the newly generated appreciation for farmer heterogeneity presents a chance to adapt WTT taking into account the financial, technical or other beneficiary obstacles in the way of technology adoption. When we take a look at the generated factors of the 4-factor solution discussed in Chapter 4.1 we find that the participants in factor 1 attach a lot of value to pump performance, but are less concerned with maintenance or running cost. The participants in factor 2 could be described as *"stepping up"* and are looking for a WTT that fits their development strategy. In terms of targeting this group the opportunities of adopting high-return WTTs for agricultural expansion, saving cost and labour are important. For participants in factor 3, with relatively more resources and greater investment capabilities, other variables than finances play a key role in the adoption of WTTs. These are farm optimization, using long-term sustainable WTTs. Also these participants have a strong preference for proven, familiar and understandable technologies in order to minimize risk. For the participants in factor 4 the cost of adopting new WTT was found to be a major constraint to technology adoption. Focussing on the possibility to adopt technology collectively and with the help

of financial support systems could encourage these participants to mobilize themselves and look at the range of options. In more general terms the section below discusses a number of strategies to target different kinds of farmer groups.

Improve adoption opportunities

The cost of new WTT was found to be a constraint for adoption to most participants. In some cases, farmers do not have the ability to pay off large expenses all at once since most do not have sufficient savings or a stable income. External financial incentives or institutional support systems can facilitate and encourage the uptake of WTTs. These financial instruments can help to make financially unattractive technologies sufficiently attractive for adoption. Paying off technology over time while using it for instance, was mentioned as a big advantage by most financially limited, but also well-endowed, farmers. This financial instrument helps to remove the financial hurdle and improve the short-term expectations related to adoption cost and profitability. Other financial instruments could be pay-per-harvest models, low interest loans and rural leasing, but more research is needed to explore the viability and benefits of these innovative services. If the farmer sees no long-term advantages, the relative advantage of the technology might still be impeded. As also indicated by Pannell et al., (2006), it is important to be realistic about the potential of these financial instruments. When tailoring a technology to a certain group of farmers, the level of incentive required to achieve satisfying adoption can be more than can be justified.

Transparent performance & price information

Also, some farmers are not aware of the performance and cost of all the technology options. In some cases, simply being unaware of the (running and maintenance) costs resulted in farmers excluding a technology in their decision-making (Annex 2 – Interview 13). Easy access to unbiased market price information and financial payment structures manages expectations and makes it easier for farmers to consider adoption. It also provides an opportunity to respond to different farming strategies.

Also, whereas some WTTs are so-called ready-to-go technologies, such as the petrol or treadle pump, others, as stand-alone products, do not reach their potential performance. Respective technological limitations can, however, be overcome in various ways. In the case of the Barsha and solar pump for instance, storage facilities can be of huge advantage to the technology performance. Open and honest communication to farmers can help to manage expectations and increase the sustainability of the technology use.

Improve familiarization strategies

As has become clear, a considerable amount of farmers attached a lot of value on risk in the sorting of their statements. This translated itself in the pronounced sorting of the familiarity and trialability statements. This presents a definite opportunity for technology sellers. Certainly online marketing tools can be used for familiarizing farmers with potential technologies for adoptions, but in the actual reality many farmers learn about technology through fellow farmers or government extension officers. Some groups especially attach a lot of value to the information or advise provided by the extension officer when making technology adoption decisions. Therefore, familiarizing and training government extension officers with new technologies is of great importance. Incentivizing them to organise WTT fairs and farm exchange visits can help to further spread the word and familiarize farmers in the rest of the respective district. Also demonstration days, organised by both technology sellers and government extension services, present farmers with the ability to try a WTT and assess the benefits and drawback of the new technologies. Familiarizing extension officers could also help alleviate the farmer uncertainty as to whether a technology fits and performs in a farmer's respective setting.

The tools mentioned above can considerably reduce the obstacles in the way of technology adoption and offer farmers added incentives to take adopt new technologies. In short, more collabouration among farmers, private institutions, governments, and donors is needed to design and introduce innovative, simple or flexible tools that are adapted to the varying needs and constraints facing farmers. Further work on how WTTs can be tailored and promoted to specific farmer types is needed, but is beyond the scope of this research.

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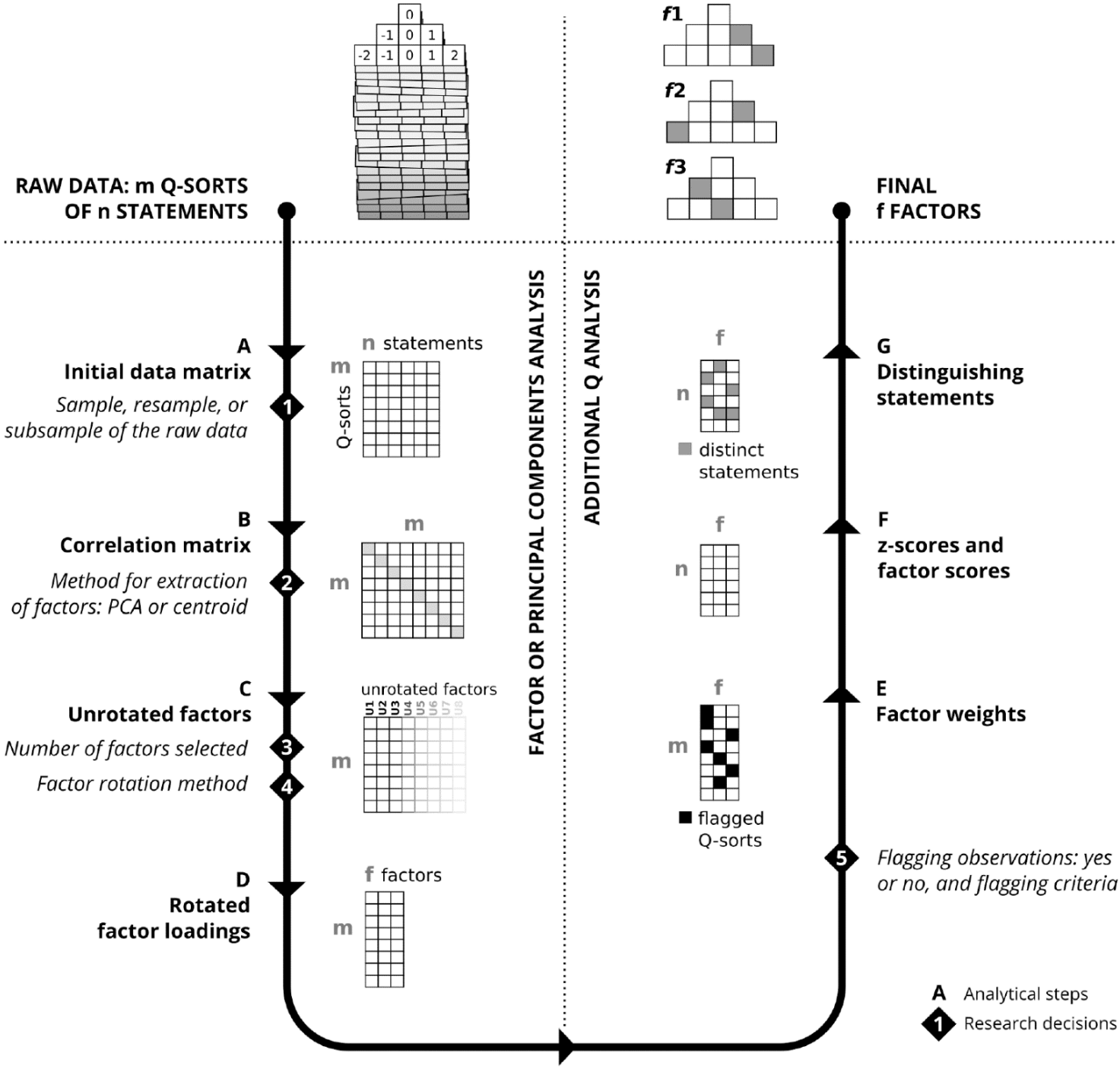
Annex

Annex 1 – Analytical process in Q methodology



Source: Zabala, A., & Pascual, U. (2016). Bootstrapping Q methodology to improve the understanding of human perspectives. *PloS one*, *11*(2), e0148087.

Annex 2 – Farmer interviews

Interview 1 / Farmer 1 / Michiru

10-06-2019

Farmer 1 is one the farmers that was chosen to be a demonstration farmer for the Barsha pump. He is able to use the pump for three months without any charge, after which he will have to pay off the pump. Upon the first visit however, the pump was not in the water because the water was running too low. Because of the close proximity of the farm to the aQysta office in Blantyre, farmer 1 was visited multiple other times. In the second visit the pump was placed and the water redirected in such a way that the pump was functional.

On his farm he is growing several crops like lettuce, sweet peppers, spinach and beetroot. He is also constructing a reservoir that will act as a storage tank for the water pumped up by the Barsha pump and a fish pond.

Farmer 1 himself is a relatively young farmer who upon graduating for his Engineering study, decided to farm on his late father's farm that he inherited.

What I'm here for is to learn about you as a farmer and why you made the decisions to make the farm the way it is. Why do you farm these crops, why have you decided to go for the Barsha pump? Because of course, there are also other options. We know that you are currently implementing the Barsha pump. What were you using before?

I was already doing farming, when I found out about this pump, but then we were watering manually. At one point we were using a treadle pump, but it got broken. Then we turned back to using water cans. Also using the treadle pump was hard work.

Okay so instead of fixing the treadle pump, you decided to go back to manually watering the crops?

Yes true. We had problems with the pipe system of the treadle pump. Look at that pipe over there. This was the one we were using. It has got many holes, so it spilled a lot of water as we were pumping it. We were losing a lot of energy through the spillages. So we just decided lets go back to the watering cans.

When was this?

That was last year. We have been doing this for some time now.

Okay so the treadle pump wasn't working and you said: lets go back to the bucket irrigation. And then you heard of the Barsha pump. What made you say, okay lets try this?

Okay, I saw it first on Facebook. I contacted the guys and left my contacts there.

And then you found out their office is just down the road?

Yes I found out they are just around. I figured out this pump was an environmentally friendly one and it was a cost cutting measure. There wasn't much it used for me. You just buy it. After you install, you don't need fuel. Once it is working, it is working. So that is what I figured out. I looked into those things and figured out this is a good invention. This one is good. And considering the environmental friendliness, there was no noise pollution or anything, I figured I am going for this one.

So I went and had talks with these guys and they offered me to use this site as a demo first. I can be using it for three months, after that I can start paying off.

You mentioned several things about the Barsha pump. The first thing you said was that you liked it because it was environmentally friendly. Why is that important to you?

Me as a farmer, we are getting affected a lot by these global warming things. You find out the time that we are expecting the weather to be different, because of the global warming, you find something else comes up. So you had seeded the ground to make it already growing, but then the weather changes around. Some of the effects of those things are air pollution and everything. Putting that into consideration I figured out that if I get some other means of pumping this water into the garden I will still be contributing to the problems that I am already facing. On my own, I figured I could turn these things around. I should do something at least to turn this thing around. To ease the pollution at least. So I saw the Barsha pump and figured out that one was good enough.

Okay. Chimoso (aQysta team) already told me you have studied and are educated very well. How do you think that other farmers that received less education message, maybe just primary school or high school, think about the environment? Do they also think like that?

The other farmers don't quite understand the effects of global warming. They think it is just natural. But given the fact that they could get this pump and then it is working cost free, no cost for it to operate, I think that is the good idea that could motivate them to go look for it. The other farmers that did not get much education, they will understand from that point that they don't have to pay running costs. Nobody wants to pay bills. When they get something that is working for free, that could be a good motivating factor for the other farmers.

Okay. Because for this one you must pay it off over a given amount of time. How does that normally work with the alternatives? The treadle pump, motorized pump etc? Can you also buy and pay off later options?
No the other pumps you buy right away. There are no alternatives for buying like that. There are shops that are selling these things. They are doing it commercially. I don't believe there is any that would let you get it and then pay later. I don't believe there is anything like that out there.

So that must make it difficult for other farmers… if you have to pay everything directly it is a big investment. You have said that now you are using the Barsha pump, before that you used the water buckets and before that you used the treadle pump. Have you used anything else? Maybe your late father before you took over? What was he using?
My late father never did much about the horticulture stuff but he was focussed mostly on livestock. He had 22 cows I think. I just inherited the land. When I came here, everything was so dilapidated..

We already mentioned a few, but some farmers are not very familiar with the Barsha pump or other technologies. Which technologies are you aware of? Which options do you have? We have already mentioned buckets, treadle pump, the Barsha pump.
Other options around here. Most farmers will buy the treadle, diesel or petrol pump. Most farmers prefer those ones.

And why is that?
I don't know. Maybe they find it a bit cheaper. They buy a motorized pump at 130, 150, 200, 250 (thousand) MWK. And then they go to work. But I don't think they have done their mathematical calculations very good. You get those pumps, you keep on paying. Petrol, diesel, maintenance. You are still paying. But the one I came across to be more reliable and affordable somehow, maybe next to the Barsha pump, is the solar pump. Those ones too have a price that is a bit higher.

Higher than the Barsha or the diesel?
It depends on the system. On a general basis, the solar water pumps are a bit higher than the diesel, petrol and treadle pump. The Barsha is a bit higher compared to the solar. But sometimes the solar system will get a bit higher than the Barsha pump. It depends on the solar system. The other one that is a bit viable, in my opinion, is the solar system. One disadvantage however, is that it gets less affective during the seasons. But yes, with a power bank and everything, I think that one could go to work better.

The Barsha pump is quite easy to understand. When it turns, it works. But for solar, if something breaks down, it is difficult. You might have to replace expensive parts or get an expensive technician. How do you think that plays a role? Is a big drawback for you that is more difficult to understand, replace and repair?
No. I tell you if I had the water system and my working really good, I would never go for a solar pump or anything else. I would take the Barsha pump. This was the ideal pump out of all pumps I came across. I figured out this one was ideal. You know this one, the last time we were filling the pond (water reservoir), it worked overnight. It goes on and on and on. I went on for 8 hours and there were no losses whatsoever. It was just working like that. So I figured out, this one is good. It is has nothing, no weather effect. Even on a cloudy day like this one. As long as the river is flowing, this pump is still going to work. I will still go for the Barsha pump instead of another pump.

No, you also mentioned the running costs of the other pumps. This one (Barsha pump) has no running cost whatsoever. I wonder if maybe you can answer this question according to your opinion first and then explain what other farmers might think. I have heard that buying a petrol, diesel, solar or Barsha pump might also give you a certain status. Or it looks cool or something like that. How do you think this influences the choice of choosing the one or the other? Or does it have no influence at all?
Can you come again?

Farmers obviously choose what is practical for them, and what maybe is affordable for them. But maybe one of the things is also that they try to impress people or they try to show how cool this Barsha pump looks or look I have a solar system. You think this plays a role? Or not at all?
Not really to me. To me not that much. All I am looking for is to get a pump to transport water from the river to the garden. I am not trying to impress anyone. In my case, I don't think that is a big deal.

And to others?
Yeah some others might think like that. Especially when you go to the rural areas. For some one that has been using bucket irrigation, then all of a sudden they get a pump. It is like they get the hype from the community. They will use the pump sometimes to improve their status in the community. Yes I would say so. And if you are looking for that, and you have this Barsha pump, you are a genius around the community. I can tell you how genius I was. People were passing by. I am the first one to use it around here. When they saw it they were like: waauw, what is that? I said it is a pump and they would ask: How does it work? Everyone was curious to know. And since a lot people around here know that I am a farmer, I am the only guy that does farming around here, people have come from all over, just to watch the pump.

So it can play a role? But maybe not such a big role.

Yeah.

I was wondering. Some of the farmers get visits from the extension officers, from the government people. They might also say: I think you should adopt this one, a diesel pump or a treadle pump. To what extent do they give advice on what technology you should pick?
I have hardly had an extension worker come around here. I have had on guy that came to examine my cows. Because first I had a lot of cows and I sold some to buy the iron sheets for my house. So there was this extension worker that used to come here to examine my cows. He had nothing to do with horticulture or anything. He only had interest into livestock. So I have never had an extension officers come around here to talk about farming. Most of the things I know I have found on the internet.

And how do you think that is in the more rural areas? The more rural farmer that won't have internet? Do you think they value to advise of these extension officers a lot?
Yes I think so. Those guys they will use the advice from the extension workers. Those are the ones that they depend on. When you go to the rural village and you tell them I am an extension worker, they will all want to listen to you.

So if these guys say: maybe not use the Barsha pump. Use something else. Farmers will listen?
If an extension guy will go there and recommend something to them, they will definitely follow that up. Because most of these guys are not educated. They have less education. Not no education per se, but less education. Most of them don't know how things work. So they want someone who is already knowledgeable on the thing. If that person comes with some advice they will definitely take it. That is why sometimes these villagers are misled by these extension officers. They come around and say don't do this or don't do that. Then when they don't do the things, they get wrong outcomes.

Looking on the internet, or looking on Facebook, and maybe not in your case but other farmers listening to extension officers…do you take advise from any other person or party? Some farmers say they listen to the radio for advice. What else is there to make informed decisions?
Sometimes I get advice from the local people. There are people that have done these things. They haven't been educated, but they know how these things work. So lets say I am growing a new seedling that is not common around here. Like the other time, I grew some Irish potatoes. I had no experience on how to grow Irish potatoes so I just found a few guys that have done that in their villages. They said no, do this, do that. But sometimes not all of the advice works. So what I do sometimes is before I grow something, I Google and get a book on how to grow it. See here (farmer 1 shows phone): bean production, cucumbers, production guidelines for cows, lettuce production, sweet peppers. Mostly this is where I get my information from. Onion seeds, small-scale popular farming, fish farming. Mostly this is where I get my information.

Many other farmers of course can't get this information.
For someone else in the rural village, it will be possible to get this much information. They will have a farm like this one, but they won't know how to use it.

You were already mentioning it when we walked around your farm: "there are unstable markets. I have chosen to do a little bit of everything". When there is no irrigation, you just depend on the rain. How does an irrigation pump like this Barsha pump influence what you grow? If you would not have a pump, would you do something different? Would you choose different crops?
Yes I would choose different crops, but basically I would do it on a very small scale. The energy of dragging the water from the river to the site. If I extent (the cultivated land) to what I have done here, that would require a lot of energy to take the water up here. So I was doing that (expanding the cultivated area) in mind that with this pump it will pump the water for a long distance. Having a pump would influence much. It influences much, because you can grow limitlessly since you know you won't be using the energy. The pump will do it on your behalf. Having a pump does influence that.

And motorized pump, treadle pump or Barsha pump all have different performance. The Barsha pump might pump less, but can pump the whole day, 24 hours. How do you think the performance of the pump; how does it pump, when does it pump, how fast does it pump and how much does it pump; does that have a big influence on your decision? Or on another farmer's decision?
That would have an influence. This Barsha pump, it pumps the whole day and every time. But sometime you want water in different sections of the farm. All those sections have to be watered. Maybe before the sun goes up, or maybe before the sun goes down; you want water over quite a huge area. And with the pace that this Barsha pump gives water, depends on the river flow. Sometimes it would be slow. Like here, I would say it somehow slow. Depending on those instances you find that some farmers say: let's just get a diesel pump or petrol pump, because that one pumps faster. As for someone that is sure of what they want, they will have to weigh their decisions. This one will be faster, but more costly than this one. That is why I said: next to this I would opt for a solar pump maybe, because I am not just looking at the pace with which I am pumping the water, I also look at the amount, the cost, that I am putting in. I am looking for something that needs little input, but gives much outcome.

And you said something very important I think. Maybe you have got lots of information sources with which you can say this is best for me. Best for me on the long-term. But some people just choose what they know. Like maybe a diesel or petrol pump. Do you think that is true? Or do you think most people think hard and consider the other options?
No. Basically most people make their decision influenced by other people. They will never do their own thinking. Do will just look at someone else and see: hey that pump is pumping and this guy is growing that area. That is when they will also get that one. They will never think: okay this one (farmer) has a petrol pump. How is he financing it to keep it running? Or how much is it taking him to grow a season? For instance a lettuce season is 60 days. No one is doing the math to calculate how much petrol they need for 60 days. They won't do that count. And even if they did. The less studied, the one seed farmer will say: this is how much I put in. This how much I have got. No…they just do it. This is why the industry keeps the information small small small.

Come again. Why do they keep it small?
It is usually on small scale, because most of them are not educated and the information they get from people, like the extension farmers. They will just say the does and don'ts. They won't really get into it. They won't digest it for them, to tell them: this is going to happen when you this & this is going to happen when you do that. If they go a bit further, I am sure most farmers would opt for option that will last them for the long term. But now they don't because they don't have extra information.

One of the things you said is that obviously, when you are not irrigating, you will keep the cultivated area small, keep it easy, keep it manageable. Lots of farmers like you, they have certain goals. They want a nice big farm and grow this and that and fish and so on. To make sure your farm is succeeding, there are so many things that you can invest in. You can invest in irrigation, but you can also invest in fertilizers and seeds and so on. What for you has made you decide to invest in irrigation? I have seen you already use manure from the livestock that you have as fertilizer. But what drove you to invest in irrigation?
As I have said, with irrigation, you have somebody doing the job for you. If you have someone doing the job for you, it is so easy to expand. As I have shown you, I want to take this farm all the way up. If I have a very viable irrigation system, a very serious irrigation system, in place, maybe I will take it all the way up to this height. Because all up to that big wall and fence (points away from the river), belongs to this farm. I think I can do a lot if I can take some of that water. Because that water is just flowing off, it is not put to use. If I had other options, I would still invest in irrigation.

Allright, thanks so much. That was good.
Ah thanks. Something else. The pump (the Barsha pump). There are a few things that could maybe be improved and improvised. Here in Africa we have problems with theft. It is very difficult to get this pump and leave it over in the river and for it to stay right there. There is the problem of such kinds as vandalism. The other thing is the carriage. As you can see it is a bit heavy. How much is it?

It is around 90kgs.
So we have to carry it down to the river, and then bring it back. Sometimes we will leave it there, but we don't want to leave it for a long time, because some vandals will take an advantage of that.
Let me show you. The size is also a little bit of a problem. It looks and is big, difficult and demanding to move around. If there is a smaller version it would be easier to take to the river and back. And a smaller version would even be easier to compete with the petrol and diesel pumps. The farmers who use motorized pumps are used to the fact that one guy can just carry the pump to river. He works around, he comes back. But with this one (Barsha pump) you have to be four. Every time you want to take this to the river, we have to be four. Two on the one side, two on the other. That takes a lot of work. Sometime we are only with three guys, we have to fetch another guy. To be with four. It is heavy. If they could come up with a small version of this one. That would help.

You mentioned another important thing. You wouldn't dare to leave the Barsha pump in the river overnight? Or not yet?
Yes, because we have problems with vandalism. They might not actually have anything to do with it, but they might just want to come and see how it works. And then they say, what would have an effect. Let's take this part off. So then they break things. But if it was a bit portable, something smaller, it would be easier to manage.

The thing is, what makes this Barsha pump better, is that it can pump 24 hours. Now when you decide to take it out of the water overnight, because it is too dangerous. Than it doesn't pump overnight. So what is you solutions for that in the long term? Are you going to lock it? Or are you going to take it out every time?
In the long term maybe… I was thinking… the other problem… putting it fixed as stationary. Like putting it there for good. When the level of the river triples, sometimes it goes all the way up, it might damage this (standing Barsha pump). So during the rainy season, it might be a bit harder to use this. If there was some serious anchorage, like with a drill that we could punch in and then you lock. If we could if fixed and then we drill in some things. In that case, I don't think someone else would come over to try to pull it and get it out.

Especially when you just get a rod up like this, you drill a hole through the rod and you put a lock through. In that case they can't even lift it up, since you have the key.
It is going all the way down. Maybe it will go down 1 meter, or 1.5 meters into the ground. That would make it difficult for vandals to come and take it out.

So you think you are going to do that?
Yes I think I might do that. But I am still have troubles with the river. It is too low now. Normally is only this low at the end of the dry season, like September or October.





Interview 2 / Farmer 2 / Mwanza

11-06-2019

During my visit to the two Mwanza District irrigation officers (Annex 3 – Interview 2) took me to the Nankokwe Irrigation Scheme. The irrigable size of the scheme is 10 hectares, but there is potential for more irrigation. A total of 45 farmers, of which 10 males and 35 females, are currently active within the scheme. Everyone has their own plot and they irrigate according to the water management rules as taught by the irrigation officers. The irrigation officers helped me to interpret.

My name is Ruben and I come from the Netherlands and I am here to learn about your farming decision. First of all we see that there is an irrigation scheme here. When was it constructed?
It was constructed in 2006.

And the irrigation scheme is using gravity?
Yes that is correct.

And what is the size of the scheme?
The size is 10 hectares.

And is all of the 10 hectares irrigated? Or are there also parts that are not irrigated?
Partly it is not yet irrigated. The other side is irrigated.

And now you are using this irrigation scheme. What were you using before 2006?
We were using watering cans.

And how come you have changed to this scheme and why?
To ease the work.

Was it your own decision to make it like this? Or was it implemented by the government?
It was implemented by the government.

And why have you decided to make it a gravity scheme? There are of course many other options. Why did you, or the government, decide to make it like this?
Using this system is cheaper compared to using a petrol pump or a treadle pump.

Okay. So you know of the treadle pumps and you have used the buckets. There are also the option of the diesel or petrol pumps, but these are more expensive. That tells me that in your decision-making cost is a big factor determining what to choose. What other factors play a role? Does the environment play a role? Do the running cost play a role? Does maintenance play a role?
The other factor is inputs in terms of fertilizers. We have been trained to use manure in the case of fertilizer.

And in case something in the irrigation scheme is broken now. Do they have to invest themselves to fix it?
We are relying on the same government to come and maintain that.

It is the government who should do it?
Yes.
Irrigation officer 1: Of course we train them to maintain on their own, but since they lack some cost.
Irrigation officer 2: They are supposed to fix themselves. I think what they need is just expertise on how to do it.

Does the systems as it is now, with this irrigation technology, satisfy your needs? And does it coincide with their expectations?
We are satisfied, but there are areas that we want to add. We would like to acquire some pipes to supply the areas currently without water.

Before 2006, this systems wasn't here. What has happened to your farming practices since the implementation of the scheme? Did they choose different crops? Do they grow more or less land? What has changed now that they can irrigate?
The land has increased and also the yield has increased. We are growing the same crops.

So because of the irrigation you have been able to grow more crops, but you still choose the same crop?
Yes.

And what are your farming goals? You have now been able to irrigate more land, but you have already mentioned that you would like to irrigate even more. What other goals do you have as farmers? What are the plans for the future? Where are you going to invest?
For now we want a tank where we can store our water, so that we can irrigate throughout the season.

Because now this source runs dry?
No it doesn't run dry, but the amount of water reduces. So there is conflict of water during irrigation.

If the reservoir is something you would want, are you going to invest in it yourself? Or are you waiting for the government?
We will mobilize some resources like bricks and sand.

When you would adopt another technology. For instance a treadle pump or a diesel pump or a solar pump. For now you have chosen gravity and we have already heard that cost is a drawback of the others. But are there other reasons why you haven't chosen for the others?
The only reason is that it is costly.

When adopting certain technology, it might be hard to retrieve information about different technologies, but you can learn from irrigation extension officers. To what extent do you work with the advice that they give you?
Gravity is the only cheapest way. Because we are not using fuel or anything. The extension officers thought it would be good to use gravity, because the water is just coming by itself.

Now that there is water, there are many opportunities to grow what you want. You can for instance even grow cash crops. Why have you decided to stick with one crop?
Even maize is bringing us more money now that it is irrigated.

And more compared to when you grow green beans and other cash crops? Or are you farming maize because you know how to do that best? Or you just don't want to farm anything else?
Sometimes we do plant beans, onion.

So you do grow different things?
Yes

And what are currently the limitations for them to produce more?
We are lacking fertilizers. It is not really the water, but the fertilizers that we are lacking.




Interview 3 / Farmer 3 / Mwanza

11-06-2019

During my visit to the two Mwanza District irrigation officers (Annex 3 – Interview 2) took me to the farm of farmer 3. He is an individual farmer renting a petrol pump to irrigate his land. The irrigation officers helped me to interpret.

My name is Ruben and I come from the Netherlands and I am here to learn about your farming decisions concerning irrigation. This morning I visited Nankokwe Irrigation Scheme and they were using gravity. Now you are using a motorized pump. So I am interested in why you have chosen this technology for your farm.
At first we were using a treadle pump. Now, I think last month, when we sat down we said it was tough…using the treadle pump. We decided to borrow a motorized pump.

Borrow?
Yes. That is why we are using it now. Because as you can see the garden is too big. To supply water…was tough. I know the motorized pump is using a lot of water. Some of it is being thrown away. But that one (treadle pump), it was okay, because we are supplying water direct on the crops. But this one (motorized pump), we are supplying water everywhere. Now when it comes to diseases, this one is bad. But now that we couldn't have another option, we decided to use the motorized one.

So you are saying you starting to use the motorized pump because it is easier?
Not easier as such. But coming from the treadle pump, we did not have any other alternative. That is why we chose that one.
Irrigation officer: I think a treadle pump is tiresome.

I can image. But with the treadle pump you were also able to irrigate this whole farm?
Yes we were able to irrigate the whole farm, but it took a lot of hours. From morning up to 6PM. So it was tiresome.

Because how big is your farm?
This one is around 0.5 hectares.

Okay. But now with the motorized pump… The treadle pump is very tiresome, but it is for free.
Yes! No expenses by the end of the day, only labour. I was once used it. I planned some tomatoes there, close to my house. We used the treadle pump, it was okay. But the distance was very short. But now this one is too long (distances on the farm). That is why we have chosen to use the motorized one.

So how are the running cost for you? At some point you became so tired from the treadle pump that you accepted the costs of the motorized pump. Is that how it went?
Yaah there is a cost of course. So what I did is, at home there, I am keeping some chickens. These are chickens for meat. So we sell them, we get money and we buy fuel. But we don't use the engine every day. For example today I have used it, that means the coming 2 to 3 days, we use the treadle pump. Just to reduce the cost.

But this motorized pump. Did you buy it? Or you said you borrowed it?
Yes it is not mine. I borrowed it. It is somebodies pump.

Ah so you are renting it from someone?
Yes we are renting it.

I see that you also have the solar pump at home now.
Irrigation officer: Yes but it is not for him. It is for other farmers, a special group. A youth group. They irrigate that area where there are drips (next door farm).

Ah okay they are using drip with solar. So when you look at that technology (next door farm), what do you think?
The solar pump is the best one. There is no expense. But it is expensive. But to monitor it, is very cheap again. One person can monitor it. As we can see it is cheap and it is easy.

So for you, the one time you are using the treadle pump, the other time you are using the motorized pump to make the cost acceptable. And are there any other factors that influence your decision-making to now use the motorized pump and then the other? There are finances that play a role, running cost, but there is also maintenance, maybe the environment, maybe you think that using a motorized pump makes you more manly. Are there any other reasons that play a role? For instance, now that you are using the motorized pump, you can pump more, which allows you to grow different crops that make you more money.
This motorized pump has a disadvantage when it comes to diseases.

Compared to the treadle pump?

Yes, because with the treadle pump, we pump the water into this bucket. Then we take the water from the bucket, direct to the plant. Now with the motorized pump, we spray the water everywhere. Now that makes diseases travel faster. So that is why we use it here and there. Because if we use it continuously it gives us another problem. Because these tomatoes are very sensitive to diseases. There is this disease where they used to wilt. If one is wilting somewhere there, it is bad water there, that problem can cause another one. You can find all that area is wilting. So that is why we choose to use the treadle pump and the motorized one.
But that one (point to the neighbours field), that one is fine, because the plant receives water direct from the drip. Unlike spreading water everywhere (motorized pump).

But the technology that you are using doesn't change what crops you grow? Or how many crops you grow? That stays the same?
It changes. Because with the motorized pump I can grow a lot of crops. Maybe even an acre. But with the treadle pump, it is difficult. One acre is difficult.

So now that you are using the motorized pump, you choose to grow more crops and also different ones?
Yes now, I can grow more crops. Because at first, when we were preparing the land, I did not dream about the motorized pump. We were just using a treadle pump, like these guys supplied us (points to irrigation extension officers). I did not dream about this. But when the time comes, it is when I thought this treadle pumps is giving us a lot of job. We starting using what, the motorized ones. That is when we went to borrow the motorized one. With this one again, we had a problem with these pipes. We had to go somewhere again to borrow these pipes. Because of the distance from the river. In that phase (treadle pump phase) we were cultivating along the riverside. Now with this flooding and the like, we stopped doing that. These guys told us that cultivating along the riverside is bad. It is better to go upwards. There you can cultivate and you reduce flooding. That is why we came up here. But my dream was to have a big, very big, farm. 2 or 3 acres! That is what I wanted. But now the challenge is pumping water.

So what are your future plans? For now you are able to borrow this one. What are you going to do next?
My future plans. I was thinking that after harvesting these ones, I will by mine (motorized pump).

And you are planning to buy a motorized pump as well?
I think these guys will advise me.
Irrigation officer: It is okay if he is able to buy fuel. You know the difference with a group is he (David) can make a decision. I want to buy fuel, lets buy fuel. But if people are working in a group somebody can make a decision to buy fuel, while others say no. That is why most of the groups fell down. That is most of the reason. In the group they will have some people who are able to buy fuel, while other cannot buy. Whilst this one (David) is an individual. If he has said I want to use a motorized pump it means he knows he will be buying fuel.

It is a conscious decision. You are aware of the running cost.
With tomato. You find that in a group every person has his ways of finding money. When you say "come to the garden", other will not come. Maybe two or three will attend. That is maybe why there are some problems with groups. I will give you an example of those guys there (points to neighbouring farm). How many are there? More than 15 right?
Irrigation officer: there are more than 15.
But you look at the garden, it is small. But they are failing to manage that one again. Because it is a group! People that are in the group, they have got different interests. Other come there just because they need someone. But there interest is not there, but somewhere else. But my interest is here. It is mine. And when I see crops are wilting, there is no water, it pains me. Most of the time, I am here. Almost every day, I am here. It was last year that those guys gave us a pump. The pump that they gave us, it was the treadle pump. That make me think twice. With this I can make money. And last year it was okay. That is why I thought this year, let me expand the garden. These guys opened my mind. Otherwise, I would just be staying at home.

But now you saying you might be buying a motorized pump myself and these guys will advise me. What other options might they be able to advise, besides the motorized pump?
I don't know…

Another pump?
Other options are expensive. I don't think I can manage. The drips…its expensive. Having the pipes…its expensive. That is why I am having no other options. I think that motorized pump and the treadle pump, to me, is okay.

But for instance the solar pump. It might be more expensive to buy, but to run it is cheap.
Very cheap.

So in the long term, it might be cheaper. How does that play a role, long term thinking? Or are you thinking I can't afford the solar pump. I can't think long term. Let me think short term. I need to have a motorized pump.
I think now, you have opened my mind. Of course in the long term the solar pump is cheaper. It is true. Maybe from now I will start saving. So that I can buy the solar one.

Irrigation officer: don't you want to know how much that one costs (system next door farm)?
I understand it is 2 million?
Irrigation officer: the whole set?
Yeah I have heard the whole set is 2 million.

And how much is the motorized pump?
75,000 MWK.
Irrigation officer: no…
No buying it. 75,000 MWK. Renting it till August is 15,000 MWK.
Irrigation officer: 75,000 MWK where?
Blantyre, Limbe.

75,000?
Irrigation officer: It is 120,000 MWK and above. Not 75. 150,000 – 160,000. That is for 5 HP. I have seen yours is 6.5 HP. So 6.5 HP is almost 180,000.
Oooh…!

Woops, sorry.
Irrigation officer: Of course it is not expensive compared to that one (solar system). It is not expensive. It is quite cheap. But the way you are irrigating is the only way it can be expensive. Because of the water loss. There is no need to irrigate the way you are irrigating. With this engine you are supposed to take the water somewhere and then… I think will come back to you. Not now. I will come back to you and help you how to do it.

To use drip or sprinkler?
Of course sprinkler is good, but we can use the same as surface. We can use the same.

But then for instance. In conclusion now you say that the initial investment for me is the limiting factor. If I have money to invest I will buy the solar. But it is too expensive for me so for now, I will buy the motorized pump. And you accept that you are going to be paying 1,000 – 2,000 MWK a day to irrigate, irrigate and irrigate. Another question. According to you. Maybe it doesn't play a role at all but I am just curious. Another farmer that I talked to said that this global warming, the environment changing, it is because of the pollution from these engines. I don't want to contribute to this global warming. I will get myself something that doesn't pollute. Does that play a role in your decision-making or not at all?
Yes it is true. I did not think of that. There is global warming and pollution. I did not think of that. The motorized one, with this global warming, it is not a good alternative. That is very true.

But even when knowing that, you can still decide that in my case, I choose to not think about the environment.
I think about the environment. 100%. This global warming, I know, is because of the smokes from the engines. I know. But is because of lack of sources. We don't have any other options.

And besides solar and treadle pump and motorized pump. Do you know of any other options besides those?
I don't know. I only know those ones.

You have already said that the extension officers help you in making your choice. But are there any other sources where you get your information from? Of course you think yourself, and think "what is best for me". They will help you to say "we think this is best for you". Is there any other sources that you use to determine what to choose?
No I only rely on these guys.

You said you have also changed your crop. Now you are growing more crops, compared to when you used to use the treadle. But are there also different crops? Or is it the same?
At first we were growing onions. From onions we went to tomatoes. This time again tomatoes. And we have got maize somewhere there again.

So the technology you use doesn't really influence your crop choice. It just depends on the season or what you think is good to grow now?
We grow the crops we think is marketable at that period of time.



Interview 4 / Farmer 4 / Mwanza

11-06-2019

During my visit to the two Mwanza District irrigation officers (Annex 3 – Interview 2) took me to the farm of the adolescents farmer group, neighbouring farmer 3. I interviewed farmer 4, the group leader. The irrigation officers helped me to interpret.

My name is Ruben and I come from the Netherlands. In the Netherland I am a Master student in Water Management. And for my master I need to do a big research. I was already here in 2017, but now I have come back again to learn about how farmers make their decisions to implement irrigation technology. So I have already spoken to your neighbour, who is using the motorized pump. Here you are also irrigating but you are using the solar pump. Maybe you can introduce yourself and tell me about your farm?

My name is Alfred Dick, chair of the youth farmer club. As club, we have decided to cultivate a garden. Some of us don't have anything to do. But as were are a group we want to have money through farming. That is why we are here to do that.

That is good. And how have you decided to use this technology.

First we started with the watering can. Then we saw it is very difficult. A lot of work. Then the irrigation officers from agriculture gave us a treadle pump.

Ah so you gave David a treadle pump, and these guys. When was this?

Irrigation officer: Last year.

Friends of Angola decided to give us a solar pump to use for our farm. Now we are learning. Because it is new to us.

And who gave it to you?

From Angola. Farmers World.

That is an NGO that is active here?

Irrigation officer: yes farmers world is an NGO that is active that is active in Mwanza.

Okay. First you were using the bucket and that was a lot of work. Then you moved to the treadle pump. Was it already better?

Yes it is easier than the bucket.

And was it in your eyes good enough for this plot?

No it wasn't good enough for us. We want to plant tomatoes. It was very difficult for us to draw water from the source to the garden, because of the distance. When we received the treadle pump, we saw it easier than the bucket, because we were able to finish in one day. Maybe by 6 o'clock.

And now you have moved on to this solar system. Is it already working? How is it going?

This thing is better compared to the treadle pump. We are happy with it. It is good, but we are learning. The problem is that Farmer World has only given us a couple of drip lines as you can see. We would have loved if they could have given us enough for the whole area. As you can see it is too few.

But okay. For this part you can use the solar system. But for the other part you can still use the treadle pump?

We will be using the treadle pump for the remaining part.

And what is it that you like about this technology so much? Why this one and not a motorized pump like the neighbour?

It is too expensive. We like this one. That one is too expensive, we can't manage, because it is using fuel. This one is using sunlight. We would love to use the same one, because with no money we can pump to the tank and then irrigate for free. We think this one is better than the motorized pump.

And now that you have been able to irrigate easier and maybe more, have you decided to grow other crops? Or are they the same?

We have a winter crop. We change. Now we grow tomatoes. After harvesting, we grow cabbage, then onion.

And how is that different compared to when you were using the bucket or the treadle pump?

We will harvest more. This solar pump will only take this part, but we will increase with the treadle pump. We think that this area will increase. But the crops will stay the same. Tomato is good here, according to the season that is coming tomato is at the good price.

This is a very nice technology of course, but it is also very expensive when you buy it yourself. What do you as for you, the farmer group, are the drawbacks, the disadvantages, of this solar pump?

Can you come again?

For instance, if there is no sunlight…it doesn't work. Are there any other disadvantages?
This pump we can also use manually and then if works just like a treadle pump. You can attach something like a handle.

Interview 5 / Farmer 5 / Zalewa

17-06-2019

During a Barsha pump installation I visited Mrs. Nyanga's farm. She herself however, was not present to answer question. A week later I was able to interview her in a telephone conversation.

My name is Ruben and I come from the Netherlands. I was already here in 2017 working together with FUM, the Farmers Union of Malawi. Now I'm here for my final thesis research of my education. I'm doing a Msc in Water Management in the Netherlands. And I'm here now for three months basically trying to understand what drives farmers towards a certain irrigation technology. And I'm doing while working together with the aQysta company and the Barsha Team. And actually last week I was at your farm trying to find a solution for your situation. So we got the pump in the water.
So I already know a little bit about your farm. Just from observation. So Marloes from the aQysta team said I could text you to see if you would be willing to some questions. So that's how I ended up giving you a text.
Ah okay. No problem. No problem. I heard that you came to my farm. You would try this and that. I'm hoping that the installation will be completed and that I will see the benefits.

Yes absolutely. It was a challenging installation. It's like a cliff going down into the river. But I think we've got a good solution and we should finalize the installation soon. Right now I am in Lilongwe but the guys in Blantyre are working on the final final solution.
Ah okay. I was told they will come again on Monday. So I did not check with the guys whether there was a the team that went back to finalize the installation. But they (aQysta Team) could have called me to say oh they came.

I'm not sure when exactly they should be coming but I asked them just today to send you an update.
They haven't done that yet.

Oh and then tomorrow that they must update you on the progress and when what is happening. I will do that.
Okay okay okay. Please do.

Thanks. First of all could you maybe introduce yourself a bit? What are you doing? Why do you have this farm? What is your daily job? believe it's being a teacher but maybe you can introduce it.
My name is Catherine Nyanga. Nyanga is my husband's name. My maiden name is Catherine Chawanda. I got married to Nyanga but unfortunately he is late. He passed on me in 2012. So I work for the University of Malawi, central office in Zomba. Yeah in Zomba. That's where I work. I'm the senior assistant the registrar in the University of Malawi.

And how did you end up doing your current job but also owning a farm?
When I started my job, that was in 2009, I said I think it's better to combine my job and some farming, because if one depends on one thing like employment, it's not enough. You need to do other things to beef it up. To beef the salary up. So I decided, we decided to do own a farm. So that maybe we can be planting something for sale. But at first it wasn't like selling per se. It was just for food because we're doing maize only. But at one point I decided, after my husband passed on, I decided this maize thing is not doing me good. I need to do something else. That's when I decided to do bananas. It's mostly during the weekends where after work I go to the farm and to do other things.

And then you already told me that previously you were growing maize. When did you decide, and why did you decide, to look into irrigation options? Where you already irrigating before trying to introduce the Barsha pump. Or was there no irrigation before that time?
I was doing irrigation. When we bought that land we decided to buy a diesel pump. A water pump. So we're using that. But since we have gone to bananas now I said I need to beef up in terms of machinery, in terms of irrigation. So there was another guy who also owns land along the Shire river. So he is the one who said: "you know what. These Barsha pumps, with what you are doing, if you buy this one you will save quite a lot in terms of energy. In terms of fuels." So I said let me look around. I googled and found out that that company was selling. When I inquired is when they said we can assist you. We can bring the pump and try it at your place. Once it is installed and you are happy about it, you can be paying us little by little. So I believe that once it's done successfully I will reduce costs in terms of the diesel. The petrol and the like. Because I have another pump a petrol pump, apart from the diesel pump. That one is a third pump.

So you're looking for ways to combine all three? Or you purely going to try and use the Barsha pump as much as possible and only when needed you use the other ones?
If the Barsha pump works to my benefit then I think the way to go is to maybe purchase another one and make it two. So that I completely cut down on purchasing fuel, because it's expensive. It is expensive. Of course where I am working one of the benefits is that I'm given like 300 liters of fuel. What if I am retired... It means that I won't have 300 liters of free benefits. I'll have to dig deep into my pockets . So I want to run away from that. That is why I decided to do go the Barsha pump way. But I'm hoping that it is going to work.

I'm hoping so too! It's still quite close to the banks where the flow is maybe a little bit too slow, but this new solution should push it away from the banks a little bit more. Where the flow is faster and then it should work.
It should work?

We believe it should do the job.
Okay. Yeah I'll just cross my fingers.

So basically why you've changed is mainly the high running costs?
The thing is I'm still planting the bananas and I am thinking of other fruits as well. So where I am, it gets too hot. So if I have reliable pumps to pump water then I'll be assured of better fruits, which can be competitive on the market. So if I don't irrigate it means that harvesting will be slowed down.

Because I've been at your place it can indeed get very very hot. And I was surprised by how remote it was from the actual main road.
Yeah yeah that's my that's my challenge. Actually I really wish I found a donor. It's my prayer. I wish I found a donor to assist me in terms of for access to my garden, to my farm. That's a challenge, because when I harvest it means that I need to rely on people to carry the whatever harvest up there to the main road. So one of my challenges is the access road to that place. Maybe one day a solution will be found, it is my prayer that one day a solution will be found and it will be his story. We will have an access road to that place.

Because there are quite some farms along the river.
Another question. Basically I'm trying to figure out by speaking to people first and then in my second stage of my research about three or four weeks I want to do a small exercise with people that I've spoken to. I'm trying to figure out which should have factors has driven them to the technology or the irrigation technology that they're using now. In your case it's clearly the running costs and the fuels that were simply too expensive and too costly, but were there any other things that you preferred looking at the Barsha pump compared to the old technologies that you used?
Come again.

Is there any other reason, besides the running costs in the fuels, that you've that you've changed? Some people have mentioned that for instance to them the environment was very important and they did not want to pollute the environment. Other people said I like to try out new things or someone advised me or something like that. You already mentioned the friend that was using it.
Basically the advice which I got, but the pollution thing is also one of them because the diesel pump which I use sometimes it does produce something more or less like smoke. So in terms of pollution...if I use the Barsha pump it doesn't pollute and it doesn't have the smoke. It's just running without any pollution. So in terms of pollution it's safes me better. The Barsha pump if it works, then I will cut down on the pollution.

And for some of the alternatives, the other pumps, I know that most of them, for instance the motorized pumps or other options, you normally go to the shop and buy them and you have to pay everything in one go. For the Barsha pump there's a more flexible paying method.
Yes little by little.

Is that something that has also made it easier for you to make your decision?
Yes I think the flexibility also gave me a breathing space. Because the pump which I bought, the diesel pump, I bought it at the 300 (thousand MWK) something that time, but now it is around 2 million (MWK). To cough like 2 million (MWK) in one go is very difficult. They can't allow me to pay in instalments, but the good about the Barsha pump, of which I am praying it is going to work on my farm, is that they are flexible. I negotiated with them. They said you can pay in 24 months. It gives me flexibility. It is not like I would just cough everything at one go, but on a monthly basis I will be able to pay little by little.

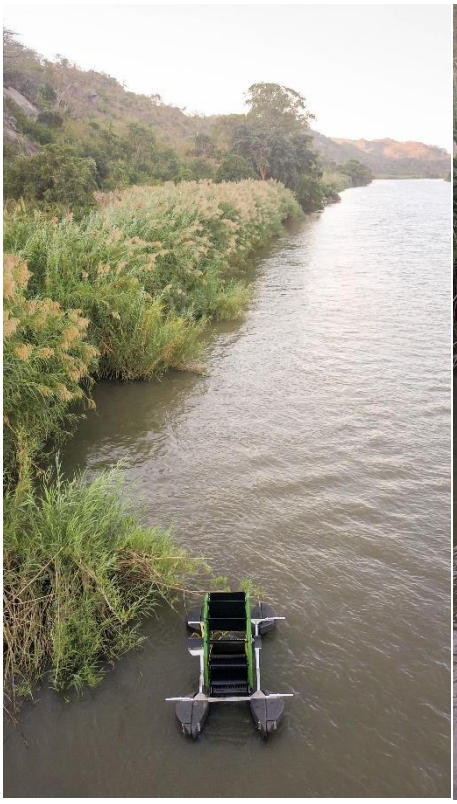
So for you that has actually made the decision to go for this pump easier?
Yes yes yes. Otherwise if it was like all paid upfront. 900 (thousand MWK) something upfront, I don't think I was ready to go that direction. I would still maintain the two pumps that I have. I'd be give myself time to raise money to buy at a later stage. But a decision was made there and then, knowing that it's not like I'm paying upfront. No I'll be paying in instalments.

And now you have the Barsha pump that is hopefully going to work soon. Is that going to change your strategy of growing bananas? Are you're going to keep on growing bananas or are you going to grow other crops as well?
The plan of growing other horticulture plants were there, but once the Barsha pump works for me it means that instead of taking long to venturing into the other crops, it will give me the drive to do it as quickly as possible. I will have no reason to delay. The water will be coming as I want. So I'll plant the other fruits as quickly as possible.

That's very good. And the main reason for that is that now that the water is going to be coming without extra costs?
Without the extra cost. Yes. And who knows, once it works for me then I may say let me purchase another one. Then another one. Maybe two or three.

All right. And you mentioned that you were advised by a friend of yours. Is there any other information or advice that you've received from other people to make a decision that you've made?
No I think basically it was the friend of mine. Of course, apart from the friend. Once he gave me the name "Barsha", I went on the Internet and Googled and I got a lot of information about the pump. I saw that this is how it works. So the Internet also gave me extra information apart from the friend. I really did not know that there was such equipment. I did not know. So once he mentioned it, of course I googled, putting in the wrong spelling but you know, there I was. I got what I was looking for.

But you're right that this technology, or this pump, is quite new to Malawi. If you hadn't heard from your friend that is also using it, you wouldn't have come across it or you wouldn't have heard from it?
I really wouldn't have heard about it. If I did not hear from him, I wouldn't know. I joined a certain group, an agricultural WhatsApp group. What I saw there, they don't mention any Barsha pump. But maybe they are using like a motorcycle and a pump connected to the motorcycle. And you use it for irrigation. And other ways of irrigation. But not the Barsha pump. If he did not mention it to me, I definitely wouldn't know. Unless I visited other farms and then found out they have Barsha pumps. Then I would ask: what is this.





Because farmers in general... many of the farmers they just adopt what they know, or what they trust, or what the neighbour uses or something like. They are normally maybe not so quickly willing to take a risk or to try something new. But because of your friends and the sort of flexibility that the aQysta team from the Barsha pump gave you, that is what made you decide I can try this?
Yes. I can try this. And thanks to the company. That's good. It's rare to have a company which is flexible like that. People want to get everything. They are in business so they want to be paid everything. But with the Barsha pump the human face is there. They really want to uplift farmers who are struggling in terms of finances. Which is good. It's a blessing actually.

Obviously there are other options; the motorized pump or the treadle pump that the smaller farmers use. There's also the option of the solar pump. Maybe the solar pump and the Barsha pump can be sort of comparable in the sense that they both don't need fuels or energy.
The solar pump. Yes I saw this solar power, but the cost now... It is also exorbitant.

That is true. And many farmers say that when it's very cloudy it doesn't work.
Yeah that's what I hear so too.

So the main reason that you did not go for that one is the costs?
The cost. Yes mainly the cost. In terms of for not working during cloudy days... I really wouldn't have minded. But the cost now... and the flexibility is not there. Because you have to pay it all in one go.

Interview 6 / Farmer 6 /Ntchisi

19-06-2019

During my visit to the Ntchisi District irrigation officer (Annex 3 – Interview 5) took me to the Kachere Agri Club Cooperative. The irrigated area is around 1.5 hectares and the group consists of approximately 20 people. The irrigation officer helped me to interpret.

My name is Ruben and I come from the Netherlands. I have come to ask some questions about this pump and your farming strategy.
I have already heard a little bit about the scheme, but I am wondering how your irrigation developed. Did you start with buckets, moved on to the next one, moved on to a motorized pump and now the Barsha pump. How did that progress go?
We started with a certain organisation called "Formento". They were helping us with groundnuts. We told them our problems and they told us that we should start irrigation. The Formento organisation helped us with watering cans. That is how we started our irrigation with watering cans. The group started growing and we saw that the watering cans are tiresome. That is when we looked from help from Total LandCare. Total LandCare gave us 4 treadle pumps on loan. We used the treadle pump for a certain period of time after which the group was growing again. Then we knew, the treadle pump is tiresome. We went to the agricultural department and to the irrigation people to seek for help. The irrigation staff came to see how we were doing our irrigation and they decided that we should do gravity fed irrigation, whereby we put sandbags along the river to obstruct the water and channel it to the irrigated area. The flow of water was too high, because of the river. The water started flooding. That is when we decided no, we should also tell other people that we have this other problem. The water was running too fast. What else can we do? Then there was a certain guy who told us about the Barsha pump.

Was this Farmer X (next door rich individual farmer also using the treadle pump)?
We just received a call from the office. A certain guy who is selling the pump.

Ah Kondwani?
Yes Kondwani. They came here to discuss with them. They said we had to pay a deposit of 50,000 MWK. We contributed the 50,000 MWK and gave it to them. Few months later the guy came and told us that he brought the pump. That is when we installed it.

And is the pump performing up to expectations? Are you happy with it?
Compared with the treadle pump, this pump is the best one. The water however, is not coming the way we wanted. We wanted the volume of water to increase.

But now with going from the treadle pump to this one, have you been able to cultivate on more land?
This is the first time we are using this pump. This is the first land.

But they are not cultivating that land there?
Expert 5: that down land there?

Yes because that pump can easily do this, and that land as well. Like I said, it should be able to do 1-2 hectares. Because where is all this water going? Where is all the water in the night going? They must use it efficiently.
For this water that is being wasted. We want to irrigate this side so that they can start land clearing, because it harder when the soil is not moist. So with time we will do all of this.

And what do you do with the water that is being pumped in the night?
During the night the water goes into the soil for moistening purposes. That makes it easier to cultivate the land. But during the night, it just goes everywhere.

That is what I said. Using this pump is better with the help of a reservoir or with a sprinkler. With the sprinkler, you can just put it somewhere during the night and when you get there in the morning, you move it to somewhere else. The water is used more effectively. Now it is just going. Instead of saying the pump is not pumping enough, it is important to think about how you can use the water more efficiently.

And you have already mentioned that this pump, the Barsha pump, is the best pump they have used so far. Why are they saying that? What do they like about it compared to the others?
We are not using fuel or diesel to pump the water. It is cheap. Also we don't waste energy, like we did with the treadle pumps. We just put it in the river, and it pumps the water. There is no other cost that is associated with the pump.

So the labour can be used on the farm here?
Yes.

Now you have done a deposit of the 50,000 MWK. What is happening next? Are you paying it of over time? Or what arrangements have you made?
The pump came in on the 5th of May. We haven't been able to discuss much on how we are going to repair the loan. But they gave us the first option, which is that we have to grow crops and when we sell we will be paying part of the profit. Whatever we get from there is what we can use to pay the pump off. The total amount of the pump is 950,000 MWK. We have deposited 50,000 MWK, with which we were able to use the pump. But we haven't yet agreed on how much we are going to give after a certain period. We haven't discussed that. But before the pump was brought in, we had decided to leave it. It is expensive, we can't afford. But the owner of the pump convinced us that we will not be paying the whole amount at once. We will be paying in instalments. So that is why they just brought the pump and they assured us they will not just come and tell us we need the money. The owner told us that he will give us the account number, so that we can deposit the money whenever we have found the money to pay back the loan. But they haven't yet given the account. So we will see. If we will not finish year, we will finish next year.

Because I know the guys from the aQysta team, they are trying to get a hold of them via the phone, but I think they can't reach them. Maybe because it there is a bad signal in this region.
Expert 5: I explained to them that before they go any further, they have to call him. And he should come to discuss with them the way forward with the payment of the loan. Sometimes, they can give them the loan. They are afraid that maybe with 2 / 3 month they will say no you have to give us the whole amount. So they have to come and discuss how they are going to repay.

Absolutely. That is what the aQysta team want as well, but they can't reach them.
Expert 5: okay then we will talk to her, because she is the one with good network on her phone.

Okay. Then one of the last questions. They say they are afraid now. I don't think there is any reason to be afraid. They will sort it out. Obviously over time they will have to pay it off, even if it is over a year or something. But to what extent does it help them to pay the pump of over time, instead of paying everything before implementation?
A diesel pump or petrol pump you have to pay all at once. We cannot do that. We cannot manage. Paying of a pump like this broadens our opportunities to use a pump like this one. We can be using it while paying it.

So for now, what are their future plans? Expert 5, I think you might agree that the water is not being used as efficiently as it could. I think with this pump there opportunities to use it more strategically. Irrigate this area, irrigate that area. Did they already think that themselves? Are they going to improve?
This is a simple thing where the water is coming to their farm. For me (a lady is answering) I am looking forward to make money from this land, so that I can built a house. I can have good things in my life. For me (a guy is answering) I cannot foresee that we can fail in succeeding in what we want in our life, now that we have the easy thing that brings water to the farm. Water is coming here easier than in the past. To us it is like a plus, to know that we can grow and we will no longer be at the same stand as we were in the past.





That is very good. It is just important that in order to make as much profit and realize these dreams, the farmers goals, they can use this water so much better through which they will be able to achieve building a house and other things so much quicker. If they irrigate and use the water that is pumped overnight efficiently. I am not sure if they know how to build a reservoir and then use a siphon? Maybe also now that you (Expert 5) are aware, you can help?

Expert 5: he was asking: how can we find a sprinkler? With all those things I think it us (Irrigation extension officers) who are supposed to come here and discuss with them.

Interview 7 / Farmer 7 / Ntchisi

19-06-2019

During my visit to the Ntchisi District irrigation officer (Annex 3 – Interview 5) took me to the farm of Benson Chinyama. Together with 11 other farmers, he is farming on 4 hectares of land using a petrol pump. The irrigation officer helped me to interpret.

My name is Ruben and I come from the Netherlands. I have come to ask some questions about this pump and your farming strategies.
I have already heard a little bit about the scheme, but let's just recall because that way I have it on tape. This is a club of farmers consisting of 12 members. They were using a solar panel and a submergible pump, but now it is broken. So maybe we can start at the beginning. How did the people start farming here?
We started as a group with 21 members. We were using a treadle pump. With the bigger land the treadle pump was not able to irrigate the whole land. So there was a certain white man, who came from Denmark, who in combination with Total LandCare supported us with this solar system. This solar systems was installed by X (name unrecognizable) construction company. They just installed it and then left it. So it was with the help of Total LandCare and the guy from Denmark and the help of the Agricultural Office.

When was this?
In 2017.

And when did they start the whole farming here?
This place is a farm. An individual farm. His name is mister Jonas. Mister Jonas is the owner of the land all up to that side. He gave it out to members of the surrounding villages to help them in irrigation. So he gave each and everybody a portion where they can do their agricultural things. But basically this farm started 2003 as an individual farm. Not doing just irrigation but a tobacco farm. He was doing tobacco and mixed cropping. So after the villages asked him to help them with the land he gave it to those villagers so that they can utilize the land.
So in 2016 is when everyone shared a piece of land, cause the were using it as a club. Because when government and these other organisations want to work with farmers, they want to work with groups. So after Total LandCare came in, after a few years, everybody started irrigation. After this solar system was installed. In 2018 is when we had problems with the solar system. So the time we were having problems with this is when everyone just thought of doing everything on their own. That is how they started doing individual farming. But in 2016 till 2018 people were doing it as a group.

So this solar system basically made sure there was a group, but as soon as it broke down, everyone was on their own?
Yes.

And you have chosen to adopt a motorized pump. Why did you pick that one?
The difference between a treadle pump and a motorized pump, motorized pump produces a lot of water. It pumps out a lot of water compared to the treadle pump. And I wanted more water.

And there is a stream here that you use as a source or you also pick it from a borehole (like the solar system)?
In a stream or in a river there are sometimes points where water is stationary and it is very deep. It is very deep and water collects there. In Malawi we call it a Zewe, a deep place. Maybe like a reservoir for the river.

And the other farmers of this club, did they also adopt a motorized pump or did they choose other methods?
Other farmers also use the motorized pump. Most of them they borrow from me.

So you share?
Yes we share, but the owner is me. It is not for free, they hire.

And this system here (solar system), how was it for them? Obviously a treadle pump is very tiresome. But did they choose to adopt this system themselves or was it just given to them, they did not have any choice?
It was chosen by those guys. The Total LandCare people. Those who came to assist the place.

Okay. Unfortunately now it is broken which means there wasn't enough collective action as a group to repair it. Why was it so difficult to maintain it as a group?
As a group, it is not for the first time. The solar pump has been on and off. So as a group we were doing it, contributing to maintain the system. But this time around, we tried with all means, but we failed. That is why we have just left it.

Because this time the problem is that big?
Yes. It is big and expensive. We can't afford it.

So it was cheaper to leave this system behind and move on to the motorized pump?

Solar system and motorized pump… to us the best is the motorized pump, because it uses fuel. Whether there is sun or not, if it is cloudy, we can still use the motorized pump. Well for this one (solar system) we need sun. To us… here in Ntchisi you can stay 3 days without sun. If that is the case it means we can't be irrigating. It is not working. But if it is happening like that, the motorized pump, we can use it. We just buy fuel and irrigate.

Okay. Previously you were using treadle pumps, then after the solar system broke you moved to motorized pumps. Is that because previously when you were using treadle pumps, you couldn't afford a motorized pump? And now you can? Or why first treadle pumps and now motorized pumps?
The time we were using irrigation with the help treadle pumps, we were small farmers. The time we were graduating to solar, we were still small farmers, but because it was just the intellective that they should bring us the solar pump… you are small, you are smallholder farmers, you cannot use an engine, because where are you going to get the money from the buy fuel. We cannot inconvenience you with running cost. So you better have the solar and you just need the repairments and the sun. After the solar system had broken, we were able to buy engine and to buy fuel. But the time this solar system was coming, we even ourselves told the Total LandCare guys that we don't need solar, we need a motorized pump. As we are, we can afford an engine, not the solar. But Total LandCare insisted that we had to have solar. But as of now, we are commercial farmers and we are able to repair and fuel the motorized pump. It is not a problem.

What I can conclude from that is that with the irrigation technology that you used, first treadle, then solar, now motorized pump, the farmers developed. From smallholders to commercial farmers. And actually the irrigation systems enabled that. Made it possible.
And now that this system (solar system) is not working anymore and now with the motorized pump, can you still grow the same crops? You don't have to decrease in size?
When we used the treadle pump, it was a small area. When we graduated to the solar pump, the land increased. When we graduated to the motorized pump, the land increased even more. Between the solar pump and the motorized pump, we better use this, because the area that we are cultivating, the solar pump was failing to supply all of it. The motorized pump is able to supply to all the land.

So if I understand correctly, because I am looking for those factors that determine which technology you pick, you did not really choose the solar pump. You just received it. But now you have picked the motorized pump because now you can afford, because it is easy, because it pumps a lot of water so that means performance, because you can share. Is there anything else that I am missing?
The goodness with the solar is it is not costly. It is not costly. But in the supplying water of water, it supplies relatively little and not to the extended area that we wanted. It doesn't reach. It is not able to do that. With the motorized pump we can irrigate a bigger area in a shorter period of time. While with solar we cannot. And once again, with the motorized pump I can irrigate when there are clouds or no clouds. While with solar, we cannot.

And the maintenance for the motorized pump compared to the solar?
The solar system all together, installation and pipes, it costed 45 million MWK. While the motorized pump can't reach up to that 45 million MWK. That is why we chose the motorized pump over the solar system.

How much is it approximately to repair this problem?
18 million MWK.

And Total LandCare. Did you contact them to say hey: you installed this pump, can't you help fix it somehow?
The project of Total LandCare faced out in December 2018. We have been telling the Total LandCare guys that they are supposed to help us with the system that they have brought us, in repairing it. But there was no positive answer. It was always on the negative side. So we know there is nothing that could have helped us. That is why we even said, we must leave it as it is.

And just out of interest, it doesn't relate to my research. This solar panel that was used to pump water, are you using it for any other purposes now? Because you can still tap energy from the panel. For instance, just an idea or suggestion, this panel here was providing energy for the pump down there. But you can even get, instead of a motorized engine, an electric engine. Using the electricity that the panel provides, you can use an electric engine to pump from the river.
For what you are proposing, using an electrical thing to pump from the river, we have done it. On our own. The problem was, when we pumped from the river, the river dried up. It was 2 to 3 days and the river dried up.

Because it was pumping so much? Can't you get a smaller electrical pump?
We haven't yet used that.

Expert 5: but the main problem that these guys have been facing, had it been that they were taught how to operate this thing they hadn't come across all these things. Total LandCare just came in and put this in. No farmer was taught how to do this. It was a construction company that installed this thing. Had it been that construction company and the Total

LandCare guys came here to select a few smallholder farmers to come for a training on how to operate this thing it could have not been a problem for them. That is why the farmers were just using a trial and error method. Getting the engine, going and pumping the water from the river. They have done it and they have failed. So of course at first, the were pumping from somewhere there, then they shifted here. They shifted here because water doesn't dry up. So they have put it here. But for them, if they can have somebody to train them on how to operate this thing, maybe it can help them.

Other farmer answers: this one (solar system) and the motorized pump, this is one is better. Because this one doesn't require fuel, it just needs energy from the sun. But their option is for the motorized pump, because it is the thing that we are able operate and run now. But when we compare the prices and expenditures on the cost of what we do, the solar system is cheaper. It only becomes expensive on maintenance.

I still don't really understand that when you put an electric pump, it dries up so quickly, that deep part in the river. But when you put a motorized pump, it doesn't dry…
Our river is not a perennial river. Sometimes it dries up. So we have ponds were we put our pumps. For this, when we pump 3 days, the water dries up. Because it is not recharging.
Expert 5: but even myself I am not getting it clear. <Expert 5 asks again>
It was that season when the water did not come in in any case. It was a dry season. But this time we have a lot of water. With this rainy season, we have a lot of water. That is why we are having no problems with that. But in those days when we were using the electric engine, there was not much water.

But you are not thinking of going back to an electric pump? Now that there is plenty of water and you can use the solar panel for free?
The pump is the one which has go the problem.

But you can even buy. Instead of buying a motorized pump, you can buy just an electric pump. I don't exactly know the details but…
This one cost us 18 million to buy it. It will cost us 18 million to buy it. But we can't afford 18 million. But we haven't thought of buying another electrical pump that is less than 18 million. We have just accepted that is done and we have to move on with the motorized pump.

And for now they are not using the solar panel?
We are not using it. We are not using it for anything.

Interview 8 / Farmer 8 / Zomba

24-06-2019

During my visit to the Zomba District, the Assistant Irrigation Extension Officer took me to the gravity Chombi Irrigation Scheme. The irrigated area is around 20 hectares and the group consists of approximately 200 people, 63 are males and 137 females. The Assistant Irrigation Extension Officer helped me to interpret.

My name is Ruben and I come from the Netherlands. In the Netherland I am a Master student in Water Management. And for my master I need to do a big research. I was already here in 2017, but now I have come back again to learn about how farmers make their decisions to implement irrigation technology.
For now, we have walked around the scheme, and I wondered what all of you were doing, irrigation wise, before this scheme was constructed?

Before Elat, we were constructing a earth canal from the intake to the fields. At the end of the earth canal we constructed something like a box, and earth box so that we could control the water. After some time, people from the government contacted people from the extension department and irrigation department. Those people worked in conjunction with World Vision and gave us pipes. So we had a pipeline from the intake to where the box was constructed. Then Elat came in and constructed the scheme.

So before the scheme was constructed, they took own initiative to construct an earth box and canal. Was that an initiative from the whole community or was it one person doing it and then two, three and so on? How did that come to be?

It was the initiative of the whole community.

And how has the construction of the scheme affected the area of cultivation, the crop choice, the harvest and the profit?

Upon completion of the scheme, the amount of cultivated hectares has increased. Now we can cultivate a larger piece of land. We have also started to diversify the crops we grow. Now we can cultivate different kinds of crops.
The reason for cultivating a larger piece of land is that initially when we had the earth canal, a lot of water was infiltrating into the soil. We had little water for irrigation. But after the lining of the canals we had a lot of water. In terms of the harvest, now we can harvest a lot because of the irrigation scheme.

And how many farmers are on the scheme? And what is the exact amount of hectares?

The scheme is 20 hectares and there are a total of 200 farmers cultivating. 63 are males and the others are females.

Now I want to introduce a couple of different concepts, technology wise. Obviously irrigation, you can do with many different kind of technologies such as motorized pumps, solar pumps, the water bucket. Why did they choose this method, using gravity, for their irrigation?

We chose to use a canal, because of the hectarage. We saw that we had a large piece of land that we needed to irrigate so we decided to use the canals instead of the treadle pumps and other technologies. We thought it wise, because with the other technologies it would take us time to irrigate the whole scheme. In terms of the watering cans and the treadle pumps, when we have drought we abandon this area and we have another area just there where we just watering cans and treadle pumps.

And why don't you use those here? Because here there is also water close by?

We decided to use the canal, because it was a small, simpler way to irrigate compared to the other technologies. If we use the watering cans, it is a very long distance from the intake to where we are irrigating. If we use the treadle pumps, it is also a long distance from the intake to here, so it will take a lot of energy to pump water and for it to reach the fields. In the other place we use shallow wells that we dig. So almost each and every field has its shallow well. So the water is closer to the field.

And with the irrigation scheme here now. Are you happy with how it is performing and how it has influenced your life's?

Yes we are satisfied.

And as farmers, do you have certain goals? We have already heard larger hectarage, or larger cultivated areas, more crops, more diverse crops, maybe cash crops. What are your goals and how is irrigation helping to achieve those goals? Do you find irrigation important to achieve those goals?

Indeed we have goals, individually and as a group. The scheme is really helping us to achieve those goals. For instance, during this last rainfed season, most of our farmers did not harvest a lot. We are using the irrigation season to complement to alleviate poverty and have enough food in our homes. After we harvest the maize, we are planning to produce beans. We will be able to sell the beans and alleviate poverty.

Coming back to those other technologies. Different technologies, like gravity, solar motorized, treadle, etc, have different advantages and disadvantages. For this location I indeed think that gravity is the best and cheapest

choice, but some farmers, even though there is water available, don't use gravity. They use another method. This might bring along running cost, maintenance, etc. With this irrigation method that you are using you don't really have that. But how could running cost, fuel, environmental impact influence the situation for you? Would you like that or dislike that?
If we use another the technology, for example a motorized pump, that would increase the cost of production. We would have to buy things like fuel and we would have maintenance cost. We would also need to employ someone, like a mechanic to fix the pump when it is broken. That would increase the production cost. We think it is cheaper to irrigate with the canal, compared to using the motorized pump.

So the cost of the technology and the running cost is very important for their decision?
When we were construction the earth canal we did think about the cost of the system. We did think about it.

In what way? You figured out this one is the cheapest and the best for us? Did you consider any other options?
We had some other options, but we did not have enough resources to explore the other options. So the option we found to be cheaper was the canalisation.

Obviously you have taken your own initiative. You have started yourself with this earth canal. How important was including the irrigation extension officers in taking that plan a step further? What would have happened if you did not include them?
After constructing the canal we had a good relation with the extension workers from the department of irrigation. Had it not been for the extension workers and the department of irrigation, the people of Elat wouldn't have known that we had a self-initiative. So it is because of the extension workers and the department of irrigation that Elat came to know us and the project was accepted in this area.

First you started irrigating yourself. Where the extension officers part of the reason that you started making an earth canal yourself? Or did you do totally start yourself without encouragement or advise from extension officers?
It was a self-help initiative. We did it on our own. First we did the canal by ourselves, then World Vision came and gave us the pipes. After that Elat came. Initially the canal was not very long. Just short till somewhere there. But with the coming in of Elat we have been able to increase the length of the canals. Up to this area we can irrigate.






How long does you own initiative irrigation date back? Before Elat, World Vision or anything, you were doing it yourself. From when was this? 20 years ago, 30 years ago?
The scheme itself started in 1989. World Vision in the 2000's. But the scheme started in 1989. In 2010/2011 Elat constructed the scheme.

Interview 9 / Farmer 9 / Zomba

24-06-2019

During my visit to the Zomba District, the Assistant Irrigation Extension Officer took me to the gravity Matiti Irrigation Scheme. The irrigated area is around 6 hectares and the group consists of 46 people. The Assistant Irrigation Extension Officer helped me to interpret.

My name is Ruben and I come from the Netherlands. In the Netherland I am a Master student in Water Management. And for my master I need to do a big research. I am here to learn about your farming decisions concerning irrigation technology.
For now, we have walked around the scheme, very impressive. Shall we start with how the scheme originated. Where did you start and how did this come to be?
In 2001 there was a famine here in Malawi. There was a shortage of food in general here in Malawi. There was a person, an individual, who started doing irrigation farming. That was in 2001. He was doing it alone. He made the canals alone. This person did the irrigation farming for 2 years. After that people were incentivised and people wanted to join in. The 3rd year there were 10 members and in the following years the numbers were increasing. World Vision came into the scheme and formalized a group and supported us with pipes. But it has been a long time. Most of those pipes are damaged. Most of them are not working. We have put in structures, whereby if a members wants to join in we charge them with a canal-fee. For using the canal. Also we have a membership fee of 500 MWK each year.

And the canal fee?
2000 MWK. As a new member you pay it once after which you can use the canals. But the members have to pay each and every year 500 MWK.

And what do you do with that money?
We use some of the money to acquire pipes, because those pipes the pipes provided by World Vision have now been missing or have been damaged. So we use to buy pipes and install into the system.

And when did World Vision come in to give these pipes?
In 2004.

And in that time the scheme was still a lot smaller?
By that time there were 25 members. Now there are a 168 members.

And Save the Children is coming to help now?
Save the Children wanted to come but I am not sure where the plans are now… There have been organisations that have come in, Save the Children and the European Union, but the progress is not tangible. We don't know where things are or where the project is. But we have challenges in terms of conveying the water. We are using earth canals so most of the water is infiltrating into the soil. That leads to a reduction of available water for irrigation.
Upstream, at the intake there is also another irrigation scheme, but that irrigation scheme has not yet started. But that irrigation scheme starts we will be sharing the water. It will be difficult for us to irrigate. We want to irrigate twice a year, but most of the time we only get once a year.

Because at the end of the dry season it is too dry?
It is too dry and also because of the transport of water. Most of the water is being evaporated or is infiltrating. So during the dry season we don't have enough water. That is how we can improve the scheme. Maybe if help could come in it would help if we could maintain or line the canals. Irrigation is one of the things that we depend on.

Obviously there are different irrigation technologies; motorized pumps, solar pumps, the water bucket. Why did they choose this method, using gravity, for their irrigation?
One of the reasons that we decided to construct canals is because of the issue of the rain. The intake is at a higher terrain compared to the field. The river that we use to irrigate doesn't have sections whereby water ponds so that we can install a pomp and irrigate. So we just thought it wise to make a canal, because it was the easiest way to do it.

I think with this terrain it is indeed the best. What further advantages of using gravity and canals?
The other advantage is that it is very easy to manoeuvre with the water. To channel the water. It doesn't take a lot of hassles to move the water around. That is an advantages when we compare it to the watering can. It can be a lot of distance to carry the water. That can be a challenge physically.

This scheme might need a lot of maintenance. If you don't maintain the earth canals they will break. How are you tackling this challenge and are there any other challenges that come with this technology?
Each and every year we have to maintain our irrigation scheme, but the maintenance works are concentrated mostly on the pipe works. Because during each and every season you find pipes breaking down due to huge rocks and also pipes are washing away at the intake due to high levels of water from the rains. We make sure that when the rains are nearing

we go to the intake and remove the pipes and store them somewhere. Also we have to think about those broken pipes each and every year.

Basically I hear that there are several things that you find very important in irrigation; flexibility, maintenance. A big advantage also is that this scheme hardly has any running cost. For flexibility however, you could argue that the treadle pump or the motorized can give more flexibility in the sense that you can irrigate whenever you want. With gravity sometimes you need to wait. How do you look at this trade-off between flexibility and running cost?
Our river is full of rocks. It doesn't have sections where the water ponds. In that case it is very difficult to insert a pump and pump the water. Also the other thing is the distance of where the water can be abstracted to the fields. It is a very long distance. We also consider that. That is why we use a gravity-fed system. We don't see any problem with using the gravity-fed system since our river is a reliable river that doesn't run dry. At least throughout the year we have enough water to irrigate so we don't see any problem.

As farmers you might have different goals, within a group or individually; building a house, paying intuitions fees, etc. How do these goals influence which crop they want to grow, does it cause you to want to expand your farm. Can they expand?
Personally, my goal is to be food secure at my household. I also want to build a house and live a good life. I try to achieve that by cultivating maize to achieve food security at household level. I also cultivate tomatoes that I can sell for economic gain.
In terms of increasing the individual hectarage under this system is very difficult and unlikely. Some of the people that are cultivating here are not landowners. They just come in on lease. The land we have under the scheme was measured and was shared accordingly. Everyone has an equal plot size of 0.1 hectare.

So for now you accept the fact that achieving those goals has to happen within those 0.1 hectares? You can't expand or grow your cultivated area.
We wish we could cultivate a larger piece of land, but it is kind of impossible. Some people are not landowners so we have to share the land. It is very unlikely for us to have more land than this 0.1 hectare. It is everyone's wish to cultivate






a larger piece of land. After the surveys it was found that the scheme is 20 hectares, but there are challenges in the transport of the water. The water doesn't reach the whole 20 hectares. Out of the 20 hectares we cultivate 6 hectares, because water cannot reach the other areas. But if possible, if we get help and can improve the transport of water into the scheme, then we can cultivate a larger piece of land.

But now you are saying there are 6 hectares that you irrigate. With 168 farmers. That means every farmers has less than 0.05 hectares. Does that mean you have a rainfed section and an irrigated section? How does that work? Do all 168 farmers irrigate?
Only a few farmers cultivate this irrigation season. Only 46 have cultivated.

So only 46 farmers do irrigation. The others use rainfed?
In terms of rainfed. There are specific landowners who own the land. There are about 8 of them. So during the rainfed season those 8 people cultivate on those lands. When it comes to the irrigation season those 8 people give the land to the scheme and they share. So 46 are irrigating now out of the 168. The others are just idle.

There are some methods like solar, gravity and the treadle pump that are not polluting the environment, because they use gravity, human energy or solar energy. Is that to you very important? Or is it just a nice advantage?
We are also concerned with the environment. There are some other organisations that we work with. The environmental protection. So they also encourage us to plant trees. So we are also concerned with the environment.

Sure. But is it just a nice advantage that this one doesn't pollute the environment with fumes and gasses. Or is it that you would also choose this technology because it is good for the environment?
The irrigation system doesn't depend on the environmental protection. It is just a bonus.

Interview 10 / Farmer 10 / Zomba

25-06-2019

During my visit to the Zomba District, the Assistant Irrigation Extension Officer took me to the Takondwa Irrigation Scheme. The farmers have the option of using three different WTTs; the petrol, treadle and solar pump. The irrigated area is around 10 hectares and the group consists of 39 people. The Assistant Irrigation Extension Officer helped me to interpret.

My name is Ruben and I come from the Netherlands. In the Netherland I am a Master student in Water Management. And for my master I need to do a big research. I am here to learn about your farming decisions concerning irrigation technology.
For now, we have walked around the scheme. Can you please introduce the farm and how it has developed over the years? I have seen three different kinds of pumps. But where did it start? What did you do before the pumps? And how did you acquire the treadle, solar and motorized pump?
We started in 2012. We just started by trying. We started by using watering cans. In 2015 we were provided with treadle pumps.

And before 2012 you were doing rainfed farming?
Yes it was only rainfed. And in 2012 we started the irrigation with watering cans.

Alright. And in 2015 you received the treadle pumps. From who? Or you bought them yourself?
It was from the office of agriculture who provided us with the pumps. This was after they saw how interested we were in doing irrigation.

And since that time you have been able to acquire a motorized pump and a solar pump. How did that happen?
The motorized pump was bought by the group village head. Because the group showed so much interest in irrigation, the group village head decided to provide it to the group. To use it for irrigation. The farmers have to buy fuel to use it. So the pump is owned by the group village head, but the farmers only buy fuel.
It was last year when the AGORA organisation provided our group with the solar pump. AGORA saw our growing interest. The number of beneficiaries in our group has also grown from 2012 to now in 2019. The number of beneficiaries was 97 members. That is what prompted the village head to give the motorized pump to be used in the group. The number is now 39.

And on how many hectares are you farming? How many is there per farmer?
In the past we were irrigating 5 hectares of land. Now we have increased to 10 hectares. Each farmer gets around 35 by 35m.

I understand there are now 39 farmers. Are all of you sharing the 3 pumps? Or is there different farmers using different pumps?
It depends on the financial resources. Especially when it comes to the engine. For those who can afford to buy fuel, they will use the engine. But for those who cannot afford, that is where they opt for the treadle pump. And for the solar, we have not yet started. The pump was given only last year. Probably this year we will start using it.

For everyone to use?
Yes, for everyone.

We have three technologies here. The motorized pump is the only one you have bought yourself. Why did you decide to buy the motorized pump? Instead of maybe buying another treadle pump for instance.
The advantage of the motorized pump is that it pumps a lot of water. It gets a lot of water from the source. And it pumps upon this area here. The water that we can pump using the motorized pump can irrigate quite a big area. Unlike with the treadle pump. Using a treadle pump, with time they get weary. They cannot irrigate a big area, unlike the motorized pump. Another advantage of the motorized pump is that we can irrigate 10 plots, or 5 to 6 individuals, at the same time. Unlike the treadle pump. Where it is just one at the time. It is very difficult to irrigate a number of plots at the same time, using the treadle pump.

And using the motorized pump, how do multiple individuals irrigate at the same time? Do you use split pipes?
Yes we use pipes. But we use the pipe one after the other.

So for now it seems like the motorized pump is preferred by some farmers in the group. Now however, there is also a new pump; the solar pump. What do you think about this pump?
We are just going to try.

How do you think it differs from the other pumps?
For the motorized pump, we need money for it to work. Unlike with the solar pump. We just need the sun.

So, so far, the people who could afford it, were using the motorized pump. Because of its is faster and easier. But now there is also a solar pump that works for free and doesn't cost any human labour. You think that the people who can afford fuel will now also want to change to the solar pump?
Yes. But we need to use both of them.

How are you going to manage this? Maybe everyone want to use the solar pump now…
It depends on the availability of the funds. If you have funds, you can take the motorized pump and use it. If you don't have funds you can take the solar pump.

Looking at the 39 farmers that the group consists of now... What do you think most farmers will want to use?
They will want to use the solar pump.

And why?
There is no labour. No need for funds.

I have spoken to some other farmers and sometimes they argued they wanted to have a solar pump or treadle pump they don't pollute the environment. The motorized pump might pollute the environment with gasses. Is environmental pollution a decision-making factor for you?
Yes it is a factor.

But is it also a specific reason why you would want and use a solar pump instead of a motorized pump? Or the environmental pollution is just a negative side effect that you accept?
No. But this motorized pump is also important. Because when you depend on the solar. The solar needs the sun. The weather, however, doesn't work sometimes. That is when we will use the motorized pump. Because it is independent from the weather.

As a group you started by using the watering cans. From there you changed to using the treadle pump, than the motorized pump, and now the solar pump as well. How has the farm grown with the new technologies that have been introduced? Has it influenced your crop choice and crop variability?
We grow a diversity of crops. We grow maize, tomatoes, carrots, green peppers, beans, sweet potatoes and onions. The land of course has increased. But it is our goal to increase to 15 hectares. But we use a motorized pump that requires fuel. But not everyone can afford the fuel. That is the major constraint for reaching up to 15 hectares. The area that we have starts from down there (points to source), to up there. But we also can't pump all the way there, because the motorized pump is small. We wish to have a bigger one. Because that one can at least cover the whole area up to there. And reach up to 15 hectares as well. That is only major challenge that we are facing.

There have been four technologies that you have been able to try. The watering cans, treadle pump, motorized pump and now the solar pump. Obviously, the watering cans and the motorized pump are the only two that you have acquired yourself. If it was the community's money that would be used to invest in a new pump. Which pump would they invest in?
We would buy the motorized pump or the solar pump.

And is there a big difference in cost between the two?
Yes there is. The motorized pump needs a lot of money. While the solar, doesn't need money.

Sure. And to buy it?
I think the motorized pump is cheaper than the solar one. For the price of buying one solar pump, we can almost buy five motorized pumps.

So if the community's money, you would invest in another motorized pump?
Yes.

Purely because it is a cheaper investment?
Yes.

Or also because it is flexible? Because it can pump far? And because it can pump a lot of water?
Yes also all these things.

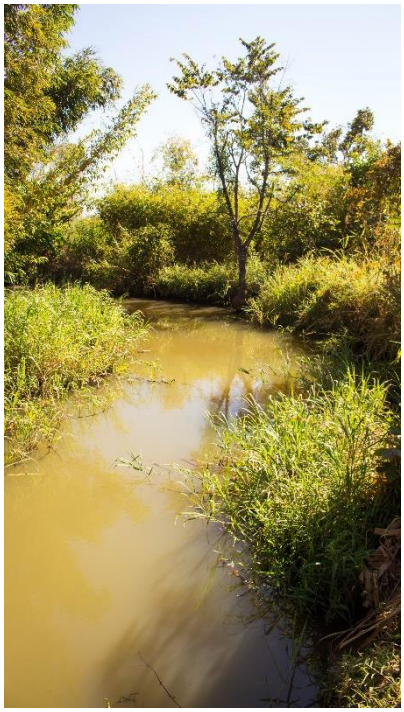
And you would still opt for the motorized pump, even when some community members can't afford the fuel?
Yes it will still be the engine.

If you want to buy all of these pumps at the market you have to pay everything in one go, before you can use them. There are also companies who allow you to pay a deposit first, after which you pay off the pumps as you

are using it. Would that encourage you to invest in a technology? Would it make it easier to choose for a company that offers this sort of payment method? Or you don't mind to pay everything in one go?
We would prefer this option were we pay a deposit and pay as we use it. It would help us. It is a good way.

With all the farmers here, there is a lot of experience between all of you. This experience can help you to choose which crops to grow, but also which pump to buy. Is there any other source of information on which you base these sorts of decisions? Do the extension officers advice you? Do you ask them for advice? Or is it purely a decision that is made within the group?
Experience we have, but extension workers also come to give us some advice on top of the experience that we already have in terms of crop production.

Do the extension workers also help with decision-making concerning technologies?
In terms of technology, it is our own choice. But once we think of a technology, it is when the extension workers come to give us guidelines on how it can work. So in terms of choices concerning technologies, it is purely our own choice.



Interview 11 / Farmer 11 / Zomba

25-06-2019

During my visit to the Zomba District, the Assistant Irrigation Extension Officer took me to the Namawato 1 Scheme. The farmers have tried using the treadle pump, but resorted back to using watering cans because of water shortage issues. The irrigated area is around 2 hectares and the group consists of 7 people.

Thanks for showing me your farm. I am mostly interested in the choice that you have made to use the watering can. We already talked about it a little bit, but can you once again explain why you have chosen to use the watering can?
We use the watering can in order to conserve water. If we use another way, we cannot conserve water. Therefore we use the watering can only.

You have mentioned that you tried a treadle pump?
Yes we have tried it. And when we tried it, we lost most of the water.

The more you are able to irrigate, the more crops you can potentially grow. Do you feel like your water source is limiting you in order to grow?
Yes, we need more water. Maybe we have to enlarge the place where we plant crops. In order to enlarge the yields. But in order to do that, we need more water. Once we have a place where we can have a big well, we can have that situation.

And within your opportunities, and within this area, you felt like the watering can was the best option.
Yes.

Of course there are also other technologies, for instance the drip irrigation, they use little amounts of water. But this one is very expensive. How you considered drip or have you decided to stick with the watering can?
No we haven't used it. Because income is small. It is too expensive.

You have used a treadle pumps that used a lot of water and was also leaking a lot of water. Are there also other treadle pumps that are performing better and more efficient?
Yes there are other treadle pumps. Maybe if there are easier more efficient treadle pumps, we can use it. And solar pumps. If we can have those, we can use it.

And you think with that one, you can conserve water as well?
Yes we can conserve water.

You think with that one there will be enough water?
Yes.

You have tried the treadle pump, but it was not efficient enough. You have now chosen the watering can. But what is in your opinion a disadvantage of the watering can compared to the other options?
A disadvantage of the watering cans is that we use a big place with only a little bit of water. The water that we take will be used only for our crops.

Okay. But you could call that an advantage. But now what is the disadvantage? The negative?
It makes us tiresome. Because when we bring the watering cans, it makes us tired.

And what are your future plans for the farm? You want to keep it like this or you have certain plans for the farm?
I have discussed this with my friend and the future plans is to hopefully have a big well and maybe buy a solar pump. In that way we can take the water from the well and take it to the field. We can make a place where we can store the water so that we can use the watering cans to irrigate.

Like a reservoir?
Yes.

So for now you have mentioned that the watering cans is the best for us. But when we find more opportunities to get more water, we can start using the treadle pump or the solar pump?
Yes. But maybe there is another way. Maybe we can find a tap. So we can use it to bring water from the tap and bring it to the fields. That could be an idea.

And on this plot, before you were using the watering cans, did you use any other technology?
There is no other way.

When did you start the irrigation?

2007.

And before that?
Before that there was a small amount of people. Maybe in 1999. We were just planting food scattered all over. The groups we formed was in 2007. Before that time there was no irrigation.

And currently, how many farmers are in the scheme?
Right now there are 7.

And do you know how big the cultivated area is?
Yes actually it is around 2 hectares. 7 people on 2 hectares.

No imagine you have enough water. What would be your favourite technology to adopt? And why?
The most one would the solar pumps. It is an easy way. The solar brings the water to come out from the wells. After bringing the water through the pipes, we can maybe connect to a sprinkler. It can irrigate by itself.

Okay so you are saying solar, because it is simple. Also because it only needs the sun, no fuel. And also because you can connect it to a sprinkler.
And if there is enough water. Why wouldn't you choose the motorized pump or the treadle pump?
We can use treadle pumps if water is running. But a good way is solar pumps.

And why wouldn't you want to choose the motorized pump?
We can use the motorized pumps. But it is only way that I see it is that it uses a lot of fuels. And fuels are expensive.

One of the disadvantages that some farmers mention is that motorized pumps pollute the environment.
Also one of the disadvantages of the motorized pumps is that it rushes the water too much. It causes the soil to degrade and causes erosion. Because the motorized pumps, pump the water faster compared to the others. The force of the water.






We have discussed the watering cans, treadle pumps, motorized pumps and the solar pumps. Do you know any other technology?
No.

Okay. There are also other options. When you would make a choice to change your technology, where would you try to find information? Information on maybe other technologies than we have just mentioned.
Maybe sometimes I go to watch TV. I find that there are ways that other countries use. Like in Egypt, they use the bubbles. They bring the bum and take those bubbles to where water comes and bring it down to the fields.

You have mentioned TV. Is there also radio or extension officers that can help?
Yes maybe.

Interview 12 / Farmer 12 / Zomba

25-06-2019

During my visit to the Zomba District, the Assistant Irrigation Extension Officer took me to the gravity Kalambo Irrigation Scheme. The Assistant Irrigation Extension Officer helped me to interpret.

My name is Ruben and I come from the Netherlands. In the Netherland I am a Master student in Water Management. And for my master I need to do a big research. I am here to learn about your farming decisions concerning irrigation technology.
We have already done a small tour around the irrigation site. Looks very good. Can you maybe tell the story of this scheme? How and when did it start? Did the scheme grow?
The program started last month. We started with clearing the land. Thereafter we started digging the soil for plantation. Then we made the water channel from the stream down there. Last of last week we planted the maize as you can see. So far I can say so. The scheme has 25 members, 6 males, 19 females.

So you only started last month?
Yes last month. With the clearing of the land. Digging it. Or in simple terms: preparation of the land.

Before that nothing was happening here?
Nothing was happening. It was just a grassland like this one, with the bushes. So we started clearing. That was last month. It was early May.

And how did this came to be? Who started the initiative? How did you come together?
It is like a group. We came together as a team and made a group. It is a local organization, whereby the villagers just mobilized themselves and organized the team. The government provided us with the seeds. For some other activities we provide the resources ourselves. But the government gave us seeds.

Very impressive. How did you decide to take this plot and irrigate like this, using the gravity and the stream?
We chose this site because of topography. Whereby the water would move with the gravity. If it could be the higher land, it could be difficult for the water to move. We chose this land because of its topography. The water is moving easier. As you can see, far from the stream, the water is able to move. From there to here.

The stream is over there. But there are several ways to get the water from the stream to here. One is gravity, or pipes, or…
…watering cans

…or treadle pump. Why did you as a group decide to use these canals?
We choose this type of system for irrigation simply because other systems need a lot of money. For example the treadle pump. To acquire a treadle pump; it means you need to raise up a lot of money. And also with one treadle pump it will be difficult to apply water for the whole of this land. Number two; irrigation using watering cans. It could be difficult. As you can see the stream is very far from here. So for somebody to take water from there to here, could be difficult. So we choose this system, because it is easier and faster. We are able to apply water at least for a big land and in a short time. As I have already said, the other systems require a lot of money and it can be difficult for the villagers to raise up such an amount and buy a treadle. This is cheaper compared to other options.

Okay for now you have chosen this option, for very good reasons that you have already pointed out. Obviously you have just started with this farm, but would you like to keep this system for the coming years? Or are there other plans to develop the scheme further and use other technologies? Or is this good enough for now?
This system has been started some years ago, but not on this land. People were doing it, but down from here on another land. But unfortunately a certain year there was not adequate rainfall, so there was little water moving in the stream. This resulted in too little force for the water to be diverted to the channels. The agricultural advisor came here and surveyed the land and then advised the members to do the activity here. At least here it is better.

And this group has the same members as the activity down there?
We are members. There are a few who joined, but the ones here were members. Other members from other villages came and joined. Villagers in a village mobilized themselves and started this. Other villagers were interested to join us.

And you were using the same canals and technology here as you were using there?
Yes we were using the same system.

With watering cans the land that you can irrigate would be quite small. Now with these canals it can be much bigger. Are you also growing different crops now that you have the opportunity to irrigate like this? I see maize, but I have also seen some vegetables?
Yes that is beans.

Okay! So irrigation provides enough water to grow a lot of crops. How did you decide to grow these crops?
We decided to plant this made for this land. We also have another land where we are going to plant vegetables.

Using a treadle pump I heard?
Yes. With that place it is difficult to use this system of irrigation. It requires treadle pump. Because of its topography. The land is higher than the stream. So according to climatical change, the problems which come with water during the rainy season, whereby a lot of gardens and crops were washed away with the rain. I mean it ran off. So we negotiated with other organisations, where they provided the seeds. At least to eliminate the hunger problem.

So is there any specific reason why here they grow the maize and the beans? And at the other place the tomatoes and other vegetables?
The reason to combine maize and beans is because beans mature earlier than other crops. Another reason is that the land is just very small. And as you can see there is demarcation of some portions, which means each portion belongs to a member. To combine the other crops in this same place, it could be difficult for other crops to develop. As you know maize is growing taller which creates shade. It is overshading the other crops that are not growing tall. For the vegetables, they have another place as I have said already.

But there is no reason concerning the irrigation, that these crops are together? It is mostly the maturing and the shade?
Yes according to the members, the land is just very small. And another noticeable reason, like Chinese rape, can not be combined with maize. Because its lifespan is very long. When the maize is growing taller, it will start shading the other crops. Which will make growing difficult.

Moving to the other site, where you use the treadle pump. I am wondering why you use the treadle pump? You have already mentioned that at this location it is difficult to use the canals. Why is the solution the treadle pump and not another technology?
That land has not yet started to be used. We plan however, to plant vegetables and tomatoes soon after we have applied fertilizer here. Once we have fertilized here, we will start to prepare that land and grow the crops that we are saying.
But in terms of technology, or how we will be lifting the water or taking the water from the source, we don't have. The treadle pump we don't have. We will use other technologies to get the water. Probably the watering can. Or buckets. But if there could be other organizations that would say "we want to give you treadle pumps", that would be welcomed since we already have land that we can use.

You mentioned that you will probably use buckets and watering cans to irrigate that land. But you also say you prefer treadle pumps. Why is that?
Because the land is big. So to use the watering cans, it will be tiresome work. At least the treadle pump can be used for a very big land.

And gravity, using the canals, doesn't work there?
No because of the topography. The water source is down. Whilst the land is upper side.

You have mentioned that you plan to use watering cans and buckets. And you would like to use the treadle pump. And here you are using the gravity and canals. Concerning all these three technologies or systems, what are their disadvantages? You already mentioned that watering cans are tiresome. What about the treadle pump or the canal system? Are there any disadvantages?
One of the disadvantages of this water canal system is that when the water level is low, that is means that the force is also reduced. It is very difficult to apply water. It means the moving of water changes. The water force is reduced. It is difficult for water to move with a larger force through the canals.
Another disadvantage of the treadle pump is that during water application, it may be difficult to move the pipes. It causes damages to the crops. When you move the pipes from one portion to another, it may cause the damaging of the crops. At least it requires a lot of people, or some people, to assist in moving the pipes. Especially the delivery pipe. When it is full, it is difficult to move. When you do, you might damage crops.

And that is the same for treadle pumps, motorized pumps and even solar pumps. Am I right?
Yes that is true.

But that problem you don't have while using the canals and the watering cans that is not a problem?
Yes sure.





Interview 13 / Farmer 13 / Zomba

25-06-2019

During my visit to the Zomba District, the Assistant Irrigation Extension Officer took me to the Tiyisi Club. The club, consisting of 12 members farming on an area of around 1 acre, use a borrowed petrol pump to perform their irrigation activities. The Assistant Irrigation Extension Officer helped me to interpret.

My name is Ruben and I come from the Netherlands. In the Netherland I am a Master student in Water Management. And for my master I need to do a big research. I am here to learn about your farming decisions concerning irrigation technology.
We learned that you are using a treadle pump. Could you explain how you started farming here? Why you using the treadle pump and the story behind it?
We started in 2016. In the beginning, us as farmers, we came from different villages. The one individual came from the one village, the other came from the other village. Together we made a group. There was another time when we disbanded. Everyone was doing their own thing in their villages. We have come back now. Only now, compared to the last time when we were all coming from different villages, this time we are all from the same village.

What happened in 2016 when you started again?
In 2016 we still came from different villages and made a group.

Before 2016 nothing was happening on this plot?
Before 2016, everyone was cultivating on his own. We were doing individual plots. We would just clean up a piece of land and irrigate using watering cans.

And in 2016 you bought a treadle pump?
In 2016 we were helped by the European Union, which helped us to get together as a group with members from different villages surrounding this area.

And they were helped also with a treadle pump? Now how has this treadle pump influences production, area that you are cultivating, your crop choice?
Currently the technology that we are using is the motorized pump. We are not using the treadle pump. The motorized pump we borrow on loan. We only buy fuel to fuel the engine. That is what we are using for now.

And in the past you were using the treadle pump?
Yes exactly.

Okay. How did the treadle pump influence the cultivated area, the crop choices and crop harvest?
In terms of production, we were better of with the treadle pump, compared to using the watering cans. Also the land increased when we started using the treadle pump. So it was of great influence in terms of production and in terms of land size. Also the production increased compared to when we were using the watering cans. The land that time, was actually small. Also in terms of production.

Okay. And how did going from the treadle pump to the motorized pump influence the cultivated area, the crop choices and crop harvest?
In terms of crops. We plant diversified crops. Like for instance we plant maize, tomatoes…

Now that they are using the petrol pump?
Now that we use the engine. And now that we are using the engine, our cultivated area has even increased further. With an engine at least we can irrigate a bigger area, compared to using a treadle pump. It has greatly influenced our production, as well as the way we choose our crops.

Why did you decide to change from the treadle pump to the motorized pump? Besides the reason that it can irrigate a larger area?
The major reason for changing is the water source. The water source is lower than the irrigated area. The motorized pump can at least get water from the source to the upland where we are irrigating. Unlike with a treadle pump with which this will be very difficult and tiresome. That is why we opted for an engine instead of a treadle pump.

But of course a treadle pump is pumping for free, with the help of human energy. What do you think about the running cost of the motorized pump?
The cost of running an engine was considered. But we had to forego that the major reason is the source of the water is low, while the land to be irrigated is about 4 meters higher. We had to consider that and that is why we chose the motorized pump. Despite it is cheaper to use the treadle pump.
And has it been cheap to run or did you underestimate the running cost?
At least using a motorized pump is cheaper…

Cheaper then what?
Cheaper in the sense that they can at least irrigate the whole of this area in a short period of time compared to when using a treadle pump. That would take the whole day. The energy that we would use to pump, or to treadle, would make it expensive compared to the motorized pump.

So it is cheap and doable to pay the running cost?
Yes.

Was it their own decision to adopt a motorized pump? Or did they get advice or see it being used at the neighbouring farm? Where did they get the idea from?
The decision came upon seeing our neighbouring farmers. They were using it in their schemes. So we opted for the engine. And it was our to decision to say “I think we can also go for that one”. It was not from extension workers.

And is the performance of the engine living up to your expectations?
It is going to our expectation. We have seen some benefits from using the motorized pump.

Besides the motorized pump, there are also other alternatives that can be used. For instance the solar pump. Is that something that you have considered?
We have never considered using other technologies. We have heard of them, but never considered to use them. It has never come to our mind to think we can use this. But if technologies were readily available for us, we would opt for technologies like solar.

They also had to go to the market to buy a petrol pump. Is it more difficult to buy a solar pump?
The motorized pump that we have, we lend it. We only buy fuel. We have never considered to check for the prices or the cost of other technologies like solar.

And you are borrowing it from the neighbours?
Yes.

Looking at for instance solar, is it something that they would prefer as compared to the motorized pump?
We have no idea how a solar pump works or what it looks like. We can’t even compare to a motorized pump to say if this technology is better. We have no idea of solar technology.

Basically because they wanted to grow as farmers and grow more, they decided to change from the treadle pump to the motorized pump. Are there plans, or goals as farmers, to develop this farm even further? And is this petrol pump capable to help accomplish that?
One of our goals is to have a pump on our own as a group. So that we are not borrowing anymore and buying fuel for the ones that want to use it. We want to have a pump on our own to do irrigation activities as a group and move forward from there.

Move forward in what sense? Would you want to grow further? Grow more intensively with sprinklers or drip?
Our goal is to grow a variety of crops. Once of the cultivated land has increased, we can have different crops like cabbage, maize, onions, tomatoes and so on for our economic gains.

Annex 3 – Expert interviews

Interview 1 – Expert 1 – Extension Officer Southern Region – Farmers Union of Malawi

11-06-2019

Expert 1 started working for FUM as an Extension Officer for the Southern Region of Malawi in 2011. After studying Agriculture at college he started working for the Ministry of Agriculture where he was an extension officer in the Phalombe District in the South of Malawi for 5 years, after which he started working for The Catholic Development Commission (CADECOM) for another 5 years, followed by World Vision Malawi for another 5 years. As an FUM Extension Officer for the Southern Region and someone with a wide understanding of the agricultural and irrigation localities in the South of Malawi I visited expert 1 in Mwanza.

Okay so in short my research is about basically how farmers make their decision to adopt certain irrigation technology. We know that there are so many different kinds of farmers in Malawi. We have smallholder farmers that are really like poor and also we have middle class and high class farmers. All these farmers make decisions and they make decisions to pursue a certain strategy, to adopt certain irrigation technology. And those choices depend on a lot of things, like for instance finances. How do I pay for the method? How is the maintenance and what uh. What are the running costs? So what in your opinion are the most important variables for farmers to make their decision?

Okay. First of all, as Malawi perspective, most farmers are women. And they are the ones who make decisions to which crops are to be grown and which technologies should be adopted. But now, they are not full empowered. Empowered in the sense that most of them are financially handicapped so it becomes a challenge for them to make informed decisions on farming. They need to be empowered. There is need to form women groups so that they can't be oppressed by men. Because there are some clubs or irrigation schemes, in which they participate communally, and it is always been dominated by men. So it will be better if we form pure women groups so that they can a leading law and so that they can make decisions on their own.

So you think they will make different decisions as compare do men?

Yes sure, because most of the time our culture doesn't allow women to speak when men are there. So they shy away from their views when men are there. So it would be very appropriate if we could form pure women groups or groups which can be dominated by women. Or deliberately electing women to be in high positions.

Okay. And then how would these women or farmers make their decision to adopt a certain technology. You mentioned they might be handicapped they might be in trouble and that might influence their decision. But what other factors have a role to play?

I think as technicians we need to conduct or mount demonstrations in which we highlight the importance of the technology, which we are advocating for. And if possible we should have exchange visits so that they can appreciate from how others have benefited from that technology. I think that can also work better than just preaching the gospel without maybe visiting some sites that have been successful and where people have benefited. It is easier to learn from their fellow farmers than from an extension worker.

Sure. You're mentioning a very interesting point here. What I've noticed so far is that people are familiar with a couple of technologies, but if their neighbouring farmers and the farmers in their community use a certain technology, they are very likely to also adopt technology without maybe thinking too much about the alternatives. You mention familiarizing the people with the choices that are there. Because the "best" choice can be different for everyone. The one person might be able to afford the diesel and the other person might not. So familiarizing the farmers with the characteristics of the technology you say is very important. In literature it's sometimes suggested that the irrigation technology that you are using can give you a certain status. For instance, if you're not irrigating that must mean you must be a poor farmer. And as soon as you're irrigating you have a maybe higher status or you may be more cool looking. In what sort of a way do you think that plays a role in the decision?

It's a lot of behaviour. We need to change the farmers mindsets, because it's not that when you are irrigating it translates to status of an individual. We have different types of irrigation. We have that small irrigation farming which involves the water can and the big one which may require sprinklers. For a small scale or a poor farmer you can easily use irrigation through by the use of watering cans. But now it depends to one farmer which choices they make. Most farmers and communities are used to rainfed agriculture. So I think if we, as an extension worker, we advocate, during extension meetings and so on, the need to use water during winter, that can assist the farmer. But it's not a matter of status. We have certain different types of irrigation. Even a poor farmer can easily use a watering can and have a garden of vegetables. But as you can see there are some streams in the community which are not being utilized even by a poor farmer. It just depends on how this farmer thinks.

Okay. And actually just now we were visiting that irrigation scheme. They were using gravity irrigation with water from the mountains flowing down. One of those things is that if you make a decision for shooting technology that allows you to grow many more crops and even other crops that could make you maybe more money. Now these people, they were actually still growing mostly maize. Normally a farmer might have certain goals, for instance making more money. Making more money requires growing maybe more cash crops and that needs irrigation. But it seems like many people don't implement irrigation to grow other crops and maximize profits.
I think the challenge is, as extension workers, we have not done enough in gross margins. I would have been appropriate if we can develop gross margin for different crops so that the farmers themselves can choose which type of crop they can benefit from. I think these trainings are very crucial, as far as farming is concerned. So as I have already said, there is a gap between a farmer and an extension worker, which needs to be adjusted. It is just a matter of given them a picture and working with them on gross margins.

Okay. Yesterday I was interviewing a farmer (Farmer 1) and he actually studied engineering himself. I already told you about him. He went to school and had a proper education and he's now adopting the Barsha pump. He is making a conscious decision. He knows that this pump, he can pay it off over time and even in the long run it is going to be cheaper, because it doesn't cost any fuel to run. He's going to be cheaper off using this one compared to a diesel or petrol pump. He also said I'm choosing this one because I've seen that we have environmental changes, global warming, and I think with this pump, not using any fuel, I make sure that I do my part to not the pollute environment. Now these two things: running cost, investment cost and the environment. How much do smallholders think about that when making their decision?
I think for smallholder it is something to do with their education level. A smallholder doesn't mind about polluting the environment, ect, because he has no capacity to think about that. What he only thinks is maximizing his production. Through whatever means. He doesn't look that way. So I think there is need to sensitise them, to teach them, to train them by giving them examples on how climate has changed the weather patterns. But as of now most farmers are very illiterate so they are just doing things blindly.

So most of the choice then comes down to: do I have the money or not?
Yes.

Are you saying they are looking for ways to maximize harvest? Not maximize profit, maximize harvest?
Yes indeed, maximize harvest.

And maximize harvest is mostly maximize maize harvest?
Yes maize.

Now in order for them to maximize harvest you also need pumps that have a certain performance. For instance with a treadle pump, you can pump the whole day and you still have pumped relatively little. How do you think the farmers look at the performance at the pump? For instance a bucket or a treadle pump, is performance wise already a big difference, and then moving on to the next technology, for instance the Barsha pump, the performance increases and increases. Now how does a farmer decide where he fits in?
I think that's that depends on how much they have and how accessible the equipment is. Because as you're saying the Barsha pump they have never seen them. We can tell even the extension worker isn't familiar with it. So it's very difficult for a farmer to know this Barsha pumps.
You know extension workers want farmers to maximize production so that they can have more income. They try as much as possible to advocate on usage of very cheap and effective equipment. Many projects have tried before to give farmers engine pumps for free, which after the projects ran out, the farmers did not even manage to buy fuel or to service it when it breaks down. At the end of the day the whole system fails. So as extension workers they are as much as possible trying to empower farmers to use a very simple and very cheap but effective type of equipment for irrigation.

So the government, maybe in the past, thought the right option was to implement motorized pumps. Now they have realized that maybe this is not a sustainable solution because farmers still can't afford it.
Yes.

Because I've spoken to farmers, like the one I visited yesterday in Michiru (Farmer 1), he has now made his own decision to adopt something. But there is a line, maybe depending on how small the farmers are, how poor they are, where it's not them deciding what they are adopting, but maybe the government implements something. A line where they can't make an educated informed choice themselves. But it's other people that basically make the decision for them.

Farmers that are farming in the schemes that have a motorized pump, implemented by the government, do you think that they, when the project was implemented, actually wanted and pump themselves? Do you think the farmers already knew that when the project is gone, this is not going to work?

There are two faces on that one. There are some irrigation sites which is being facilitated by the government or the nongovernmental organizations. For example, World Vision has funding and they submitted proposals to donors. But in the proposal they say they will do irrigation. So they start mobilizing the farmers and telling them about the good of irrigation and the like. So it is like World Vision is bringing an intervention to the community. So they start registering farmers interested to do the irrigation. So they start pumping all the resources to them.
It is unlike the scenario where there is a group of farmers who started it on their own where they come and look for help. They can go to a certain organization who can just assist them to maybe solidizing the scheme or the like. But most of the situations where funding is, the farmers are being driven to where we want them. So that's the difference.

Interview 2 – Expert 2 – Irrigation Extension Officers in Mwanza District – Government of Malawi

11-06-2019

Expert 2 are both Irrigation Extension Officers in the Mwanza District. We visited irrigating farmers in the district, after which we held an interview.

Thanks guys for a nice day out. I learned a lot.
As I have already told you, there are lots of factors that can push a farmed into a certain direction to adopt a certain technology. How does that work here in Mwanza.
Here in Mwanza cost is the most important factor actually. If they cannot afford a certain technology, it is not even an option. The only option that is left is using gravity. Fuel is very expensive and maintenance is high on motorized pumps. This has caused motorized government schemes in the area to not be functional.

Is it just the fuel and the maintenance why the government motorized schemes are not functional?
The problem is fuel. And also part of the problem is maintenance cost. Also, the problem with these farmers is that they wait for the government to maintain their motorized pumps. But actually, they are supposed to maintain it on their own. If the government has just bought an engine for them, you shouldn't expect the same government to come and fix the pumps. If we do that we are not empowering them. We are just supposed to tell them what to do. If they need a mechanic, we can just go there and take a mechanic who fixes the problem. But the farmers pay themselves.

But then why did the government decide to implement these motorized pumps? Is that because gravity was not possible in the area?
Yes in some areas gravity cannot work. What it needs in these areas is a pump to just pump water. Maybe pump to a tank and then the gravity can come from the tank. The places we wanted to go, in Impete, just before the speed humps when you come in, that side. Most of the schemes there are motorized.

But now…the government has implemented these motorized pumps, but now many are not functional and not working. So what is the future strategy for the government and for you. Clearly, these motorized pumps are sometimes not working. So in the future are you going to be careful with implementing motorized pumps?
Of course, for those schemes, we are trying to fix the motorized pumps.

But you just said they must do it themselves?
Yes, it is supposed to be like that. But since they are saying they can't manage…for now I think it is good for us to do that. But the government has to have some solar panels. Some solar irrigation schemes. So that the farmers do not meet such challenges.

Okay. And for the people that can afford it in this area. Maybe middle or upper class farmers. How do they decide which technology they want? Will they still go for gravity?
If there is possibility for gravity, they will go for gravity. But some of them are using motorized pump, but they buy small pumps, like maybe 5 HP. And some they use treadle pumps on their own. Some buckets or watering cans.

And how they make the decision to choose one of these? Depending on the needs? Depending on how much they can pay?
Most of the individual farmers are deciding to have a motorized pump, because that one is relatively cheap and manageable. And the fuel consumption is good. Then maybe treadle pump. Because the treadle pump has no cost. It is their job, their labour.

We've seen a lot of farmers and we've already seen that farmers can be very different. The one is able to make an investment, the other is not. So basically two different groups. One group that is mostly implementing technology was given to them by the government or by an NGO and another that is able to invest themselves. Now for the ones that have been able to invest themselves we have seen that their physical environment has a big impact on which decision they make. If there is options for gravity irrigation they use gravity because it's maybe the easiest and cheapest. But now these farmers down there that we have visited, they have no gravity irrigation opportunities. And we have learned that their decision depends heavily on what you advised them. There are however, several other options. I'm wondering, how you as experts give advice? What do you base your advice on? Do you also look at how much can this guy afford? For instance you have told me there is this government scheme where the farmers were given motorized pumps is not performing well. Maybe that was a wrong decision looking back. What do you look at to give advice?
There are so many factors. One thing, we look at symptoms of course that indicate whether they can manage to buy. Next thing, we look at the source of water. If it is located like downstream they have no choice but to use a modernized bump or a treadle bump. And if their source is upstream, they can use gravity. It depends on what is there.

For the last two farmers that we visited, they are doing good. Especially that one that makes his own decisions. Maybe we can just encourage them to keep it up. I think we can also encourage him if he has something, he can buy. We'll go back to that place, because I have seen he needs some help. Especially the way of irrigating. There is no way you should buy a motorized pump and then irrigate as if you were watering with the watering can. You're getting.

Yes very inefficient.
So he needs something. He needs to be trained. So we will go back.

This guy he was able to make his own decisions, but for instance if he wants to decide to go and buy big big engine…and he is determined to do that. What do you do?
We discourage him. Why? Because that price… And have you seen the river there? It is not perennial. It is very small. If he takes the very big one it means there will be some conflicts of water there. So to manage water there, he is just supposed to take the small one. If he is tapping water, and at the same time the guy's using solar and they will also come up with a treadle pump to maximize their potential. So yes, I think it's not good for him to come up with more than 5 HP. It doesn't make sense. Unless, it would be big river maybe. But right now, it cannot work.

And for instance these young farmer group. I'm not sure if they irrigating every day using the solar pump, but what if they can share? Or is that something that is just going to raise conflict?
I don't know their agreement, but that can work. They can say you are irrigating today. Me tomorrow. That can work. Of course there is already a good relationship between them. As you can see, their equipment. They are keeping it together. And from the past two years they've been using the two treadle pumps together. Yeah we gave them three treadle pumps. But the treadle pumps were not given to that guy (David Chimbuna). They were given to the young group, because the government doesn't help a person by supporting in materials. So we give them the youth club, the 3/4/5 treadle pumps. Yeah, so he's (David Chimbuna) the one who keeps those things and in return he was able to use them. I think if they are able to do that, I think that can be better because, they can share even the cost of fuel. But the problem is that you find that this one willingly found that engine, the motorized pump. That is also why is willingly buying fuel to irrigate. So if they mix up one day…you'll find that he buys fuel and the other guys are not buying. So I think it is better they do it the way they are. He should be using his own. The other use also their own. Otherwise there might be a conflict.

And what I've asked today, to all the farmers that we spoke to, is what factors play a role in your decision-making. And then as I've learned today payment and finance, basically how costly it is, is the most important determinant for them to buy the one thing or the other. Whereas when I'm reading research literature, I also find that they need to be supported, support from their wife, from their community, before they buy. They need to understand the technology. For instance, everyone now understands treadle pumps. Easy, simple, but to really understand how a solar pump works, it takes training and education. But today it did not really feel like these guys, the student group, fully understand the technology that they're using. How it works. It seems that they don't know how they should repair.
Yes that is right. It seems like they don't know. They don't have enough knowledge.

So maybe for instance David, the other farmer. I don't think he really knows how to repair the engine. Or for both the motorized and especially the solar pump, I think it is also very difficult to get a technician for that pump here to fix it. How do you think that also plays a role in the decision-making?
I think those farmers, the youth group, they just need training. The only problem is they installed this solar pump without consulting our office. They were supposed to come to our office first. It is around the corner. The time we were installing, we could have told them what to do. We would have trained them. What I think is just training for the solar. How to use. How to maintain. The same goes for David. He also needs the same for the motorized pump. They will be mixed up, because we can't take only one person to train. We just take them together and maybe train different technologies. For the treadle pump, I already trained them. They know what to do.

And for any other farmers like David. You would maybe still advise him to buy a 5 HP motorized pump. When would you start consider to advise a farmer to buy solar? Or is that something that you don't really advice? Or you just advise that when he's really willing?
If he is willing. And we look at his ability, if he can manage to buy the solar or the motorized pump. And if we see that there is potential, that when he is able to use those, he can make more profit…we can advise him that.

As of me, I don't force a farmer to start irrigation. I even don't like telling a farmer, go and buy this. He should be willing to do it himself. Most of the farmers you have seen, even the gravity ones, they are the ones that came to the office. They said: "We have water, but we don't have expertise. But we are using the buckets." That is when we say, okay lets go see and see the price. We went there to see and saw that there is a possibility of having a gravity irrigation scheme. So we helped them. So you see, they must be really willing. Willingness is very important.
If a farmer comes and says I really need a treadle pump. Please help me to find a treadle pump. If the government gives us a treadle pump, he is the first one on the list. Like the youth club famers. They came to the office. We went there and we saw it was good. So when the treadle pumps from the government came, we almost received 100 of them, we had

to help them, because they really had interest. The same goes for David. David has more interest in irrigation. He is determined to make it work. They are very easy to be helped.

And for instance a motorized pump you have to pay in one go. When you buy, for instance in Limbe or Blantyre, you pay the whole amount at once. But there are also technologies, like actually the one I showed you this morning (Barsha Pump), where you pay a small deposit and then you pay of the pump as you use it over half of your time. Do you think this helps farmers? Is it easier for them to do it that way? Or does it make a little bit deceiving to commit to investments that are simply to large? When sellers say: you only have to pay a little bit now and then a little bit next month and then suddenly the farmers are broke and in trouble. Or does it actually help them if they can for instance pay a pump over a half a year time? Not all in one go.
I think that can help. Considering our farmers, they don't always have enough money. Like David said, he is already saving for a pump he wants to buy later. Which mean that when an opportunity like you mentioned can be found, that can assist and help the farmer.

But only when the farmer has shown he can actually do that?
Yes, and willingness.

Because some farmers might think: I will put all my money down and then I can pay the deposit. And then they can't pay the next month.
So that is why we don't force farmers. Yeah.

But you find it for instance even with cars. People buy cars. They pay for the first month. Then they're broke. Then they can't pay the rest of their car. So it's something that might be good. And it gives them opportunities to buy something they really want. But it can also give them problems. They stuck with this irrigation pump that they need to pay off.
Yes, but we sit down with them and we see how we do it the best.

Okay. Than something else. I also ask David. Some farmers that I have spoken to earlier that were maybe a little bit better educated actually started taking the environment into account, when making their decision. But just to verify. If, like here in Mwanza, people are poor and are having financial issues, that's not something they take in mind?
As for David, I think that is how he responded. Although he thinks about the environment. Most of all, he found it very important to use a technology that will help him do his work the best he can. That is why he want to buy that one, the motorized pump. Regardless of the bad effects and so on. But it is good to tell them. That is why I am saying, they have to be trained. Because after training, that is when they will be able to make an informed decision.
Solar is good. Solar is okay as we are talking about the environment. But according to our farmers, their capability, that is where the problem is. Unless there are some organizations, like this one from Angola, that can help the farmers. We have some big farmers in the area that use solar pumps on a large scale. 500 – 600 hectares. So it depends. If there are some organizations that can help them with a large pump and with construction.

But do you think that this organization gave this young group of farmers enough training to actually properly stand and use the technology.
That solar system was not enough for 15 person. It maybe is enough for one. That area is only good for one person.

But for instance now if there if the pump breaks down. The pump is in the water, there is electricity… it can go wrong like that. Has this organization taught them what they must do now if it breaks down? I think that's very important.
It's important but we can't know because they did not come to our office. I think we will find them because this has to be stopped. You have to come to our office if you want to install such and such. We should go together. Next time. But we also follow it up.

Interview 3 – Expert 3 – Principle Extension Methodologist Officer – Department of Agricultural Extension Services

17-06-2019

Expert 3 is the Principle Extension Methodologist Officer working for the Department of Agricultural Extension Services. I met him at his office in Lilongwe.

Hello my name is Ruben. My research is about how farmers make decisions for certain irrigation technology. And of course extension services also have a role to play in that. If I can I would like to ask you some general questions first. You as an expert, that knows a lot about what is happening in the field, can maybe some answers concerning these general questions. And after I would like to focus on how extension services play a role in that decision-making of the farmers.

So we will start with a general question first. As I have just slightly introduced, there are many irrigation technologies out there. Different options. Farmers have differences sources where they might get their information from, but ultimately it is them making a decision to introduce a certain technology. But there are so many factors that might influence that decision; finance, payment methods, performance of the pump, does it fit in my specific situation, but maybe there are more. Could you elabourate on which factors you think that are very important in that decision-making? Factors that I might be missing?

Okay. For now I would start with three factors. One is in terms of the cost. Most farmers even though they might wish to have a motorized pump, but if they can not afford it, it will still be difficult for them to use a motorized pump.

The other major factor is the cost of the technology. For most farmers they find it easier to just use watering cans, the buckets. The cost plays a larger part. The other element is I think the water. The availability of the water. They might have the pump, but sometimes even the farmers will know that if I put a pump here I can end up almost depleting the water. So maybe if I use lets say a bucket or watering can, I will be able to use this water for a number of times. More sustainably. So sometimes it is the water availability.

The other thing is with regard to topography. If the farmers are on a steep slope, you would find there are certain equipments (technologies) that are more favorable with a topography that is either slopy or that is flat. But if it is hilly, maybe even if the farmer is using a treadle pump, it might be hard, because they will have to pump the water. So sometimes using a motorized pump would be great for them.

The other thing is the size of their plot. If they are farming on a smaller scale, using a water bucket would be enough. But if they are irrigating 2 or 3 hectares using a water bucket might not be enough. So if it a larger scale, if the area that they are irrigating is big, usually the farmers would come together and maybe buy a pump, buy a treadle pump, so that they will be able to irrigate on a larger scale.

What I have learned over the time is that some farmers are finding themselves in a certain situation and they might be looking at what the neighbor is doing. Or what the community is doing. At what is a common technology to use. I was wondering if you give your view on to what extent farmers are actually familiarizing themselves with all the opportunities that are out there. Are they just looking at the neighbor or is there also an opportunity for them to look at the other alternatives?

I would say that in terms of equipment, like the buckets, they are just very common. For the treadle pumps, they are also common, except of the fact that there are different kinds of treadle pumps. There are treadle pumps that are hard to pump, whilst there are other that are relatively softer. For the softer ones and for the farmers that are irrigation a larger area, these softer treadle pumps still need exposure. So exposure comes in different ways. Either they will see a new technology on a neighbors farm, or they sometimes there are, what we call, field days. When we are conducting these field days, sometimes we are also displaying these equipments. We also have, what we call, fairs. Agricultural fairs. In many cases agricultural fairs are conducted at district level and national level. So when they are conducted at national level, there are a lot of companies that will come to display a lot of equipment. In other cases, when there displaying their equipments they have a small plot for demonstration. During these fairs, we will also take the farmers to the fairs so that they can learn. So when they learn and they have interest they get to interact with the business people and they get to access these equipments. But there are other cases where for the farmers there is still need for a scheme. They will need to construct a scheme. That would help them to irrigate. In such cases, with the income level of the majority of our farmers, even though they will be able to appreciate constructing a scheme and designing the irrigation area would be a good thing, but for them to get to that level is get costly. They may not be able to afford it. So usually even though you might take them to a scheme that is well designed and performing, it is not usual that the farmers will take it. That would probably need an assistance form government, in terms of surveying and construction of the irrigation scheme.
So yes we do sometimes take farmers to a field day to see a well-designed irrigation scheme, but it is not a guarantee that they will adopt that, because that is way too costly for them.
For the treadle pumps they are able to pick this from fellow farmers as well as from other business men.

One of the things that you also indicate is that; they might get familiar with technology, but it might still be too costly. But now imagine that they can afford. Recent literature seems to suggest that introducing a new, maybe relatively unfamiliar technology also takes a lot of courage. Some farmers are risk takers. They want to try new things and experiment. But there's also lots of farmers that first want to see someone else use a technology before they do it and pick it up. So do you think that, for instance these agriculture irrigation fairs, are creating enough confidence in a farmer, if you can't afford of course, to pick an irrigation technology that he has never seen before?
Yeah for sure. For government, I remember there was a time government was distributing treadle pumps. But they were the hard ones. So when we took most of the farmers to the fairs and they were able to see these new ones, the newer treadle pumps which are relatively softer, most of the farmers were able to buy them. They would say I think this is good, because with this one I can pump for a long time without getting tired. Whilst for the ones that we were distributing as government. They really needed much more effort. But when we took them to the fairs they're able to see and try it out.

That is definitely true but it is a newer treadle pump. But the basic principle of the old treadle pump and the easier treadle pump is still the same. But maybe for instance just to give an example: solar power takes an investment to implement. But ones you have made the investment it's quite a good strategy because there's no running costs or fuel. Of course the disadvantage is that it's hard to understand and to repair. But also for many farmers it is a thing that they've never seen or seen working. Now to what extent can a trade fair, but also an extension officer, advocating this certain technology help to convince the farmer to do it or not? Or do you think that many farmers will still go for the ones they really know?
For irrigation technologies, I think most of the farmers still go for technologies that would help them to save time in terms of irrigation as well as save energy. If you're using a pump, and the pump is costly an then we will be able to use a solar system. That will help you can easily go for it.
I think what I've seen so far in terms of irrigation and with regard to equipment, usually the farmers would want a better technology. A much more better technology. But the issue comes now in terms of cost. If they are able to afford it they'll go for it. If they are able to afford it they'll go for it. But they wouldn't be hesitant to say I don't think so.
Actually for most of the technologies that are released in irrigation they pick up very fast, unlike maybe crop technologies, livestock technologies. But for equipment, they pick up very fast. As long as the equipment is within what the farmers can be able to afford. That's so far my experience.

All right. Always try to cut down on costs.
Yeah, always trying to cut down on the cost.

Okay. And then going more to the agricultural extension officers and how they communicate about irrigation technology. As you said, maybe in the recent history of Malawi, the government very much advocated for treadle pumps. It's one of the technologies that they've really tried to stimulate, because there are so many advantages. But as of now, how do agricultural officers, besides the treadle pump, look for a specific farmer or a community of farmers to see whether this group of farmers can do something more than using treadle pump? Are they really looking at specific cases to advocate a technology that fits this community? And how? And is there some sort of information on that coming from national level to train extension officers to do this advocating maybe in a more specific way? Besides just doing only advocating the treadle pump?
I think on that one. What I would say is that in many cases when there's a technology that has to be passed on to the extension workers, usually in our case... We as Extension Department, we also have the Irrigation Department and the Livestock Department. So if there's a technology that has been cleared by our colleagues from research, and it has to be passed on to the farmers, usually the extension workers would first of all be oriented to this technology. Either at district level or at EPA level. But now, when they've been oriented on this technology, the advantages of it, the disadvantages of it, then the farmers or the extension workers would then go to demonstrate about this technology. Now when it comes to irrigation I think this is where we have a tricky part, because for the extension workers to be able to demonstrate their technology it means that they need to have the technology at hand to do so. To say these are my farmers. This is a new technology that has just come. I want to demonstrate to these farmers the potential of this technology. But then if they are not provided with this technology it means that even if they have the will to demonstrate and to out scale the technology, they may not be able to do that because they have not been provided with the technology.

So I think the gap, or the hiccup, comes in that sense that sometimes because the technology is not available for the extension worker to demonstrate, it leaves a gap. If anything, then the extension worker can only demonstrate if within the community that he works there's one farmer who has that technology and him as any special that has been oriented on that technology. So he would use this farmer, who has the technology, to demonstrate to other farmers. But I think for government, in terms of irrigation, usually it goes for scheme. The construction of schemes. So in the construction of schemes, for the extension worker, then I think they will just go to demonstrate in terms of scheme operations, scheme maintenance and so on. So in many cases, in terms of demonstration, you'd find that the extension worker will demonstrate at an irrigation scheme that has been well constructed and is performing well. That's where he will go to demonstrate. But for the other equipment's (technologies) the issue mostly is the availability. For me what I know: for the technologies that I've been released, maybe recently, the number one technology that has been disseminated to

farmers is still the treadle pump. So if anything extension has been demonstrating on the treadle pump. But not much on these others. Because the issue is, you need to have the technology to demonstrate. The extension worker needs the technology to demonstrate. In the absence of the technology, with demonstration coming from the government, it would be difficult, because you would be demonstrating but you would still need the equipment to prove that this is what I'm saying.

Because farmers actually want to see?
They want to see the technology.
Because government is not providing these other equipments (technologies) to the extension workers it is difficult. So unless there's a farmer who has the technology, then the extension workers would use this farmer to demonstrate about that technology. But in many cases I think for extension workers, they still demonstrate on the treadle pump. How it can be assembled, how it can be done, how the process can be laid out. And then on these schemes. In terms of government, the government promotes scheme construction. So if you would demonstrate the other things on a scheme basis.

Sure. And then maybe a last question. The treadle pump at some point in time was also subsidized by the government. Is it still subsidized by the government or have there been subsidies for any other irrigation technology?
For now I'm not as sure as to whether the treadle pump is still subsidized. But there are times when government still distributes the treadle pumps to farmers. But I'm not quite as sure as where they are still subsidized. But there are times when government would stay this time we're distributing these treadle pumps. But it's not fully subsidized. It's not fully subsidized as it is with the other inputs like fertilizers and maize or legumes. So the treadle pumps are not fully subsidized, but there are times when government comes in and provides the treadle pumps.

And do they provide for free?
Yeah there are cases when they provide them for free. Apart from that there are also times when the government would provide subsidized inputs especially fertilizers to targeted schemes. Not all schemes but targeted schemes. So there are times when you have the general subsidy which is meant to support rainfed farmers. But there are also times when the same subsidy is rolled out to farmers that are doing irrigation. But it is targeted. Not for all farmers. But it is not as consistent as it is with the subsidy for rainfed agriculture. That one happens almost year in year. For the subsidy that goes to irrigation is not consistent. Here is where you get the subsidy, but there are certain periods where you will not get it.

Interview 4 – Expert 4 – Deputy director – Department of Irrigation

18-06-2019

Expert 4 is the deputy director working for the Department of Irrigation. The purpose of the department is to contribute to sustainable national economic growth and development through enhanced irrigated agriculture production and productivity. The Department promotes irrigated agriculture production and productivity for local purposes and export using irrigation technologies. I met him at his office in Lilongwe.

I am here in Malawi to learn about how farmers make their decisions to adopt certain irrigation technologies. There are many option, but what drives them towards a certain technology… I am looking how individual farmers do this, but also how groups of farmers do this. Also, I am interested to learn how the government, or the department of irrigation, stimulate certain technologies. Or how they try to inform and familiarize farmers. But maybe for now, the first general question is: what ors, which variables actually influence a farmer's choice? There are some many options, and farmers might fit in only certain technologies. But what drives a farmer to a certain technology or to another?

Basically it is affordability. If they can afford a better technology, why not? Looking at the size of the field that they have, the amount of water that is available and then the affordability aspect.

So you are saying that affordability is the main driver, which I have also learned. But are there any other drivers, such as perhaps how technology looks, how familiar they are with the technology, how much of an impact is has on the environment or on the river flow? How subsidies, payment methods or extension services play a role? You say affordability is the most important driver, but how do all these other play a role?

Yeah, those could contribute to the choice, but I think the main aspect is how affordable is the technology and how simple it is to operate and maintain the system. So the operational aspects also come into play.

Elabourating on those operational aspects. We have some pumps like the treadle pumps and the buckets that they use for irrigation, these are very easy to understand and easy to operate technologies. Now, we also have the motorized pump, solar pump and other systems, that maybe for farmers are a little more difficult to understand. How important is that understandability and easy working process of a technology for a farmer to adopt is yes or no?

The example that you have given, the motorize versus solar. The farmers will definitely go for solar, because of the operational cost. They don't have operational cost in terms of solar, whereas with the motorized pump they have to pay an electricity bill, if it is electric powered, or they have to pay fuel cost, if it operated by diesel or petrol. The operational cost of the technology, the maintenance requirements, they come into play when making a decision.

Okay. You mentioned some of the advantages of the solar pump, but of course the solar pump might also have some disadvantages. For instance that people don't exactly know how it works. Spare parts might not be readily available. Or technicians that can fix it might be expensive. Of course solar has basically zero running costs, but the engines in motorized pumps a more understandable and easier to fix. Engines we find plenty in cars and have become part of everyday life. Parts have become readily available and there are people around that might know how to fix it. So what do you think about these disadvantages of solar? Are farmers scared by it?

Solar powered systems are relatively new technologies to be used by farmers. And hence back-up services are not regular available in remote areas, but that disadvantage outweighs the disadvantage of motorized in terms of operational pumps. So farmers still go for solar as the preferred choice, because of the almost zero running cost. When they have challenges they go through the extension system and one or two technicians. They can assistant in the maintenance or repairs that are required.

Okay good. I know there are different forms of solar systems, and different form of motorized pumps as well. The difference between a solar and motorized system, in terms of initial investment that the people need to make to buy it. Is it a big difference between the two?

It depends on the area that has been targeted. In general, solar systems are expensive, because of the panels, the reticulation. Yes, everything is expensive as solar is concerned. Even though the initial investment high, there is a gain in terms of operational cost. There is a big saving on operation costs.

And do you think most farmers are able to realize that in the long-term solar might be the preferred option? Because of the low running cost?

In fact what is happening at the moment, those smallholder groups that have motorized pumps, are requesting assistance to change to solar powered systems. And there are a few that have changed in solar powered systems, because they were not able to afford the operational cost of the diesel.

Okay. I been visiting different irrigation extension officers throughout the country. In Mwanza I learned that the government in the last decades has actually introduced schemes a lot, to make sure that there are farmers groups, and introduced in some schemes the motorized pumps to provide water. But in some situations unfortunately as soon as the pumps were there, the system did not really work because of the high running and maintenance costs. I was wondering to what extent the farmers already knew that they couldn't afford the

pumps? Or is it instead of a problem in terms of affordability, ore more about mismanagement within the farmer groups?
We have farmers that have failed to run motorized pumps. It is not necessarily an issue of high costs, but rather the organisation of the group. Where the groups are well organized, they pay their membership fees, they are able to operate and maintain the systems. But where the group is disorganized, and they are not able to make contribution for their membership, then it becomes a challenge. They eventually end up disbanding and leaving the facilities.

And how does this change when the running cost of the technology isn't really a factor anymore, for instance now with solar? Does that improve management? Or is the issue of management between the farmers still the same?
Management is not necessarily an aspect of the cost of the technology, but rather how the group dynamics are. If the group is cohesive, they operate is as a unit, even if the technology is expensive, they can still manage to operate it. But where the group is disjointed, they don't work as a unit, then it becomes a challenge. Even with a local technology. They might not been able to operate it.

That is a new insight. I thought that one of the conflict that often arises in these groups, is that if one person is paying for the petrol or diesel, and the other one says he can't afford this time, that is where conflicts can arise. You be right that in a cohesive group these issues can be fixed.

Now one of the following up questions that is very applicable to this department is that extension, on a national level and then district and EPA level, is that extension officers are trying to inform the farmers on what technologies are out there, and which might suitable for them. I am wondering, how this process goes? How do extension officers decide which technology might be best for a specific farmer? Which things do they look at? Or do they present the whole spectrum of technologies to the farmers and they say hey you choose? How does that normally work?
The Extension Service gets information from the Department of Irrigation. Technical issues, technical recommendations, technologies that are applicable in the country. They get transferred to our colleagues in the Department of Agricultural Extension Services. And that is the information they pass on to the communities. The farming communities. Where they have got hitches and challenges, they linkup with the specialists in the Department of Irrigation, that are available at district level. And then they are able to get information there. Where they're not able to explain on their own, then they actually invite them to the meetings. Then together they brief the farming communities.

In terms of organizing the groups. We rely on our colleagues in the Department of Agricultural Extension Services. But in terms of technologies, what is appropriate under these circumstances or different circumstances, is that this information is provided by specialists in the Department of Irrigation.

Over the last 20 years the government has mainly also stimulated and subsidized at some point the treadle pumps, because I think for most small farmers this is a step up from the buckets and the watering can. But as of now, is there also a step up from treadle pump to the next level? To the next improvement? This is maybe a more difficult one, because you've got so many more options. A 5 horsepower engine, solar and there are quite some other alternatives. Is there a sort of straightforward technology that the government advocates for? Or is it's basically a specific case situation where you judge which is best?
For groups of smallholder farmers the best technology, that is also preferred by the farmers, are the gravity systems.

Ah yes I have found the same.
The gravity systems. If you look at the area under smallholder irrigation, the gravity systems top the list, because of low operational cost. But where gravity systems are not possible, the option of lifting the water, pumping the water out; the cheapest is the treadle pump, because after all it's the one that uses manual labour in order to lift the water. After the treadle pump the farmer now go into this option of solar. Solar is now the preferred option. After the treadle pump. And then thereafter motorized… yeah it's an option, but it's not preferred, because of the challenges that are related to the operational costs.

Okay. I have also spoken to farmers who said "I like solar but in a season like this one it's cloudy". I also see lots of disadvantages and it's maybe not as flexible as the treadle pump. Mainly these disadvantages of solar might make it inflexible system. Obviously you can fix that with reservoirs or containers, but all these things take quite a big investment and that's why sometimes maybe the farmers choose for the short term less expensive option, namely the motorized pump. If extension officers find a farmer who could actually afford solar system, but this farmer himself says he prefers motorized system... To what extent do the farmers really take the advice from the extension officers seriously? Is it to the extent that they adopt something else than what they think is the best? That after listening to extension officer experts they change their mind and say I will do that?
What normally happens is the options are discussed with the farmers. There's this option for this area. These are the advantages and disadvantages. There's this option, advantages and disadvantages. From our professional point of view we would recommend this, what do you say? So the farmers will always have a say. The technologies are not imposed

on the farmers, but they are made aware of the consequences of each one of these technologies. And the most beneficial option is presented to them. If they agree with us, then we proceed and assist them on that one. If they've got reservations they will tell them and we will discuss some more. That is the process.

What I have often experienced is that some farmers really want to go into irrigation, because it's such a step up from rainfed agriculture. But the goal of the farmers is not always so clear to me. Sometimes I see people that are one a scheme of gravity or are using motor or whatever, who are still just growing maize. Obviously I think that is also a characteristic of the culture of Malawi but that tells me that irrigation is not necessarily a method to maximize profits, but it's more a method to reach food security or harvest maximization. How do you feel that these farming goals differ per farmer or farmer groups?
Previously the focus was on food security. If you were here some years back the Ministry used to be called Ministry of Agriculture and Food Security. So there was a very big focus on food security and irrigation was geared towards improving the food security of the country. But it's no longer the case at the moment. If you look at our policy, which was launched two years ago, November 2016, the focus is to commercialize irrigation and hence at central level our focus is to support medium and large scale irrigation development, with a commercial orientation. The district councils can still support the small, small, small farmers who are geared for food security. So there are two buttons here running concurrently. Food security is not completely wiped out. District councils can support the farmers for food security, central government is looking at our commercial irrigation.

These farmers doing commercial irrigation are mostly diversifying their crops, are looking for markets and their goal is maybe really to improve profits?
Yes and that's why what we're doing is organizing the schemes into vibrant Water Users Association, to make sure that there's efficiency in the utilization of water to attain high productivity, but at the same time we're organizing cooperatives around the produce that are producing the scheme plus the surrounding areas. So that they're able to do proper marketing of the produce that comes from the schemes. So all working together with our colleagues in Agri-business, at the Department of Agricultural Extension Services, as well as the Department of Cooperatives in means of Industry, Trade to make sure that we have a commercial intention in irrigation development.

I think one thing that might also drive the choice to invest in certain technology, is the ownership of the land. If the farmers is farming for someone else, or is farming land is not necessarily his. How do you think that influences investment in a technology?
Land ownership is a critical factor in irrigation. We're just hoping that the new land laws will be able to assist us to drive irrigation in a proper way. At the moment what is happening is there is an agreement between the land owners and the scheme users on how the parcels of land should be used. In some cases during the rainy season the owners take control of the land. Than during dry season it's handed over to the scheme members to use it for irrigation. In other cases the land is given to the scheme. This is your land. You can use it the way it want it. So they use it during the dry season as well as the rainy season under supplementary irrigation. So these two aspects are now in operation. But with the coming in of the new land laws we should be able to move to another dimension.

Then I was talking to a certain farmer last week and he's chosen technology that is just like solar basically. His main driver was A) the low running cost, but also B) the fact that it doesn't have an environmental impact. So it doesn't pollute and such a such. But I'm not sure to what extent you think that farmers or smallholder farmers actually take the environmental aspect into account. For instance he said "Okay I don't want air pollution and CO2. I feel the effects of global warming, I don't want to contribute to that". How much do you think for an average farmer this is an important factor? Or is he one of the only ones?
For farmers that have been supported this far, environmental issues are discussed with them and they are made aware. Because it's a requirement for us if we are to develop irrigation, they are going to have to go through the environmental and social impact assessments. For big areas that is. For small areas it's just environmental scoping. So environmental issues are discussed with the communities and they are aware. And hence the change from diesel to solar. If you ask the farmer why did you change from diesel to solar? One of the issues would be the pollution aspect. Yes, he is going to talk about it.

Do you feel it is more the running cost that plays a major role though?
Mostly it is the running cost. But in terms of environmental pollution yes they are aware.

Okay that is interesting. Most of the technologies often you have to pay the pump, the solar system all at once. But there are certain technologies, actually one is the one that I want to introduce to you now, that have options to pay the system off. So you do small deposit and then you pay off over a certain amount of time. Do you think it is a big advantage for a farmer to make the decision to take such a technology rather than one that you have to pay in one go?
Of course, of course, of course. If there is that possibility of paying by instalments, the farmers will go for that. Rather than one off payment. For obvious reasons.

But can is also be deceiving? Where you say you just have to do a small deposit now. Doing a small deposit might already make the farmer broke and he can't pay for the additional months... or do you feel farmers are conscious that it's not just the deposit but that they need to make sure that he can pay?
He pays for the deposit? And gets the equipment? And starts using it? He makes money out of that. He should be able to pay back.

Fantastic. Then I'm here as a student doing research. But as I said I come from Delft University in the Netherlands and actually there is a group of students that 10 years ago started to come up with an idea; a water pump called the Barsha Pump. They started last year here in Malawi. They're already working in a couple of other countries throughout the world; India, Nepal, etc. And what they've developed is this water wheel. It is a technology that works very well, but only in flowing rivers. The Shire sometimes if it flows fast enough, but mainly the tributaries of the Shire. So this one, you anchor it and it's floating in the water. Or you can even have a standing version. The wheel turns and these spirals that you can see on the on the sides, they scoop up water and scoop up an air column, they scoop up water, than they scoop up an air column, and the pressure is built inside this spiral towards the middle. And this is where you find such high pressure that it spits out the water into a pipe and you can actually pump up to one to two kilometers away and 10 to 20 meters up in height. It basically it's the same as the solar pump where there is no running costs. But what is even maybe better with this one is that it's an very easy principle. When it turns, it works. The solar system can be a little bit more difficult. But I was wondering if you were already familiar with the system or not?
No I haven't seen it.

Because we've already installed a couple of demos throughout the country and actually last week in Zalewa there were some people from the government as well that came to look at it. And I was just wondering about your opinion on one of the issues that this company is having. I'm looking at all these technologies, and because this one is from Delft where I come from I'm also considering this in my pool of technologies. I'm wondering what you think about this technology, but also I had a meeting yesterday with the National Water Rights Association. Since this is institutionalized people are expected to pay for their water rights services. And I was there with one of the ladies from this company and we were discussing with them because the government and some donors wants to help with implementing this technology. But now one of the requirements is that whenever this pump is introduced people need to get their water rights. When we calculated our water rights payments for this pump, it pumps around 20,000 - 80,000 liter a day, which is a relatively low amount. Enough for 1 to 2 hectares. Our annual water fee would come to 10,000 MWK, which is manageable. But now the administration and application fee that this institution now charges 90,000 MWK. On top of the price of these pumps. But even if people get treadle pumps or motorized pumps, they are expected to pay an application fee of 90,000 MWK. To what extent do you think this is something that farmers can actually pay for? For especially maybe commercial farmers, it is possible. But for people that are buying a treadle pump, it is a pretty high amount. What do you think about this value and how the water rights are institutionalized now?
Yes before they raised the application fee the farmers were able to make contributions and make the applications. I think it used to be 3000 MWK. Quite low and quite affordable. Now with this increase, yeah maybe some modalities will have to be worked out. Where groups are big enough and can afford it, why not. Where they cannot, maybe the development facilitator should be able to come in and assist with the initial application fee. While for them (the smallholder famers) it will be the annual fees that they will have to pay. But they will be getting their proceeds from the pump. So the annual fees they should be able to pay.

I can agree with that. But for me the strange thing is that big users like ESCOM use 4.6 million cubic meters per day and now there are small farmers using 20 cubic meters per day. Thee application fee for the one and the other is still 90,000 MWK for both. It's two different worlds and my thinking is that this is going to cause problems to really institutionalize and regulate the water rights.
The application fee is the same because the process is the same. So it goes through the same process. Where you are using 1 liter or 20,000 liters the application process is the same. That's why the fee is standardized. But the difference comes in to the annual requirements. We pay more when you use more or less when you use less.

Yes I understand that, but the application fee, with the one using so little, while the other is using so much, I think to make it work there might also need to be a difference in the application fee. Perhaps.
Maybe. Maybe if they can have a different system where the amount of water use is low so that this process is cheaper then rather than having the same process for everyone.

Okay good. And what is your impression about this technology?
This is quite good. Who is the contact person?

Is there an office in Blantyre. There are currently 4 employees. And we have some demos throughout the country, one in Zalewa, one Ntchisi, one in Michure next Blantyre, and there are a lot of people that are interested in this technology and that are willing to buy.

Interview 5 – Expert 5 – Irrigation Extension Officer – Department of Irrigation – Ntchisi

19-06-2019

Expert 5 is an Irrigation Extension Officer working for the Department of Irrigation in the District of Ntchisi. After traveling into the field to visit irrigating farmers in the area, we had an interview in her office in Ntchisi town.

A couple of questions to you specifically as an expert. First of all, you saw the Barsha pump this morning for the first time. What did you think?

It is a very nice technology to me. First of all, it doesn't need energy. The energy just comes from the flow of the water. Not a human energy. The other thing, it is cheap. I don't see it costly unless those flaps and spirals ware out.

Ah they will not ware out quickly.

What about the pipes?

The pipes are just like any other pipes.

I have watched the pipes and at least from looking at them, they are at least hard and thick. They will not ware out in one or two or three years' time. Unless you are careless. But it's a good technology. This is my first time to see it. I've liked it so much and I can even encourage some of the farmer groups which can afford to buy it. Of course at 950,000 MWK for a group, it is expensive. It is expensive to a smallholder farmer.

The pump itself actually is 850,000 MWK. But the pipes add to the price.

Okay so 950 (thousand MWK). Yes to smallholder farmers, it is expensive. But to commercial farmers it is not. Like those farmers we have seen (Annex 2 – Interview 6). That thing, they can afford it. And it can be so beneficial to them. Yeah. They can benefit a lot.

They don't have any maintenance or running costs.

The other goodness is, it's 24/7. So they can use it night and day.

One farmer that is in Michiru, in Blantyre. He's using it and what he's doing is irrigating during the day and then during the night he fills his pond. So that he can also irrigate more during the day. But this pond is not just a reservoir. It is also a fish pond. He is doing fish farming. So that's one extra thing you can do with it. During the night, you fill your reservoir.

Allright, we can encourage farmers to do that. They can use it as a pond. They can construct a reservoir and put some motor in there and us it during the day.

The other people can use the water during the day with the direct pumping. The others can use the water which is in the reservoir. That can be so good. Yeah I think I can even say if projects or in NGO's are looking for technology, I prefer to use this one. Even rather than using the treadle pumps, the motorized pumps. This one is good.

No I think so to. That's why I also so enthusiastic about this technology. What I feel is that some farmers are only aware of certain technologies that are common. The treadle pump, the bucket, motorized and solar. Those are the technologies that the farmers know. But the Barsha is not familiar yet. So for them it is not an option if they don't know it.

Yes they don't know it. Even for that one. If we, the irrigation engineers, if we can be selling out, telling farmers about the technology. Or even as a department, if they can add on the Barsha pump as one of the technologies, I think people they're going to adopt it.

So what must happen in order for that to happen? Farmers using it can be a demonstration.

Yeah it can!

The Barsha pump can be an example now. But how we or you as irrigation officer familiarize farmers with the possibilities? The Barsha or any other technology. Some people they might not even know that solar for instance, is an option.

The only thing is farmer tours, officers tours, to go and see the technologies. After that, we can sell it out. Or as I have already said, if the department can include it in the irrigation technologies. We have the bucket, we have the motorized pump, we have the treadle pump, we have the solar. If that can be included in that means it will be more selling out on the technology. We can have farmers from Zomba, from Mulanje, to go and see. That means we are selling it out that we have this new technology.

And in order to do that... I'm not sure you agree. Farmers sometimes if they just hear about it, they'd be OK. But they want to see it and see it working and touch or whatever. I think that's is also important and it's nice that there is now one here for farmers to see. One thing that doesn't concern a technology, just any irrigation in general. I become aware that now the national water rights authority is now institutionalized/ So water users,

that are not using the water for domestic purposes but for irrigation, now officially need a water right. And I actually visited their office the national water rights authority office earlier this week with someone else of the Barsha pump team. In order for the Department of Irrigation and for government to advocate this technology, they say okay we must make sure that when people adopt this technology they must have water rights. It's the same for the treadle pump, or the motorized pump for anything. I'm not sure, this is maybe a relative new thing...how many people actually that are irrigating have official water rights or not?
So many farmers they don't. They don't apply for water rights. They just use. It's only the farmers who are cultivating on a big area and are abstracting more water from the river. Those ones, we normally put them to fill the forms of the Water Resources Board. But not all farmers have it. It's something that we have to work on. That every farmer who abstracts water from the river has to have it right. Because it's a affects this farmers, because if the up-stream user broke the water the downstream user has a problem.

No, that's also what they said during the meeting. But one of the problems I think is that for a treadle pump, the Barsha pump or any other pump, they now have a minimum, annual fee every year, which is 10000 MWK a year. That's sort of OK I assume. But now there's the application fee, that every farmer or even ESCOM as a huge user or the big commercial farmers and small farmers using the Barsha or the treadle pump, need to pay. Previously it was 3000 - 4000 MWK.
It was 3000 MWK.

You know what it is now?
No.

Ninety thousand.
Ninety? Farmers can not afford.

No I agree. So I don't know...
Ninety thousand MWK?

Yes.
That's too much. From 3000 to 90,000 MWK. Annualy?

The application is 90,000 MWK and then annually 10,000 MWK.
Last time it was 3,000 application. Annually it was 1,000 MWK for some of the sites. Others were paying 2,000 MWK. Depending on the land and so on.

Even now it's still according to volume, source and abstraction of water. So we calculated with this formula that for us, for the Barsha pump, they used to pay 500 MWK a year. But now they've said that's too little. Even if you're using less the minimum for any farmer is 10,000 MWK a year.

Anyway I'm seeing some problems there. People can't afford that.
They cannot.

Even when they have a treadle pump, that's what they must pay. So that to me is in general an issue now. I just wanted to ask you what you think about it?
It is expensive and farmers they can't afford it. They'll end up just having these rules on paper, but not having it actually implemented on the ground. They will have more problems to collect that money. If they were not able to pay the 3,000 MWK... what about the 90,000 MWK? They can't.

I agree... But as of now we have seen that farmers make their own decisions to adopt a motorized pump or to adopt Barsha, or anything else. We've already seen a couple of things that they base their choices on. On the money, on the payment method, etc. We also already said that the technology that they're not familiar with, they're not going to use because they don't know they don't. But what other sources, besides from information from you as irrigation engineer, do they take information from to base their choice on? On radio, on their neighbor, on you? What other information is out there that they look for to base their decision on?
I think the only thing that we can do is we should have farm exchange visits. Like for the farmers we visited today, gather with a group of farmers and show them. Gather and show them a gravity irrigation site, show them a field tour. So that they can compare for themselves!

Is that something that's already being done or not yet?
Not yet. Not yet for the Barsha pump.

But we are planning to maybe do it in the future?

Yeah we can do it. But have never planned for that. We have done it with other farmers, but not for this technology, but for other technologies. Like for gravity fed, motorized pumps, solar pumps, drip. Yes we have those exchange visits. But I think that one (Barsha pump) is more better than the treadle pump or motorized pump.

I agree. You need to have water and a flowing river, but in that situation it is the best.
We already saw today that they some farmers might have different goals, farmer goals, compared to other farmers. For instance our visit in the morning, they had farmers dreams. Building a nice house, etc. etc, but they were not really acting to realize their dreams. So in order to achieve those dreams you need to use your water efficient efficiently. You need to grow as much as you can. But even though they had these dreams, and they had the technology (Barsha Pump), they were not really realizing these dreams. With the Barsha currently. Hopefully in the future. How do you think this certain goal that they have as a farmer influences their decision to introduce a certain kind of technology? Maybe a farmer who is not really ambitious might just go for a treadle pump. A farmer who is very ambitious however go for something else.
I think we have to convince farmers on these technologies. If we train them and tell them. The problem with us Africans is, we don't just believe in theory and hearing, but we believe in something that we have seen with our naked eyes. If there are other farmers that have done better than these farmers with that technology. If they go and see it, and compare where they are, they boost up their moral. So with what they want, they can do it with purpose. They have seen somewhere that other Malawians are doing the same thing and they are flourishing. But if they have just been told this and that, no…they won't adopt very easily.

Okay great. Two last questions. One thing, that I am checking if you agree, it is quite important for a farmer to understand the technology. To be taught how to use it. And we have seen today that, in this case with solar, it failed. Solar might also be difficult, but is it easier for a farmer to go for a technology that is easy understand? Like a treadle pump. Easy to understand. Even the Barsha Pump. As it turns, it works. Does that help to better understand and be convinced of the technology?
Yes, absolutely.

Some people solar is good, but then as soon as something breaks they don't know how to fix it. Even for the motorized pump, there are enough technicians. But for solar it can be a problem…

Okay last question. Some farmers think that the environment is quite important. Mostly these are educated farmers. They say motorized pumps are bad for the environment, they pollute and so on. That is why I am choosing the Barsha Pump. Because it doesn't pollute the environment. Do you think that this is something that only the better educated farmers think about? Or does every farmer, also the poor farmer, think about it?
Even the poor farmers think about that. I can say they will even ask their colleagues who have done that before: how do you irrigate your crops? When they hear what the other farmers have gone through, that is how they decide what they will go through.

But the main thing is not environment? Is environment on place number two, three or four, but number one is always costs and payment?
Not much. That factor (environment) is not very common. Environment is not. Environment is not one of the contributing factors that determines people to say I can't go for that.

And what would you consider the main contributing factor then?
The main contributing factor is cost. Main, very main, is cost. How costly that thing is. The operation. How costly it will be.

Interview 6 – Expert 6 – Intern Irrigation Extension Officer - Department of Irrigation – Ntchisi

19-06-2019

Expert 6 is an intern at the Ntchisi Irrigation office. Doing an internship at an district irrigation office somewhere in the country is part of the study curriculum. During my two visits to Ntchisi expert 6 joined me in the field, helping as an interpreter. During an interesting conversation I asked him if I could record our talk and us it as an interview. I started the interview halfway the conversation.

You started by saying that there are quite some gravity irrigation schemes with 150 farmers and that there are only a couple of individual farmers that do irrigation. Can you repeat why there are only a few?
There are a few just because most of them, most farmers, actually don't know the importance of irrigation. Because of that they are lacking the knowledge. Where there is potential irrigatable area however, we do sensitize them.

As an officer you try to promote and advocate irrigation, because it has so many advantages. How do you do that?
We do promote the irrigation system by giving them civic education on the importance of irrigation. Especially here there is a potential for irrigation. We try to convince the farmers to start irrigating their land and crops for an extra source of income.

You mentioned that some people use gravity. And that some people use the treadle pump. Are there also other technologies that other farmers use?
Yes they do, but it expensive. Like motorized pump, where they are required to fuel it and have a maintenance. Because of those costs, it is like a burden to them. Since it is only a small group of people. And it is not a developed one. They are lacking fund to maintain the machines.

You mentioned that the motorized pump is expensive because of fuel and maintenance, but now there are also systems that don't need fuel at all. The solar system for instance and there is also a pump called the Barsha Pump. I will tell you about that one a little bit later. Is the solar a system that the farmers take into consideration?
Yes as of now, as irrigation officer we are trying to promote running away from the motorized pump to solar. This is because solar uses free energy. Maybe if they can operate with that one it can be better than with motorized pump. To learn away from costs like fuel. And maintenances is a little bit cheaper compared to the motorized pump. So as officers we are trying to encourage to use solar instead of the motorized pumps.

And what is the biggest obstacle for farmers to adopt solar?
As here, we have some seasons. This season we have a challenge of sunshine. Because of that the solar pump can't work properly. And mostly during the dry season, summer, there are very few months (August, September, October) were irrigation can take place, compared to the normal ones (other irrigation technologies) where the season is a little bit longer than those few months August, September and October. So the main challenge is the weather.

Some people are also not very familiar with how solar works. For instance a treadle pump is easy to understand for a farmer. Bucket irrigation even simpler. Gravity, simple. But than going to motorized and even solar, things get difficult to understand how the pump is working. Do you think farmers are discouraged by that? Because they think "Ai this is difficult.
Yes that is also another challenge. How to inform them about how the solar pump works. And how to maintain them is also another barrier for the local farmers. And how to utilize it properly.

And do you try to train them on how these things work. Or how do you try to take this "barrier" away? The barrier of difficulty.
Yes as it just started. At the office we try to train them, before we deliver them the system. Such that the people should know cats and dogs on the system were are trying to implement. If we see that there a lot of challenges, they are not fully convinced, we keep on teaching them on how good the system is compared to gravity and treadle pumps. So why try to teach them in such a way that they understand it better than treadle pump and gravity.

And do you think there are any factors that influence the choice of technology besides the costs? Some people say that by getting a solar pump it gives you a sort of status. Or the motorized pumps is making a lot of noise so it is cool. Is there thinking like that, that influences the choice? Or you don't think so?
As of now, I don't see these sort of things happening.

Interview 7 – Expert 7 – Chief Irrigation Officer – Government of Malawi – Department of Irrigation – Zomba

27-06-2019

Expert 7 is an Irrigation Extension Officer in the Zomba District. She studied irrigation engineering at Lilongwe University of Agriculture & Natural Resources and started working for the GoM right afterwards. She first worked in the Phalombe district as an Irrigation Extension Officer for 4 years, before heading to her current position in Zomba. I already visited two informal irrigation schemes with expert 7 in 2017 that have received GoM extension services and are going to receive development interventions in 2017, from World Vision and the GoM Lower Shire Basin Management project respectively. This time I spoke to her during the Irrigation and Manure Launch in Zomba.

I have already briefly introduce my research topic, but I will quickly do it again. Basically I have come to Malawi to understand what drives farmers to make certain decisions concerning irrigation technology. So why are they choosing a treadle pump? Or why are they using an engine or solar? What drives these sort of decision? Now obviously you as Irrigation Officer in Zomba, you have specific about this environment and what farmers make for decisions here. So I am wondering what you would answer to this first general question. What drives farmers to adopt certain technology?

What drives the farmers to choose any type of technology. Lets say they go for treadle pump. Why? Gravity fed. Why? Okay.

Basically what it takes for a farmers to choose a thing has several factors. The factors that suite that technology. For example, the availability of water. And also, the source of that water. If there is a lot of water and the source is quite good, and the river is not that deep, then the farmers can go for gravity fed irrigation. Because the water is easy to be diverted from the river into the fields. But if the river is deep the farmers might go for other technologies, such as motorized pumps, treadle pumps or sometimes watering cans. But now these technologies differ in terms of cost. So another factor is cost. Financial muscle of the farmer. If the technology is expensive, the farmer might not go for it. For example the motorized pump. Not all the farmers have motorized pumps, because of the financial aspect attached to it. So most of the farmers they go for the treadle pump. Because they are cheaper and also because when the river is deep than they are actually able to tap water from that river. But the cheapest is the gravity fed systems, but because the availability of water in most of the rivers is not quite that simple. Most of the rivers are deep. Not all of the rivers are shallow. And on the issue of cost, there is the option of using solar. Such technology is a little bit expensive. It is cheaper in terms of running costs. The energy source is costless, but installation is quite expensive. That is why you find that farmers are not that able to adopt that technology; the solar system one.

So the factors are: cost, source of water and also how deep the river is. I think those are the main factors that affect farmers. Of course there is this aspect of weather, the type of crop… For instance, if they (the farmers) might go for drip irrigation, some areas might not be suitable for drip irrigation. Maybe because of the landscape. That might also affect farmers. But drip is also quite good, because it is economical in terms of water. But now, it is quite expensive for a local farmer to access the whole set. So I think the main factors are: cost and the availability of water.

And these solar systems. Where there is no river, they are using groundwater. That means a hole has to be drilled in order to tap water from the ground. And that is expensive. A local farmer cannot be able to drill any type of borehole. It needs some good amount of money. Maybe only donors can be able to provide for that. So the main factors are: cost and the availability of water.

You mentioned it briefly, but for instance if a farmer has a goal to use drip, you automatically need to choose different technologies. For drip for instance, you need pressure, so maybe that make farmers exclude the treadle pump in their decision. How does that work when you want to use sprinkler or direct application? In what way does that influence the technology choice?

Can you come again?

Basically I am asking questions that I already sort of know the answers to. But I am wondering what you think about it. You said for drip, you need specific technology. You can't really use gravity and drip, or at least that combination is rare. But if you for instance have the goal to use sprinklers. How does that influence the farming decision? Basically what I have seen over the last days is that still many farmers are using gravity and furrow irrigation or direct application. But for instance if they want to move on to a better technology, or a better more advanced irrigation method, like a sprinkler, how does that influence their pumping technology? If they want to move on and develop from furrow irrigation, they need to go and buy a motor, or use solar or the Barsha Pump. And that is quite a big step up in terms of finance and cost and maintenance. To go that extra step in developing your farm… it is quite a big leap from gravity and furrow irrigation to the next step.

It is like what influence can be there for a farmer to adopt these other technologies? For them to move from one thing to another? Maybe leaving gravity fed and lets say adopt the Barsha Pump?

Yes exactly.

Most of the times, what can influence the farmers is the efficiency. How efficient is that pump? If we demonstrate with them and show how efficient the pump is, or the system is, that can definitely motivate them to go for that system. Maybe in terms of water management it is quite efficient. Because nowadays, most of the rivers, most of the water sources, they are drying up. If there is something that is more efficient in terms of water management farmers will go for that.
Another thing is that in terms of maintenance; how simple is that system? In terms of maintenance. Because you know, most of the challenges in Malawi are marketing. And if the farmers harvest the crops its is somehow difficult for them to realize a good amount of money from that harvest. So for them to sustain the system, is quite difficult. If the system was good in terms of maintenance, they will also go for it. Because it means they won't have problems in terms of maintenance. Maybe they will be maintaining using a small amount of money.

You also mentioned briefly that the market might play a role. For instance if they want to grow bigger, develop their farm and be more efficient this will mean they also will produce more. How important do you a safe and secure market is, and how does that influence the confidence to invest?
In term of market? The market is a harbor of how the farmers are going to realize income from their harvest. It is the core. After everything is done in the field, next is market. So if this market is available, it is one of the most important things that can motivate and drive the farmers motive to actually continue farming. So basically what we do, through other departments like Agribusiness, we do encourage our farmers to practice in a group. To form cooperatives with which they can sell in groups. Through these groups it is much cheaper, unlike selling individually. Because selling individually, the farmers might have few things to sell, but as a group they might have more things to sell. They might find a good market, maybe they can supply a shop like Shoprite. So through that they can get more money.

So you say if they have a safe harbor, a safe market, that also gives them more confidence and more trust that their investment will ultimately earn them more money?
Yes market is very important for farmers.

What I have also noticed is that some people are just not familiar with some of the other technology options. For instance we were visiting a place yesterday and they were using an engine. I asked them if they thought of different options than adopting an engine. Buying solar instead of the engine for example. And some farmers are not really aware of some of the other technology options that are out there for them to buy as an alternative. So for me, it seems like familiarization with the technology options is very important. How do you think about that?
Yes it is very important for a farmer to actually know there is another option that might be better than the one that they are using. We need to expose them to those technologies. So that is very true. And maybe for example, the Barsha Pump that you bring, what we can do is take more farmers from other areas to see that pump. Maybe the can them to understand what is happening and they can make a decision.

Yes exactly. Because there are different levels of familiarization. First level can be that you have seen it in a flyer or on TV. Next step is that you actually see it physically. Next step is you touch it. Next step is you see the neighbor using it. With these different levels and steps of familiarization… where do you think farmers start to be convinced of something? Some farmers, as soon as they hear something on the radio or see something on TV, they can buy. But maybe for most farmers that is a little different.
Of course some farmers are quick to listen and also to adopt. Even if they hear it from the radio or from word of mouth they can adopt it. But that is a very small number of people. You know a farmer is an adult. So mostly adults they learn through seeing and physically doing the thing. So I think the best way for farmers to adopt is to expose them to those technologies by physically seeing the thing being used and done. We might take the technologies from somewhere and bring them to a place where they can see the actual thing being used. That is the best way in which a farmer can learn, because they are adults. Unlike just telling them through flyers.

So for instance today, we are demonstrating all these technologies here. This is maybe the first step for farmers to get to know the technologies. Do you think an event like this is really building enough confidence for farmers to adopt?
Yes it does, but mostly they adopt it fully if they see it from their fellow farmer using it. If they just see it here they will say: "No, it is a matter of demonstrating. That one is expensive. Nobody can do it". But if a fellow farmer is actually using it, they say: "Ah it is possible. It can be done". If a fellow farmer is doing it, I can also do it.

You also mentioned that ownership can be important. I have learned some farmers lease the land, or it is not their land but they are allowed to used it. To what extent do you think that lack of ownership actually influences the willingness to invest in a new technology?
Greatly. It affects the farmers greatly. The issue of land is one of our challenges as far as irrigation development is concerned in Malawi. What happens is if a development is coming, or a technology is coming to a particular area, irrigation mostly happens on a small piece of land, maybe 10 hectares, belonging to a few individuals. Maybe 10 people. Or 5 people, or 2 maybe people. But what we expect is that that land will be used by maybe 50 people. Just an example. By then those 50 people, or maybe 40 people, they don't have part of the land. Now these 10 people who own the land physically, they may accept it at the beginning that they will give away their land for the development of the community.

But now the problem is, where the actual irrigation has started, the farmers, the owners, they change tune. They say: "no, you cannot irrigate on my land freely. You have to pay". They may even say: "You pay maybe 10,000 MWK. Maybe even 20,000 MWK". You see. A thing that is not easy for all the farmers to manage. So what we do from the beginning, before the actual development takes places on the ground, we take the land owners to sign a land agreement. They have to sign it that they have given op their land for development and that whatever will be happening during irrigation it won't be part of their concern. It will be managed by a committee that complies of the landowners and even other members that do not own land in the scheme. Those people that just come to irrigate and do not own the land, they need to have ownership of that land. That one is a havoc, friction for development. Otherwise, if you don't do that the scheme might be abandoned.

Like you see to many times…
Yes it is a quite challenge. You have to do it directly to it at the beginning of the development. Don't wait to actually develop the land.

Obviously in terms of irrigation, first you need to do an investment and afterwards you hope to earn more money back. Unless you do gravity or bucket irrigation, with which you need human investment. But basically it is about an investment and then having more harvest and profit afterwards. So there is this cost and investment that come along when you want to do irrigation. I have learned now that the government wants everyone that is irrigating to have water rights. Especially now with the Barsha Pump, we are running into a bit of trouble. We are obviously looking for the NGO's or the government to work with us, to support us and to advocate us. The UNDP or the government have certain milestones that we need to confirm with before they will actually help us. Like we need to arrange that the farmers that implement the Barsha Pump acquire water rights. And water rights previously only used to be 3,000 MWK for application and then an annual fee. But are you aware that the Water Right Authority has now been in institutionalized?
You mean the price has gone up?

There is now Water Right Authority office. First it was inside agriculture, now it is outside and it is a separate entity. And the water right application has now gone up in price.
Yes that I am aware.

Do you how much?
Is it 80,000 MWK?

It is 80,000 plus 10,000 MWK advertisement. So 90,000 MWK
90,000…

How do you think this influences farmers to develop? Because it quite a significant amount of money.
Yes it is quite a lot. Obviously it is going to affect our farmers. Because for them to apply for water rights before was quite cheap. Now you can imagine from 3,000 to 90,000 MWK… that is quite a lot. Before we were having for problems to convince our farmers to pay that amount of money, 3,000 MWK.

And now?
It will take us more time to convince them, because the money is quite a lot. And I am not sure in terms of the rest that they are supposed to pay annually, because before it was quite cheap. But if the application has gone up, definitely the annual fee has also gone up.

The annual fee, for instance for using the Barsha pump, should be 600 MWK a year. But now what they have done is that for everything that is under 10,000 MWK, you have to pay 10,000 MWK. So they have put a minimum. So for this one (Barsha Pump), but even the treadle pump, you have to pay 10,000 MWK.
You can imagine. It means we are going to have challenges with our farmers. To convince them they have to pay for that. It is a bit of a challenge.

As an extension officer, you try to inform the farmers and make them aware of all the technologies. To what extent do you think they listen to your advice and maybe adopt what you advise them? To what extent does your advise as extension officer influence their ultimate decision? They might have other sources of information.
I think as extension workers, we contribute more. As far as farmer decision-making is concerned, what we say to them carries more weight than hearing from another farmer. Because they believe in us.

Even more weight than the neighbor that is using it?
Yes they believe in what we tell them, but mostly what they see with their eyes physically. Is what carries most weight.

Annex 4 – Q statements as identified through literature & interviews

	Q sort - Decision making irrigation technologies
	UMBRELLA QUESTION FOR THE Q-SORTING
	What are the most important decision making elements for me as a famer in adopting certain water pumping technology for irrigation?
	The characteristics of the water pumping technology
	Financial aspects and affordability
1	I would prefer to pay for the technology through installments over time
2	I want the overall costs to be affordable
3	I dont mind paying fuel/petrol/diesel to keep the technology working
4	I want the technology to give me short-term financial gains
5	I want to pay all the costs of the technology up front
6	I am not going to invest in new pumping technologies because I have other farming limitations that need investments
7	I am not going to invest in new pumping technologies because I think it is too expensive
8	I am not going to invest in new pumping technologies because I am saving money
9	I prefer to adopt a technology that is subsidized
10	I don't mind paying periodically for the pumping technology (renting)
11	I prefer to adopt and pay for a technology collectively with a group of farmers instead of individually
12	I don't want to invest in irrigation pumping technology, because I prefer to wait for a donor to give it to me
13	I prefer to adopt a more expensive technology but safe on running cost later on
	Management
14	I want the technology to be easily manageable
15	I find it important that it is easy for one individual to operate the technology
16	I would prefer if the technology is owned and managed collectively
17	I find it important that the pump is easy to move around
18	I want the pump to be easy to store away during the night
19	I find it important that the pump is hard to vandalize or steal
20	I prefer the pump to be fixed in at one point
	Technology characteristics
21	I am happy with my current watering method so I am not looking to invest in other irrigation technology
22	I want spare parts to be readily available
23	I want spare parts to be cheaply available
24	I want my irrigation technology to look cool / give me a better image in my community
25	I want the technology to be newly available on the market
26	I find it important that the technology is easy and cheap to maintain
27	I would prefer a pump that uses clean energy (not diesel or petrol)
28	I prefer a pump that works automatically without human power
29	I choose an irrigation technology that can give me a high volume of water
30	I choose an irrigation technology that can give me a high pressure
31	I choose an irrigation technology depending on the range of pressure and volumes it can provide me
32	I want the technology to enable me to grow whatever crop I want. (and not push me towards growing a specific crop)
33	I want the technology to enable me to produce more crops and expand my farm
34	I want the technology to improve my food security
35	I would like to convert to a technology that enables me to use my water more efficiently
	Environment
36	I find it important that my irrigation technology is not impacting the environment negatively by emitting polluting gasses and smokes
37	I prefer a pump that doesn't need fuel
38	I want to protect the environment
39	I don't mind watering the crops myself without the use of a pumping technology
40	I want it to be easy to change the technology afterwards adaptation
41	My water availability and water source determine my technology choice because I don't want my source to run dry
42	I want to adopt the technology that is the cheapest fit in the natural landscape of my farm
	Characteristics & circumstances of farmer within their (social) environment
	Community
43	The active emotional support of my family
44	The support of the rest of the community
45	I want the technology to enable me to grow more food
46	I want to produce food independent of the rains
	Market
47	Before I invest and adopt an irrigation technology I need a secure market where I can sell my crops
	Ownership
48	I don't want to invest in irrigation pumping technologies since I don't own the land on which I farm
49	I don't want to invest in irrigation pumping technologies since I can't expand my cultivated area
	Agricultural extension services
50	I prefer a technology that has been advocated by the exentsion officers
51	I want the agricultural extension officers to be able to give support if I have problems with my technology
	Company relationship
52	I want to be actively supported post-implementation by the company selling the technology
53	I want to have a history of a respectful relationships between farmers and the advocates of the technology
54	I prefer if the company representatives are Malawian
	The process of learning and experience
	Familiarity
55	I find it important to have heard about the technology before I adopt it
56	I find it important to have seen the technology working in practice before I adopt it
57	I find it important to try out the technology before I adopt it
58	I prefer if other people that I know have succesfully tried out the technology before I adopt it
59	I prefer to adopt a technology that is widely used by other farmers
	Understandability
60	I prefer technology that is easy to understand (or do I need new skills)
61	I am interested in how the pump actually works

Annex 5 – Q-sort statements

	Q sort - Decision making irrigation technologies	
	English	**Chichewa**
	UMBRELLA QUESTION FOR THE Q-SORTING	**UMBRELLA QUESTION FOR THE Q-SORTING**
	What are the most important decision making elements for me as a farmer in adopting water transport technology for irrigation?	**Kodi ndi zinthu ziti zofunika zimene zingandipangitse ine ngati mlimi kusankha njira ya makono ya mthilira?**
	The characteristics of the water pumping technology	**The characteristics of the water pumping technology**
	Financial aspects and affordability	**Financial aspects and affordability**
1	I prefer paying through installments over time.	Ndikanakonda kuti ndizilipira pangóno pang'ono.
2	I want overall affordable costs.	Ndikufuna mtengo wabwino.
3	I don't mind paying fuel to keep the technology working.	Ndikhoza kulipira mtengo wa mafuta kuti machine azigwila nchito.
4	I am happy with my current pumping method. I don't want to invest	Ndine okhutitsidwa ndi njira ya mthilira yomwe ndimagwilitsa ntchito. Sindikufuna kuononga ndalama pa njira imeneyi.
5	I prefer to wait for someone to give me an irrigation technology.	Ndikhoza kukonda kudikira kuti munthu andithandize kupeza njira yothilira
6	It is too expensive. I don't want to invest.	Ndizodula kwambiri. Sindikufuna kuononga ndalama pa njira imeneyi.
7	I have other farming limitations. I don't want to invest.	Ndili ndi zovuta zambili ku nkhani ya ulimi. Sindikufuna kuononga ndalama pa njira imeneyi.
8	I prefer to use and pay for a technology with a group of farmers instead of individually.	Ndikhoza kukonda kukhala mu magulu mu nkhani za ulimi kusiyana ndi kukhala pa ndekha.
9	I prefer to adopt a more expensive technology but safe on running cost.	Ndikhoza kukonda kugwilitsa ntchito njira ya ulimi yodula yomwe sili yoononga ndalama.
	Management	**Management**
10	I find easy individual operation important.	Njira yosavuta kugwilitsa ntchito ndi yofunikila kwa ine.
11	I find easy maneuverability important.	Njira yokuti utha kuyinyamula mosavuta ndi yofunikila kwa ine.
12	I find it important that the technlogy is hard to vandalize or steal.	Njira yokuti anthu aupandu sangakwanitse kuononga mosavuta ndi yofunikila kwa ine.
	Technology characteristics	**Technology characteristics**
13	I want to be able to maintain the technology myself.	Ndikufuna njira yokuti ndikhoza kukwanilitsa kusamala.
14	I want it to be cheap to maintain the technology.	Ndikufuna njira yosaononga makodili.
15	I want my irrigation technology to give me a better status in my community.	Ndikufuna njira ya mthirira yokuti anthu a mmudzi mwathu akandiona azitha kuzindikila ndi kundilemekeza.
16	I prefer a technology that works automatically without human power.	Ndikufuna njira ya nthilira yosafuna anthu kuti iyende.
17	I prefer a technology that can give me a high volume of water.	Ndikufuna njira yomwe ingandipatse madzi ambiri.
18	I prefer a technology that can give me a high pressure.	Ndikufuna njira yomwe ingathandize kupeleka madzi othamanga kwambiri.
19	I want the technology to enable me to grow crops that I can sell at the market.	Ndikufuna njira yomwe ingandipatse zokolora zambiri zomwe ndingagulitse kumsika.
20	I want the technology to enable me to grow crops that I can eat.	Ndikufuna kuti njira yomwe ingandipatse chakudya chokwanila.
21	I prefer a technology that uses water efficiently.	Ndikufuna nira yosaononga madzi.
	Environment	**Environment**
22	I don't mind watering the crops myself without the use of a technology.	Ndikhoza kuthira mbeu zanga ndekha opanda kugwiritsa njira zamakono.
23	My water availability and water source determine my technology choice.	Kupezeka kwa madzi ndi komwe kunganene njira ya nthilira yomwe ndingagwilitse ntchito.
	Characteristics & circumstances of farmer within their (social) environment	**Characteristics & circumstances of farmer within their (social) environment**
	Community	**Community**
24	I want support from my community and family.	Ndikufuna chithandizo kuchokela kwa apabanja panga.
	Ownership	**Ownership**
25	I don't own the land on which I farm. I don't want to invest.	Mala omwe ndikulimapo si anga. Sindikufuna kuononga ndalama pa njira imeneyi.
26	I can't expand my farm. I don't want to invest.	Sindingathe kuwonjezeramalo anga olima. Sindikufuna kuononga ndalama pa njira imeneyi.
	Agricultural extension services	**Agricultural extension services**
27	I prefer a technology that has been advocated by the extension officers.	Ndikhoza kukonda njila yomwe akulimbikitsa alangizi a zaulimi.
	Company relationship	**Company relationship**
28	I need external support after implementation.	Ndidzafuna thandizo kuchokela ku mabungwe.
29	I prefer if the company representatives are Malawian.	Ndikhoza kukhala okondwa ngtai mabungwe amenewa atakhala a chi Malawi.
	The process of learning and experience	**The process of learning and experience**
	Familiarity	**Familiarity**
30	I want to hear about the technology before I adopt it.	Ndimafuna kumva zazambiri za njira yamakono ndisanayambe kuyigwiritsa ntchito.
31	I want to have seen the technology before I adopt it.	Ndimafuna nditayiwona njira yamakonoyi ndisanayambe kuyigwiritsa ntchito.
32	I want to try out the technology before I adopt it.	Ndimafuna nditayiyesa kaye njira yamakonoyi ndisanayambe kuyigwiritsa ntchito.
33	I want a technology that other farmers have used successfully before I adopt it.	Ndikmafuna njira yomwe ena anayigwilitsapo kale ntchito ndipo sanapezepo nayo mavuto ndisanayambe kuyigwilitsa nthcito.
	Understandability	**Understandability**
34	I prefer technology that I can understand.	Ndimafuna njira yokuti ndikhoza kuyimvetsetsa.

Annex 6 – Q-sorting instruction

English:

This an instruction for undertaking a Q-sort (We will review this with you in person, as well).

1. Count the chips. You should have 34 statements. If you count more or less chips, contact the Q-sort project leader.

2. Familiarize yourself with the header. In the header you can find the general umbrella question. Underneath the header you can find numbers ranging from -4 to +4. On the left, -4 means you ***strongly disagree*** *with the statement. On the right, +4 means you* ***strongly agree*** *with the statement. In the middle, 0 means you have a* ***neutral agreement or no opinion*** *with the statement.*

3. Review the statements. Each statement on the chip concerns one statement concerning WTTs, that to you can be interpreted as "more" or "less" important to the umbrella question at hand.

4. To complete the exercise, you should organize the chips in the shape indicated by the diagram: 2 statements go under the column marked "-4: least important", 3 statements under "-3", 4 under "-2", 5 under "-1" and 6 under "0: neutral", and so on. There is no difference among the importance of items as long as they are placed in the same column.

5. With the question in mind, sort the items. Most people find it difficult to do this prioritization in one step. Instead, it is easier to start by separating the statements into three piles: Strongly disagree, neutral (or no opinion) and strongly agree.

6. Once you have three piles, focus first on the "strongly agree" pile and simply try to organize the chips you strongly agreed with into the appropriate number of slots. You are encouraged to adjust statements on the fly, as many times as you want until you finish with the right number of statements arranged under each column.

7. Take a step back, review the sort, and make changes if needed. You should now have a complete sort with all the empty spaces filled. Feel free to look at the whole picture and make any changes you want.

8. Record the sort. You can record the sortation by writing the number corresponding to each element in the space on the answer sheet that represents its place on the sort on the table.

9. Check the recorded sort.

Chichewa:

Awa ndi malangizo opanga mtundu wa Q (Tidzakambirana izi ndi inu, komanso).

1. Awerengeni chips. Muyenera kukhala ndi mawu 34. Ngati muwerengera mapepala ochepa kwambiri, funsani mtsogoleri wa polojekiti ya Q.

2. Dzidziwitse nokha ndi funsoli. Pansi pa funso lomwe mungapeze manambala kuyambira -4 mpaka 4. Kumanzere, -4 kumatanthauza kuti **simukugwirizana kwambiri** ndi mawuwo. Kumanja, +4 kukutanthauza kuti **mumagwirizana kwambiri** ndi mawuwo. Pakatikati, 0 zimatanthauza kuti **muli ndi mgwirizano wosalowerera kapena palibe maganizo enieni ndi mawu.**

3. Onaninso mawu. Ndemanga iliyonse pa chip chi imakhudza ndemanga imodzi ponena za kugwiritsa ntchito njira za makono, kuti kwa inu mukhoza kutanthauzidwa kuti "zambiri" kapena "zochepa" zofunika pa funso liri pafupi.

4. Kuti mutsirizitse ntchitoyi, muyenera kukonza mapepala omwe amawonetsedwa ndi chithunzichi: Mawu awiri akupita pansi pa mndandanda wotchulidwa "-4: ochepa", mawu atatu pansi pa "-3", 4 pansi pa "-2", 5 pansi pa "-1" ndi 6 pansi pa "0: ndale", ndi zina zotero. Palibe kusiyana pakati pa kufunika kwa zinthu malingana ngati akuyikidwa pamalo omwewo.

5. Poganizira funsoli, sankhani zinthuzo. Anthu ambiri amavutika kuti achite izi patsogolo pa gawo limodzi. M'malo mwake, n'zosavuta kuyamba ndi kulekanitsa mawuwa mu milandu itatu: Sagwirizane, salowerera (kapena palibe maganizo) ndipo amavomereza.

6. Mukakhala ndi milandu itatu, yambani kutsogolo pa "mzere wogwirizana" ndipo muyesetse kukonza mapepala omwe munavomerezana nawo mu malo oyenera. Mukulimbikitsidwa kusintha ndemanga pamene mukupita, mobwerezabwereza momwe mukufunira mpaka mutatsiriza ndi nambala yolondola ya mawu omwe ali pansi pa ndime iliyonse.

7. Tengani tsatanetsatane, onetsetsani njira yo, ndikusintha ngati pakufunika. Muyenera kukhala ndi mtundu wathunthu ndi malo opanda kanthu odzazidwa. Khalani omasuka kuyang'ana chithunzi chonse ndikupanga kusintha komwe mukufuna.

8. *Lembani mtunduwo.* Mungathe kulembetsa mtunduwu polemba nambala yofanana ndi chinthu chilichonse pazenera pa pepala loyankha lomwe likuyimira malo ake pa tebulo.

9. *Onani mtundu wolembedwa pa bokosi losatilari.*

Annex 7 – Conducted Q-sorts

Q-sort 1 – Transformation Administrator – Mponele

Category: Expert

Strongly disagree				Neutral				Strongly agree	
-4	-3	-2	-1	0	1	2	3	4	Total
2	3	4	5	6	5	4	3	2	34
22	4	7	29	13	31	30	1	19	9
15	18	25	24	27	9	5	2	23	9
	16	6	3	11	34	33	8		7
		26	28	17	10	20			5
			21	14	12				3
				32					1
								Total	34

Q-sort 2 – Irrigation Engineer – Mponele

Category: Expert

Strongly disagree				Neutral				Strongly agree	
-4	-3	-2	-1	0	1	2	3	4	Total
2	3	4	5	6	5	4	3	2	34
6	16	25	24	5	34	30	19	23	9
22	18	9	15	20	21	11	27	2	9
	26	8	28	4	33	31	1		7
		32	7	3	13	12			5
			17	29	10				3
				14					1
								Total	34

Q-sort 3 – Individual Commercial farmer – Mzuzu

Category: Barsha pump

Strongly disagree				Neutral				Strongly agree	
-4	-3	-2	-1	0	1	2	3	4	Total
2	3	4	5	6	5	4	3	2	**34**
3	5	15	8	21	24	20	2	17	9
11	4	31	22	30	23	10	14	16	9
	25	29	6	9	27	13	1		7
		7	32	18	33	19			5
			26	34	12				3
				28					1
								Total	**34**

Q-sort 4 – Individual Smallholder farmer – Rumphi

Category: Gravity, watering cans

Strongly disagree				Neutral				Strongly agree	
-4	-3	-2	-1	0	1	2	3	4	Total
2	3	4	5	6	5	4	3	2	**34**
6	29	22	15	8	12	1	33	17	9
7	26	4	23	5	2	14	13	20	9
	25	16	21	32	3	18	19		7
		27	31	10	34	9			5
			11	24	30				3
				28					1
									34

Q-sort 5 – Individual Smallholder farmer – Rumphi

Category: Gravity, Barsha pump

Strongly disagree				Neutral				Strongly agree	
-4	-3	-2	-1	0	1	2	3	4	Total
2	3	4	5	6	5	4	3	2	34
25	26	32	6	29	9	1	8	2	9
22	5	20	31	3	13	23	14	17	9
	28	7	16	15	18	21	19		7
		12	24	11	27	10			5
			30	33	34				3
				4					1
								Total	34

Q-sort 6 – Cooperative Smallholder farmers – Rumphi

Category: Gravity, Barsha pump

Strongly disagree				Neutral				Strongly agree	
-4	-3	-2	-1	0	1	2	3	4	Total
2	3	4	5	6	5	4	3	2	34
25	16	4	32	13	31	20	33	30	9
7	9	29	15	3	10	1	19	28	9
	26	24	22	21	23	11	8		7
		6	14	5	27	34			5
			2	18	12				3
				17					1
								Total	34

Q-sort 7 – Irrigation Extension Officer – Department of Irrigation – Ntchisi

Category: Expert

Strongly disagree				Neutral				Strongly agree	
-4	-3	-2	-1	0	1	2	3	4	Total
2	3	4	5	6	5	4	3	2	34
6	18	24	26	11	14	23	12	10	9
25	19	5	15	30	17	33	34	8	9
	22	28	16	29	3	31	13		7
		27	4	2	7	32			5
			21	9	20				3
				1					1
								Total	34

Q-sort 8 – Individual Commercial farmer – Ntchisi

Category: Barsha pump

Strongly disagree				Neutral				Strongly agree	
-4	-3	-2	-1	0	1	2	3	4	Total
2	3	4	5	6	5	4	3	2	34
3	25	4	32	31	10	14	21	9	9
6	33	29	5	26	17	19	23	20	9
	12	34	11	7	18	16	30		7
		22	15	8	27	28			5
			2	24	1				3
				13					1
								Total	34

Q-sort 9 – Cooperative Smallholder farmer – Ntchisi

Category: Barsha pump

Strongly disagree				Neutral				Strongly agree	
-4	-3	-2	-1	0	1	2	3	4	Total
2	3	4	5	6	5	4	3	2	34
24	3	5	17	30	12	23	20	1	9
16	18	25	4	31	10	11	8	28	9
	6	22	26	29	21	32	27		7
		7	9	34	13	19			5
			33	14	2				3
				15					1
								Total	34

Q-sort 10 – Cooperative Smallholder farmers – Ntchisi

Category: Barsha pump

Strongly disagree				Neutral				Strongly agree	
-4	-3	-2	-1	0	1	2	3	4	Total
2	3	4	5	6	5	4	3	2	34
24	26	22	3	28	27	30	4	19	9
25	7	5	6	9	10	8	1	2	9
	17	29	12	16	13	23	21		7
		18	34	31	11	20			5
			32	15	14				3
				33					1
								Total	34

Q-sort 11 – Cooperative Smallholder farmers – Ntchisi

Category: Barsha pump

Strongly disagree				Neutral				Strongly agree	
-4	-3	-2	-1	0	1	2	3	4	Total
2	3	4	5	6	5	4	3	2	**34**
29	32	24	31	15	23	3	10	27	9
12	25	34	7	22	8	17	21	28	9
	5	30	26	33	20	18	1		7
		14	6	16	4	19			5
			9	11	2				3
				13					1
								Total	**34**

Q-sort 12 – Commercial Individual farmer – Ntchisi

Category: Petrol pump, Barsha pump

Strongly disagree				Neutral				Strongly agree	
-4	-3	-2	-1	0	1	2	3	4	Total
2	3	4	5	6	5	4	3	2	**34**
25	11	22	8	32	13	33	20	14	9
3	15	6	31	23	17	21	27	2	9
	1	18	5	29	12	16	9		7
		34	4	26	19	10			5
			24	7	28				3
				30					1
								Total	**34**

Q-sort 13 – Commercial Individual farmer – Michiru

Category: Barsha pump

Strongly disagree				Neutral				Strongly agree	
-4	-3	-2	-1	0	1	2	3	4	Total
2	3	4	5	6	5	4	3	2	**34**
25	7	29	24	3	19	32	28	23	9
6	8	22	17	15	18	10	2	1	9
	4	9	34	16	13	33	12		7
		20	27	21	30	14			5
			31	5	11				3
				26					1
								Total	**34**

Q-sort 14 – Cooperative Smallholder farmer – Zomba

Category: Gravity

Strongly disagree				Neutral				Strongly agree	
-4	-3	-2	-1	0	1	2	3	4	Total
2	3	4	5	6	5	4	3	2	**34**
7	5	26	9	23	28	27	8	19	9
6	25	29	16	20	1	3	14	18	9
	11	22	32	33	21	10	34		7
		12	4	30	2	17			5
			24	15	31				3
				13					1
								Total	**34**

Q-sort 15 – Cooperative Smallholder farmer – Zomba

Category: Gravity

Strongly disagree				Neutral				Strongly agree	
-4	-3	-2	-1	0	1	2	3	4	Total
2	3	4	5	6	5	4	3	2	34
32	11	5	8	29	28	3	21	19	9
15	22	33	4	26	1	2	27	17	9
	9	6	31	7	10	25	20		7
		24	23	12	30	13			5
			14	34	16				3
				18					1
								Total	34

Q-sort 16 – Cooperative Smallholder farmers – Zomba

Category: Gravity

Strongly disagree				Neutral				Strongly agree	
-4	-3	-2	-1	0	1	2	3	4	Total
2	3	4	5	6	5	4	3	2	34
29	22	5	12	1	31	13	10	17	9
16	26	9	6	33	20	14	19	3	9
	25	7	15	21	30	18	27		7
		24	4	28	11	2			5
			23	34	32				3
				8					1
								Total	34

Q-sort 17 – Cooperative Smallholder farmers – Zomba

Category: Treadle pump, Petrol pump, Solar pump, Water Cans

Strongly disagree				Neutral				Strongly agree	
-4	-3	-2	-1	0	1	2	3	4	Total
2	3	4	5	6	5	4	3	2	34
22	6	15	5	33	18	3	27	28	9
26	29	34	7	30	2	13	23	17	9
	24	16	25	31	20	10	21		7
		9	12	8	11	19			5
			4	1	14				3
				32					1
								Total	34

Q-sort 18 – Cooperative Smallholder farmer – Zomba

Category: Treadle pump, Petrol pump, Solar pump

Strongly disagree				Neutral				Strongly agree	
-4	-3	-2	-1	0	1	2	3	4	Total
2	3	4	5	6	5	4	3	2	34
6	15	4	7	11	17	2	5	19	9
26	8	24	12	31	21	18	9	3	9
	25	29	10	32	34	22	23		7
		28	20	1	14	30			5
			16	27	33				3
				13					1
								Total	34

Q-sort 19 – Individual Smallholder farmer – Zomba

Category: Water cans

Strongly disagree				Neutral				Strongly agree	
-4	-3	-2	-1	0	1	2	3	4	Total
2	3	4	5	6	5	4	3	2	**34**
29	24	25	6	16	33	23	18	27	9
22	4	1	26	17	8	13	3	30	9
	11	12	10	14	34	21	19		7
		28	15	7	20	2			5
			32	9	31				3
				5					1
								Total	**34**

Q-sort 20 – Cooperative Smallholder farmers – Zomba

Category: Petrol pump

Strongly disagree				Neutral				Strongly agree	
-4	-3	-2	-1	0	1	2	3	4	Total
2	3	4	5	6	5	4	3	2	**34**
22	7	4	6	32	23	11	27	13	9
25	3	5	18	12	34	20	21	14	9
	28	29	33	1	30	19	10		7
		17	31	9	8	2			5
			24	15	16				3
				26					1
								Total	**34**

Q-sort 21 – Cooperative Smallholder farmers – Zomba

Category: Petrol pump

Strongly disagree				Neutral				Strongly agree	
-4	-3	-2	-1	0	1	2	3	4	Total
2	3	4	5	6	5	4	3	2	34
3	15	12	30	24	5	8	21	14	9
26	25	7	29	28	10	16	33	2	9
	22	31	27	4	13	11	20		7
		6	9	32	23	18			5
			34	19	17				3
				1					1
								Total	34

Q-sort 22 – Cooperative Smallholder farmers – Zomba

Category: Petrol pump

Strongly disagree				Neutral				Strongly agree	
-4	-3	-2	-1	0	1	2	3	4	Total
2	3	4	5	6	5	4	3	2	34
22	30	4	7	34	32	18	21	2	9
5	24	25	3	15	27	9	33	14	9
	26	12	31	1	23	8	20		7
		6	16	28	19	13			5
			29	11	17				3
				10					1
								Total	34

Q-sort 23 – Individual Commercial farmer – Zomba

Category: Petrol pump

Strongly disagree				Neutral				Strongly agree	
-4	-3	-2	-1	0	1	2	3	4	Total
2	3	4	5	6	5	4	3	2	**34**
22	7	6	16	24	3	9	10	19	9
25	26	4	11	28	29	30	32	17	9
	1	5	18	20	12	31	27		7
		2	14	15	34	8			5
			23	33	13				3
				21					1
								Total	**34**

Q-sort 24 – Individual Commercial farmer – Zomba

Category: Petrol pump

Strongly disagree				Neutral				Strongly agree	
-4	-3	-2	-1	0	1	2	3	4	Total
2	3	4	5	6	5	4	3	2	**34**
26	6	19	8	32	2	12	3	14	9
25	7	27	24	34	17	9	23	10	9
	22	18	11	29	28	13	16		7
		31	4	1	21	30			5
			20	15	33				3
				5					1
								Total	**34**

Q-sort 25 – Cooperative Smallholder farmers – Zomba

Category: Gravity

Strongly disagree				Neutral				Strongly agree	
-4	-3	-2	-1	0	1	2	3	4	Total
2	3	4	5	6	5	4	3	2	34
24	26	3	11	2	20	27	17	1	9
5	22	30	6	18	34	21	32	28	9
	29	25	16	9	23	12	33		7
		4	7	10	8	19			5
			14	13	31				3
				15					1
								Total	34

Q-sort 26 – Cooperative Smallholder farmers – Zomba

Category: Gravity

Strongly disagree				Neutral				Strongly agree	
-4	-3	-2	-1	0	1	2	3	4	Total
2	3	4	5	6	5	4	3	2	34
29	3	26	5	30	2	13	20	28	9
6	25	4	34	15	19	33	8	27	9
	22	32	12	16	23	21	31		7
		10	18	9	1	17			5
			24	7	14				3
				11					1
								Total	34

Q-sort 27 – Cooperative Smallholder farmers – Zomba

Category: Gravity

Strongly disagree				Neutral				Strongly agree	
-4	-3	-2	-1	0	1	2	3	4	Total
2	3	4	5	6	5	4	3	2	**34**
7	26	3	34	4	10	32	14	27	9
16	25	23	22	9	1	11	17	28	9
	24	33	30	12	13	18	20		7
		6	5	31	21	19			5
			15	29	8				3
				2					1
								Total	**34**

Q-sort 28 – Cooperative Smallholder farmers – Zomba

Category: Gravity

Strongly disagree				Neutral				Strongly agree	
-4	-3	-2	-1	0	1	2	3	4	Total
2	3	4	5	6	5	4	3	2	**34**
25	4	6	17	18	32	29	28	20	9
3	26	7	8	33	13	27	23	2	9
	16	22	21	10	12	1	19		7
		14	9	31	15	30			5
			11	5	34				3
				24					1
								Total	**34**

Q-sort 29 – Cooperative Smallholder farmers – Zomba

Category: Gravity

Strongly disagree				Neutral				Strongly agree	
-4	-3	-2	-1	0	1	2	3	4	Total
2	3	4	5	6	5	4	3	2	**34**
29	24	31	26	2	33	14	11	28	9
5	4	6	32	30	23	34	27	17	9
	22	25	18	7	16	20	12		7
		3	19	21	1	8			5
			9	10	13				3
				15					1
								Total	**34**

Q-sort 30 – Cooperative Smallholder farmers – Zomba

Category: Gravity

Strongly disagree				Neutral				Strongly agree	
-4	-3	-2	-1	0	1	2	3	4	Total
2	3	4	5	6	5	4	3	2	**34**
24	26	9	22	11	21	23	12	27	9
25	1	5	6	8	13	28	18	19	9
	7	16	3	14	33	30	20		7
		10	4	32	34	15			5
			2	31	17				3
				29					1
								Total	**34**

Q-sort 31 – Cooperative Smallholder farmers – Zomba

Category: Petrol pump

Strongly disagree				Neutral				Strongly agree	
-4	-3	-2	-1	0	1	2	3	4	Total
2	3	4	5	6	5	4	3	2	**34**
7	21	3	32	5	27	2	16	9	9
6	24	4	26	12	30	23	10	1	9
	25	22	33	29	8	18	19		7
		15	14	31	20	11			5
			17	28	13				3
				34					1
								Total	**34**

Q-sort 32 – Cooperative Smallholder farmers – Zomba

Category: Petrol pump

Strongly disagree				Neutral				Strongly agree	
-4	-3	-2	-1	0	1	2	3	4	Total
2	3	4	5	6	5	4	3	2	**34**
26	24	7	21	15	23	2	17	28	9
6	4	16	12	5	20	18	19	14	9
	25	22	32	3	30	8	1		7
		29	9	10	27	34			5
			11	31	33				3
				13					1
								Total	**34**

Q-sort 33 – Cooperative Smallholder farmers – Zomba

Category: Petrol pump

Strongly disagree				Neutral				Strongly agree	
-4	-3	-2	-1	0	1	2	3	4	Total
2	3	4	5	6	5	4	3	2	34
26	5	27	33	16	10	12	11	14	9
7	4	22	31	13	15	21	24	19	9
	25	3	2	34	20	8	23		7
		28	32	17	9	29			5
			6	1	18				3
				30					1
								Total	34

Q-sort 34 – Cooperative Smallholder farmers – Zomba

Category: Water cans

Strongly disagree				Neutral				Strongly agree	
-4	-3	-2	-1	0	1	2	3	4	Total
2	3	4	5	6	5	4	3	2	34
32	24	7	16	26	15	1	9	18	9
12	25	33	31	23	29	21	8	20	9
	5	22	10	3	14	19	17		7
		28	27	11	34	13			5
			30	4	2				3
				6					1
								Total	34

Q-sort 35 – Cooperative Smallholder farmers – Zomba

Category: Water cans

Strongly disagree				Neutral				Strongly agree	
-4	-3	-2	-1	0	1	2	3	4	Total
2	3	4	5	6	5	4	3	2	34
29	32	22	26	28	31	30	18	17	9
21	25	16	6	5	33	27	23	19	9
	14	24	4	1	9	20	13		7
		11	2	3	8	10			5
			15	12	34				3
				7					1
								Total	34

Q-sort 36 – Cooperative Smallholder farmers – Zomba

Category: Water cans

Strongly disagree				Neutral				Strongly agree	
-4	-3	-2	-1	0	1	2	3	4	Total
2	3	4	5	6	5	4	3	2	34
29	5	14	15	31	13	19	8	17	9
21	25	32	4	34	20	3	9	18	9
	7	23	16	22	1	30	12		7
		6	24	11	33	2			5
			26	27	28				3
				10					1
								Total	34

Q-sort 37 – Senior Irrigation Extension Officer – Zomba

Category: Expert

Strongly disagree				Neutral				Strongly agree	
-4	-3	-2	-1	0	1	2	3	4	Total
2	3	4	5	6	5	4	3	2	34
3	29	1	4	34	12	2	16	23	9
22	24	7	5	11	10	9	20	17	9
	25	15	21	13	14	8	18		7
		31	26	6	19	30			5
			32	28	27				3
				33					1
								Total	34

Q-sort 38 – Assistant Irrigation Extension Officer – Zomba

Category: Expert

Strongly disagree				Neutral				Strongly agree	
-4	-3	-2	-1	0	1	2	3	4	Total
2	3	4	5	6	5	4	3	2	34
11	5	12	32	16	17	34	21	19	9
7	26	22	15	14	10	13	27	8	9
	6	4	25	1	23	18	20		7
		33	29	28	31	30			5
			24	9	2				3
				3					1
								Total	34

Q-sort 39 – Irrigation Agronomist – Zomba

Category: Expert

Strongly disagree				Neutral				Strongly agree	
-4	-3	-2	-1	0	1	2	3	4	Total
2	3	4	5	6	5	4	3	2	34
15	3	7	6	17	2	34	23	31	9
26	29	25	5	11	13	9	20	19	9
	24	28	4	33	1	32	16		7
		18	30	10	14	12			5
			8	22	27				3
				21					1
								Total	34

Q-sort 40 – Individual Smallholder farmer – Mwanza

Category: Treadle pump

Strongly disagree				Neutral				Strongly agree	
-4	-3	-2	-1	0	1	2	3	4	Total
2	3	4	5	6	5	4	3	2	34
22	11	26	3	33	10	9	29	14	9
15	5	24	6	7	27	19	21	16	9
	4	8	23	13	20	34	25		7
		12	18	17	28	1			5
			32	31	2				3
				30					1
								Total	34

Q-sort 41 – Cooperative Smallholder farmers – Mwanza

Category: Solar pump

Strongly disagree				Neutral				Strongly agree	
-4	-3	-2	-1	0	1	2	3	4	Total
2	3	4	5	6	5	4	3	2	34
25	6	26	5	3	9	16	10	19	9
7	30	31	32	18	13	27	14	2	9
	29	33	4	28	23	11	21		7
		12	17	22	8	15			5
			34	1	20				3
				24					1
								Total	34

Q-sort 42 – Individual Smallholder farmer – Mwanza

Category: Water cans

Strongly disagree				Neutral				Strongly agree	
-4	-3	-2	-1	0	1	2	3	4	Total
2	3	4	5	6	5	4	3	2	34
34	3	6	8	24	30	10	12	14	9
7	31	29	9	21	27	16	15	13	9
	1	23	2	11	25	26	18		7
		17	5	22	20	19			5
			32	33	4				3
				28					1
								Total	34

Q-sort 43 – Individual Smallholder farmer – Mwanza

Category: Water cans

Strongly disagree				Neutral				Strongly agree	
-4	-3	-2	-1	0	1	2	3	4	Total
2	3	4	5	6	5	4	3	2	**34**
33	4	15	18	8	10	27	24	28	9
22	25	21	5	9	20	6	14	1	9
	32	16	31	13	3	23	11		7
		17	29	7	19	2			5
			12	26	30				3
				34					1
								Total	**34**

Q-sort 44 – Individual Smallholder farmer – Mwanza

Category: Petrol pump

Strongly disagree				Neutral				Strongly agree	
-4	-3	-2	-1	0	1	2	3	4	Total
2	3	4	5	6	5	4	3	2	**34**
13	15	22	3	18	11	23	21	27	9
26	31	9	24	4	29	33	20	8	9
	30	6	32	10	5	2	34		7
		17	12	25	28	19			5
			7	14	1				3
				16					1
								Total	**34**

Q-sort 45 – Cooperative Smallholder farmers – Mwanza

Category: Gravity

Strongly disagree				Neutral				Strongly agree	
-4	-3	-2	-1	0	1	2	3	4	Total
2	3	4	5	6	5	4	3	2	**34**
25	16	31	3	33	34	1	32	19	9
26	6	4	12	30	27	18	20	13	9
	7	21	24	15	23	5	17		7
		22	29	2	28	11			5
			9	8	10				3
				14					1
								Total	**34**

Q-sort 46 – Cooperative Smallholder farmers – Mwanza

Category: Gravity

Strongly disagree				Neutral				Strongly agree	
-4	-3	-2	-1	0	1	2	3	4	Total
2	3	4	5	6	5	4	3	2	**34**
5	6	11	33	31	12	2	19	21	9
26	3	1	14	8	23	17	34	15	9
	25	16	10	32	27	13	28		7
		4	29	22	30	18			5
			24	7	20				3
				9					1
								Total	**34**

Q-sort 47 – Cooperative Smallholder farmers – Mwanza

Category: Gravity

Strongly disagree				Neutral				Strongly agree	
-4	-3	-2	-1	0	1	2	3	4	Total
2	3	4	5	6	5	4	3	2	**34**
5	3	7	26	28	8	27	11	15	9
6	33	14	31	16	13	23	17	18	9
	29	24	25	21	12	1	20		7
		30	4	9	32	2			5
			22	19	34				3
				10					1
								Total	**34**

Q-sort 48 – Irrigation Extension Officer & Intern – Mwanza

Category: Expert

Strongly disagree				Neutral				Strongly agree	
-4	-3	-2	-1	0	1	2	3	4	Total
2	3	4	5	6	5	4	3	2	**34**
33	22	7	5	28	8	14	21	27	9
25	26	6	29	11	18	10	2	19	9
	15	4	31	16	3	13	23		7
		24	30	17	20	34			5
			32	1	9				3
				12					1
								Total	**34**

Q-sort 49 – Individual Smallholder farmer – Mwanza

Category: Water cans

Strongly disagree				Neutral				Strongly agree	
-4	-3	-2	-1	0	1	2	3	4	Total
2	3	4	5	6	5	4	3	2	**34**
33	25	9	16	32	14	30	12	28	9
22	29	7	24	13	21	5	18	19	9
	4	31	3	10	15	20	8		7
		6	26	23	27	11			5
			17	2	1				3
				34					1
								Total	**34**

Q-sort 50 – Individual Smallholder farmer – Mwanza

Category: Water cans, Petrol pump

Strongly disagree				Neutral				Strongly agree	
-4	-3	-2	-1	0	1	2	3	4	Total
2	3	4	5	6	5	4	3	2	**34**
15	1	26	31	30	20	13	4	2	9
8	25	24	23	29	33	27	9	10	9
	7	17	32	22	16	19	14		7
		6	3	11	34	28			5
			5	12	21				3
				18					1
								Total	**34**

Q-sort 51 – Individual Smallholder farmer – Mwanza

Category: Water cans

Strongly disagree				Neutral				Strongly agree	
-4	-3	-2	-1	0	1	2	3	4	Total
2	3	4	5	6	5	4	3	2	**34**
4	33	31	7	24	34	3	9	5	9
26	22	32	21	25	28	27	15	19	9
	17	30	16	11	1	2	10		7
		20	6	29	13	8			5
			23	14	12				3
				18					1
								Total	**34**

Q-sort 52 – Extension Officers Southern Region Farmers Union of Malawi – Mwanza

Category: Expert

Strongly disagree				Neutral				Strongly agree	
-4	-3	-2	-1	0	1	2	3	4	Total
2	3	4	5	6	5	4	3	2	**34**
25	26	4	7	11	21	32	9	19	9
22	28	3	31	8	1	27	20	23	9
	6	5	15	2	13	12	17		7
		29	10	18	33	16			5
			24	30	14				3
				34					1
								Total	**34**

Q-sort 53 – Individual Commercial farmer – Blantyre

Category: Petrol pump

Strongly disagree				Neutral				Strongly agree	
-4	-3	-2	-1	0	1	2	3	4	Total
2	3	4	5	6	5	4	3	2	**34**
7	25	5	33	2	31	21	23	14	9
18	22	29	16	9	13	19	34	32	9
	10	26	11	27	4	17	12		7
		3	8	24	1	30			5
			6	20	15				3
				28					1
								Total	**34**

Q-sort 54 – Cooperative Smallholder farmers – Golomoti

Category: Barsha pump

Strongly disagree				Neutral				Strongly agree	
-4	-3	-2	-1	0	1	2	3	4	Total
2	3	4	5	6	5	4	3	2	**34**
3	4	31	15	11	5	8	23	28	9
29	7	32	33	2	13	24	17	19	9
	26	6	34	22	10	9	20		7
		25	21	12	1	27			5
			18	14	16				3
				30					1
								Total	**34**

Q-sort 55 – Cooperative Smallholder farmers – Golomoti

Category: Barsha pump

Strongly disagree				Neutral				Strongly agree	
-4	-3	-2	-1	0	1	2	3	4	Total
2	3	4	5	6	5	4	3	2	34
25	29	14	3	5	34	13	33	28	9
22	24	16	9	6	32	20	1	31	9
	7	4	11	26	27	30	19		7
		17	21	2	8	23			5
			18	12	10				3
				15					1
								Total	34

Q-sort 56 – Cooperative Smallholder farmers – Golomoti

Category: Barsha pump

Strongly disagree				Neutral				Strongly agree	
-4	-3	-2	-1	0	1	2	3	4	Total
2	3	4	5	6	5	4	3	2	34
25	26	18	5	34	20	4	1	19	9
6	28	16	7	21	13	2	8	24	9
	3	31	29	14	15	10	12		7
		11	22	30	9	17			5
			32	23	27				3
				33					1
								Total	34

Q-sort 57 – Individual Commercial farmer – Lunzu

Category: Barsha pump, Solar pump

Strongly disagree				Neutral				Strongly agree	
-4	-3	-2	-1	0	1	2	3	4	Total
2	3	4	5	6	5	4	3	2	**34**
25	5	24	16	1	32	34	23	19	9
26	22	3	29	11	33	20	31	30	9
	6	4	17	18	10	27	12		7
		28	14	2	9	15			5
			7	21	13				3
				8					1
								Total	**34**

Q-sort 58 – Social Entrepreneur – Lilongwe

Category: Expert

Strongly disagree				Neutral				Strongly agree	
-4	-3	-2	-1	0	1	2	3	4	Total
2	3	4	5	6	5	4	3	2	**34**
15	29	18	6	12	19	31	23	20	9
26	25	4	3	9	34	8	16	27	9
	22	5	7	2	30	24	17		7
		14	33	21	11	1			5
			32	10	28				3
				13					1
								Total	**34**

Annex 8 – Correlation table all participants

	QS1	QS2	QS3	QS4	QS5	QS6	QS7	QS8	QS9	QS10	QS11	QS12	QS13	QS14	QS15	QS16	QS17	QS18	QS19	QS20	QS21	QS22	QS23	QS24	QS25	QS26	QS27	QS28	QS29	QS30	QS31	QS32	QS33	QS34	QS35	QS36	QS37	QS38	QS39	QS40	QS41	QS42	QS43	QS44	QS45	QS46	QS47	QS48	QS49	QS50	QS51	QS52	QS53	QS54	QS55	QS56	QS57	QS58
QS1	100	70	35	53	46	61	46	31	57	53	9	33	44	34	24	38	41	43	41	43	41	38	39	31	41	44	26	60	28	25	56	55	37	17	47	30	43	44	55	21	24	-22	39	44	52	13	9	51	39	18	33	57	40	49	63	48	56	53
QS2	70	100	23	32	47	52	35	19	56	62	22	25	56	31	35	44	52	41	38	48	29	31	28	34	35	43	27	61	29	37	41	46	31	4	31	11	19	33	43	18	33	-9	39	38	41	29	22	55	31	33	28	46	44	25	50	46	64	43
QS3	35	23	100	54	51	19	19	51	21	31	30	66	44	44	44	28	31	16	26	51	53	48	26	43	45	44	28	40	49	21	45	48	37	29	35	34	61	47	49	49	44	27	23	14	35	35	33	46	21	36	3	61	37	60	24	50	31	51
QS4	53	32	54	100	46	54	35	34	28	32	23	33	44	60	29	61	47	52	39	34	48	54	46	45	46	45	49	42	39	41	46	70	41	44	56	68	45	50	39	16	36	19	13	12	73	38	35	39	39	31	19	60	39	52	42	50	45	36
QS5	46	47	51	46	100	26	34	30	29	56	44	34	29	68	33	59	50	34	43	57	54	68	44	43	38	36	39	26	34	27	42	57	55	64	36	35	49	56	28	31	60	-2	28	34	42	39	37	68	23	29	30	56	36	30	18	56	39	35
QS6	61	52	19	54	26	100	32	23	64	51	39	7	48	53	21	53	53	29	36	31	31	25	45	25	54	55	53	58	50	63	41	69	33	16	50	47	31	49	30	-4	24	0	31	40	61	39	24	37	61	16	18	31	33	49	76	29	57	48
QS7	46	35	19	35	34	32	100	6	36	21	-7	24	30	26	-3	29	23	7	15	38	23	35	43	54	33	26	11	18	40	11	25	28	23	8	26	23	24	21	31	3	7	-14	1	7	27	15	17	26	6	10	2	38	33	2	34	34	47	28
QS8	31	19	51	34	30	23	6	100	36	40	38	54	24	36	29	16	41	26	36	48	43	39	28	29	27	58	38	38	34	26	51	41	38	44	33	15	57	54	38	39	46	20	33	15	31	39	36	50	43	28	6	57	26	63	28	28	39	51
QS9	57	56	21	28	29	64	36	36	100	63	38	26	44	33	22	36	53	0	12	46	28	44	32	13	66	59	68	66	56	48	44	55	26	21	22	16	25	43	36	13	36	2	39	45	54	41	48	48	54	18	21	38	43	44	64	35	49	40
QS10	53	62	31	32	56	51	21	40	63	100	49	37	39	43	26	40	45	28	39	63	50	52	21	34	41	47	41	47	28	41	51	45	36	41	22	20	38	52	49	20	63	14	29	43	36	34	29	60	39	48	21	46	43	33	53	44	54	37
QS11	9	22	30	23	44	39	-7	38	38	49	100	16	23	55	47	53	66	17	35	22	26	39	16	10	49	51	45	18	39	29	29	45	1	43	41	34	26	47	8	9	55	3	29	34	29	33	42	48	29	24	13	19	-9	42	34	18	10	41
QS12	33	25	66	33	34	7	24	54	26	37	16	100	26	23	31	20	32	17	30	56	57	56	33	42	28	49	35	36	36	28	31	29	21	15	15	11	56	33	44	46	43	30	11	23	17	30	6	48	13	68	2	53	29	41	18	34	30	33
QS13	44	56	44	44	29	48	30	24	44	39	23	26	100	34	6	34	45	38	19	38	36	31	13	57	45	29	28	51	39	29	49	54	31	-9	18	23	28	12	27	8	40	21	35	9	47	24	30	37	46	29	19	39	41	31	51	23	39	17
QS14	34	31	44	60	68	53	26	36	33	43	55	23	34	100	43	69	56	39	57	42	36	57	54	33	47	47	54	31	36	49	41	78	39	53	48	52	38	81	26	30	55	14	20	36	49	52	39	64	45	31	29	41	31	36	40	39	44	34
QS15	24	35	44	29	33	21	-3	29	22	26	47	31	6	43	100	44	57	16	48	23	16	26	24	8	28	34	28	20	31	27	18	34	-1	34	38	23	28	59	18	54	19	8	18	28	19	27	16	51	26	24	9	26	3	27	14	17	13	41
QS16	38	44	28	61	59	53	29	16	36	40	53	20	34	69	44	100	76	43	59	43	30	51	58	30	46	41	63	28	42	49	24	64	21	34	55	53	33	53	25	7	43	8	30	14	63	36	34	59	41	31	23	39	29	26	42	27	42	36
QS17	41	52	31	47	50	53	23	41	53	45	66	32	45	56	57	76	100	39	53	36	46	57	45	41	61	63	64	36	57	51	28	67	21	26	47	29	44	54	29	25	44	6	30	36	57	44	39	64	48	31	19	46	29	47	43	16	36	50
QS18	43	41	16	52	34	29	7	26	0	28	17	17	38	39	16	43	39	100	53	13	23	24	24	39	11	14	16	22	-3	28	38	46	20	16	38	31	21	30	43	11	34	-14	3	16	43	23	3	49	15	37	26	44	19	24	14	16	36	18
QS19	41	38	26	39	43	36	15	36	12	39	35	30	19	57	48	59	53	53	100	44	23	45	41	21	27	46	16	26	24	50	26	46	7	35	59	34	48	66	30	24	28	5	13	21	31	38	16	59	36	19	22	48	18	20	44	8	52	37
QS20	43	48	51	34	57	31	38	48	46	63	22	56	38	42	23	43	36	13	44	100	56	59	38	41	26	43	40	38	44	37	48	33	56	38	19	9	50	52	46	31	68	43	36	26	41	33	37	69	44	46	26	59	46	35	36	41	54	38
QS21	41	29	53	48	54	31	23	43	28	50	26	57	36	36	16	30	46	23	23	56	100	70	11	41	29	49	42	33	36	22	37	48	46	35	8	11	58	35	37	31	54	21	16	53	45	23	26	46	31	45	4	49	23	43	17	33	19	38
QS22	38	31	48	54	68	25	35	39	44	52	39	56	31	57	26	51	57	24	45	59	70	100	31	36	59	57	53	36	50	41	33	59	43	58	21	26	51	54	38	44	57	14	15	44	44	49	46	58	25	39	16	60	31	29	29	27	39	29
QS23	39	28	26	46	44	45	43	28	32	21	16	33	13	54	24	58	45	24	41	38	11	31	100	37	43	34	49	35	30	53	32	39	41	19	47	41	36	57	34	16	26	4	4	9	51	44	20	48	32	24	28	55	43	34	40	41	63	45
QS24	31	34	43	45	43	25	54	29	13	34	10	42	57	33	8	30	41	39	21	41	41	36	37	100	20	17	15	18	32	15	38	40	41	7	11	18	37	23	26	29	41	16	18	4	28	17	4	43	18	45	26	43	41	25	18	25	33	24
QS25	41	35	45	46	38	54	33	27	66	41	49	28	45	47	28	46	61	11	27	26	29	59	43	20	100	63	56	46	68	51	31	61	18	21	37	38	39	43	48	28	23	-9	10	34	47	54	51	38	36	11	6	56	47	41	63	27	51	48
QS26	44	43	44	45	36	55	26	58	59	47	51	49	29	47	34	41	63	14	46	43	49	57	34	17	63	100	52	47	67	48	33	64	19	30	44	33	46	54	41	21	40	8	28	36	41	52	43	44	45	17	9	52	34	63	58	33	46	65
QS27	26	27	28	49	39	53	11	38	68	41	45	35	28	54	28	63	64	16	16	40	42	53	49	15	56	52	100	47	49	60	36	64	33	39	27	36	35	48	29	14	45	23	28	33	68	44	49	54	56	39	19	36	35	46	36	28	31	32
QS28	60	61	40	42	26	58	18	38	66	47	18	36	51	31	20	28	36	22	26	38	33	36	35	18	46	47	47	100	30	58	48	54	35	18	38	22	36	45	37	11	29	0	38	36	64	58	41	46	50	26	29	46	38	52	62	44	64	43
QS29	28	29	49	39	34	50	40	34	56	28	39	36	39	36	31	42	57	-3	24	44	36	50	30	32	68	67	49	30	100	48	30	58	25	21	35	42	58	31	31	20	29	14	33	29	38	44	57	40	49	13	4	50	38	51	37	20	38	56
QS30	25	37	21	41	27	63	11	26	48	41	29	28	29	49	27	49	51	28	50	37	22	41	53	15	51	48	60	58	48	100	24	53	38	29	49	38	48	54	34	-1	28	29	3	29	54	69	45	48	55	26	10	51	43	36	48	20	68	31
QS31	56	41	45	46	42	41	25	51	44	51	29	31	49	41	18	24	28	38	26	48	37	33	32	38	31	33	36	48	30	24	100	48	38	38	46	49	56	43	53	28	49	15	33	24	51	13	45	55	42	41	40	54	11	53	45	34	49	44
QS32	55	46	48	70	57	69	28	41	55	45	45	29	54	78	34	64	67	46	46	33	48	59	39	40	61	64	64	54	58	53	48	100	34	40	50	50	46	59	33	29	44	2	37	40	68	52	40	56	59	24	34	46	38	56	53	34	45	40
QS33	37	31	37	41	55	33	23	38	26	36	1	21	31	39	-1	21	21	20	7	56	46	43	41	41	18	19	33	35	25	38	38	34	100	38	8	16	36	41	33	21	53	26	31	26	39	37	31	48	42	16	29	56	44	43	9	48	50	31
QS34	17	4	29	44	64	16	8	44	21	41	43	15	-9	53	34	34	26	16	35	38	35	58	19	7	21	30	39	18	21	29	38	40	38	100	38	39	44	56	12	24	41	4	18	18	34	35	46	46	23	12	11	37	6	23	12	24	20	20
QS35	47	31	35	56	36	50	26	33	22	22	41	15	18	48	38	55	47	38	59	19	8	21	47	11	37	44	27	38	35	49	46	50	8	38	100	66	57	49	33	-8	12	3	16	3	56	34	34	39	33	12	18	48	8	53	54	34	53	48
QS36	30	11	34	68	35	47	23	15	16	20	34	11	23	52	23	53	29	31	34	9	11	26	41	18	38	33	36	22	42	38	49	50	16	39	66	100	48	40	20	-13	20	13	13	-5	41	30	44	26	36	16	16	35	7	41	33	37	36	34
QS37	43	19	61	45	49	31	24	57	25	38	26	56	28	38	28	33	44	21	48	50	58	51	36	37	39	46	35	36	58	48	56	46	36	44	57	48	100	46	48	21	35	24	18	26	40	33	48	52	43	33	3	69	29	59	30	26	44	54
QS38	44	33	47	50	56	49	21	54	43	52	47	33	12	81	59	53	54	30	66	52	35	54	57	23	43	54	48	45	31	54	43	59	41	56	49	40	46	100	41	42	49	14	15	41	44	60	41	71	45	27	28	51	33	49	41	41	55	54
QS39	55	43	49	39	28	30	31	38	36	49	8	44	27	26	18	25	29	43	30	46	37	38	34	26	48	41	29	37	31	34	53	33	33	12	33	20	48	41	100	36	35	-3	4	27	36	26	26	53	16	41	4	70	52	44	43	29	61	60
QS40	21	18	49	16	31	-4	3	39	13	20	9	46	8	30	54	7	25	11	24	31	31	44	16	29	28	21	14	11	20	-1	28	29	21	24	-8	-13	21	42	36	100	17	-2	18	31	-2	13	-7	41	-1	38	13	31	16	12	5	-3	13	26
QS41	24	33	44	36	60	24	7	46	36	63	55	43	40	55	19	43	44	34	28	68	54	57	26	41	23	40	45	29	29	28	49	44	53	41	12	20	35	49	35	17	100	37	31	37	42	39	46	71	44	51	46	45	24	52	17	43	29	29
QS42	-22	-9	27	19	-2	0	-14	20	2	14	3	30	21	14	8	8	6	-14	5	43	21	14	4	16	-9	8	23	0	14	29	15	2	26	4	3	13	24	14	-3	-2	37	100	-9	-18	13	14	23	7	32	33	8	11	7	20	-3	15	9	-21
QS43	39	39	23	13	28	31	1	33	39	29	11	35	20	18	30	30	3	13	36	16	15	4	18	10	28	28	38	33	3	33	37	31	18	16	13	18	15	4	18	31	-9	100	19	26	0	9	46	49	13	38	12	14	39	33	14	11	42
QS44	44	38	14	12	34	40	7	15	45	43	34	23	9	36	28	14	36	16	21	26	53	44	9	4	34	36	33	36	29	29	24	40	26	18	3	-5	26	41	27	31	37	-18	19	100	26	19	19	49	32	22	27	30	6	32	17	25	18	41
QS45	52	41	35	73	42	61	27	31	54	36	29	17	47	49	19	63	57	43	31	41	45	44	51	28	47	41	68	64	38	54	51	68	39	34	56	41	40	44	36	-2	42	13	26	26	100	42	49	51	57	23	34	56	36	57	49	43	49	39
QS46	13	29	35	38	39	39	15	39	41	34	33	30	24	52	27	36	44	23	38	33	23	49	44	17	54	52	44	58	44	69	13	52	37	35	34	30	33	60	26	13	39	14	0	19	42	100	57	47	42	22	18	43	43	39	30	38	61	26
QS47	9	22	33	35	37	24	17	36	48	29	42	6	30	39	16	34	39	3	16	37	26	46	20	4	51	43	49	41	57	45	45	40	31	46	34	44	48	41	26	-7	46	23	9	19	49	57	100	39	45	1	11	49	24	41	19	32	43	36
QS48	51	55	46	39	68	37	26	50	48	60	48	48	37	64	51	59	64	49	59	69	46	58	48	43	38	44	54	46	40	48	55	56	48	46	39	26	52	71	53	41	71	7	46	49	51	47	39	100	54	53	48	61	37	48	32	38	49	54
QS49	39	31	21	39	23	61	6	43	54	39	29	13	46	45	26	41	48	15	36	44	31	25	32	18	36	45	56	50	49	55	42	59	42	23	33	36	43	45	16	-1	44	32	49	32	57	42	45	54	100	7	49	36	29	54	46	28	41	33
QS50	18	33	36	31	29	16	10	28	18	48	24	68	29	31	24	31	31	37	19	46	45	39	24	45	11	17	39	26	13	26	41	24	16	12	12	16	33	27	41	38	51	33	13	22	23	22	1	53	7	100	14	25	18	23	15	18	23	13
QS51	33	28	3	19	30	18	2	6	21	21	13	2	19	29	9	23	19	26	22	26	4	16	28	26	6	9	19	29	4	10	40	34	29	11	18	16	3	28	4	13	46	8	38	27	34	18	11	48	49	14	100	13	-4	33	17	29	22	6
QS52	57	46	61	60	56	31	38	57	38	46	19	53	39	41	26	39	46	44	48	59	49	60	55	43	56	52	36	46	50	51	54	46	56	37	48	35	69	51	70	31	45	11	12	30	56	43	49	61	36	25	13	100	58	55	34	54	71	63
QS53	40	44	37	39	36	33	33	26	43	43	-9	29	41	31	3	29	29	19	18	46	23	31	43	41	47	34	35	38	38	43	11	38	44	6	8	7	29	33	52	16	24	7	14	6	36	43	24	37	29	18	-4	58	100	28	38	40	54	34
QS54	49	25	60	52	30	49	2	63	44	33	42	41	31	36	27	26	47	24	20	35	43	29	34	25	41	63	46	52	51	36	53	56	43	23	53	41	59	49	44	12	52	20	39	32	57	39	41	48	54	23	33	55	28	100	38	49	34	66
QS55	63	50	24	42	18	76	34	28	64	53	34	18	51	40	14	42	43	14	44	36	17	29	40	18	63	58	36	62	37	48	45	53	9	12	54	33	30	41	43	5	17	-3	33	17	49	30	19	32	46	15	17	34	38	38	100	16	60	43
QS56	48	46	50	50	56	29	34	28	35	44	18	34	23	39	17	27	16	16	8	41	33	27	41	25	27	33	28	44	20	20	34	34	48	24	34	37	26	41	29	-3	43	15	14	25	43	38	32	38	28	18	29	54	40	49	16	100	48	38
QS57	56	64	31	45	39	57	47	39	49	54	10	30	39	44	13	42	36	36	52	54	19	39	63	33	51	46	31	64	38	68	49	45	50	20	53	36	44	55	61	13	29	9	11	18	49	61	43	49	41	23	22	71	54	34	60	48	100	48
QS58	53	43	51	36	35	48	28	51	40	37	41	33	17	34	41	36	50	18	37	38	38	29	45	24	48	65	32	43	56	31	44	40	31	20	48	34	54	54	60	26	29	-21	42	41	39	26	36	54	33	13	6	63	34	66	43	38	48	100

Annex 9 – Analysis Farmers only

When including only the Q-sorts of the 49 farming participants the unrotated factors accounted for 70% of the total variance (Table 21). Looking at the statistical data (Table 18), the first factor explained the greatest part of the variation as it accounts for ~37% of the variability in the data. An amount more than 12 times greater than factor 8.

	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Factor 7	Factor 8
Eigenvalues	18.1161	3.5736	2.743	2.5371	2.1701	2.0827	1.8449	1.609
% Explained Variance	37	7	6	5	4	4	4	3
Cumulative % Expln Var	37	44	50	55	59	63	67	70

Table 21 – The 8 unrotated factors of the 49 farming Q-sort participants after PCA with their respective eigenvalues and explained variance %.

After the factors were rotated using the *varimax* method their respective relevance were assed. First step in this process is applying the *eigenvalue* criterion. With all *eigenvalues* above the criterion of unity (Table 21 & Figure 12), no factors can be discarded. We therefore have to base the number of factors to include based on the explained variance of the factor, composite reliability, the number of distinguishing statements in a factor and the number of participants loading on a factor. In order to compare the statistical data for the different amounts of factors, the case of 2, 3, 4, 5, 6, 7 and 8 factors were generated. The Q-sorts were loaded to the factor using the automatic *flagging* process using a 5% significance level (P < 0.05). The statistical data is presented in Figure 13.

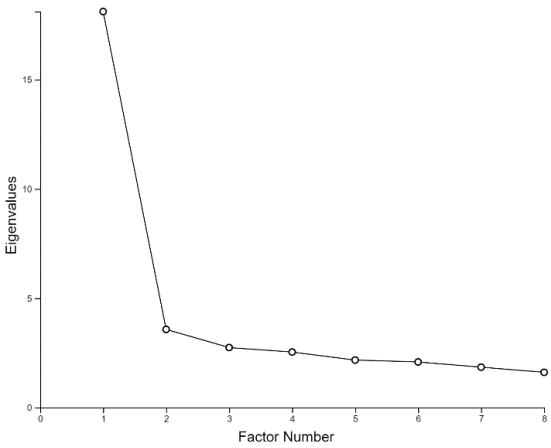


Figure 12 – Graph depicting the eigenvalues of the 49 farming Q-sort participants after PCA.

When looking at representative scores in Table 22, one can see that as the number of factors increases, the number of unflagged Q-sorts increases. All factors, however, still significantly load more than 50% of the participants, which gives us no grounds to discard factors based on the *representativeness criterion.*

Farmers only	flagged	unflagged	flagged %
2 factors	45	4	92
3 factors	45	4	92
4 factors	39	10	80
5 factors	36	13	73
6 factors	33	16	67
7 factors	28	21	57
8 factors	28	21	57

Table 22 – Factor solution representative scores; the respective flagged to unflagged ratio of the respective factor solution.

As a consequence of the decrease in the number of respondents loading significantly on a factor, however, the composite reliability (Eq.3) decreases. This is also evidenced by the slightly increasing standard errors of the factor Z-scores. This is understandable since the more factors there are, the more possibility there is that part of the pattern of an individual's sorting of the statements is similar to another factor (Herrington & Coogan, 2011). It is also clear that as the number of factors increases, the amount of distinguishing statement (P ≤ 0.05) decreases.

On the basis of the composite reliability criterion we can discard the option of 5-, 6-, 7- and 8-factor solution, because they show results of unreliable composite reliability values of < 0.94. Another reason to reject the 5-, 6-, 7- and 8-factor solution is their low number of distinguishing statements.

Therefore, based on the rules of statistics and criteria brought forward in other Q-methodology studies, we can go forward with the analysis of the 2-, 3- and 4- factor solution. Choosing the amount of factors to be analyzed is a trade-off between extent of explained variance and a meaningful set of farmer types (Pereira et al., 2016). Therefore this study now goes on an exploratory journey to find out which factor solution is the most interesting fit for the data.

2 FACTORS	factor 1	factor 2
# Participants defining Factor	27	18
Composite Reliability	0.991	0.986
S.E. of Factor Z-scores	0.095	0.118
Distinguishing Statements (P ≤ 0.05)	24	24

3 FACTORS	factor 1	factor 2	factor 3
# Participants defining Factor	19	15	11
Composite Reliability	0.987	0.984	0.978
S.E. of Factor Z-scores	0.114	0.126	0.148
Distinguishing Statements (P ≤ 0.05)	12	16	11

4 FACTORS	factor 1	factor 2	factor 3	factor 4
# Participants defining Factor	14	6	8	11
Composite Reliability	0.982	0.96	0.97	0.978
S.E. of Factor Z-scores	0.134	0.2	0.173	0.148
Distinguishing Statements (P ≤ 0.05)	6	13	9	8

5 FACTORS	factor 1	factor 2	factor 3	factor 4	factor 5
# Participants defining Factor	13	8	8	4	3
Composite Reliability	0.981	0.97	0.97	0.941	0.923
S.E. of Factor Z-scores	0.138	0.173	0.173	0.243	0.277
Distinguishing Statements (P ≤ 0.05)	5	6	4	5	6

6 FACTORS	factor 1	factor 2	factor 3	factor 4	factor 5	factor 6
# Participants defining Factor	10	6	8	3	3	3
Composite Reliability	0.976	0.96	0.97	0.923	0.923	0.923
S.E. of Factor Z-scores	0.155	0.2	0.173	0.277	0.277	0.277
Distinguishing Statements (P ≤ 0.05)	4	4	3	2	5	6

7 FACTORS	factor 1	factor 2	factor 3	factor 4	factor 5	factor 6	factor 7
# Participants defining Factor	9	6	6	1	3	1	2
Composite Reliability	0.973	0.96	0.96	0.8	0.923	0.8	0.889
S.E. of Factor Z-scores	0.164	0.2	0.2	0.447	0.277	0.447	0.333
Distinguishing Statements (P ≤ 0.05)	1	1	2	3	3	5	2

8 FACTORS	factor 1	factor 2	factor 3	factor 4	factor 5	factor 6	factor 7	factor 8
# Participants defining Factor	8	2	5	2	3	3	4	1
Composite Reliability	0.97	0.889	0.952	0.889	0.923	0.923	0.941	0.8
S.E. of Factor Z-scores	0.173	0.333	0.219	0.333	0.277	0.277	0.243	0.447
Distinguishing Statements (P ≤ 0.05)	1	0	2	1	1	2	1	4

Figure 13 - Factor Characteristics of the respecitve 2, 3, 4, 5, 6, 7 & 8 number of factor solution cases.

2-factor solution

In this analysis two factors were kept in rotation, accounting for 44% of the total variance. 45 of the 49 farmers (92% of the sample) were automatically *flagged* to the factor with which they had significant loading. For each factor, a factor matrix, factor visualization and a list of distinguishing statements can be found in Annex 9.1.

An important reason for the relatively high representative percentage (Table 20) is the fact that no farmers were disregarded on the basis of criterion two for automatic *flagging*. This criterion states that Q-sorts need to have a square loading that is higher than the sum of square loadings of the same Q-sort in all other factors. Because in the case of a 2 factor solution there is only one other factor to consider, the highest loading, if significant, is automatically *flagged* independent of the loading on the other factor. If we for instance look at the factor loading of Q-sort 28 in Annex 9.1, we find that this Q-sort was flagged for factor 2. The loading values are 0.44 and 0.46 respectively for factor 1 and 2. Because both loadings are significant, the Q-sort is automatically *flagged* to factor 2. Similar *flagging* behavior, where the loading difference is less than 0.10, happens in the case of Q-sorts 31, 38, 45 and 48. If we disregard these Q-sorts the solution represents 40 of the 49 farmers (82% of the sample). For this adopted 2 factors solution, a factor matrix, factor visualization and a list of distinguishing statements can be found in Annex 9.2. The full set of statements and scores can be seen found below in Table 23.

Detailed accounts are presented below for both factor 1 and factor 2. These were composed by examining the sorting of statements in relation to the other statements within the factor and by comparing this with the other factors. It is the relative positions within the entire sort that describe the factor and not just the individual statements themselves. From the two factors, each of which can be considered as a synthetic representative farmer according to their key sorting behavior, a brief farmer typology was created (Table 24).

2-Factor Solution
Factor 1
Characteristics: follower, risk-averse, dependent
The farmers in this factor prefer WTTs that are cheaper, more familiar and more understandable. If these highly valued variables result in WTT for irrigation that are relatively more expensive to run, this is accepted. External support or advice is hugely appreciated because of lack of knowledge about the technologies and financial capabilities.
Factor 2
Characteristics: cost-effective decision maker, long-term thinking
The farmers in this factor are looking for a cost-effective long-term investment. Their decision-making to adopt WTT for irrigation is heavily influenced by the ease of use and the labour saving technologies ability of the technology.

Table 24 - A brief summary of the two factors

Theme Q statement	Factor scores	
The characteristics of the WTT	F1	F2
Financial aspects and affordability		
1. I prefer paying through installments over time.	2	0
2. I want overall affordable costs.	0	4
3. I don't mind paying fuel to keep the technology working.	-1	-3
4. I am happy with my current pumping method. I don't want to invest.	-2	-1
5. I prefer to wait for someone to give me an irrigation technology.	-1	-2
6. It is too expensive. I don't want to invest.	-3	-2
7. I have other farming limitations. I don't want to invest.	-3	-3
8. I prefer to use and pay for a technology with a group of farmers instead of individually.	2	1
9. I prefer to adopt a more expensive technology but safe on running cost.	-1	2
Management		
10. I find easy individual operation important.	1	3
11. I find easy maneuverability important.	0	0
12. I find it important that the technology is hard to vandalize or steal.	0	-1
Technology characteristics		
13. I want to be able to maintain the technology myself.	2	2
14. I want it to be cheap to maintain the technology.	0	4
15. I want my irrigation technology to give me a better status in my community.	-1	-2
16. I prefer a technology that works automatically without human power.	-2	2
17. I prefer a technology that can give me a high volume of water.	3	1
18. I prefer a technology that can give me a high pressure.	2	0
19. I want the technology to enable me to grow crops that I can sell at the market.	4	3
20. I want the technology to enable me to grow crops that I can eat.	3	2
21. I prefer a technology that uses water efficiently.	-1	3
Environment		
22. I don't mind watering the crops myself without the use of a technology.	-2	-4
23. My water availability and water source determine my technology choice.	1	1
Characteristics & circumstances of farmer within their (social) environment		
Community		
24. I want support from my community and family.	-2	-1
Ownership		
25. I don't own the land on which I farm. I don't want to invest.	-4	-4
26. I can't expand my farm. I don't want to invest.	-4	-3
Agricultural extension services		
27. I prefer a technology that has been advocated by the extension officers.	3	1
Company relationship		
28. I need external support after implementation.	4	0
29. I prefer if the company representatives are Malawian.	-3	-1
The process of learning and experience		
Familiarity		
30. I want to hear about the technology before I adopt it.	1	0
31. I want to have seen the technology before I adopt it.	0	-2
32. I want to try out the technology before I adopt it.	0	-1
33. I want a technology that other farmers have used successfully before I adopt it.	1	1
Understandability		
34. I prefer technology that I can understand.	1	0

Table 23 - Raw scores of statements for the 2-factor solution.

Factor 1

26 farmers loaded significantly on factor 1. The farmers in factor 1 seem to be heavily influenced by variables involving external support. This support can involve finances and help with farming inputs, but also knowledge about irrigation management, local markets or the different WTT options. The decision-making process for instance is heavily impacted by the advice given by governmental extension officers. Also, statement 29 was often associated with external support from development organizations and the disagreeing sorting behavior of factor 1 can be interpreted as another expression of the request to be supported by external organizations:

28	I need external support after implementation.	**4**
27	I prefer a technology that has been advocated by the extension officers.	**3**
29	I prefer if the company representatives are Malawian.	**-3**

As a supplement to the statements mentioned above, from the statements on the right can be concluded that the farmers are financially limited in their adoption of WTTs. More advanced and more expensive technologies might therefore be difficult to attain. Paying for technologies by installments and in a group, however, helps to open a wider range of technology options:

1	I prefer paying through installments over time.	**2**
8	I prefer to use and pay for a technology with a group of farmers instead of individually.	**2**
9	I prefer to adopt a more expensive technology but safe on running cost.	**-1**

Especially compared to factor 2, the sorting behavior of factor 1 is significantly more risk-averse. This is expressed in the relatively high valued importance of familiarity and understandability, but also in their preference to adopt a WTT in a group, spreading the financial risk:

30	I want to hear about the technology before I adopt it.	**2**
8	I prefer to use and pay for a technology with a group of farmers instead of individually.	**2**
34	I prefer technology that I can understand.	**1**
31	I want to have seen the technology before I adopt it.	**0**

The sorting behavior of factor 1 seems to express a stronger focus on high volumes of water compared to the efficient use of water. This means that the farmers of factor 1 experiences water more as an abundant resource to be utilized rather than a scarce resource that needs to be used efficiently.

17	I prefer a technology that can give me a high volume of water.	**3**
21	I prefer a technology that uses water efficiently.	**0**

Factor 2

14 farmers loaded significantly on factor 2. The cost effectiveness of the WTT is something that factor 2 values relatively much compared to factor 1. In financial terms this does not just involve the size of the initial investment, but also the long-term maintenance and running cost of the technology:

2	I want overall affordable costs.	**4**
14	I want it to be cheap to maintain the technology.	**4**
21	I prefer a technology that uses water efficiently.	**3**
9	I prefer to adopt a more expensive technology but safe on running cost.	**2**
3	I don't mind paying fuel to keep the technology working.	**-2**

Unlike factor 1, the farmers in factor 2 have a stronger preference for the WTT enabling the efficient use of water compared to giving high volumes of water:

21	I prefer a technology that uses water efficiently.	**3**
17	I prefer a technology that can give me a high volume of water.	**1**

The farmers in factor 2 greatly value, compared to factor 1, the ease of use of the WTT. The ability of WTTs to work automatically is therefore strongly preferred. Unlike when using watering cans were one has to walk up and down to the water source, these technologies require little human effort or attention when pumping water. This enables the farmers to focus on other activities such as working on the crops or expanding the farm:

16	I prefer a technology that works automatically without human power.	**2**
10	I find easy individual operation important.	**2**

Consensus

Besides statements that distinguished the Q-sort participants into two factors, there are also statements that participants agree on. This happens when similar sorting of some statements, which in the Q-methodology is called *consensus*, appears. It means that there is no significant difference between the factors. In the midst of all the subjectivity between

participants, it can be especially interesting to discover statements that people have agreement on. The consensus statements are colored green in the factor visualizations (Annex 9.2).

Out of all statements in the 2-factor solution there were 10 out of 34 statements which were sorted significantly similar by all participants (Table 25). There was a strong consensus against the notion that investment in WTT for irrigation is entirely blocked by financial, farm size or ownership limitations. Using a technology to pump water to irrigate crops is strongly preferred to the alternative; manually retrieving it from the river oneself. There was also significant consensus in favor of edible crops that can be sold to the market:

Consensus statements		**F1**	**F2**
20	I want the technology to enable me to grow crops that I can eat.	3	2
13	I want to be able to maintain the technology myself.	2	2
23	My water availability and water source determine my technology choice.	1	1
33	I want a technology that other farmers have used successfully before I adopt it.	1	1
11	I find easy maneuverability important.	0	0
6	It is too expensive. I don't want to invest.	-3	-2
22	I don’t mind watering the crops myself without the use of a technology.	-2	-4
7	I have other farming limitations. I don't want to invest.	-3	-3
26	I can't expand my farm. I don't want to invest.	-4	-3
25	I don't own the land on which I farm. I don't want to invest.	-4	-4

Table 25 - Raw scores of consensus statements for the 2-factor solution.

3-factor solution

In this analysis three factors were kept in rotation, accounting for 50% of the total variance. 45 of the 49 farmers (92% of the sample) were automatically *flagged* to the factor with which they had significant loading. The remaining 4 farmers were disregarded for this part of the analysis because they loaded insignificant or loaded significantly on more than one factor (multiple loaders). For each factor, a factor matrix, factor visualization and a list of distinguishing statements can be found in Annex 9.3. Detailed accounts of all three factors are presented below. These were composed by examining the sorting of statements in relation to the other statements within the factor and by comparing this with the other factors (Table 26). It is the relative positions within the entire sort that describe the factor and not just the individual statements themselves. From the three factors, each of which can be considered as a synthetic representative farmer according to their key sorting behavior, a brief farmer typology was created (Table 27).

3-Factor Solution
Factor 1
Characteristics: risk averse, environmentally aware
For the farmers in factor 3 it is very important to minimize risk. Therefore they have a strong preference for proven, familiar and understandable technologies. They pay special attention that this technology fits their specific situation and topography.
Factor 2
Characteristics: risk taker, cost-effective decision maker, long-term thinking.
The farmers in this factor are looking for a technology that is affordable and labour saving, but also offers low running cost, in order to expand their farm and grow more crops for the market.
Factor 3
Characteristics: follower, dependent
The farmers in this factor prefer WTTs that are relatively affordable. If this means that a WTT is relatively more expensive to run, this is accepted. External support or advice is hugely appreciated because of lack of knowledge about the technologies or low financial capabilities.

Table 27 - A brief summary of the three factors

Factor 1

19 farmers loaded significantly on factor 1. This farmers in this factor express high value to the notion that different physical situations influence the suitability of a WTT, and they are determined to find the best technology fit with theirs:

23	My water availability and water source determine my technology choice.	**4**

The sorting behavior of factor 1 also shows that its farmers are significantly more risk-averse when choosing WTT for irrigation. This is expressed in the relatively high valued importance of familiarity and understandability, but also in the preference for technologies that are hard to vandalize or steal:

30	I want to hear about the technology before I adopt it.	**2**
12	I find it important that the technology is hard to vandalize or steal.	**2**
34	I prefer technology that I can understand.	**1**
32	I want to try out the technology before I adopt it.	**1**

Besides the risk-averse sorting behavior mentioned above, the farmers of factor 1 also express financially risk-averse behavior. Paying in installments reduces the initial financial risk and helps to open a wider range of technology options:

1	I prefer paying through installments over time.	**2**

The participants of factor 1 seem to attach little value to the performance indicators of the technology. Neither efficiency, water volume or pressure are of significant distinguishment:

17	I prefer a technology that can give me a high volume of water.	**1**
21	I prefer a technology that uses water efficiently.	**0**
18	I prefer a technology that can give me a high pressure.	**-1**

The maneuverability of the technology, however, is a characteristic that the farmers in factor 1 prefer as it is sorted most in agreement relative to the other 2 factors:

11	I find easy maneuverability important.	**1**

The decision-making process of factor 1 is also heavily impacted by the advice and support or given by governmental extension officers or external organizations:

28	I need external support after implementation.	**4**
27	I prefer a technology that has been advocated by the extension officers.	**3**

Theme Q statement	Factor scores		
The characteristics of the WTT	F1	F2	F3
Financial aspects and affordability			
1. I prefer paying through installments over time.	2	0	1
2. I want overall affordable costs.	0	4	2
3. I don't mind paying fuel to keep the technology working.	-2	-3	3
4. I am happy with my current pumping method. I don't want to invest.	-2	-1	-1
5. I prefer to wait for someone to give me an irrigation technology.	-1	-2	-2
6. It is too expensive. I don't want to invest.	-3	-2	-3
7. I have other farming limitations. I don't want to invest.	-4	-3	-2
8. I prefer to use and pay for a technology with a group of farmers instead of individually.	1	1	1
9. I prefer to adopt a more expensive technology but safe on running cost.	-1	2	0
Management			
10. I find easy individual operation important.	0	3	2
11. I find easy maneuverability important.	1	0	-1
12. I find it important that the technology is hard to vandalize or steal.	2	-1	-1
Technology characteristics			
13. I want to be able to maintain the technology myself.	2	2	2
14. I want it to be cheap to maintain the technology.	-1	4	0
15. I want my irrigation technology to give me a better status in my community.	0	-2	-1
16. I prefer a technology that works automatically without human power.	-2	2	-1
17. I prefer a technology that can give me a high volume of water.	1	1	4
18. I prefer a technology that can give me a high pressure.	-1	0	3
19. I want the technology to enable me to grow crops that I can sell at the market.	4	3	4
20. I want the technology to enable me to grow crops that I can eat.	3	2	2
21. I prefer a technology that uses water efficiently.	0	3	0
Environment			
22. I don't mind watering the crops myself without the use of a technology.	-3	-4	-3
23. My water availability and water source determine my technology choice.	3	1	1
Characteristics & circumstances of farmer within their (social) environment			
Community			
24. I want support from my community and family.	-2	-1	-3
Ownership			
25. I don't own the land on which I farm. I don't want to invest.	-4	-4	-4
26. I can't expand my farm. I don't want to invest.	-3	-3	-2
Agricultural extension services			
27. I prefer a technology that has been advocated by the extension officers.	3	1	3
Company relationship			
28. I need external support after implementation.	4	0	1
29. I prefer if the company representatives are Malawian.	-1	-1	-4
The process of learning and experience			
Familiarity			
30. I want to hear about the technology before I adopt it.	2	0	1
31. I want to have seen the technology before I adopt it.	0	-2	0
32. I want to try out the technology before I adopt it.	1	-1	-2
33. I want a technology that other farmers have used successfully before I adopt it.	0	1	0
Understandability			
34. I prefer technology that I can understand.	1	0	0

Table 26 - Raw scores of statements for the 3-factor solution.

Factor 2

15 farmers loaded significantly on factor 2. The cost effectiveness of the WTT is something that the farmers in factor 2 value relatively much. In financial terms this does not just involve the size of the initial investment, but also the long-term maintenance and running cost of the WTT:

2	I want overall affordable costs.	**4**
14	I want it to be cheap to maintain the technology.	**4**
21	I prefer a technology that uses water efficiently.	**3**
9	I prefer to adopt a more expensive technology but safe on running cost.	**2**

An important variable of the cost-effectiveness of a technology that drives the decision-making of the farmers in factor 2 is their ease of use and labour saving ability. The ability of the WTT to work automatically is therefore strongly preferred. Unlike when using watering cans were one has to walk up and down to the water source, these technologies require little human effort or attention when pumping water. This enables the farmers to focus on other activities such as working on the crops or expanding the farm:

10	I find easy individual operation important.	**3**
16	I prefer a technology that works automatically without human power.	**2**

The farmers in factor 2 attach relatively little value to the familiarity, understandability or status of a technology. As long as the WTT satisfies their most important decision-making variables, they are confident enough to adopt:

34	I prefer technology that I can understand.	**0**
30	I want to hear about the technology before I adopt it.	**0**
31	I want to have seen the technology before I adopt it.	**-2**
15	I want my irrigation technology to give me a better status in my community.	**-2**

Also, the farmers in factor 2 attach significant little, relatively to the other factors, value to external support. This can be support in terms of advice, farm inputs or financial tools to help obtain WTTs. Paying for technologies in installments for instance, is not of huge importance to the farmers in factor 2. This could suggest they have enough financial resources themselves to pay for the technology:

27	I prefer a technology that has been advocated by the extension officers.	**1**
1	I prefer paying through installments over time.	**0**
28	I need external support after implementation.	**0**

Factor 3

11 farmers loaded significantly on factor 3. The decision-making process of factor 3 is heavily impacted by the advice given by governmental extension officers. Also, statement 29 was often associated with external support from development organizations and the disagreeing sorting behavior of factor 1 can be interpreted as an expression of the request to be supported by external organizations, or to be helped by technologies developed outside of Malawi:

27	I prefer a technology that has been advocated by the extension officers.	**3**
29	I prefer if the company representatives are Malawian.	**-4**

The sorting behavior of factor 3 seems to express a stronger focus on high volumes of water compared to the efficient use of water. This means that the participants of factor 3 experience water more as an abundant recourse to be utilized rather than a scarce resource that needs to be used efficiently. Statement 18 was often associated with the use of petrol water pump. From respective sorting of this statement 18 and statement 3, we can conclude that the participants in the group have a strong preference for the performance characteristics of the petrol pump technology:

17	I prefer a technology that can give me a high volume of water.	**4**
3	I don't mind paying fuel to keep the technology working.	**3**
18	I prefer a technology that can give me a high pressure.	**3**
21	I prefer a technology that uses water efficiently.	**0**

The easy maneuverability that is inherent to the petrol pump, however, is not something that the farmers of factor 3 value much:

11	I find easy maneuverability important.	**-2**

From the way the farmers of factor 3 ordered the statements on the right, we learn that this group attaches the most amount of value to hearing about, rather than seeing or trying, the technologies:

30	I want to hear about the technology before I adopt it.	**1**
31	I want to have seen the technology before I adopt it.	**0**
32	I want to try out the technology before I adopt it.	**-2**

Consensus

Besides statements that distinguished the Q-sort participants into three factors, there are also statements that participants agree on. This happens when similar sorting of some statements, which in the Q-methodology is called *consensus*, appears. It means that there is no significant difference between the factors. In the midst of all the subjectivity between participants, it can be especially interesting to discover statements that people have agreement on. The consensus statements are colored green in the factor visualizations (Annex 9.3).

Out of all statements in the 2-factor solution there were 8 out of 34 statements which were sorted significantly similar by all participants (Table 28). There was a strong consensus against the notion that investment in WTT for irrigation is entirely blocked by financial, farm size or ownership limitations. There was also significant consensus in favor of edible crops that can be sold to the market:

Consensus statements		F1	F2	F3
6	It is too expensive. I don't want to invest.	-3	-2	-3
22	I don’t mind watering the crops myself without the use of a technology.	-3	-4	-3
33	I want a technology that other farmers have used successfully before I adopt it.	0	1	0
26	I can't expand my farm. I don't want to invest.	-3	-3	-2
13	I want to be able to maintain the technology myself.	2	2	2
5	I prefer to wait for someone to give me an irrigation technology.	-1	-2	-2
20	I want the technology to enable me to grow crops that I can eat.	3	2	2
7	I have other farming limitations. I don't want to invest.	-4	-3	-2

Table 28 - Raw scores of consensus statements for the 3-factor solution.

4-factor solution

In this analysis four factors were kept in rotation, accounting for 55% of the total variance. 39 of the 49 farmers (80% of the sample) were automatically *flagged* to the factor with which they had significant loading. The remaining 10 farmers were disregarded for this part of the analysis because they loaded insignificant or loaded significantly on more than one factor (multiple loaders). For each factor, a factor matrix, factor visualization and a list of distinguishing statements can be found in Annex 9.4. Detailed accounts of all four factors are presented below. These were composed by examining the sorting of statements in relation to the other statements within the factor and by comparing this with the other factors (Table 29). It is the relative positions within the entire sort that describe the factor and not just the individual statements themselves. From the four factors, each of which can be considered as a synthetic representative farmer according to their key sorting behavior, a brief farmer typology was created (Table 30).

4-Factor Solution
Factor 1
Characteristics: dependent, team player, environmentally aware
The farmers in this factor appreciate external support or advice because of lack of knowledge about WTTs or low financial capabilities. Being financially limited, paying in installments and using the technology in a group makes it easier to invest and helps to open a wider range of technology options. When adopting a new WTT the farmers pay special attention that this technology fits their specific situation and topography.
Factor 2
Characteristics: risk taker, cost-effective decision maker, long-term thinking.
The farmers in this factor are looking for a technology that is affordable and labour saving, but also offers low running cost, in order to expand their farm and grow more crops for the market. In this process the farmers attach relatively little value to the familiarity, understandability or safety of a technology.
Factor 3
Characteristics: follower, independent, risk averse
For the farmers in factor 3 it is very important to minimize risk. Therefore they have a strong preference for proven, familiar and understandable technologies.
Factor 4
Characteristics: independent, cost-effective decision maker, individual farmer
The farmers in factor 4 prefer affordable cost-effective WTTs that offer low running cost. The ease of use and labour saving ability of the technologies are regarded as an important benefit.

Table 30 - A brief summary of the four factors

Factor 1

14 farmers loaded significantly on factor 1. The farmers of factor 1 seem to be somewhat influenced by variables involving external support and advice. This support can involve finances and help with farming inputs, but also knowledge about irrigation management, local markets or the different WTT options. The sorting of statement 27 for instance shows the decision-making process is heavily impacted by the advice given by governmental extension officers. The sorting of statement 29 suggests that the farmers do not attach great value to where this support comes from, be from within Malawi, be it from outside Malawi:

28	I need external support after implementation.	**4**
27	I prefer a technology that has been advocated by the extension officers.	**3**
29	I prefer if the company representatives are Malawian.	**-1**

As a supplement to the statements mentioned above, from the sorting of statement 9 can be concluded that the participants are financially limited in their adoption of WTTs. More advanced and more expensive technologies might therefore be difficult to attain:

9	I prefer to adopt a more expensive technology but safe on running cost.	**-1**

The problem with the less expensive available WTTs, however, is that they might come with higher running cost. The statements that are related to running cost, however, are sorted in an inconsistent way. On the one hand the farmers do not want to accept or can't afford high running cost:

3	I don't mind paying fuel to keep the technology working.	**-3**

Theme Q statement	Factor scores			
The characteristics of the WTT	F1	F2	F3	F4
Financial aspects and affordability				
1. I prefer paying through installments over time.	3	2	0	1
2. I want overall affordable costs.	1	3	1	3
3. I don't mind paying fuel to keep the technology working.	-3	0	3	-2
4. I am happy with my current pumping method. I don't want to invest.	-2	-1	-2	-2
5. I prefer to wait for someone to give me an irrigation technology.	-1	-4	-1	-2
6. It is too expensive. I don't want to invest.	-3	-2	-3	-3
7. I have other farming limitations. I don't want to invest.	-2	-1	-3	-4
8. I prefer to use and pay for a technology with a group of farmers instead of individually.	2	1	1	0
9. I prefer to adopt a more expensive technology but safe on running cost.	-1	0	1	2
Management				
10. I find easy individual operation important.	0	1	2	4
11. I find easy maneuverability important.	1	-1	-1	0
12. I find it important that the technology is hard to vandalize or steal.	2	-3	0	1
Technology characteristics				
13. I want to be able to maintain the technology myself.	2	1	2	3
14. I want it to be cheap to maintain the technology.	-1	2	0	4
15. I want my irrigation technology to give me a better status in my community.	0	-2	-1	-1
16. I prefer a technology that works automatically without human power.	-2	1	-2	2
17. I prefer a technology that can give me a high volume of water.	1	2	4	0
18. I prefer a technology that can give me a high pressure.	-1	2	3	-1
19. I want the technology to enable me to grow crops that I can sell at the market.	3	3	4	3
20. I want the technology to enable me to grow crops that I can eat.	4	4	2	1
21. I prefer a technology that uses water efficiently.	0	4	-1	2
Environment				
22. I don't mind watering the crops myself without the use of a technology.	-3	-4	-2	-3
23. My water availability and water source determine my technology choice.	2	0	0	2
Characteristics & circumstances of farmer within their (social) environment				
Community				
24. I want support from my community and family.	-4	-3	-2	0
Ownership				
25. I don't own the land on which I farm. I don't want to invest.	-4	-1	-4	-4
26. I can't expand my farm. I don't want to invest.	-2	-2	-3	-3
Agricultural extension services				
27. I prefer a technology that has been advocated by the extension officers.	3	3	2	1
Company relationship				
28. I need external support after implementation.	4	1	0	-1
29. I prefer if the company representatives are Malawian.	-1	0	-4	-1
The process of learning and experience				
Familiarity				
30. I want to hear about the technology before I adopt it.	1	-2	3	1
31. I want to have seen the technology before I adopt it.	0	-1	0	-2
32. I want to try out the technology before I adopt it.	0	-3	-1	-1
33. I want a technology that other farmers have used successfully before I adopt it.	0	0	1	0
Understandability				
34. I prefer technology that I can understand.	1	0	1	0

Table 29 - Raw scores of statements for the 4-factor solution.

On the other hand, cheap maintenance of a technology is sorted lowest compared to the other factors:

14	I want it to be cheap to maintain the technology.	**-1**

Paying in installments and using the technology in a group, however, makes it easier to invest and helps to open a wider range of technology options. Hence the farmers in factor 1 attach significant value to the statements on the right:

1	I prefer paying through installments over time.	**3**
8	I prefer to use and pay for a technology with a group of farmers instead of individually.	**2**

Easy individual operation when using the technology in a group, is not a of great importance. This can be concluded by the fact that statement 10 is sorted lowest out of all factors in this 4-factor solution. Maneuverability, however, is preferred, as it is sorted highest relative to the other factors:

11	I find easy maneuverability important.	**1**
10	I find easy individual operation important.	**0**

The farmers in this factor express high value to the notion that different physical situations influence the suitability of a WTT, and they try to find the best technology fit with theirs:

23	My water availability and water source determine my technology choice.	**2**

Factor 2

6 farmers loaded significantly on factor 2. The cost effectiveness of the WTT is something that the participants in factor 2 value relatively much. In financial terms this does not just involve the size of the initial investment, but also the long-term maintenance and running cost of the WTT:

2	I want overall affordable costs.	**3**
17	I prefer a technology that can give me a high volume of water.	**2**
18	I prefer a technology that can give me a high pressure.	**2**
14	I want it to be cheap to maintain the technology.	**4**
21	I prefer a technology that uses water efficiently.	**4**

Investing a little more to safe on running cost, however, is not significantly agreed with:

9	I prefer to adopt a more expensive technology but safe on running cost.	**0**

If the farmers have to deal with external parties when adopting a WTT, there is not much value attached to whether the company or organization is based in Malawi or not:

29	I prefer if the company representatives are Malawian.	**0**

The farmers in factor 2 attach relatively little value to the familiarity, understandability, status or safety of a technology. As long as the WTT satisfies their most important decision-making variables, they are confident enough to adopt:

34	I prefer technology that I can understand.	**0**
31	I want to have seen the technology before I adopt it.	**-1**
30	I want to hear about the technology before I adopt it.	**-2**
15	I want my irrigation technology to give me a better status in my community.	**-2**
32	I want to try out the technology before I adopt it.	**-3**
12	I find it important that the technology is hard to vandalize or steal.	**-3**

Factor 3

8 farmers loaded significantly on factor 3. The sorting behavior of factor 3 seems to express a stronger focus on high volumes of water compared to the efficient use of water. Statement 18 was often associated with the use of petrol water pumps. From respective sorting of this statement 18 and statement 3, we can conclude that the participants in the group have a strong preference for the performance characteristics of the petrol pump technology:

17	I prefer a technology that can give me a high volume of water.	**4**
18	I prefer a technology that can give me a high pressure.	**3**
3	I don't mind paying fuel to keep the technology working.	**3**
21	I prefer a technology that uses water efficiently.	**-1**

The sorting behavior of factor 3 also shows that its participants are significantly more risk-averse when choosing WTT for irrigation. This is expressed in the relatively high valued importance of familiarity and understandability:

30	I want to hear about the technology before I adopt it.	**3**
34	I prefer technology that I can understand.	**1**
31	I want to have seen the technology before I adopt it.	**2**
32	I want to try out the technology before I adopt it.	**1**

Also, the participants in factor 2 attach significant little, relatively to the other factors, value to external support. This can be support in terms of advice, farm inputs or financial tools to help obtain WTTs. If the farmer has to deal with external parties when adopting a WTT, there is no preference for Malawian based companies or organizations:

27	I prefer a technology that has been advocated by the extension officers.	**0**
28	I need external support after implementation.	**-1**
29	I prefer if the company representatives are Malawian.	**-4**

Factor 4

11 farmers loaded significantly on factor 4. The cost effectiveness of the WTT is something that the farmers in factor 4 value relatively much. In financial terms this does not just involve the size of the initial investment, but also the long-term maintenance and running cost of the WTT:

2	I want overall affordable costs.	**3**
14	I want it to be cheap to maintain the technology.	**4**
21	I prefer a technology that uses water efficiently.	**2**
9	I prefer to adopt a more expensive technology but safe on running cost.	**2**
3	I don't mind paying fuel to keep the technology working.	**-2**

An important variable of the cost-effectiveness of a technology that drives the decision-making of the farmers in factor 4 is their ease of use and labour saving ability. The ability of the WTT to work automatically is therefore strongly preferred. Unlike when using watering cans were one has to walk up and down to the water source, these technologies require little human effort or attention when pumping water. This enables the farmers to focus on other activities such as working on the crops or expanding the farm:

10	I find easy individual operation important.	**4**
16	I prefer a technology that works automatically without human power.	**2**

The farmers in factor 4 attach significant little, relatively to the other factors, value to external support. This can be support in terms of advice, farm inputs or financial tools to help obtain WTTs:

27	I prefer a technology that has been advocated by the extension officers.	**1**
28	I need external support after implementation.	**-1**
29	I prefer if the company representatives are Malawian.	**-1**

Consensus

Besides statements that distinguished the Q-sort participants into four factors, there are also statements that participants agree on. This happens when similar sorting of some statements, which in the Q-methodology is called *consensus*, appears. It means that there is no significant difference between the factors. In the midst of all the subjectivity between participants, it can be especially interesting to discover statements that people have agreement on. The consensus statements are colored green in the factor visualizations (Annex 9.4).

Out of all statements in the 4-factor solution there were 5 out of 34 statements which were sorted significantly similar by all participants (Table 31). There was a strong consensus in favor of the need to invest in WTT, and against the notion that investment in WTT for irrigation is entirely blocked by farm size or ownership limitations or other farming limitations:

Consensus statements		F1	F2	F3	F4
34	I prefer technology that I can understand.	1	0	1	0
26	I can't expand my farm. I don't want to invest.	-2	-2	-3	-3
6	It is too expensive. I don't want to invest.	-3	-2	-3	-3

Table 31 - Raw scores of consensus statements for the 4-factor solution.

Conclusion

After analyzing all factor solutions, we can draw several conclusions. It is clear that, although the 2-factor solution has a high representative score (82%), it does not embrace the variety represented in the group of farmers. This is supported by the fact that the 2 factor solution only represents 44% of the total variance. Also, when looking at the factor visualizations in Annex 9.2, we find that all statements are either significantly distinct or of consensus, indicating that significance is easily reached and that there is more variety to this group of participants than a 2-factor solution can display.

The three and 4-factor solution were found to both give enough distinguishing statements for analysis. It was, however, found that a 4-factor solution was the most interesting fit for the data. The reason for this is that it is able to embrace more variety and subjectivity, while still providing enough information to make a meaningful ontology.

Although it is clear that the amount of significant consensus statements decreases when the amount of factors increases, the statements are generally the same for each factor solution. For all factor solutions there was a strong consensus in favor of the need to invest in WTT, and against the notion that investment in WTT is entirely blocked by farm size or other farming limitations.

Differences between all participants versus farmers only

The effect of the removal of the 9 experts in the analysis largely depends on the amount factors in the factor solution. In the 2 factor solution for instance, the differences between the sorting behavior of the respective factors of all participants versus only the farming participants are minimal. The removal of the 9 expert participants does not seem to influence the factor scores. This is understandable because of the relatively large size of the factors.

In the case of the 4-factor solution, however, we find that the removal of the experts has made a considerable difference. Factors 3 of the 4-factor solution with all participants shows no or little affinity with the factors of the 4-factor solution with farmers only. Hence, the presented detailed account shows considerable differences in sorting behavior. Factor 1, 2 and 4 in the 4-factor solution with all participants, however, have strong resemblance with factor 3, 4 and 1 respectively in the 4-factor solution for farmers only (Table 32). When investigating further this makes sense, because only one of the experts in the 4-factor solution with all participants loaded on factor 1 and none of the experts loaded on factor 2 or 4 (Annex 11.4). Therefore the sorting behavior of the experts had relatively little influence on the factor scores of these factors. The remaining factor 3 in the 4-factor solution for all participants, however, consisted of 9 participants in total, of which 4 experts. The removal of the experts results in the scattering of the remaining participants over the rest of the factors and the unflagged group. A detailed overview of how the consistency of the factors change when excluding the experts, can be found below in Table 33.

4-factor solution	
All participants	**Farmers only**
Factor 1 →	Factor 3
Factor 2 →	Factor 4
Factor 4 →	Factor 1

Table 32 - Strong resemblance between the factors in the 4-factor solution with and without experts.

When investigating a little further, perhaps not unsurprisingly, we find that when including the experts more value is attached to the aspects of familiarity and safety. Surprisingly however, is that when excluding the experts participants a little less value is attached to the support and advise given by extension officers.

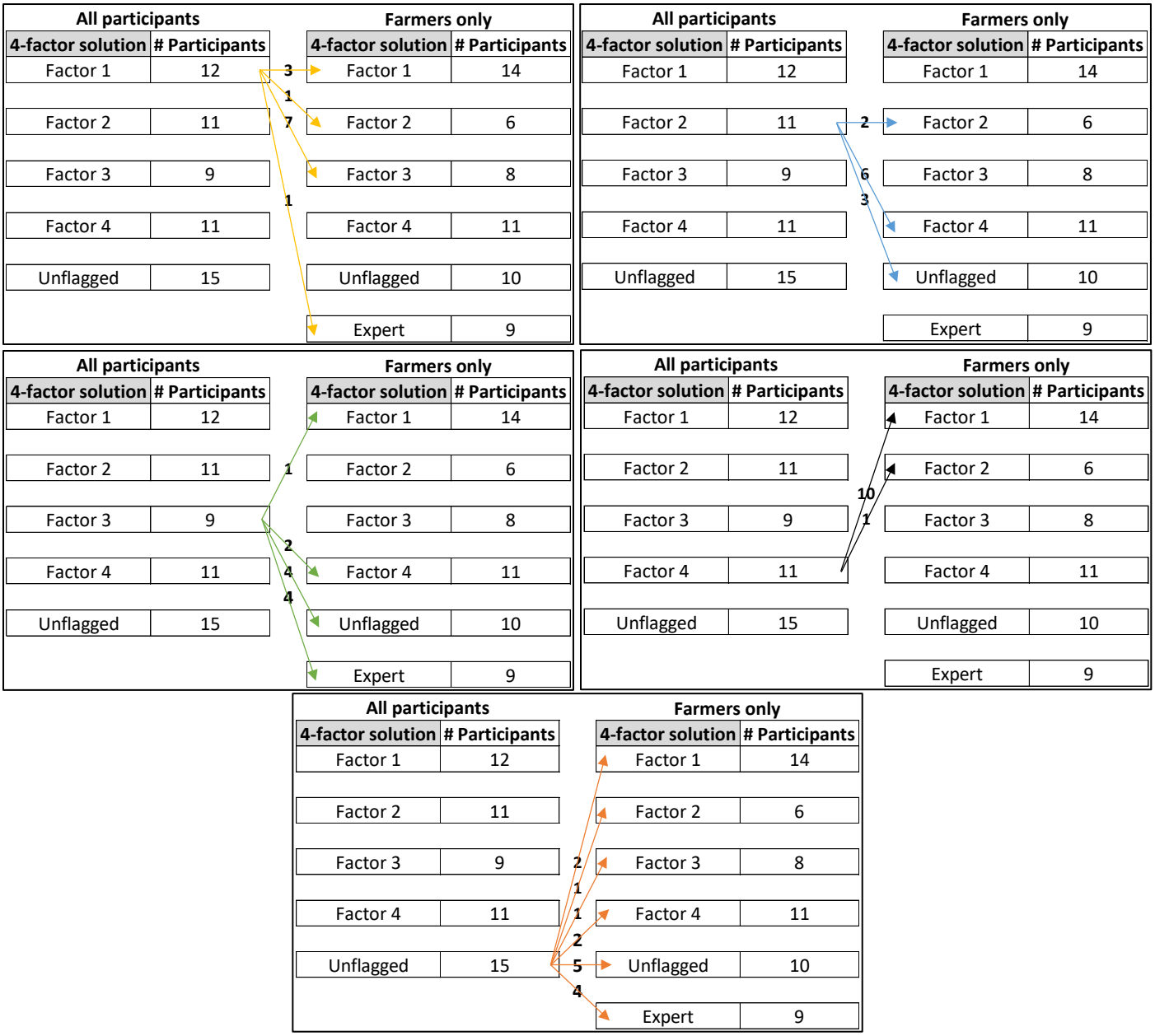


Table 33 - Split up of factor 1, 2, 3 and when excluding expert participant.

Annex 9.1 – 2-Factor Solution Farmers Only

Factor Matrix with sorts Auto-Flagged (P < 0.05) & Factor Characteristics

Qsort #	Q-sort	Factor 1		Factor 2	
1	QSORT3	0.27		0.68	flagged
2	QSORT4	0.62	flagged	0.38	
3	QSORT5	0.38		0.64	flagged
4	QSORT6	0.84	flagged	0.03	
5	QSORT8	0.32		0.57	flagged
6	QSORT9	0.67	flagged	0.22	
7	QSORT10	0.44		0.55	flagged
8	QSORT11	0.50	flagged	0.26	
9	QSORT12	0.09		0.75	flagged
10	QSORT13	0.46	flagged	0.33	
11	QSORT14	0.63	flagged	0.42	
12	QSORT15	0.31		0.32	
13	QSORT16	0.69	flagged	0.24	
14	QSORT17	0.67	flagged	0.35	
15	QSORT18	0.33		0.26	
16	QSORT19	0.51	flagged	0.26	
17	QSORT20	0.30		0.73	flagged
18	QSORT21	0.20		0.74	flagged
19	QSORT22	0.39		0.68	flagged
20	QSORT23	0.58	flagged	0.21	
21	QSORT24	0.17		0.57	flagged
22	QSORT25	0.71	flagged	0.19	
23	QSORT26	0.65	flagged	0.35	
24	QSORT27	0.64	flagged	0.33	
25	QSORT28	0.65	flagged	0.24	
26	QSORT29	0.59	flagged	0.29	
27	QSORT30	0.74	flagged	0.13	
28	QSORT31	0.44		0.46	flagged
29	QSORT32	0.76	flagged	0.36	
30	QSORT33	0.26		0.55	flagged
31	QSORT34	0.32		0.41	flagged
32	QSORT35	0.72	flagged	0.00	
33	QSORT36	0.63	flagged	0.04	
34	QSORT40	-0.07		0.62	flagged
35	QSORT41	0.29		0.73	flagged
36	QSORT42	0.00		0.35	flagged
37	QSORT43	0.29		0.26	
38	QSORT44	0.27		0.36	flagged
39	QSORT45	0.75	flagged	0.24	
40	QSORT46	0.60	flagged	0.26	
41	QSORT47	0.56	flagged	0.21	
42	QSORT49	0.67	flagged	0.20	
43	QSORT50	0.07		0.66	flagged
44	QSORT51	0.27		0.22	
45	QSORT53	0.39	flagged	0.32	
46	QSORT54	0.56	flagged	0.40	
47	QSORT55	0.75	flagged	0.02	
48	QSORT56	0.36		0.41	flagged
49	QSORT57	0.67	flagged	0.25	
%Explained Variance		**27**		**18**	
Total %Explained Variance			**45**		

	Factor 1
	Factor 2
	Unflagged

Factor Characteristics

	factor 1	factor 2
No. of Defining Variables	27	18
Avg. Rel. Coef.	0.8	0.8
Composite Reliability	0.991	0.986
S.E. of Factor Z-scores	0.095	0.118

Composite Q sort for Factor 1

-4	-3	-2	-1	0	1	2	3	4
I can't expand my farm. I don't want to invest.	I prefer if the company representatives are Malawian.	I am happy with my current pumping method. I don't want to invest.	I prefer a technology that uses water efficiently.	I find easy individual operation important.	I want to hear about the technology before I adopt it.	I want to be able to maintain the technology myself.	I prefer a technology that has been advocated by the extension officers.	I want the technology to enable me to grow crops that I can sell at the market.
I don't own the land on which I farm. I don't want to invest.	I have other farming limitations. I don't want to invest.	I prefer a technology that works automatically without human power.	I want my irrigation technology to give me a better status in my community.	I want overall affordable costs.	I prefer a technology that can give me a high pressure.	I prefer to use and pay for a technology with a group of farmers instead of individually.	I want the technology to enable me to grow crops that I can eat.	I need external support after implementation.
	It is too expensive. I don't want to invest.	I want support from my community and family.	I prefer to adopt a more expensive technology but safe on running cost.	I want to have seen the technology before I adopt it.	I prefer technology that I can understand.	I prefer paying through installments over time.	I prefer a technology that can give me a high volume of water.	
		I dont mind watering the crops myself without the use of a technology.	I don't mind paying fuel to keep the technology working.	I want to try out the technology before I adopt it.	I want a technology that other farmers have used successfully before I adopt it.	My water availability and water source determine my technology choice.		
			I prefer to wait for someone to give me an irrigation technology.	I find easy maneuverability important.	I find it important that the technology is hard to vandalize or steal.			
				I want it to be cheap to maintain the technology.				

Legend

- Distinguishing statement at P< 0.05
- Distinguishing statement at P< 0.01
- Consensus statement

Composite Q sort for Factor 2

-4	-3	-2	-1	0	1	2	3	4
I dont mind watering the crops myself without the use of a technology.	I can't expand my farm. I don't want to invest.	I want my irrigation technology to give me a better status in my community.	I find it important that the technology is hard to vandalize or steal.	I prefer paying through installments over time.	I prefer a technology that has been advocated by the extension officers.	I want the technology to enable me to grow crops that I can eat.	I prefer a technology that uses water efficiently.	I want it to be cheap to maintain the technology.
I don't own the land on which I farm. I don't want to invest.	It is too expensive. I don't want to invest.	I want to have seen the technology before I adopt it.	I want to try out the technology before I adopt it.	I prefer a technology that can give me a high pressure.	My water availability and water source determine my technology choice.	I prefer a technology that works automatically without human power.	I want the technology to enable me to grow crops that I can sell at the market.	I want overall affordable costs.
	I have other farming limitations. I don't want to invest.	I prefer to wait for someone to give me an irrigation technology.	I prefer if the company representatives are Malawian.	I find easy maneuverability important.	I prefer to use and pay for a technology with a group of farmers instead of individually.	I want to be able to maintain the technology myself.	I find easy individual operation important.	
		I don't mind paying fuel to keep the technology working.	I want support from my community and family.	I prefer technology that I can understand.	I prefer a technology that can give me a high volume of water.	I prefer to adopt a more expensive technology but safe on running cost.		
			I am happy with my current pumping method. I don't want to invest.	I need external support after implementation.	I want a technology that other farmers have used successfully before I adopt it.			
				I want to hear about the technology before I adopt it.				

Legend

- Distinguishing statement at P< 0.05
- Distinguishing statement at P< 0.01
- Consensus statement

Distinguishing Statements

Factor 1

Threshold	Z scr.	Q Sort Value	State. No.	Statement
P < 0.0001	-1.372	-3	29	I prefer if the company representatives are Malawian.
P < 0.0005	-1.115	-2	4	I am happy with my current pumping method. I don't want to invest.
P < 0.0001	-1.245	-2	24	I want support from my community and family.
P < 0.0001	-1.135	-2	16	I prefer a technology that works automatically without human power.
P < 0.05	-0.723	-1	5	I prefer to wait for someone to give me an irrigation technology.
P < 0.0001	-0.385	-1	9	I prefer to adopt a more expensive technology but safe on running cost.
P < 0.0001	0.058	-1	21	I prefer a technology that uses water efficiently.
P < 0.0001	0.056	-1	15	I want my irrigation technology to give me a better status in my community.
P < 0.0001	-0.388	-1	3	I don't mind paying fuel to keep the technology working.
P < 0.0005	0.126	0	32	I want to try out the technology before I adopt it.
P < 0.0001	0.089	0	14	I want it to be cheap to maintain the technology.
P < 0.0001	0.362	0	2	I want overall affordable costs.
P < 0.0001	0.386	0	10	I find easy individual operation important.
P < 0.0001	0.248	0	31	I want to have seen the technology before I adopt it.
P < 0.0001	0.39	1	12	I find it important that the technology is hard to vandalize or steal.
P < 0.0001	0.694	1	18	I prefer a technology that can give me a high pressure.
P < 0.0001	0.73	1	30	I want to hear about the technology before I adopt it.
P < 0.0001	0.519	1	34	I prefer technology that I can understand.
P < 0.01	0.773	2	8	I prefer to use and pay for a technology with a group of farmers instead of individually.
P < 0.001	0.75	2	1	I prefer paying through installments over time.
P < 0.001	1.218	3	27	I prefer a technology that has been advocated by the extension officers.
P < 0.0001	1.123	3	17	I prefer a technology that can give me a high volume of water.
P < 0.005	1.785	4	19	I want the technology to enable me to grow crops that I can sell at the market.
P < 0.0001	1.506	4	28	I need external support after implementation.

Factor 2

Threshold	Z scr.	Q Sort Value	State. No.	Statement
P < 0.05	-1.025	-2	5	I prefer to wait for someone to give me an irrigation technology.
P < 0.0001	-1.261	-2	3	I don't mind paying fuel to keep the technology working.
P < 0.0001	-0.82	-2	31	I want to have seen the technology before I adopt it.
P < 0.0001	-0.678	-2	15	I want my irrigation technology to give me a better status in my community.
P < 0.0005	-0.542	-1	4	I am happy with my current pumping method. I don't want to invest.
P < 0.0005	-0.449	-1	32	I want to try out the technology before I adopt it.
P < 0.0001	-0.367	-1	12	I find it important that the technology is hard to vandalize or steal.
P < 0.0001	-0.461	-1	29	I prefer if the company representatives are Malawian.
P < 0.0001	-0.537	-1	24	I want support from my community and family.
P < 0.001	0.242	0	1	I prefer paying through installments over time.
P < 0.0001	-0.119	0	34	I prefer technology that I can understand.
P < 0.0001	-0.149	0	28	I need external support after implementation.
P < 0.0001	-0.172	0	30	I want to hear about the technology before I adopt it.
P < 0.0001	0.096	0	18	I prefer a technology that can give me a high pressure.
P < 0.01	0.36	1	8	I prefer to use and pay for a technology with a group of farmers instead of individually.
P < 0.001	0.715	1	27	I prefer a technology that has been advocated by the extension officers.
P < 0.0001	0.245	1	17	I prefer a technology that can give me a high volume of water.
P < 0.0001	0.911	2	16	I prefer a technology that works automatically without human power.
P < 0.0001	0.853	2	9	I prefer to adopt a more expensive technology but safe on running cost.
P < 0.005	1.296	3	19	I want the technology to enable me to grow crops that I can sell at the market.
P < 0.0001	1.319	3	21	I prefer a technology that uses water efficiently.
P < 0.0001	1.246	3	10	I find easy individual operation important.
P < 0.0001	1.745	4	2	I want overall affordable costs.
P < 0.0001	2.016	4	14	I want it to be cheap to maintain the technology.

Annex 9.2 – Adopted 2-Factor Solution Farmers Only

Factor Matrix with sorts Auto-Flagged (P < 0.05) & Factor Characteristics

Qsort #	Q-sort	Factor 1		Factor 2	
1	QSORT3	0.27		0.68	flagged
2	QSORT4	0.62	flagged	0.38	
3	QSORT5	0.38		0.64	flagged
4	QSORT6	0.84	flagged	0.03	
5	QSORT8	0.32		0.57	flagged
6	QSORT9	0.67	flagged	0.22	
7	QSORT10	0.44		0.55	flagged
8	QSORT11	0.50	flagged	0.26	
9	QSORT12	0.09		0.75	flagged
10	QSORT13	0.46	flagged	0.33	
11	QSORT14	0.63	flagged	0.42	
12	QSORT15	0.31		0.32	
13	QSORT16	0.69	flagged	0.24	
14	QSORT17	0.67	flagged	0.35	
15	QSORT18	0.33		0.26	
16	QSORT19	0.51	flagged	0.26	
17	QSORT20	0.30		0.73	flagged
18	QSORT21	0.20		0.74	flagged
19	QSORT22	0.39		0.68	flagged
20	QSORT23	0.58	flagged	0.21	
21	QSORT24	0.17		0.57	flagged
22	QSORT25	0.71	flagged	0.19	
23	QSORT26	0.65	flagged	0.35	
24	QSORT27	0.64	flagged	0.33	
25	QSORT28	0.65	flagged	0.24	
26	QSORT29	0.59	flagged	0.29	
27	QSORT30	0.74	flagged	0.13	
28	QSORT31	0.44		0.46	
29	QSORT32	0.76	flagged	0.36	
30	QSORT33	0.26		0.55	flagged
31	QSORT34	0.32		0.41	
32	QSORT35	0.72	flagged	0.00	
33	QSORT36	0.63	flagged	0.04	
34	QSORT40	-0.07		0.62	flagged
35	QSORT41	0.29		0.73	flagged
36	QSORT42	0.00		0.35	flagged
37	QSORT43	0.29		0.26	
38	QSORT44	0.27		0.36	
39	QSORT45	0.75	flagged	0.24	
40	QSORT46	0.60	flagged	0.26	
41	QSORT47	0.56	flagged	0.21	
42	QSORT49	0.67	flagged	0.20	
43	QSORT50	0.07		0.66	flagged
44	QSORT51	0.27		0.22	
45	QSORT53	0.39		0.32	
46	QSORT54	0.56	flagged	0.40	
47	QSORT55	0.75	flagged	0.02	
48	QSORT56	0.36		0.41	
49	QSORT57	0.67	flagged	0.25	
%Explained Variance		**27**		**18**	
Total %Explained Variance			**45**		

	Factor 1
	Factor 2
	Unflagged

Factor Characteristics

	factor 1	factor 2
No. of Defining Variables	26	14
Avg. Rel. Coef.	0.8	0.8
Composite Reliability	0.99	0.982
S.E. of Factor Z-scores	0.1	0.134

Composite Q sort for Factor 1

-4	-3	-2	-1	0	1	2	3	4
I can't expand my farm. I don't want to invest.	I prefer if the company representatives are Malawian.	I am happy with my current pumping method. I don't want to invest.	I want my irrigation technology to give me a better status in my community.	I find it important that the technology is hard to vandalize or steal.	My water availability and water source determine my technology choice.	I want to be able to maintain the technology myself.	I prefer a technology that has been advocated by the extension officers.	I want the technology to enable me to grow crops that I can sell at the market.
I don't own the land on which I farm. I don't want to invest.	I have other farming limitations. I don't want to invest.	I prefer a technology that works automatically without human power.	I prefer a technology that uses water efficiently.	I want overall affordable costs.	I want to hear about the technology before I adopt it.	I prefer to use and pay for a technology with a group of farmers instead of individually.	I want the technology to enable me to grow crops that I can eat.	I need external support after implementation.
	It is too expensive. I don't want to invest.	I want support from my community and family.	I don't mind paying fuel to keep the technology working.	I want to have seen the technology before I adopt it.	I prefer technology that I can understand.	I prefer paying through installments over time.	I prefer a technology that can give me a high volume of water.	
		I dont mind watering the crops myself without the use of a technology.	I prefer to adopt a more expensive technology but safe on running cost.	I find easy maneuverability important.	I find easy individual operation important.	I prefer a technology that can give me a high pressure.		
			I prefer to wait for someone to give me an irrigation technology.	I want to try out the technology before I adopt it.	I want a technology that other farmers have used successfully before I adopt it.			
				I want it to be cheap to maintain the technology.				

Legend

- Distinguishing statement at P< 0.05
- Distinguishing statement at P< 0.01
- Consensus statement

Composite Q sort for Factor 2

-4	-3	-2	-1	0	1	2	3	4
I dont mind watering the crops myself without the use of a technology.	I can't expand my farm. I don't want to invest.	I want my irrigation technology to give me a better status in my community.	I want to try out the technology before I adopt it.	I prefer paying through installments over time.	I prefer a technology that has been advocated by the extension officers.	I want the technology to enable me to grow crops that I can eat.	I prefer a technology that uses water efficiently.	I want it to be cheap to maintain the technology.
I don't own the land on which I farm. I don't want to invest.	I don't mind paying fuel to keep the technology working.	I want to have seen the technology before I adopt it.	I find it important that the technology is hard to vandalize or steal.	I prefer a technology that can give me a high pressure.	My water availability and water source determine my technology choice.	I prefer a technology that works automatically without human power.	I find easy individual operation important.	I want overall affordable costs.
	I have other farming limitations. I don't want to invest.	I prefer to wait for someone to give me an irrigation technology.	I prefer if the company representatives are Malawian.	I need external support after implementation.	I want a technology that other farmers have used successfully before I adopt it.	I want to be able to maintain the technology myself.	I want the technology to enable me to grow crops that I can sell at the market.	
		It is too expensive. I don't want to invest.	I want support from my community and family.	I find easy maneuverability important.	I prefer a technology that can give me a high volume of water.	I prefer to adopt a more expensive technology but safe on running cost.		
			I am happy with my current pumping method. I don't want to invest.	I want to hear about the technology before I adopt it.	I prefer to use and pay for a technology with a group of farmers instead of individually.			
				I prefer technology that I can understand.				

Legend

- Distinguishing statement at P< 0.05
- Distinguishing statement at P< 0.01
- Consensus statement

Distinguishing Statements

Factor 1

Threshold	Z scr.	Q Sort Value	State. No.	Statement
P < 0.0001	-1.367	-3	29	I prefer if the company representatives are Malawian.
P < 0.001	-1.135	-2	4	I am happy with my current pumping method. I don't want to invest.
P < 0.0001	-1.258	-2	24	I want support from my community and family.
P < 0.0001	-1.136	-2	16	I prefer a technology that works automatically without human power.
P < 0.05	-0.712	-1	5	I prefer to wait for someone to give me an irrigation technology.
P < 0.0001	-0.389	-1	9	I prefer to adopt a more expensive technology but safe on running cost.
P < 0.0001	0.04	-1	21	I prefer a technology that uses water efficiently.
P < 0.0001	0.047	-1	15	I want my irrigation technology to give me a better status in my community.
P < 0.0001	-0.373	-1	3	I don't mind paying fuel to keep the technology working.
P < 0.01	0.09	0	32	I want to try out the technology before I adopt it.
P < 0.0001	0.053	0	14	I want it to be cheap to maintain the technology.
P < 0.0001	0.366	0	12	I find it important that the technology is hard to vandalize or steal.
P < 0.0001	0.366	0	2	I want overall affordable costs.
P < 0.0001	0.241	0	31	I want to have seen the technology before I adopt it.
P < 0.0001	0.417	1	10	I find easy individual operation important.
P < 0.0001	0.718	1	30	I want to hear about the technology before I adopt it.
P < 0.0001	0.496	1	34	I prefer technology that I can understand.
P < 0.0005	0.79	2	8	I prefer to use and pay for a technology with a group of farmers instead of individually.
P < 0.0001	0.748	2	1	I prefer paying through installments over time.
P < 0.0001	0.739	2	18	I prefer a technology that can give me a high pressure.
P < 0.005	1.23	3	27	I prefer a technology that has been advocated by the extension officers.
P < 0.0001	1.116	3	17	I prefer a technology that can give me a high volume of water.
P < 0.0005	1.784	4	19	I want the technology to enable me to grow crops that I can sell at the market.
P < 0.0001	1.521	4	28	I need external support after implementation.

Factor 2

Threshold	Z scr.	Q Sort Value	State. No.	Statement
P < 0.0001	-1.25	-3	3	I don't mind paying fuel to keep the technology working.
P < 0.05	-1.054	-2	5	I prefer to wait for someone to give me an irrigation technology.
P < 0.0001	-0.783	-2	31	I want to have seen the technology before I adopt it.
P < 0.0001	-0.68	-2	15	I want my irrigation technology to give me a better status in my community.
P < 0.01	-0.349	-1	32	I want to try out the technology before I adopt it.
P < 0.001	-0.582	-1	4	I am happy with my current pumping method. I don't want to invest.
P < 0.0001	-0.361	-1	12	I find it important that the technology is hard to vandalize or steal.
P < 0.0001	-0.519	-1	29	I prefer if the company representatives are Malawian.
P < 0.0001	-0.516	-1	24	I want support from my community and family.
P < 0.0001	0.054	0	1	I prefer paying through installments over time.
P < 0.0001	-0.199	0	34	I prefer technology that I can understand.
P < 0.0001	-0.081	0	28	I need external support after implementation.
P < 0.0001	-0.141	0	30	I want to hear about the technology before I adopt it.
P < 0.0001	0.017	0	18	I prefer a technology that can give me a high pressure.
P < 0.005	0.688	1	27	I prefer a technology that has been advocated by the extension officers.
P < 0.0005	0.184	1	8	I prefer to use and pay for a technology with a group of farmers instead of individually.
P < 0.0001	0.225	1	17	I prefer a technology that can give me a high volume of water.
P < 0.0001	0.979	2	16	I prefer a technology that works automatically without human power.
P < 0.0001	0.789	2	9	I prefer to adopt a more expensive technology but safe on running cost.
P < 0.0005	1.189	3	19	I want the technology to enable me to grow crops that I can sell at the market.
P < 0.0001	1.417	3	21	I prefer a technology that uses water efficiently.
P < 0.0001	1.266	3	10	I find easy individual operation important.
P < 0.0001	1.76	4	2	I want overall affordable costs.
P < 0.0001	2.199	4	14	I want it to be cheap to maintain the technology.

Annex 9.3 – 3-Factor Solution Farmers Only

Factor Matrix with sorts Auto-Flagged (P < 0.05) & Factor Characteristics

Factor Characteristics

	factor 1	factor 2	factor 3
No. of Defining Variables	19	15	11
Avg. Rel. Coef.	0.8	0.8	0.8
Composite Reliability	0.987	0.984	0.978
S.E. of Factor Z-scores	0.114	0.126	0.148

Qsort #	Q-sort	Factor 1		Factor 2		Factor 3	
1	QSORT3	0.21		0.64	flagged	0.28	
2	QSORT4	0.43		0.29		0.53	flagged
3	QSORT5	0.17		0.56	flagged	0.53	
4	QSORT6	0.78	flagged	-0.03		0.33	
5	QSORT8	0.29		0.54	flagged	0.24	
6	QSORT9	0.78	flagged	0.21		0.07	
7	QSORT10	0.44		0.52	flagged	0.22	
8	QSORT11	0.19		0.16		0.64	flagged
9	QSORT12	0.10		0.74	flagged	0.14	
10	QSORT13	0.57	flagged	0.33		0.02	
11	QSORT14	0.32		0.31		0.70	flagged
12	QSORT15	-0.02		0.22		0.63	flagged
13	QSORT16	0.36		0.12		0.74	flagged
14	QSORT17	0.42		0.25		0.64	flagged
15	QSORT18	0.11		0.18		0.47	flagged
16	QSORT19	0.17		0.15		0.69	flagged
17	QSORT20	0.37		0.72	flagged	0.11	
18	QSORT21	0.19		0.72	flagged	0.19	
19	QSORT22	0.24		0.61	flagged	0.46	
20	QSORT23	0.44	flagged	0.14		0.41	
21	QSORT24	0.19		0.56	flagged	0.11	
22	QSORT25	0.62	flagged	0.12		0.38	
23	QSORT26	0.54	flagged	0.28		0.41	
24	QSORT27	0.56	flagged	0.27		0.37	
25	QSORT28	0.76	flagged	0.23		0.07	
26	QSORT29	0.55	flagged	0.24		0.29	
27	QSORT30	0.6541	flagged	0.0653		0.3675	
28	QSORT31	0.4262		0.4293		0.2386	
29	QSORT32	0.5768		0.2699		0.5674	
30	QSORT33	0.3994		0.5592	flagged	-0.028	
31	QSORT34	0.0415		0.3217		0.5723	flagged
32	QSORT35	0.4061		-0.1161		0.6775	flagged
33	QSORT36	0.35		-0.0657		0.6032	flagged
34	QSORT40	-0.1662		0.5877	flagged	0.22	
35	QSORT41	0.2572		0.7007	flagged	0.2548	
36	QSORT42	0.1052		0.3668	flagged	-0.0897	
37	QSORT43	0.3473	flagged	0.2527		0.0517	
38	QSORT44	0.2414		0.3368	flagged	0.187	
39	QSORT45	0.6729	flagged	0.1746		0.379	
40	QSORT46	0.5178	flagged	0.2065		0.3412	
41	QSORT47	0.5056	flagged	0.1592		0.2831	
42	QSORT49	0.699	flagged	0.1639		0.1853	
43	QSORT50	0.0327		0.6335	flagged	0.1901	
44	QSORT51	0.2578		0.1985		0.1303	
45	QSORT53	0.5481	flagged	0.3307		-0.0605	
46	QSORT54	0.5493	flagged	0.3591		0.2424	
47	QSORT55	0.736	flagged	-0.0199		0.244	
48	QSORT56	0.4049		0.3916		0.1169	
49	QSORT57	0.6896	flagged	0.2109		0.2142	
%Explained Variance		**20**		**15**		**15**	
Total %Explained Variance			**50**				

	Factor 1
	Factor 2
	Factor 3
	Unflagged

Composite Q sort for Factor 1

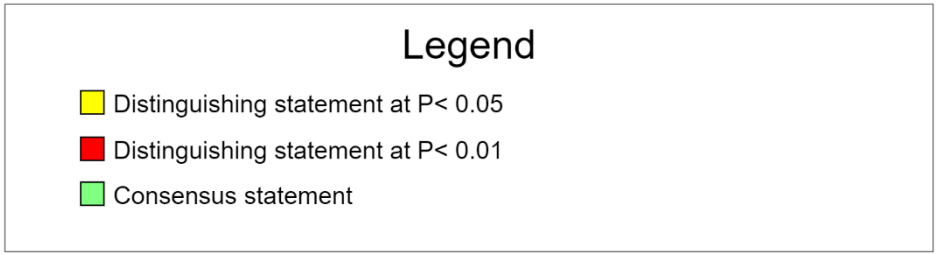
-4	-3	-2	-1	0	1	2	3	4
I have other farming limitations. I don't want to invest.	It is too expensive. I don't want to invest.	I want support from my community and family.	I prefer a technology that can give me a high pressure.	I want overall affordable costs.	I prefer to use and pay for a technology with a group of farmers instead of individually.	I prefer paying through installments over time.	I want the technology to enable me to grow crops that I can eat.	I need external support after implementation.
I don't own the land on which I farm. I don't want to invest.	I can't expand my farm. I don't want to invest.	I don't mind paying fuel to keep the technology working.	I want it to be cheap to maintain the technology.	I want my irrigation technology to give me a better status in my community.	I prefer technology that I can understand.	I find it important that the technology is hard to vandalize or steal.	I prefer a technology that has been advocated by the extension officers.	I want the technology to enable me to grow crops that I can sell at the market.
	I dont mind watering the crops myself without the use of a technology.	I prefer a technology that works automatically without human power.	I prefer to adopt a more expensive technology but safe on running cost.	I want to have seen the technology before I adopt it.	I want to try out the technology before I adopt it.	I want to hear about the technology before I adopt it.	My water availability and water source determine my technology choice.	
		I am happy with my current pumping method. I don't want to invest.	I prefer to wait for someone to give me an irrigation technology.	I find easy individual operation important.	I find easy maneuverability important.	I want to be able to maintain the technology myself.		
			I prefer if the company representatives are Malawian.	I prefer a technology that uses water efficiently.	I prefer a technology that can give me a high volume of water.			
				I want a technology that other farmers have used successfully before I adopt it.				

Legend

- Distinguishing statement at P< 0.05
- Distinguishing statement at P< 0.01
- Consensus statement

Composite Q sort for Factor 2

-4	-3	-2	-1	0	1	2	3	4
I dont mind watering the crops myself without the use of a technology.	I can't expand my farm. I don't want to invest.	I want my irrigation technology to give me a better status in my community.	I find it important that the technology is hard to vandalize or steal.	I prefer paying through installments over time.	I prefer a technology that has been advocated by the extension officers.	I want the technology to enable me to grow crops that I can eat.	I prefer a technology that uses water efficiently.	I want it to be cheap to maintain the technology.
I don't own the land on which I farm. I don't want to invest.	I don't mind paying fuel to keep the technology working.	I want to have seen the technology before I adopt it.	I want to try out the technology before I adopt it.	I prefer a technology that can give me a high pressure.	My water availability and water source determine my technology choice.	I prefer a technology that works automatically without human power.	I find easy individual operation important.	I want overall affordable costs.
	I have other farming limitations. I don't want to invest.	I prefer to wait for someone to give me an irrigation technology.	I prefer if the company representatives are Malawian.	I find easy maneuverability important.	I want a technology that other farmers have used successfully before I adopt it.	I want to be able to maintain the technology myself.	I want the technology to enable me to grow crops that I can sell at the market.	
		It is too expensive. I don't want to invest.	I want support from my community and family.	I need external support after implementation.	I prefer to use and pay for a technology with a group of farmers instead of individually.	I prefer to adopt a more expensive technology but safe on running cost.		
			I am happy with my current pumping method. I don't want to invest.	I want to hear about the technology before I adopt it.	I prefer a technology that can give me a high volume of water.			
				I prefer technology that I can understand.				



Composite Q sort for Factor 3

-4	-3	-2	-1	0	1	2	3	4
I don't own the land on which I farm. I don't want to invest.	I want support from my community and family.	I prefer to wait for someone to give me an irrigation technology.	I find easy maneuverability important.	I prefer a technology that uses water efficiently.	I want to hear about the technology before I adopt it.	I want to be able to maintain the technology myself.	I prefer a technology that can give me a high pressure.	I want the technology to enable me to grow crops that I can sell at the market.
I prefer if the company representatives are Malawian.	It is too expensive. I don't want to invest.	I want to try out the technology before I adopt it.	I am happy with my current pumping method. I don't want to invest.	I prefer technology that I can understand.	I prefer to use and pay for a technology with a group of farmers instead of individually.	I want the technology to enable me to grow crops that I can eat.	I don't mind paying fuel to keep the technology working.	I prefer a technology that can give me a high volume of water.
	I dont mind watering the crops myself without the use of a technology.	I have other farming limitations. I don't want to invest.	I find it important that the technology is hard to vandalize or steal.	I want a technology that other farmers have used successfully before I adopt it.	My water availability and water source determine my technology choice.	I want overall affordable costs.	I prefer a technology that has been advocated by the extension officers.	
		I can't expand my farm. I don't want to invest.	I want my irrigation technology to give me a better status in my community.	I want it to be cheap to maintain the technology.	I prefer paying through installments over time.	I find easy individual operation important.		
			I prefer a technology that works automatically without human power.	I want to have seen the technology before I adopt it.	I need external support after implementation.			
				I prefer to adopt a more expensive technology but safe on running cost.				

Legend

- Distinguishing statement at P< 0.05
- Distinguishing statement at P< 0.01
- Consensus statement

Distinguishing Statements

Factor 1

Threshold	Z scr.	Q Sort Value	State. No.	Statement
P < 0.01	-1.2	-2	4	I am happy with my current pumping method. I don't want to invest.
P < 0.05	-0.5	-1	9	I prefer to adopt a more expensive technology but safe on running cost.
P < 0.05	-0.92	-1	29	I prefer if the company representatives are Malawian.
P < 0.05	0.36	0	2	I want overall affordable costs.
P < 0.01	0.2	0	10	I find easy individual operation important.
P < 0.0001	0.3	0	15	I want my irrigation technology to give me a better status in my community.
P < 0.005	0.43	1	11	I find easy maneuverability important.
P < 0.0001	0.52	1	32	I want to try out the technology before I adopt it.
P < 0.005	0.98	2	1	I prefer paying through installments over time.
P < 0.0001	0.8	2	12	I find it important that the technology is hard to vandalize or steal.
P < 0.05	1.02	3	23	My water availability and water source determine my technology choice.
P < 0.0001	1.75	4	28	I need external support after implementation.

Factor 2

Threshold	Z scr.	Q Sort Value	State. No.	Statement
P < 0.0001	-0.83	-2	31	I want to have seen the technology before I adopt it.
P < 0.01	-0.48	-1	29	I prefer if the company representatives are Malawian.
P < 0.005	-0.36	-1	32	I want to try out the technology before I adopt it.
P < 0.0005	-0.5	-1	24	I want support from my community and family.
P < 0.05	-0.16	0	34	I prefer technology that I can understand.
P < 0.05	-0.06	0	28	I need external support after implementation.
P < 0.005	-0.06	0	11	I find easy maneuverability important.
P < 0.0005	-0.14	0	30	I want to hear about the technology before I adopt it.
P < 0.01	0.74	1	27	I prefer a technology that has been advocated by the extension officers.
P < 0.0001	0.74	2	9	I prefer to adopt a more expensive technology but safe on running cost.
P < 0.0001	1	2	16	I prefer a technology that works automatically without human power.
P < 0.01	1.2	3	19	I want the technology to enable me to grow crops that I can sell at the market.
P < 0.005	1.27	3	10	I find easy individual operation important.
P < 0.0001	1.44	3	21	I prefer a technology that uses water efficiently.
P < 0.0001	2.19	4	14	I want it to be cheap to maintain the technology.
P < 0.0001	1.72	4	2	I want overall affordable costs.

Factor 3

Threshold	Z scr.	Q Sort Value	State. No.	Statement
P < 0.05	-1.42	-4	25	I don't own the land on which I farm. I don't want to invest.
P < 0.0001	-1.76	-4	29	I prefer if the company representatives are Malawian.
P < 0.005	-0.93	-2	32	I want to try out the technology before I adopt it.
P < 0.005	-0.62	-1	11	I find easy maneuverability important.
P < 0.05	-0.05	0	9	I prefer to adopt a more expensive technology but safe on running cost.
P < 0.05	0.34	1	28	I need external support after implementation.
P < 0.05	0.79	2	2	I want overall affordable costs.
P < 0.01	0.72	2	10	I find easy individual operation important.
P < 0.0001	1.56	3	18	I prefer a technology that can give me a high pressure.
P < 0.0001	1.3	3	3	I don't mind paying fuel to keep the technology working.
P < 0.0001	1.83	4	17	I prefer a technology that can give me a high volume of water.

Annex 9.4 – 4-Factor Solution Farmers Only

Factor Matrix with sorts Auto-Flagged (P < 0.05) & Factor Characteristics

Qsort #	Q-sort	Factor 1		Factor 2		Factor 3		Factor 4	
1	QSORT3	0.18		0.44		0.17		0.54	flagged
2	QSORT4	0.28		0.14		0.66	flagged	0.39	
3	QSORT5	0.12		0.49		0.43		0.45	
4	QSORT6	0.75	flagged	0.00		0.40		0.08	
5	QSORT8	0.30		0.42		0.09		0.41	
6	QSORT9	0.87	flagged	0.20		-0.05		0.15	
7	QSORT10	0.44		0.35		0.12		0.44	
8	QSORT11	0.34		0.64	flagged	0.30		-0.14	
9	QSORT12	0.10		0.49		-0.03		0.58	flagged
10	QSORT13	0.46		-0.04		0.16		0.47	
11	QSORT14	0.28		0.43		0.63	flagged	0.23	
12	QSORT15	0.10		0.63	flagged	0.32		-0.07	
13	QSORT16	0.32		0.33		0.70	flagged	0.08	
14	QSORT17	0.49		0.53		0.41		0.06	
15	QSORT18	-0.06		0.06		0.63	flagged	0.30	
16	QSORT19	0.13		0.36		0.63	flagged	0.07	
17	QSORT20	0.31		0.33		0.07		0.68	flagged
18	QSORT21	0.21		0.52		0.00		0.54	
19	QSORT22	0.29		0.64	flagged	0.21		0.38	
20	QSORT23	0.31		0.01		0.56	flagged	0.28	
21	QSORT24	0.03		0.10		0.24		0.66	flagged
22	QSORT25	0.71	flagged	0.33		0.21		0.01	
23	QSORT26	0.65	flagged	0.47		0.17		0.10	
24	QSORT27	0.60	flagged	0.34		0.24		0.17	
25	QSORT28	0.71	flagged	-0.01		0.15		0.34	
26	QSORT29	0.64	flagged	0.37		0.10		0.10	
27	QSORT30	0.61	flagged	0.07		0.42		0.13	
28	QSORT31	0.32		0.14		0.31		0.50	flagged
29	QSORT32	0.56		0.35		0.50		0.22	
30	QSORT33	0.25		0.01		0.13		0.70	flagged
31	QSORT34	0.07		0.51	flagged	0.39		0.14	
32	QSORT35	0.32		0.08		0.77	flagged	-0.04	
33	QSORT36	0.23		0.04		0.73	flagged	0.04	
34	QSORT40	-0.08		0.62	flagged	-0.08		0.30	
35	QSORT41	0.21		0.43		0.16		0.61	flagged
36	QSORT42	0.02		0.01		-0.01		0.43	flagged
37	QSORT43	0.38	flagged	0.18		-0.03		0.20	
38	QSORT44	0.38		0.48	flagged	-0.10		0.10	
39	QSORT45	0.56		0.03		0.51		0.31	
40	QSORT46	0.50	flagged	0.20		0.31		0.20	
41	QSORT47	0.53	flagged	0.21		0.21		0.12	
42	QSORT49	0.67	flagged	0.05		0.23		0.23	
43	QSORT50	-0.03		0.36		0.12		0.55	flagged
44	QSORT51	0.15		-0.03		0.25		0.31	
45	QSORT53	0.44		-0.08		0.08		0.48	flagged
46	QSORT54	0.52	flagged	0.22		0.22		0.35	
47	QSORT55	0.72	flagged	0.00		0.29		0.06	
48	QSORT56	0.27		0.01		0.26		0.52	flagged
49	QSORT57	0.54		-0.10		0.42		0.42	
%Explained Variance		**18**		**11**		**13**		**13**	
Total %Explained Variance			**55**						

	Factor 1
	Factor 2
	Factor 3
	Factor 4
	Unflagged

Factor Characteristics

	factor 1	factor 2	factor 3	factor 4
No. of Defining Variables	14	6	8	11
Avg. Rel. Coef.	0.8	0.8	0.8	0.8
Composite Reliability	0.982	0.96	0.97	0.978
S.E. of Factor Z-scores	0.134	0.2	0.173	0.148

Composite Q sort for Factor 1

-4	-3	-2	-1	0	1	2	3	4
I prefer if the company representatives are Malawian.	It is too expensive. I don't want to invest.	I find easy maneuverability important.	I prefer a technology that uses water efficiently.	My water availability and water source determine my technology choice.	I prefer technology that I can understand.	I want the technology to enable me to grow crops that I can eat.	I prefer a technology that can give me a high pressure.	I want the technology to enable me to grow crops that I can sell at the market.
I don't own the land on which I farm. I don't want to invest.	I dont mind watering the crops myself without the use of a technology.	I want support from my community and family.	I want my irrigation technology to give me a better status in my community.	I need external support after implementation.	I want overall affordable costs.	I want to hear about the technology before I adopt it.	I prefer a technology that has been advocated by the extension officers.	I prefer a technology that can give me a high volume of water.
	I have other farming limitations. I don't want to invest.	I prefer to wait for someone to give me an irrigation technology.	I want to try out the technology before I adopt it.	I want a technology that other farmers have used successfully before I adopt it.	I find easy individual operation important.	I prefer to use and pay for a technology with a group of farmers instead of individually.	I want to be able to maintain the technology myself.	
		I can't expand my farm. I don't want to invest.	I am happy with my current pumping method. I don't want to invest.	I prefer paying through installments over time.	I want to have seen the technology before I adopt it.	I don't mind paying fuel to keep the technology working.		
			I prefer a technology that works automatically without human power.	I want it to be cheap to maintain the technology.	I prefer to adopt a more expensive technology but safe on running cost.			
				I find it important that the technlogy is hard to vandalize or steal.				

Legend

- Distinguishing statement at P< 0.05
- Distinguishing statement at P< 0.01
- Consensus statement

Composite Q sort for Factor 2

-4	-3	-2	-1	0	1	2	3	4
I don't mind paying fuel to keep the technology working.	I have other farming limitations. I don't want to invest.	I want to have seen the technology before I adopt it.	I want to try out the technology before I adopt it.	I prefer to use and pay for a technology with a group of farmers instead of individually.	I prefer to adopt a more expensive technology but safe on running cost.	I want the technology to enable me to grow crops that I can eat.	I prefer a technology that uses water efficiently.	I want it to be cheap to maintain the technology.
I don't own the land on which I farm. I don't want to invest.	It is too expensive. I don't want to invest.	I want my irrigation technology to give me a better status in my community.	I want support from my community and family.	I need external support after implementation.	My water availability and water source determine my technology choice.	I prefer a technology that works automatically without human power.	I find easy individual operation important.	I want overall affordable costs.
	I dont mind watering the crops myself without the use of a technology.	I can't expand my farm. I don't want to invest.	I prefer if the company representatives are Malawian.	I prefer paying through installments over time.	I prefer a technology that can give me a high volume of water.	I want to be able to maintain the technology myself.	I want the technology to enable me to grow crops that I can sell at the market.	
		I prefer to wait for someone to give me an irrigation technology.	I find it important that the technlogy is hard to vandalize or steal.	I prefer technology that I can understand.	I want a technology that other farmers have used successfully before I adopt it.	I prefer a technology that has been advocated by the extension officers.		
			I am happy with my current pumping method. I don't want to invest.	I find easy maneuverability important.	I prefer a technology that can give me a high pressure.			
				I want to hear about the technology before I adopt it.				

Legend

- Distinguishing statement at P< 0.05
- Distinguishing statement at P< 0.01
- Consensus statement

Composite Q sort for Factor 3

-4	-3	-2	-1	0	1	2	3	4
It is too expensive. I don't want to invest.	I prefer a technology that can give me a high pressure.	I want support from my community and family.	I prefer a technology that works automatically without human power.	I prefer to adopt a more expensive technology but safe on running cost.	I find easy individual operation important.	I prefer paying through installments over time.	I want the technology to enable me to grow crops that I can sell at the market.	My water availability and water source determine my technology choice.
I don't own the land on which I farm. I don't want to invest.	I can't expand my farm. I don't want to invest.	I am happy with my current pumping method. I don't want to invest.	I want my irrigation technology to give me a better status in my community.	I prefer to use and pay for a technology with a group of farmers instead of individually.	I want it to be cheap to maintain the technology.	I want overall affordable costs.	I want to hear about the technology before I adopt it.	I find it important that the technlogy is hard to vandalize or steal.
	I dont mind watering the crops myself without the use of a technology.	I prefer if the company representatives are Malawian.	I prefer to wait for someone to give me an irrigation technology.	I prefer a technology that has been advocated by the extension officers.	I want to try out the technology before I adopt it.	I want to have seen the technology before I adopt it.	I prefer technology that I can understand.	
		I have other farming limitations. I don't want to invest.	I don't mind paying fuel to keep the technology working.	I prefer a technology that can give me a high volume of water.	I want the technology to enable me to grow crops that I can eat.	I want to be able to maintain the technology myself.		
			I need external support after implementation.	I prefer a technology that uses water efficiently.	I want a technology that other farmers have used successfully before I adopt it.			
				I find easy maneuverability important.				

Legend

- Distinguishing statement at P< 0.05
- Distinguishing statement at P< 0.01
- Consensus statement

Composite Q sort for Factor 4

-4	-3	-2	-1	0	1	2	3	4
I dont mind watering the crops myself without the use of a technology.	It is too expensive. I don't want to invest.	I can't expand my farm. I don't want to invest.	I want my irrigation technology to give me a better status in my community.	I want to try out the technology before I adopt it.	I find it important that the technlogy is hard to vandalize or steal.	I prefer to use and pay for a technology with a group of farmers instead of individually.	I prefer paying through installments over time.	I need external support after implementation.
I don't own the land on which I farm. I don't want to invest.	I want support from my community and family.	I am happy with my current pumping method. I don't want to invest.	I prefer a technology that can give me a high pressure.	I find easy individual operation important.	I prefer a technology that uses water efficiently.	My water availability and water source determine my technology choice.	I prefer a technology that has been advocated by the extension officers.	I want the technology to enable me to grow crops that I can eat.
	I prefer a technology that works automatically without human power.	I don't mind paying fuel to keep the technology working.	I prefer to wait for someone to give me an irrigation technology.	I want it to be cheap to maintain the technology.	I prefer technology that I can understand.	I find easy maneuverability important.	I want the technology to enable me to grow crops that I can sell at the market.	
		I have other farming limitations. I don't want to invest.	I prefer to adopt a more expensive technology but safe on running cost.	I want to have seen the technology before I adopt it.	I want to hear about the technology before I adopt it.	I want overall affordable costs.		
			I prefer if the company representatives are Malawian.	I want a technology that other farmers have used successfully before I adopt it.	I want to be able to maintain the technology myself.			
				I prefer a technology that can give me a high volume of water.				

Legend

- Distinguishing statement at P< 0.05
- Distinguishing statement at P< 0.01
- Consensus statement

Distinguishing Statements

Factor 1

Threshold	Z scr.	Q Sort Value	State. No.	Statement
P < 0.05	-0.97	-1	29	I prefer if the company representatives are Malawian.
P < 0.01	-0.54	-1	9	I prefer to adopt a more expensive technology but safe on running cost.
P < 0.05	0.34	0	21	I prefer a technology that uses water efficiently.
P < 0.01	0.31	0	32	I want to try out the technology before I adopt it.
P < 0.05	0.54	1	11	I find easy maneuverability important.
P < 0.0001	2.17	4	28	I need external support after implementation.

Factor 2

Threshold	Z scr.	Q Sort Value	State. No.	Statement
P < 0.005	-1.69	-4	5	I prefer to wait for someone to give me an irrigation technology.
P < 0.005	-1.28	-3	32	I want to try out the technology before I adopt it.
P < 0.0001	-1.41	-3	12	I find it important that the technology is hard to vandalize or steal.
P < 0.0001	-0.82	-2	30	I want to hear about the technology before I adopt it.
P < 0.01	-0.5	-1	7	I have other farming limitations. I don't want to invest.
P < 0.0001	-0.28	-1	25	I don't own the land on which I farm. I don't want to invest.
P < 0.0005	0.18	0	3	I don't mind paying fuel to keep the technology working.
P < 0.05	0.39	1	16	I prefer a technology that works automatically without human power.
P < 0.005	0.66	1	28	I need external support after implementation.
P < 0.01	0.7	2	14	I want it to be cheap to maintain the technology.
P < 0.01	0.99	2	17	I prefer a technology that can give me a high volume of water.
P < 0.005	0.73	2	18	I prefer a technology that can give me a high pressure.
P < 0.0001	1.9	4	21	I prefer a technology that uses water efficiently.

Factor 3

Threshold	Z scr.	Q Sort Value	State. No.	Statement
P < 0.0005	-1.82	-4	29	I prefer if the company representatives are Malawian.
P < 0.05	-0.86	-2	24	I want support from my community and family.
P < 0.0001	-0.65	-1	21	I prefer a technology that uses water efficiently.
P < 0.005	0.01	0	12	I find it important that the technology is hard to vandalize or steal.
P < 0.01	1.04	3	30	I want to hear about the technology before I adopt it.
P < 0.005	1.54	3	18	I prefer a technology that can give me a high pressure.
P < 0.0001	1.21	3	3	I don't mind paying fuel to keep the technology working.
P < 0.05	1.99	4	19	I want the technology to enable me to grow crops that I can sell at the market.
P < 0.005	1.82	4	17	I prefer a technology that can give me a high volume of water.

Factor 4

Threshold	Z scr.	Q Sort Value	State. No.	Statement
P < 0.001	-1.96	-4	7	I have other farming limitations. I don't want to invest.
P < 0.05	0.04	0	8	I prefer to use and pay for a technology with a group of farmers instead of individually.
P < 0.05	0.07	0	11	I find easy maneuverability important.
P < 0.0001	0.06	0	24	I want support from my community and family.
P < 0.05	0.91	2	16	I prefer a technology that works automatically without human power.
P < 0.05	0.85	2	21	I prefer a technology that uses water efficiently.
P < 0.0005	1.5	4	10	I find easy individual operation important.
P < 0.0001	2.07	4	14	I want it to be cheap to maintain the technology.

Annex 10 – Analysis Experts only

When including only the Q-sorts of the 9 expert participants the unrotated factors accounted for 99% of the total variance (Table 34). This, however, is not a representative figure as we will learn below. Looking at the statistical data (Table 34), the first factor explained the greatest part of the variation as it accounts for ~54% of the variability in the data.

	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Factor 7	Factor 8
Eigenvalues	4.8694	1.0783	0.8156	0.6494	0.4602	0.4217	0.3186	0.2258
% Explained Variance	54	12	9	7	5	5	4	3
Cumulative % Expln Var	54	66	75	82	87	92	96	99

Table 34 – The 8 unrotated factors of the 9 expert Q-sort participants after PCA with their respective eigenvalues and explained variance %.

After the factors were rotated using the *varimax* method their respective relevance were assed. First step in this process is applying the *eigenvalue* criterion. With only 2 *eigenvalues* above the criterion of unity (Table 34 & Figure 14), factor 3 up to 8 can be discarded.

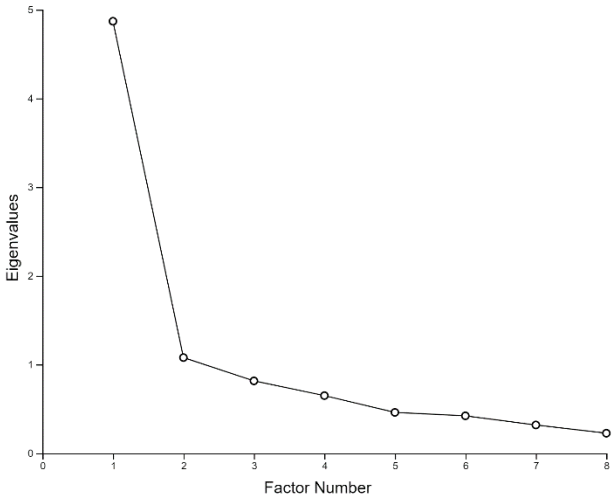


Figure 14 – Graph depicting the eigenvalues of the 9 expert Q-sort participants after PCA.

We can still further investigate factor 1 and 2 by exploring the explained variance of the factor, composite reliability, the number of distinguishing statements in a factor and the number of loading participants. In order to compare the statistical data for the different amounts of factors, the case of 2 factors was generated. The Q-sorts were loaded to the factor using the automatic *flagging* process using a 5% significance level ($P < 0.05$). The statistical data is presented in Figure 15.

When looking at number of number of loading participants we find that all 9 experts loaded on a factor. This results in a representative score of 100%. This gives us no grounds to discard factors based on the *representativeness criterion.*

On the basis of the composite reliability criterion we can also discard the option of the 2-factor solution, because factor 2 shows a result of unreliable composite reliability with a value < 0.94.

Therefore, based on the rules of statistics and criteria brought forward in other Q-methodology studies, we can't go forward with any of the factor solution. It can, however, still be interesting to investigate the 2-factor solution to see if there are considerable differences between the sorting behavior of experts and farmers.

2 FACTORS	factor 1	factor 2
# Participants defining Factor	6	3
Composite Reliability	0.96	0.923
S.E. of Factor Z-scores	0.2	0.277
Distinguishing Statements (P ≤ 0.05)	18	18

Figure 15 - Factor Characteristics of the 2-factor solution.

2-factor solution

In this analysis two factors were kept in rotation, accounting for 66% of the total variance. 9 of the 9 farmers (100% of the sample) were automatically *flagged* to the factor with which they had significant loading. For each factor, a factor matrix, factor visualization and a list of distinguishing statements can be found in Annex 10.1.

Just like in the analysis for all participants and farmers only, a possible reason for the relatively high representative percentage is the fact that no farmers were disregarded on the basis of criterion two for automatic *flagging*. This criterion states that Q-sorts need to have a square loading that is higher than the sum of square loadings of the same Q-sort in all other factors. Because in the case of a 2 factor solution there is only one other factor to consider, the highest loading, if significant, is automatically *flagged* independent of the loading on the other factor. If we for instance look at the factor loading of Q-sort 28 in Annex 10.1, we find that this Q-sort was flagged for factor 2. There are, however, no cases of similar *flagging* behavior, where the loading difference is less than 0.10, in this 2-factor solution. Therefore we can go forward with this factor loading. The full set of statements and scores can be seen found below in Table 33.

Detailed accounts are presented below for both factor 1 and factor 2. These were composed by examining the sorting of statements in relation to the other statements within the factor (Table 35). It is the relative positions within the entire sort that describe the factor and not just the individual statements themselves. It must be noted that the participating experts were requested to perform the Q-sort in the perspective of a SF, but with their expert knowledge. From the two factors, each of which can be considered as a synthetic representative farmer according to their key sorting behavior, a brief expert typology was created (Table 36).

2-Factor Solution
Factor 1
Characteristics: cost-effective decision maker, appreciates support
The experts in this factor are looking for a technology that has good water transport performance, but also offers low running cost and labour saving abilities. In this process the farmers attach relatively little value to the familiarity, understandability or safety of a technology. External support or advice, however, is hugely appreciated.
Factor 2
Characteristics: looking for a easy to use and cheap to adopt technology
The experts in this factor prefer WTTs that are relatively proven and affordable. If this means that a WTT is relatively more expensive to run or requires human input, this is accepted. In this process the experts attach relatively high value to ease of use and safety of the technology.

Table 36 - A brief summary of the two factors

Factor 1

6 experts loaded significantly on factor 1. The experts in factor 1 attach relatively more value to performance indicators:

17	I prefer a technology that can give me a high volume of water.	**3**
21	I prefer a technology that uses water efficiently.	**1**
18	I prefer a technology that can give me a high pressure.	**1**

The sorting from the statements on the right, however, indicate that good technology performance should not be accompanied with high running cost or continuous human effort or attention. The experts in factor 2 therefore prefer technologies that are a little more expensive, but have lower running cost and work automatically:

16	I prefer a technology that works automatically without human power.	**2**
9	I prefer to adopt a more expensive technology but safe on running cost.	**2**

The experts in factor 1 attached more value to variables involving external support, like support from extension officers. This support can involve finances and help with farming inputs, but also knowledge about irrigation management, local markets or the different WTT options. Also, statement 29 was often associated with external support from development organizations and the disagreeing sorting behavior of factor 1 can be interpreted as another expression of the request to be supported by external organizations:

27	I prefer a technology that has been advocated by the extension officers.	**3**
29	I prefer if the company representatives are Malawian.	**-3**

Factor 2

3 experts loaded significantly on factor 2. The experts in factor 2 sorted statements related to finances in such a way that the financial burden on smallholder farmer would be minimal. From the sorting behavior we can conclude that the size of the initial investment for instance, was more important than minimizing the running cost:

1	I prefer paying through installments over time.	**3**
2	I want overall affordable costs.	**4**
3	I don't mind paying fuel to keep the technology working.	**0**
9	I prefer to adopt a more expensive technology but safe on running cost.	**-1**

If a cheaper technology requires more human effort or attention that is accepted:

16	I prefer a technology that works automatically without human power.	**-3**

The experts in factor 2 attached relatively more value to ease of use, safety and technology management aspects:

12	I find it important that the technology is hard to vandalize or steal.	**3**
11	I find easy maneuverability important.	**1**
10	I find easy individual operation important.	**3**

Theme Q statement	Factor scores	
The characteristics of the WTT	F1	F2
Financial aspects and affordability		
1. I prefer paying through installments over time.	0	3
2. I want overall affordable costs.	2	4
3. I don't mind paying fuel to keep the technology working.	-1	0
4. I am happy with my current pumping method. I don't want to invest.	-2	-1
5. I prefer to wait for someone to give me an irrigation technology.	-2	0
6. It is too expensive. I don't want to invest.	-2	-4
7. I have other farming limitations. I don't want to invest.	-2	-1
8. I prefer to use and pay for a technology with a group of farmers instead of individually.	2	1
9. I prefer to adopt a more expensive technology but safe on running cost.	2	-1
Management		
10. I find easy individual operation important.	0	3
11. I find easy maneuverability important.	-1	1
12. I find it important that the technology is hard to vandalize or steal.	0	3
Technology characteristics		
13. I want to be able to maintain the technology myself.	1	1
14. I want it to be cheap to maintain the technology.	0	0
15. I want my irrigation technology to give me a better status in my community.	-3	-2
16. I prefer a technology that works automatically without human power.	2	-3
17. I prefer a technology that can give me a high volume of water.	3	0
18. I prefer a technology that can give me a high pressure.	1	-3
19. I want the technology to enable me to grow crops that I can sell at the market.	4	2
20. I want the technology to enable me to grow crops that I can eat.	3	1
21. I prefer a technology that uses water efficiently.	1	0
Environment		
22. I don't mind watering the crops myself without the use of a technology.	-4	-4
23. My water availability and water source determine my technology choice.	4	4
Characteristics & circumstances of farmer within their (social) environment		
Community		
24. I want support from my community and family.	-1	-2
Ownership		
25. I don't own the land on which I farm. I don't want to invest.	-4	-3
26. I can't expand my farm. I don't want to invest.	-3	-2
Agricultural extension services		
27. I prefer a technology that has been advocated by the extension officers.	3	0
Company relationship		
28. I need external support after implementation.	-1	-2
29. I prefer if the company representatives are Malawian.	-3	-1
The process of learning and experience		
Familiarity		
30. I want to hear about the technology before I adopt it.	1	1
31. I want to have seen the technology before I adopt it.	0	2
32. I want to try out the technology before I adopt it.	0	-1
33. I want a technology that other farmers have used successfully before I adopt it.	-1	2
Understandability		
34. I prefer technology that I can understand.	1	2

Table 35 - Raw scores of statements for the 2-factor solution.

Conclusion

From the results it is clear that different experts in the agriculture and irrigation sector have different sorting behaviour. Although the amount of Q-sorts in this data set with only experts is limited, we can still conclude that experts have different sorting behaviour.

Perhaps unsurprisingly, most of the extension officers that performed the Q-sort exercise loaded on the factor characterized by a preference for cost-effective and labour saving technologies; factor 1. Also, external support or advice, however, is highly valued and of influence in the decision-making process. The experts in factor 2 expressed relatively more value to affordability, familiarity and ease of use.

Annex 10.1 – 2-Factor Solution Experts Only

Factor Matrix with sorts Auto-Flagged (P < 0.05) & Factor Characteristic

Qsort #	Q-sort	Factor 1		Factor 2	
1	QSORT1	0.42		0.77	flagged
2	QSORT2	0.25		0.81	flagged
3	QSORT7	0.09		0.73	flagged
4	QSORT37	0.82	flagged	0.05	
5	QSORT38	0.76	flagged	0.14	
6	QSORT39	0.65	flagged	0.41	
7	QSORT48	0.75	flagged	0.33	
8	QSORT52	0.78	flagged	0.37	
9	QSORT58	0.73	flagged	0.32	
%Explained Variance		**40**		**26**	
Total %Explained Variance			**66**		

	Factor 1
	Factor 2
	Unflagged

Factor Characteristics

	factor 1	factor 2
No. of Defining Variables	6	3
Avg. Rel. Coef.	0.8	0.8
Composite Reliability	0.96	0.923
S.E. of Factor Z-scores	0.2	0.277

Composite Q sort for Factor 1

-4	-3	-2	-1	0	1	2	3	4
I don't own the land on which I farm. I don't want to invest.	I prefer if the company representatives are Malawian.	It is too expensive. I don't want to invest.	I find easy maneuverability important.	I want it to be cheap to maintain the technology.	I prefer technology that I can understand.	I prefer a technology that works automatically without human power.	I want the technology to enable me to grow crops that I can eat.	My water availability and water source determine my technology choice.
I dont mind watering the crops myself without the use of a technology.	I want my irrigation technology to give me a better status in my community.	I am happy with my current pumping method. I don't want to invest.	I need external support after implementation.	I find easy individual operation important.	I want to be able to maintain the technology myself.	I prefer to use and pay for a technology with a group of farmers instead of individually.	I prefer a technology that has been advocated by the extension officers.	I want the technology to enable me to grow crops that I can sell at the market.
	I can't expand my farm. I don't want to invest.	I prefer to wait for someone to give me an irrigation technology.	I want a technology that other farmers have used successfully before I adopt it.	I find it important that the technology is hard to vandalize or steal.	I prefer a technology that uses water efficiently.	I prefer to adopt a more expensive technology but safe on running cost.	I prefer a technology that can give me a high volume of water.	
		I have other farming limitations. I don't want to invest.	I want support from my community and family.	I prefer paying through installments over time.	I want to hear about the technology before I adopt it.	I want overall affordable costs.		
			I don't mind paying fuel to keep the technology working.	I want to have seen the technology before I adopt it.	I prefer a technology that can give me a high pressure.			
				I want to try out the technology before I adopt it.				

Legend

- Distinguishing statement at P< 0.05
- Distinguishing statement at P< 0.01
- Consensus statement

Composite Q sort for Factor 2

-4	-3	-2	-1	0	1	2	3	4
It is too expensive. I don't want to invest.	I prefer a technology that works automatically without human power.	I need external support after implementation.	I want to try out the technology before I adopt it.	I prefer a technology that has been advocated by the extension officers.	I want to hear about the technology before I adopt it.	I want the technology to enable me to grow crops that I can sell at the market.	I prefer paying through installments over time.	My water availability and water source determine my technology choice.
I dont mind watering the crops myself without the use of a technology.	I don't own the land on which I farm. I don't want to invest.	I want support from my community and family.	I prefer if the company representatives are Malawian.	I want it to be cheap to maintain the technology.	I want to be able to maintain the technology myself.	I want to have seen the technology before I adopt it.	I find it important that the technology is hard to vandalize or steal.	I want overall affordable costs.
	I prefer a technology that can give me a high pressure.	I want my irrigation technology to give me a better status in my community.	I prefer to adopt a more expensive technology but safe on running cost.	I prefer to wait for someone to give me an irrigation technology.	I prefer to use and pay for a technology with a group of farmers instead of individually.	I want a technology that other farmers have used successfully before I adopt it.	I find easy individual operation important.	
		I can't expand my farm. I don't want to invest.	I have other farming limitations. I don't want to invest.	I don't mind paying fuel to keep the technology working.	I want the technology to enable me to grow crops that I can eat.	I prefer technology that I can understand.		
			I am happy with my current pumping method. I don't want to invest.	I prefer a technology that can give me a high volume of water.	I find easy maneuverability important.			
				I prefer a technology that uses water efficiently.				

Legend

- Distinguishing statement at P< 0.05
- Distinguishing statement at P< 0.01
- Consensus statement

Distinguishing Statements

Factor 1

Threshold	Z scr.	Q Sort Value	State. No.	Statement
P < 0.0001	-0.531	-1	33	I want a technology that other farmers have used successfully before I adopt it.
P < 0.0001	0.384	1	18	I prefer a technology that can give me a high pressure.
P < 0.0001	1.035	2	16	I prefer a technology that works automatically without human power.
P < 0.0005	1.188	3	17	I prefer a technology that can give me a high volume of water.
P < 0.001	0.074	0	1	I prefer paying through installments over time.
P < 0.005	-1.222	-3	29	I prefer if the company representatives are Malawian.
P < 0.005	-0.949	-2	5	I prefer to wait for someone to give me an irrigation technology.
P < 0.005	0.788	2	9	I prefer to adopt a more expensive technology but safe on running cost.
P < 0.005	1.389	3	27	I prefer a technology that has been advocated by the extension officers.
P < 0.005	1.604	3	20	I want the technology to enable me to grow crops that I can eat.
P < 0.01	-0.93	-2	6	It is too expensive. I don't want to invest.
P < 0.05	-1.135	-2	7	I have other farming limitations. I don't want to invest.
P < 0.05	-0.907	-1	3	I don't mind paying fuel to keep the technology working.
P < 0.05	-0.3	-1	11	I find easy maneuverability important.
P < 0.05	0.048	0	31	I want to have seen the technology before I adopt it.
P < 0.05	0.27	0	12	I find it important that the technology is hard to vandalize or steal.
P < 0.05	0.301	0	10	I find easy individual operation important.
P < 0.05	0.687	2	2	I want overall affordable costs.

Factor 2

Threshold	Z scr.	Q Sort Value	State. No.	Statement
P < 0.0001	-1.645	-3	18	I prefer a technology that can give me a high pressure.
P < 0.0001	-1.356	-3	16	I prefer a technology that works automatically without human power.
P < 0.0001	0.868	2	33	I want a technology that other farmers have used successfully before I adopt it.
P < 0.0005	-0.084	0	17	I prefer a technology that can give me a high volume of water.
P < 0.001	1.212	3	1	I prefer paying through installments over time.
P < 0.005	-0.281	-1	9	I prefer to adopt a more expensive technology but safe on running cost.
P < 0.005	-0.176	-1	29	I prefer if the company representatives are Malawian.
P < 0.005	0.063	0	5	I prefer to wait for someone to give me an irrigation technology.
P < 0.005	0.396	0	27	I prefer a technology that has been advocated by the extension officers.
P < 0.005	0.496	1	20	I want the technology to enable me to grow crops that I can eat.
P < 0.01	-1.842	-4	6	It is too expensive. I don't want to invest.
P < 0.05	-0.436	-1	7	I have other farming limitations. I don't want to invest.
P < 0.05	-0.032	0	3	I don't mind paying fuel to keep the technology working.
P < 0.05	0.457	1	11	I find easy maneuverability important.
P < 0.05	0.921	2	31	I want to have seen the technology before I adopt it.
P < 0.05	0.981	3	10	I find easy individual operation important.
P < 0.05	1.065	3	12	I find it important that the technology is hard to vandalize or steal.
P < 0.05	1.441	4	2	I want overall affordable costs.

Annex 11 – Analysis All Participants

2-factor solution

In this analysis two factors were kept in rotation, accounting for 44% of the total variance. 55 of the 58 participants (95% of the sample) were automatically *flagged* to the factor with which they had significant loading. For each factor, a factor matrix, factor visualization and a list of distinguishing statements can be found in Annex 11.

An important reason for the relatively high representative percentage (Table 4) is the fact that no participants were disregarded on the basis of criterion two for automatic *flagging*. This criterion states that Q-sorts need to have a square loading that is higher than the sum of square loadings of the same Q-sort in all other factors. Because in the case of a 2 factor solution there is only one other factor to consider, the highest loading, if significant, is automatically *flagged* independent of the loading on the other factor. If we for instance look at the factor loading of Q-sort 56 in Annex 11.1, we find that this Q-sort was flagged for factor 2. The loading values, however, for both factors is 0.39. In fact, when we look at the third and fourth decimal, the loadings are 0.3873 and 0.3919 respectively for factor 1 and 2. Because both loadings are significant, the Q-sort is automatically *flagged* to factor 2. Similar *flagging* behavior, where the loading difference is less than 0.10, happens in the case of Q-sorts 10, 15, 31, 38, 44 and 53. If we disregard these Q-sorts the solution represents 47 of the 58 participants (81% of the sample). For this adopted 2 factors solution, a factor matrix, factor visualization and a list of distinguishing statements can be found in Annex 11.2. The full set of statements and scores can be seen found below in Table 37.

Detailed accounts are presented below for both factor 1 and factor 2. These were composed by examining the sorting of statements in relation to the other statements within the factor and by comparing this with the other factors. It is the relative positions within the entire sort that describe the factor and not just the individual statements themselves (Table 37). From the two factors, each of which can be considered as a synthetic representative farmer according to their key sorting behavior, a brief participant typology was created (Table 38).

2-Factor Solution
Factor 1
Characteristics: follower, risk-averse, dependent
The participants in this factor prefer WTTs that are cheaper, more familiar and more understandable. If these highly valued variables result in WTT for irrigation that are relatively more expensive to run, this is accepted. External support or advice is hugely appreciated because of lack of knowledge about the technologies and financial capabilities.
Factor 2
Characteristics: cost-effective decision maker, long-term thinking
The participants in this factor are looking for a cost-effective long-term investment. Their decision-making to adopt WTT for irrigation is heavily influenced by the ease of use and the labour saving technologies ability of the technology.

Table 38 - A brief summary of the two factors

Factor 1

30 participants loaded significantly on factor 1. The participants of factor 1 seem to be heavily influenced by variables involving external support. This support can involve finances and help with farming inputs, but also knowledge about irrigation management, local markets or the different WTT options. The decision-making process for instance is heavily impacted by the advice given by governmental extension officers. Also, statement 29 was often associated with external support from development organizations and the disagreeing sorting behavior of factor 1 can be interpreted as another expression of the request to be supported by external organizations:

28	I need external support after implementation.	**4**
27	I prefer a technology that has been advocated by the extension officers.	**3**
29	I prefer if the company representatives are Malawian.	**-2**

Theme Q statement	Factor scores	
The characteristics of the WTT	F1	F2
Financial aspects and affordability		
1. I prefer paying through installments over time.	2	0
2. I want overall affordable costs.	0	4
3. I don't mind paying fuel to keep the technology working.	-1	-3
4. I am happy with my current pumping method. I don't want to invest.	-2	-2
5. I prefer to wait for someone to give me an irrigation technology.	-1	-2
6. It is too expensive. I don't want to invest.	-3	-2
7. I have other farming limitations. I don't want to invest.	-3	-3
8. I prefer to use and pay for a technology with a group of farmers instead of individually.	2	1
9. I prefer to adopt a more expensive technology but safe on running cost.	-1	2
Management		
10. I find easy individual operation important.	1	2
11. I find easy maneuverability important.	0	0
12. I find it important that the technology is hard to vandalize or steal.	0	0
Technology characteristics		
13. I want to be able to maintain the technology myself.	1	1
14. I want it to be cheap to maintain the technology.	-1	4
15. I want my irrigation technology to give me a better status in my community.	-1	-2
16. I prefer a technology that works automatically without human power.	-2	2
17. I prefer a technology that can give me a high volume of water.	3	1
18. I prefer a technology that can give me a high pressure.	1	1
19. I want the technology to enable me to grow crops that I can sell at the market.	4	3
20. I want the technology to enable me to grow crops that I can eat.	3	3
21. I prefer a technology that uses water efficiently.	0	3
Environment		
22. I don't mind watering the crops myself without the use of a technology.	-3	-4
23. My water availability and water source determine my technology choice.	2	2
Characteristics & circumstances of farmer within their (social) environment		
Community		
24. I want support from my community and family.	-2	-1
Ownership		
25. I don't own the land on which I farm. I don't want to invest.	-4	-4
26. I can't expand my farm. I don't want to invest.	-4	-3
Agricultural extension services		
27. I prefer a technology that has been advocated by the extension officers.	3	1
Company relationship		
28. I need external support after implementation.	4	-1
29. I prefer if the company representatives are Malawian.	-2	-1
The process of learning and experience		
Familiarity		
30. I want to hear about the technology before I adopt it.	2	0
31. I want to have seen the technology before I adopt it.	0	-1
32. I want to try out the technology before I adopt it.	0	-1
33. I want a technology that other farmers have used successfully before I adopt it.	1	0
Understandability		
34. I prefer technology that I can understand.	1	0

Table 37 - Raw scores of statements for the 2-factor solution.

As a supplement to the statements mentioned above, from the statements on the right can be concluded that the participants are financially limited in their adoption of WTTs. More advanced and more expensive technologies might therefore be difficult to attain. Paying for technologies by installments and in a group, however, helps to open a wider range of technology options:

1	I prefer paying through installments over time.	**2**
8	I prefer to use and pay for a technology with a group of farmers instead of individually.	**2**
9	I prefer to adopt a more expensive technology but safe on running cost.	**-1**

Especially compared to factor 2, the sorting behavior of factor 1 is significantly more risk-averse. This is expressed in the relatively high valued importance of familiarity and understandability, but also in their preference to adopt a WTT in a group, spreading the financial risk:

30	I want to hear about the technology before I adopt it.	**2**
8	I prefer to use and pay for a technology with a group of farmers instead of individually.	**2**
33	I want a technology that other farmers have used successfully before I adopt it.	**1**
34	I prefer technology that I can understand.	**1**
31	I want to have seen the technology before I adopt it.	**0**

The sorting behavior of factor 1 seems to express a stronger focus on high volumes of water compared to the efficient use of water. This means that the participants of factor 1 experiences water more as an abundant resource to be utilized rather than a scarce resource that needs to be used efficiently:

17	I prefer a technology that can give me a high volume of water.	**3**
21	I prefer a technology that uses water efficiently.	**0**

Factor 2

17 participants loaded significantly on factor 2. The cost effectiveness of the WTT is something that factor 2 values relatively much compared to factor 1. In financial terms this does not just involve the size of the initial investment, but also the long-term maintenance and running cost of the technology:

2	I want overall affordable costs.	**4**
14	I want it to be cheap to maintain the technology.	**4**
21	I prefer a technology that uses water efficiently.	**3**
9	I prefer to adopt a more expensive technology but safe on running cost.	**2**
3	I don't mind paying fuel to keep the technology working.	**-2**

Unlike factor 1, the participants have a stronger preference for the WTT enabling the efficient use of water compared to giving high volumes of water:

21	I prefer a technology that uses water efficiently.	**3**
17	I prefer a technology that can give me a high volume of water.	**1**

The participants in factor 2 greatly value, compared to factor 1, the ease of use of the WTT. The ability of WTTs to work automatically is therefore strongly preferred. Unlike when using watering cans were one has to walk up and down to the water source, these technologies require little human effort or attention when pumping water. This enables the farmers to focus on other activities such as working on the crops or expanding the farm:

16	I prefer a technology that works automatically without human power.	**2**
10	I find easy individual operation important.	**2**

Consensus

Besides statements that distinguished the Q-sort participants into two factors, there are also statements that participants agree on. This happens when similar sorting of some statements, which in the Q-methodology is called *consensus*, appears. It means that there is no significant difference between the factors. In the midst of all the subjectivity between participants, it can be especially interesting to discover statements that people have agreement on. The consensus statements are colored green in the factor visualizations (Annex 11.2).

Out of all statements in the 2-factor solution there were 12 out of 34 statements which were sorted significantly similar by all participants (Table 39). There was a strong consensus against the notion that investment in WTT for irrigation is entirely blocked by financial, farm size or ownership limitations. Using a technology to pump water to irrigate crops is strongly preferred to the alternative; manually retrieving it from the river oneself. There was also significant consensus in favor of edible crops that can be sold to the market:

Consensus statements		F1	F2
20	I want the technology to enable me to grow crops that I can eat.	**3**	**3**
23	My water availability and water source determine my technology choice.	**2**	**2**
18	I prefer a technology that can give me a high pressure.	**1**	**1**
13	I want to be able to maintain the technology myself.	**1**	**1**
11	I find easy maneuverability important.	**0**	**0**
32	I want to try out the technology before I adopt it.	**0**	**-1**
4	I am happy with my current pumping method. I don't want to invest.	**-2**	**-2**
6	It is too expensive. I don't want to invest.	**-3**	**-2**
7	I have other farming limitations. I don't want to invest.	**-3**	**-3**
22	I don’t mind watering the crops myself without the use of a technology.	**-3**	**-4**
26	I can't expand my farm. I don't want to invest.	**-4**	**-3**
25	I don't own the land on which I farm. I don't want to invest.	**-4**	**-4**

Table 39 - Raw scores of consensus statements for the 2-factor solution.

3-factor solution

In this analysis three factors were kept in rotation, accounting for 50% of the total variance. 48 of the 58 participants (83% of the sample) were automatically *flagged* to the factor with which they had significant loading. The remaining 10 participants were disregarded for this part of the analysis because they loaded insignificant or loaded significantly on more than one factor (multiple loaders). For each factor, a factor matrix, factor visualization and a list of distinguishing statements can be found in Annex 11.3. Detailed accounts of all three factors are presented below. These were composed by examining the sorting of statements in relation to the other statements within the factor and by comparing this with the other factors. It is the relative positions within the entire sort that describe the factor and not just the individual statements themselves (Table 40). From the three factors, each of which can be considered as a synthetic representative farmer according to their key sorting behavior, a brief participant typology was created (Table 41).

3-Factor Solution
Factor 1
Characteristics: follower, dependent, team player
The participants in this factor prefer WTTs that are relatively affordable. If this means that a WTT is relatively more expensive to run, this is accepted. External support or advice is hugely appreciated because of lack of knowledge about the technologies or low financial capabilities.
Factor 2
Characteristics: risk taker, cost-effective decision maker, long-term thinking.
The participants in this factor are looking for a technology that is affordable and labour saving, but also offers low running cost, in order to expand their farm and grow more crops for the market.
Factor 3
Characteristics: risk averse, environmentally aware
For the participants in factor 3 it is very important to minimize risk. Therefore they have a strong preference for proven, familiar and understandable technologies. They pay special attention that this technology fits their specific situation and topography.

Table 41 - A brief summary of the three factors

Factor 1

21 participants loaded significantly on factor 1. The participants of factor 1 seem to be heavily influenced by variables involving external support. This support can involve finances and help with farming inputs, but also knowledge about irrigation management, local markets or the different WTT options. The decision-making process for instance is heavily impacted by the advice given by governmental extension officers. Also, statement 29 was often associated with external support from development organizations and the disagreeing sorting behavior of factor 1 can be interpreted as another expression of the request to be supported by external organizations:

27	I prefer a technology that has been advocated by the extension officers.	**3**
28	I need external support after implementation.	**2**
29	I prefer if the company representatives are Malawian.	**-4**

As a supplement to the statements mentioned above, from the statements on the right can be concluded that the participants are financially limited in their adoption of WTTs. More advanced and more expensive technologies might therefore be difficult to attain. Paying for technologies by installments and in a group, however, helps to open a wider range of technology options:

8	I prefer to use and pay for a technology with a group of farmers instead of individually.	**2**
2	I want overall affordable costs.	**2**
1	I prefer paying through installments over time.	**1**

The highest sorting of statement 3, compared to factor 2 and 3, indicates that if WTTs are relatively cheaper to obtain, higher running cost are accepted:

3	I don't mind paying fuel to keep the technology working.	**0**

Although the participants of factor 1 have a preference for adopting technologies in a group, support from their respective communities and families is not an important decision-making variables in the decision-making process:

24	I want support from my community and family.	**-3**

Theme Q statement	Factor scores		
The characteristics of the WTT	F1	F2	F3
Financial aspects and affordability			
1. I prefer paying through installments over time.	1	0	3
2. I want overall affordable costs.	2	4	2
3. I don't mind paying fuel to keep the technology working.	0	-3	-2
4. I am happy with my current pumping method. I don't want to invest.	-1	-1	-2
5. I prefer to wait for someone to give me an irrigation technology.	-2	-2	-1
6. It is too expensive. I don't want to invest.	-3	-2	-3
7. I have other farming limitations. I don't want to invest.	-2	-3	-3
8. I prefer to use and pay for a technology with a group of farmers instead of individually.	2	1	0
9. I prefer to adopt a more expensive technology but safe on running cost.	-1	2	-1
Management			
10. I find easy individual operation important.	1	3	1
11. I find easy maneuverability important.	-1	0	0
12. I find it important that the technology is hard to vandalize or steal.	-1	-1	3
Technology characteristics			
13. I want to be able to maintain the technology myself.	2	2	1
14. I want it to be cheap to maintain the technology.	0	4	0
15. I want my irrigation technology to give me a better status in my community.	0	-2	-1
16. I prefer a technology that works automatically without human power.	-2	2	-2
17. I prefer a technology that can give me a high volume of water.	4	1	0
18. I prefer a technology that can give me a high pressure.	3	1	-2
19. I want the technology to enable me to grow crops that I can sell at the market.	4	3	4
20. I want the technology to enable me to grow crops that I can eat.	3	2	2
21. I prefer a technology that uses water efficiently.	1	3	0
Environment			
22. I don't mind watering the crops myself without the use of a technology.	-2	-4	-4
23. My water availability and water source determine my technology choice.	1	1	4
Characteristics & circumstances of farmer within their (social) environment			
Community			
24. I want support from my community and family.	-3	-1	-1
Ownership			
25. I don't own the land on which I farm. I don't want to invest.	-4	-4	-4
26. I can't expand my farm. I don't want to invest.	-3	-3	-3
Agricultural extension services			
27. I prefer a technology that has been advocated by the extension officers.	3	1	1
Company relationship			
28. I need external support after implementation.	2	0	0
29. I prefer if the company representatives are Malawian.	-4	-1	-1
The process of learning and experience			
Familiarity			
30. I want to hear about the technology before I adopt it.	0	0	3
31. I want to have seen the technology before I adopt it.	0	-2	2
32. I want to try out the technology before I adopt it.	-1	-1	1
33. I want a technology that other farmers have used successfully before I adopt it.	0	0	1
Understandability			
34. I prefer technology that I can understand.	1	0	2

Table 40 - Raw scores of statements for the 3-factor solution.

The sorting behavior of factor 1 seems to express a stronger focus on high volumes of water compared to the efficient use of water. This means that the participants of factor 1 experience water more as an abundant recourse to be utilized rather than a scarce resource that needs to be used efficiently:

17	I prefer a technology that can give me a high volume of water.	**4**
18	I prefer a technology that can give me a high pressure.	**3**
21	I prefer a technology that uses water efficiently.	**1**

Factor 2

15 participants loaded significantly on factor 2. The cost effectiveness of the WTT is something that the participants in factor 2 value relatively much. In financial terms this does not just involve the size of the initial investment, but also the long-term maintenance and running cost of the WTT:

2	I want overall affordable costs.	**4**
14	I want it to be cheap to maintain the technology.	**4**
21	I prefer a technology that uses water efficiently.	**3**
9	I prefer to adopt a more expensive technology but safe on running cost.	**2**

An important variable of the cost-effectiveness of a technology that drives the decision-making of the participants in factor 2 is their ease of use and labour saving ability. The ability of the WTT to work automatically is therefore strongly preferred. Unlike when using watering cans were one has to walk up and down to the water source, these technologies require little human effort or attention when pumping water. This enables the farmers to focus on other activities such as working on the crops or expanding the farm:

10	I find easy individual operation important.	**3**
16	I prefer a technology that works automatically without human power.	**2**

The participants in factor 2 attach relatively little value to the familiarity, understandability or status of a technology. As long as the WTT satisfies their most important decision-making variable, they are confident enough to adopt:

34	I prefer technology that I can understand.	**0**
30	I want to hear about the technology before I adopt it.	**0**
31	I want to have seen the technology before I adopt it.	**-2**
15	I want my irrigation technology to give me a better status in my community.	**-2**

Also, the participants in factor 2 attach significant little, relatively to the other factors, value to external support. This can be support in terms of advice, farm inputs or financial tools to help obtain WTTs. Paying for technologies in installments for instance, is not of huge importance to the participants in factor 2. This could suggest they have enough financial resources themselves to pay for the technology:

27	I prefer a technology that has been advocated by the extension officers.	**1**
1	I prefer paying through installments over time.	**0**
28	I need external support after implementation.	**0**
29	I prefer if the company representatives are Malawian.	**-1**

Factor 3

12 participants loaded significantly on factor 3. The participants in this factor express high value to the notion that different physical situations influence the suitability of a WTT, and they are determined to find the best technology fit with theirs:

23	My water availability and water source determine my technology choice.	**4**

The sorting behavior of factor 3 also shows that its participants are significantly more risk-averse when choosing WTT for irrigation. This is expressed in the relatively high valued importance of familiarity and understandability, but also in the preference for technologies that are hard to vandalize or steal:

30	I want to hear about the technology before I adopt it.	**3**
12	I find it important that the technology is hard to vandalize or steal.	**3**
34	I prefer technology that I can understand.	**2**
31	I want to have seen the technology before I adopt it.	**2**
33	I want a technology that other farmers have used successfully before I adopt it.	**1**
32	I want to try out the technology before I adopt it.	**1**

Besides the risk-averse sorting behavior mentioned above, the participants of factor 3 also express financially risk-averse behavior. Paying in installments reduces the initial financial risk and helps to open a wider range of technology options:

1	I prefer paying through installments over time.	**3**

Consensus

Besides statements that distinguished the Q-sort participants into three factors, there are also statements that participants agree on. This happens when similar sorting of some statements, which in the Q-methodology is called *consensus*, appears. It means that there is no significant difference between the factors. In the midst of all the subjectivity between participants, it can be especially interesting to discover statements that people have agreement on. The consensus statements are colored green in the factor visualizations (Annex 11.3).

Out of all statements in the 2-factor solution there were 9 out of 34 statements which were sorted significantly similar by all participants (Table 42). There was a strong consensus against the notion that investment in WTT for irrigation is entirely blocked by financial, farm size or ownership limitations. There was also significant consensus in favor of edible crops that can be sold to the market:

Consensus statements		F1	F2	F3
20	I want the technology to enable me to grow crops that I can eat.	**3**	**2**	**2**
13	I want to be able to maintain the technology myself.	**2**	**2**	**1**
11	I find easy maneuverability important.	**-1**	**0**	**0**
4	I am happy with my current pumping method. I don't want to invest.	**-1**	**-1**	**-2**
7	I have other farming limitations. I don't want to invest.	**-2**	**-3**	**-3**
6	It is too expensive. I don't want to invest.	**-3**	**-2**	**-3**
26	I can't expand my farm. I don't want to invest.	**-3**	**-3**	**-3**
22	I don’t mind watering the crops myself without the use of a technology.	**-2**	**-4**	**-4**
25	I don't own the land on which I farm. I don't want to invest.	**-4**	**-4**	**-4**

Table 42 - Raw scores of consensus statements for the 3-factor solution.

4-factor solution

In this analysis four factors were kept in rotation, accounting for 55% of the total variance. 43 of the 58 participants (74% of the sample) were automatically *flagged* to the factor with which they had significant loading. The remaining 15 participants were disregarded for this part of the analysis because they loaded insignificant or loaded significantly on more than one factor (multiple loaders). For each factor, a factor matrix, factor visualization and a list of distinguishing statements can be found in Annex 11.4. Detailed accounts of all four factors are presented below. These were composed by examining the sorting of statements in relation to the other statements within the factor and by comparing this with the other factors (Table 43). It is the relative positions within the entire sort that describe the factor and not just the individual statements themselves. From the four factors, each of which can be considered as a synthetic representative farmer according to their key sorting behavior, a brief participant typology was created (Table 44).

4-Factor Solution
Factor 1
Characteristics: dependent, resource constrained, team player, water volume seeker The participants in factor 1 prefer WTTs that give a high volume of water. External support or advice is hugely appreciated because of lack of knowledge about WTTs or low financial capabilities.
Factor 2
Characteristics: individual farmer, risk taker, cost-effective decision maker, long-term thinker The participants in this factor have profit maximization as a primary objective. In order to realize this they are looking for a technology that is affordable and labour saving, but also offers low running cost, in order to expand their farm and grow more crops for the market. In their decision-making process they pay special attention to the gross margin and cost of production.
Factor 3
Characteristics: high resource-endowed, attach strong value to individuality and independency, risk averse, environmentally aware For the participants in factor 3 it is important to minimize risk. Therefore they have a strong preference for proven, familiar and understandable WTTs. Diagnosis of the environment and assessment of available water resources for irrigation are taken into account to make sure the WTT fits their specific situation.
Factor 4
Characteristics: dependent, resource constrained, team player The participants in factor 4 prefer affordable WTTs that have low running cost. In order to obtain a WTT, external support or advice is hugely appreciated. Paying for technologies by installments and using it in a group helps to invest in a technology options. Easy maneuverability helps to share the technology with other farmers in the group.

Table 44 - A brief summary of the four factors

Factor 1

12 participants loaded significantly on factor 1. The sorting behavior of factor 1 seems to express a stronger focus on high volumes of water compared to the efficient use of water. Statement 18 was often associated with the use of petrol water pumps. From respective sorting of this statement 18 and statement 3, we can conclude that the participants in the group have a strong preference for the performance characteristics of the petrol pump technology:

17	I prefer a technology that can give me a high volume of water.	**4**
18	I prefer a technology that can give me a high pressure.	**3**
3	I don't mind paying fuel to keep the technology working.	**2**
21	I prefer a technology that uses water efficiently.	**-1**

The participants of factor 1 seem to be somewhat influenced by variables involving external support. This support can involve finances and help with farming inputs, but also knowledge about irrigation management, local markets or the different WTT options. The decision-making process for instance is heavily impacted by the advice given by governmental extension officers. Also, statement 29 was often associated with external support from development organizations and the disagreeing sorting behavior of factor 1 can be interpreted as another expression of the request to be supported by external organizations:

27	I prefer a technology that has been advocated by the extension officers.	**3**
29	I prefer if the company representatives are Malawian.	**-4**

Theme Q statement	Factor scores			
The characteristics of the WTT	F1	F2	F3	F4
Financial aspects and affordability				
1. I prefer paying through installments over time.	0	0	2	3
2. I want overall affordable costs.	1	4	2	2
3. I don't mind paying fuel to keep the technology working.	2	-4	-1	-2
4. I am happy with my current pumping method. I don't want to invest.	-1	-1	-2	-2
5. I prefer to wait for someone to give me an irrigation technology.	-2	-2	-1	-1
6. It is too expensive. I don't want to invest.	-3	-3	-4	-3
7. I have other farming limitations. I don't want to invest.	-3	-3	-2	-2
8. I prefer to use and pay for a technology with a group of farmers instead of individually.	2	0	0	2
9. I prefer to adopt a more expensive technology but safe on running cost.	1	1	0	-1
Management				
10. I find easy individual operation important.	1	3	1	0
11. I find easy maneuverability important.	-2	0	0	2
12. I find it important that the technology is hard to vandalize or steal.	0	-1	4	1
Technology characteristics				
13. I want to be able to maintain the technology myself.	3	2	2	1
14. I want it to be cheap to maintain the technology.	0	4	1	0
15. I want my irrigation technology to give me a better status in my community.	-1	-2	-1	-1
16. I prefer a technology that works automatically without human power.	-1	2	-1	-3
17. I prefer a technology that can give me a high volume of water.	4	1	0	0
18. I prefer a technology that can give me a high pressure.	3	1	-3	-1
19. I want the technology to enable me to grow crops that I can sell at the market.	4	3	3	3
20. I want the technology to enable me to grow crops that I can eat.	2	2	1	4
21. I prefer a technology that uses water efficiently.	-1	3	0	1
Environment				
22. I don't mind watering the crops myself without the use of a technology.	-3	-3	-3	-4
23. My water availability and water source determine my technology choice.	0	1	4	2
Characteristics & circumstances of farmer within their (social) environment				
Community				
24. I want support from my community and family.	-2	-1	-2	-3
Ownership				
25. I don't own the land on which I farm. I don't want to invest.	-4	-4	-4	-4
26. I can't expand my farm. I don't want to invest.	-2	-2	-3	-2
Agricultural extension services				
27. I prefer a technology that has been advocated by the extension officers.	3	2	0	3
Company relationship				
28. I need external support after implementation.	0	0	-1	4
29. I prefer if the company representatives are Malawian.	-4	-1	-2	-1
The process of learning and experience				
Familiarity				
30. I want to hear about the technology before I adopt it.	2	0	3	1
31. I want to have seen the technology before I adopt it.	1	-2	2	0
32. I want to try out the technology before I adopt it.	-1	-1	1	0
33. I want a technology that other farmers have used successfully before I adopt it.	0	1	1	0
Understandability				
34. I prefer technology that I can understand.	1	0	3	1

Table 43 - Raw scores of statements for the 4-factor solution.

Paying and using technology in a group, however, makes it easier to invest and helps to open a wider range of technology options:

8	I prefer to use and pay for a technology with a group of farmers instead of individually.	**2**

Factor 2

11 participants loaded significantly on factor 2. The cost effectiveness of the WTT is something that the participants in factor 2 value relatively much. In their decision-making process they pay special attention to the gross margin and cost of production. In financial terms this does not just involve the size of the initial investment, but also the long-term maintenance and running cost of the WTT:

2	I want overall affordable costs.	**4**
14	I want it to be cheap to maintain the technology.	**4**
21	I prefer a technology that uses water efficiently.	**3**
9	I prefer to adopt a more expensive technology but safe on running cost.	**1**
3	I don't mind paying fuel to keep the technology working.	**-4**

Paying for technologies in installments, however, is not of huge importance to the participants in factor 2. This could suggest they have enough financial resources themselves to pay for the technology:

1	I prefer paying through installments over time.	**0**

An important variable of the cost-effectiveness of a technology that drives the decision-making of the participants in factor 2 is their ease of use and labour saving ability. The ability of the WTT to work automatically is therefore strongly preferred. Unlike when using watering cans were one has to walk up and down to the water source, these technologies require little human effort or attention when pumping water. This enables the farmers to focus on other activities such as working on the crops or expanding the farm:

10	I find easy individual operation important.	**3**
16	I prefer a technology that works automatically without human power.	**2**

The participants in factor 2 attach relatively little value to the familiarity, understandability, safety or status of a technology. As long as the WTT satisfies their most important decision-making variables, they are confident enough to adopt:

34	I prefer technology that I can understand.	**0**
30	I want to hear about the technology before I adopt it.	**0**
12	I find it important that the technology is hard to vandalize or steal.	**-1**
31	I want to have seen the technology before I adopt it.	**-2**
15	I want my irrigation technology to give me a better status in my community.	**-2**

Factor 3

9 participants loaded significantly on factor 3. The participants in this factor express high value to the notion that different physical situations influence the suitability of a WTT, and they are determined to find the best technology fit with theirs:

23	My water availability and water source determine my technology choice.	**4**

The sorting behavior of factor 3 also shows that its participants are significantly more risk-averse when choosing WTT for irrigation. This is expressed in the relatively high valued importance of familiarity and understandability, but also in the preference for technologies that are hard to vandalize or steal:

12	I find it important that the technology is hard to vandalize or steal.	**4**
30	I want to hear about the technology before I adopt it.	**3**
34	I prefer technology that I can understand.	**3**
31	I want to have seen the technology before I adopt it.	**2**
32	I want to try out the technology before I adopt it.	**1**

Besides the risk-averse sorting behavior mentioned above, the participants of factor 3 also express financially risk-averse behavior. Paying in installments reduces the initial financial risk and helps to open a wider range of technology options:

1	I prefer paying through installments over time.	**2**

Also, the participants in factor 2 attach significant little, relatively to the other factors, value to external support. This can be support in terms of advice, farm inputs or financial tools to help obtain WTTs:

27	I prefer a technology that has been advocated by the extension officers.	**0**
28	I need external support after implementation.	**-1**

Factor 4

11 participants loaded significantly on factor 4. The participants of factor 4 seem to be heavily influenced by variables involving external support. This support can involve finances and help with farming inputs, but also knowledge about irrigation management, local markets or the different WTT options. The decision-making process for instance is heavily impacted by the advice given by governmental extension officers:

28	I need external support after implementation.	**4**
27	I prefer a technology that has been advocated by the extension officers.	**3**

From the respective sorting of statements on the right can be concluded that the participants are financially limited in their adoption of WTTs. Paying for technologies by installments and in a group, however, helps to open a wider range of technology options. Easy maneuverability helps to share the technology with other farmers in the group:

1	I prefer paying through installments over time.	**3**
8	I prefer to use and pay for a technology with a group of farmers instead of individually.	**2**
11	I find easy maneuverability important.	**2**

Although financially limited, from the respective sorting of statements on the right we can conclude that the participants of factor 4 do want to develop their farm. Although they do not want to water the crops themselves without the use of a technology, a technology that pumps automatically without human power or input is also not preferred. The problem with some of the available WTTs, however, is that they might come with higher running cost, which the farmers do not want to accept or can't afford:

9	I prefer to adopt a more expensive technology but safe on running cost.	**-1**
3	I don't mind paying fuel to keep the technology working.	**-2**
16	I prefer a technology that works automatically without human power.	**-3**

Consensus

Besides statements that distinguished the Q-sort participants into four factors, there are also statements that participants agree on. This happens when similar sorting of some statements, which in the Q-methodology is called *consensus*, appears. It means that there is no significant difference between the factors. In the midst of all the subjectivity between participants, it can be especially interesting to discover statements that people have agreement on. The consensus statements are colored green in the factor visualizations (Annex 11.4).

Out of all statements in the 4-factor solution there were 4 out of 34 statements which were sorted significantly similar by all participants (Table 45). There was a strong consensus in favor of the need to invest in WTT, and against the notion that investment in WTT for irrigation is entirely blocked by farm size or ownership limitations or other farming limitations:

Consensus statements		F1	F2	F3	F4
4	I am happy with my current pumping method. I don't want to invest.	-1	-1	-2	-2
7	I have other farming limitations. I don't want to invest.	-3	-3	-2	-2
22	I don't mind watering the crops myself without the use of a technology.	-3	-3	-3	-4
25	I don't own the land on which I farm. I don't want to invest.	-4	-4	-4	-4

Table 45 - Raw scores of consensus statements for the 4-factor solution.

5-factor solution

In this analysis five factors were kept in rotation, accounting for 59% of the total variance. 41 of the 58 participants (71% of the sample) were automatically *flagged* to the factor with which they had significant loading. The remaining 17 participants were disregarded for this part of the analysis because they loaded insignificant or loaded significantly on more than one factor (multiple loaders). For each factor, a factor matrix, factor visualization and a list of distinguishing statements can be found in Annex 11.5. Detailed accounts of all five factors are presented below. These were composed by examining the sorting of statements in relation to the other statements within the factor and by comparing this with the other factors. It is the relative positions within the entire sort that describe the factor and not just the individual statements themselves (Table 46). From the five factors, each of which can be considered as a synthetic representative farmer according to their key sorting behavior, a brief participant typology was created (Table 47).

5-Factor Solution
Factor 1
Characteristics: dependent, team player, status seeker
The participants in this factor prefer WTTs that give a high volume of water. External support or advice is hugely appreciated. Paying for technologies by installments and using it in a group helps to invest in a technology options. The participants in this factor would also appreciate it if the technology gives the group a better status in the community. Easy maneuverability helps to share the technology with other farmers in the group.
Factor 2
Characteristics: independent, risk taker, cost-effective decision maker, long-term thinking.
The participants in this factor are looking for a technology that is affordable and labour saving, but also offers low running cost, in order to expand their farm and grow more crops for the market. Familiarity, understandability, status or support do not play a large role in their decision-making process.
Factor 3
Characteristics: independent, risk averse, environmentally aware
For the participants in factor 3 it is very important to minimize risk. Therefore they have a strong preference for proven, familiar and understandable technologies. They pay special attention that this technology fits their specific situation and topography.
Factor 4
Characteristics: financially limited, risk taker
The participants in factor 4 attach minimal value to the familiarity of a technology, but do advice from experts very seriously.
Factor 5
Characteristics: water volume seeker
The sorting behavior of factor 5 expresses strong focus on high volumes of water compared to the efficient use of water.

Table 47 - A brief summary of the five factors

Factor 1

12 participants loaded significantly on factor 1. The participants of factor 1 seem to be heavily influenced by variables involving external support. This support can involve finances and help with farming inputs, but also knowledge about irrigation management, local markets or the different WTT options. The decision-making process for instance is heavily impacted by the advice given by governmental extension officers. Also, statement 29 was often associated with external support from development organizations and the disagreeing sorting behavior of factor 1 can be interpreted as another expression of the request to be supported by external organizations:

27	I prefer a technology that has been advocated by the extension officers.	**4**
28	I need external support after implementation.	**4**
29	I prefer if the company representatives are Malawian.	**-3**

Paying and using a technology in a group makes it easier to invest and helps to open a wider range of technology options. When using the technology in a group, easy individual operation is not a of upmost importance:

8	I prefer to use and pay for a technology with a group of farmers instead of individually.	**2**
10	I find easy individual operation important.	**0**

Theme Q statement	Factor scores				
The characteristics of the WTT	F1	F2	F3	F4	F5
Financial aspects and affordability					
1. I prefer paying through installments over time.	2	0	2	3	0
2. I want overall affordable costs.	0	4	1	4	1
3. I don't mind paying fuel to keep the technology working.	-3	-4	-2	1	3
4. I am happy with my current pumping method. I don't want to invest.	-2	-1	-2	-3	-1
5. I prefer to wait for someone to give me an irrigation technology.	-2	-2	-1	1	-2
6. It is too expensive. I don't want to invest.	-4	-3	-4	-2	-3
7. I have other farming limitations. I don't want to invest.	-1	-3	-2	-1	-2
8. I prefer to use and pay for a technology with a group of farmers instead of individually.	2	0	0	1	2
9. I prefer to adopt a more expensive technology but safe on running cost.	-1	2	0	0	0
Management					
10. I find easy individual operation important.	0	3	1	2	1
11. I find easy maneuverability important.	2	0	0	2	-2
12. I find it important that the technology is hard to vandalize or steal.	2	-1	4	0	-1
Technology characteristics					
13. I want to be able to maintain the technology myself.	1	2	1	-1	2
14. I want it to be cheap to maintain the technology.	0	4	1	1	0
15. I want my irrigation technology to give me a better status in my community.	1	-2	-1	-1	-1
16. I prefer a technology that works automatically without human power.	-1	2	-1	-2	-1
17. I prefer a technology that can give me a high volume of water.	3	1	0	-3	3
18. I prefer a technology that can give me a high pressure.	1	1	-3	-2	4
19. I want the technology to enable me to grow crops that I can sell at the market.	3	2	3	3	4
20. I want the technology to enable me to grow crops that I can eat.	3	3	2	1	2
21. I prefer a technology that uses water efficiently.	1	3	0	0	0
Environment					
22. I don't mind watering the crops myself without the use of a technology.	-2	-3	-3	-4	-3
23. My water availability and water source determine my technology choice.	1	1	4	3	1
Characteristics & circumstances of farmer within their (social) environment					
Community					
24. I want support from my community and family.	-3	-1	-1	0	-3
Ownership					
25. I don't own the land on which I farm. I don't want to invest.	-4	-4	-4	-2	-4
26. I can't expand my farm. I don't want to invest.	-2	-2	-3	-4	-2
Agricultural extension services					
27. I prefer a technology that has been advocated by the extension officers.	4	1	0	4	3
Company relationship					
28. I need external support after implementation.	4	0	-1	2	0
29. I prefer if the company representatives are Malawian.	-3	-1	-2	0	-4
The process of learning and experience					
Familiarity					
30. I want to hear about the technology before I adopt it.	0	0	2	0	2
31. I want to have seen the technology before I adopt it.	-1	-2	3	-1	1
32. I want to try out the technology before I adopt it.	0	0	2	-3	-1
33. I want a technology that other farmers have used successfully before I adopt it.	-1	1	1	-1	0
Understandability					
34. I prefer technology that I can understand.	0	-1	3	2	1

Table 46 - Raw scores of statements for the 5-factor solution.

The sorting behavior of factor 1 also seems to express a stronger focus on high volumes of water compared to the efficient use of water. Statement 18 was often associated with the use of petrol water pumps. From respective sorting of this statement 18 and statement 3, we can conclude that the participants in the group have a strong preference for the performance characteristics of the petrol pump technology:

17	I prefer a technology that can give me a high volume of water.	**3**
3	I don't mind paying fuel to keep the technology working.	**2**
21	I prefer a technology that uses water efficiently.	**-1**

Noticeably factor 1 in the 5 factor solution is the only factor that results in agreeing sorting with statement 15. The participants in factor 1 attach value to the status that a technology can provide:

15	I want my irrigation technology to give me a better status in my community.	**1**

Factor 2

11 participants loaded significantly on factor 2. The cost effectiveness of the WTT is something that the participants in factor 2 value relatively much. In financial terms this does not just involve the size of the initial investment, but also the long-term maintenance and running cost of the WTT:

2	I want overall affordable costs.	**4**
14	I want it to be cheap to maintain the technology.	**4**
21	I prefer a technology that uses water efficiently.	**3**
9	I prefer to adopt a more expensive technology but safe on running cost.	**2**
3	I don't mind paying fuel to keep the technology working.	**-4**

An important variable of the cost-effectiveness of a technology that drives the decision-making of the participants in factor 2 is their ease of use and labour saving ability. The ability of the WTT to work automatically is therefore strongly preferred. Unlike when using watering cans were one has to walk up and down to the water source, these technologies require little human effort or attention when pumping water. This enables the farmers to focus on other activities such as working on the crops or expanding the farm:

10	I find easy individual operation important.	**3**
16	I prefer a technology that works automatically without human power.	**2**

The participants in factor 2 attach relatively little value to the familiarity, understandability or status of a technology. As long as the WTT satisfies their most important decision-making variables, they are confident enough to adopt:

30	I want to hear about the technology before I adopt it.	**0**
34	I prefer technology that I can understand.	**-1**
31	I want to have seen the technology before I adopt it.	**-2**
15	I want my irrigation technology to give me a better status in my community.	**-2**

Also, the participants in factor 2 attach significant little, relatively to the other factors, value to external support. This can be support in terms of advice, farm inputs or financial tools to help obtain WTTs. Paying for technologies in installments for instance, is not of huge importance to the participants in factor 2. This could suggest they have enough financial resources themselves to pay for the technology.

1	I prefer paying through installments over time.	**0**
28	I need external support after implementation.	**0**

Factor 3

7 participants loaded significantly on factor 3. The participants in this factor express high value to the notion that different physical situations influence the suitability of a WTT, and they are determined to find the best technology fit with theirs:

23	My water availability and water source determine my technology choice.	**4**

The sorting behavior of factor 3 also shows that its participants are significantly more risk-averse when choosing WTT for irrigation. This is expressed in the relatively high valued importance of familiarity and understandability, but also in the preference for technologies that are hard to vandalize or steal:

12	I find it important that the technology is hard to vandalize or steal.	**4**
34	I prefer technology that I can understand.	**3**
31	I want to have seen the technology before I adopt it.	**3**
30	I want to hear about the technology before I adopt it.	**2**
32	I want to try out the technology before I adopt it.	**2**

Also, the participants in factor 3 attach significant little, relatively to the other factors, value to external support. This can be support in terms of advice, farm inputs or financial tools to help obtain WTTs:

27	I prefer a technology that has been advocated by the extension officers.	**0**
28	I need external support after implementation.	**-1**

Factor 4

4 participants loaded significantly on factor 4. The participants in factor 4 attach relatively little value to the familiarity of a technology, continually scoring lowest for the statements on the right. As long as the WTT satisfies their most important decision-making variables, they are confident enough to adopt:

30	I want to hear about the technology before I adopt it.	**0**
31	I want to have seen the technology before I adopt it.	**-1**
32	I want to try out the technology before I adopt it.	**-3**
33	I want a technology that other farmers have used successfully before I adopt it.	**-1**

Where on the one hand the notion of familiarity of the technology does not play a big role, the advice of the extension officers has very strong role to play in the decision-making process of the participants in factor 4:

27	I prefer a technology that has been advocated by the extension officers.	**4**

Noticeable sorting behavior of the participants of factor 4 is that they are the only group, in all respective factor solutions, which has sorted statement 5 in the agreeing part of the spectrum. Together with the agreeing sorting of statement 28, this would suggest that the participants in factor 4 have strong financial limitations that prevent them to adopt the WTTs that they wish for:

28	I need external support after implementation.	**2**
5	I prefer to wait for someone to give me an irrigation technology.	**1**
1	I prefer paying through installments over time.	**3**

Although the statements above would suggest financial limitations, the participants of factor 4 do not have a problem with paying for fuel:

3	I don't mind paying fuel to keep the technology working.	**1**

Despite the sorting behavior of the statement above, which might suggest a preference for petrol pump technology, the sorting behavior of factor 4 seems to express little value for high volumes of water:

17	I prefer a technology that can give me a high volume of water.	**-3**

Factor 5

9 participants loaded significantly on factor 5. The sorting behavior of factor 5 seems to express a stronger focus on high volumes of water compared to the efficient use of water. Statement 18 was often associated with the use of petrol water pumps. From respective sorting of this statement 18 and statement 3, we can conclude that the participants in the group have a strong preference for the performance characteristics of the petrol pump technology:

18	I prefer a technology that can give me a high pressure.	**4**
17	I prefer a technology that can give me a high volume of water.	**4**
3	I don't mind paying fuel to keep the technology working.	**3**
21	I prefer a technology that uses water efficiently.	**0**

The easy maneuverability that is inherent to the petrol pump, however, is not something that the participants of factor 5 value much:

11	I find easy maneuverability important.	**-2**

Consensus

Besides statements that distinguished the Q-sort participants into five factors, there are also statements that participants agree on. This happens when similar sorting of some statements, which in the Q-methodology is called *consensus*, appears. It means that there is no significant difference between the factors. In the midst of all the subjectivity between participants, it can be especially interesting to discover statements that people have agreement on. The consensus statements are colored green in the factor visualizations (Annex 11.5).

Out of all statements in the 5-factor solution there were 3 out of 34 statements which were sorted significantly similar by all participants (Table 48). There was a strong consensus in favor of the need to invest in WTT, and against the notion that investment in WTT is entirely blocked by farm size or other farming limitations.

Consensus statements		F1	F2	F3	F4	F5
4	I am happy with my current pumping method. I don't want to invest.	-2	-1	-2	-3	-1
7	I have other farming limitations. I don't want to invest.	-1	-3	-2	-1	-2
26	I can't expand my farm. I don't want to invest.	-2	-2	-3	-4	-2

Table 48 - Raw scores of consensus statements for the 5-factor solution.

Conclusion

After analyzing all factor solutions, we can draw several conclusions. It is clear that, although the 2-factor solution has the highest representative score (81%), it does not embrace the complexity represented in the group of participants. This is supported by the fact that the 2 factor solution only represents 44% of the total variance. Also, when looking at the factor visualizations in Annex 11.2, we find that all statements are either significantly distinct or of consensus, indicating that significance is easily reached and that there is more variety to this group of participants than a 2-factor solution can display.

The 5-factor solution on the other hand, embraces a lot of variety, 59% of the total variance, but was found to give too little distinguishment between the different groups. This is mostly due to the low number of participants loading on a factor. As a result, it becomes difficult to pinpoint and understand the sorting behavior of a respective factor.

Although the 3- and 4-factor solution were found to both give enough distinguishing statements for analysis, it was found that a 4-factor solution was the most interesting fit for the data. The reason for this is that it is able to embrace more variety and subjectivity, while still providing enough information to make a meaningful ontology.

Although it is clear that the amount of significant consensus statements decreases when the amount of factors increases, the statements are generally the same for each factor solution. For all factor solutions there was a strong consensus in favor of the need to invest in WTT, and against the notion that investment in WTT is entirely blocked by farm size or other farming limitations.

Annex 11.1 – 2-Factor Solution All Participants

Factor Matrix with sorts Auto-Flagged (P < 0.05) & Factor Characteristics

Qsort #	Q-sort	Factor 1		Factor 2	
1	QSORT1	0.62	flagged	0.30	
2	QSORT2	0.56	flagged	0.28	
3	QSORT3	0.27		0.70	flagged
4	QSORT4	0.61	flagged	0.37	
5	QSORT5	0.39		0.64	flagged
6	QSORT6	0.86	flagged	-0.01	
7	QSORT7	0.35	flagged	0.19	
8	QSORT8	0.31		0.59	flagged
9	QSORT9	0.70	flagged	0.17	
10	QSORT10	0.47		0.52	flagged
11	QSORT11	0.47	flagged	0.24	
12	QSORT12	0.09		0.76	flagged
13	QSORT13	0.48	flagged	0.27	
14	QSORT14	0.61	flagged	0.42	
15	QSORT15	0.31		0.35	flagged
16	QSORT16	0.68	flagged	0.24	
17	QSORT17	0.67	flagged	0.34	
18	QSORT18	0.34		0.29	
19	QSORT19	0.49	flagged	0.31	
20	QSORT20	0.32		0.73	flagged
21	QSORT21	0.21		0.72	flagged
22	QSORT22	0.38		0.67	flagged
23	QSORT23	0.57	flagged	0.24	
24	QSORT24	0.19		0.55	flagged
25	QSORT25	0.71	flagged	0.18	
26	QSORT26	0.65	flagged	0.34	
27	QSORT27	0.62	flagged	0.30	
28	QSORT28	0.67	flagged	0.21	
29	QSORT29	0.59	flagged	0.29	
30	QSORT30	0.71	flagged	0.15	
31	QSORT31	0.46		0.47	flagged
32	QSORT32	0.76	flagged	0.33	
33	QSORT33	0.27		0.54	flagged
34	QSORT34	0.28		0.44	flagged
35	QSORT35	0.70	flagged	0.05	
36	QSORT36	0.60	flagged	0.06	
37	QSORT37	0.42		0.57	flagged
38	QSORT38	0.58	flagged	0.49	
39	QSORT39	0.38		0.49	flagged
40	QSORT40	-0.06		0.62	flagged
41	QSORT41	0.28		0.71	flagged
42	QSORT42	-0.04		0.33	
43	QSORT43	0.33		0.21	
44	QSORT44	0.30		0.35	flagged
45	QSORT45	0.75	flagged	0.22	
46	QSORT46	0.57	flagged	0.27	
47	QSORT47	0.53	flagged	0.23	
48	QSORT48	0.50		0.68	flagged
49	QSORT49	0.66	flagged	0.17	
50	QSORT50	0.07		0.64	flagged
51	QSORT51	0.28		0.19	
52	QSORT52	0.51		0.61	flagged
53	QSORT53	0.41	flagged	0.32	
54	QSORT54	0.55	flagged	0.40	
55	QSORT55	0.77	flagged	0.00	
56	QSORT56	0.39		0.39	flagged
57	QSORT57	0.69	flagged	0.27	
58	QSORT58	0.56	flagged	0.35	
%Explained Variance		**26**		**18**	
Total %Explained Variance			**44**		

	Factor 1
	Factor 2
	Unflagged

Factor Characteristics

	factor 1	factor 2
No. of Defining Variables	32	22
Avg. Rel. Coef.	0.8	0.8
Composite Reliability	0.992	0.989
S.E. of Factor Z-scores	0.089	0.105

Composite Q sort for Factor 1

-4	-3	-2	-1	0	1	2	3	4
I can't expand my farm. I don't want to invest.	I have other farming limitations. I don't want to invest.	I prefer a technology that works automatically without human power.	I want it to be cheap to maintain the technology.	I want a technology that other farmers have used successfully before I adopt it.	I want to be able to maintain the technology myself.	My water availability and water source determine my technology choice.	I want the technology to enable me to grow crops that I can eat.	I want the technology to enable me to grow crops that I can sell at the market.
I don't own the land on which I farm. I don't want to invest.	I dont mind watering the crops myself without the use of a technology.	I am happy with my current pumping method. I don't want to invest.	I want my irrigation technology to give me a better status in my community.	I find it important that the technlogy is hard to vandalize or steal.	I prefer technology that I can understand.	I prefer to use and pay for a technology with a group of farmers instead of individually.	I prefer a technology that has been advocated by the extension officers.	I need external support after implementation.
	It is too expensive. I don't want to invest.	I want support from my community and family.	I prefer to adopt a more expensive technology but safe on running cost.	I want to have seen the technology before I adopt it.	I want overall affordable costs.	I prefer paying through installments over time.	I prefer a technology that can give me a high volume of water.	
		I prefer if the company representatives are Malawian.	I don't mind paying fuel to keep the technology working.	I find easy maneuverability important.	I prefer a technology that can give me a high pressure.	I want to hear about the technology before I adopt it.		
			I prefer to wait for someone to give me an irrigation technology.	I prefer a technology that uses water efficiently.	I find easy individual operation important.			
				I want to try out the technology before I adopt it.				

Legend

- Distinguishing statement at P< 0.05
- Distinguishing statement at P< 0.01
- Consensus statement

Composite Q sort for Factor 2

-4	-3	-2	-1	0	1	2	3	4
I dont mind watering the crops myself without the use of a technology.	It is too expensive. I don't want to invest.	I want support from my community and family.	I need external support after implementation.	I prefer a technology that can give me a high pressure.	I prefer a technology that has been advocated by the extension officers.	I find easy individual operation important.	I want the technology to enable me to grow crops that I can sell at the market.	I want it to be cheap to maintain the technology.
I don't own the land on which I farm. I don't want to invest.	I have other farming limitations. I don't want to invest.	I want my irrigation technology to give me a better status in my community.	I want to try out the technology before I adopt it.	I prefer technology that I can understand.	I want to be able to maintain the technology myself.	I prefer a technology that works automatically without human power.	I want the technology to enable me to grow crops that I can eat.	I want overall affordable costs.
	I can't expand my farm. I don't want to invest.	I prefer to wait for someone to give me an irrigation technology.	I prefer if the company representatives are Malawian.	I want a technology that other farmers have used successfully before I adopt it.	I prefer a technology that can give me a high volume of water.	My water availability and water source determine my technology choice.	I prefer a technology that uses water efficiently.	
		I don't mind paying fuel to keep the technology working.	I am happy with my current pumping method. I don't want to invest.	I find easy maneuverability important.	I prefer to use and pay for a technology with a group of farmers instead of individually.	I prefer to adopt a more expensive technology but safe on running cost.		
			I want to have seen the technology before I adopt it.	I want to hear about the technology before I adopt it.	I prefer paying through installments over time.			
				I find it important that the technlogy is hard to vandalize or steal.				

Legend

- Distinguishing statement at P< 0.05
- Distinguishing statement at P< 0.01
- Consensus statement

Distinguishing Statements

Factor 1

Threshold	Z scr.	Q Sort Value	State. No.	Statement
P < 0.0001	-1.3	-2	29	I prefer if the company representatives are Malawian.
P < 0.0001	-1.103	-2	16	I prefer a technology that works automatically without human power.
P < 0.0001	-0.4	-1	3	I don't mind paying fuel to keep the technology working.
P < 0.0001	-0.388	-1	9	I prefer to adopt a more expensive technology but safe on running cost.
P < 0.0001	-0.132	-1	15	I want my irrigation technology to give me a better status in my community.
P < 0.0001	0.041	-1	14	I want it to be cheap to maintain the technology.
P < 0.0001	0.087	0	21	I prefer a technology that uses water efficiently.
P < 0.0001	0.363	0	31	I want to have seen the technology before I adopt it.
P < 0.0001	0.398	0	12	I find it important that the technlogy is hard to vandalize or steal.
P < 0.0001	0.433	1	10	I find easy individual operation important.
P < 0.0001	0.449	1	2	I want overall affordable costs.
P < 0.0001	0.808	2	30	I want to hear about the technology before I adopt it.
P < 0.0001	0.853	2	1	I prefer paying through installments over time.
P < 0.0001	1.36	4	28	I need external support after implementation.
P < 0.0005	0.579	1	34	I prefer technology that I can understand.
P < 0.0005	0.855	2	8	I prefer to use and pay for a technology with a group of farmers instead of individually.
P < 0.0005	0.996	3	17	I prefer a technology that can give me a high volume of water.
P < 0.001	-1.142	-2	4	I am happy with my current pumping method. I don't want to invest.
P < 0.001	0.084	0	32	I want to try out the technology before I adopt it.
P < 0.005	-1.159	-2	24	I want support from my community and family.
P < 0.01	0.422	0	33	I want a technology that other farmers have used successfully before I adopt it.
P < 0.05	-0.681	-1	5	I prefer to wait for someone to give me an irrigation technology.
P < 0.05	0.437	1	18	I prefer a technology that can give me a high pressure.
P < 0.05	1.217	3	27	I prefer a technology that has been advocated by the extension officers.
P < 0.05	1.781	4	19	I want the technology to enable me to grow crops that I can sell at the market.

Factor 2

Threshold	Z scr.	Q Sort Value	State. No.	Statement
P < 0.0001	-1.177	-2	3	I don't mind paying fuel to keep the technology working.
P < 0.0001	-0.932	-2	15	I want my irrigation technology to give me a better status in my community.
P < 0.0001	-0.677	-1	31	I want to have seen the technology before I adopt it.
P < 0.0001	-0.573	-1	29	I prefer if the company representatives are Malawian.
P < 0.0001	-0.236	-1	28	I need external support after implementation.
P < 0.0001	-0.208	0	12	I find it important that the technlogy is hard to vandalize or steal.
P < 0.0001	-0.128	0	30	I want to hear about the technology before I adopt it.
P < 0.0001	0.254	1	1	I prefer paying through installments over time.
P < 0.0001	0.921	2	9	I prefer to adopt a more expensive technology but safe on running cost.
P < 0.0001	0.941	2	16	I prefer a technology that works automatically without human power.
P < 0.0001	1.071	2	10	I find easy individual operation important.
P < 0.0001	1.221	3	21	I prefer a technology that uses water efficiently.
P < 0.0001	1.63	4	2	I want overall affordable costs.
P < 0.0001	1.737	4	14	I want it to be cheap to maintain the technology.
P < 0.0005	0.069	0	34	I prefer technology that I can understand.
P < 0.0005	0.348	1	8	I prefer to use and pay for a technology with a group of farmers instead of individually.
P < 0.0005	0.495	1	17	I prefer a technology that can give me a high volume of water.
P < 0.001	-0.676	-1	4	I am happy with my current pumping method. I don't want to invest.
P < 0.001	-0.378	-1	32	I want to try out the technology before I adopt it.
P < 0.005	-0.71	-2	24	I want support from my community and family.
P < 0.01	0.042	0	33	I want a technology that other farmers have used successfully before I adopt it.
P < 0.05	-1.016	-2	5	I prefer to wait for someone to give me an irrigation technology.
P < 0.05	0.121	0	18	I prefer a technology that can give me a high pressure.
P < 0.05	0.879	1	27	I prefer a technology that has been advocated by the extension officers.
P < 0.05	1.466	3	19	I want the technology to enable me to grow crops that I can sell at the market.

Annex 11.2 – Adopted 2-Factor Solution All Participants

Factor Matrix with sorts Auto-Flagged (P < 0.05) & Factor Characteristics

Qsort #	Q-sort	Factor 1		Factor 2	
1	QSORT1	-0.62	flagged	0.30	
2	QSORT2	-0.56	flagged	0.28	
3	QSORT3	-0.27		0.70	flagged
4	QSORT4	-0.61	flagged	0.37	
5	QSORT5	-0.39		0.64	flagged
6	QSORT6	-0.86	flagged	-0.01	
7	QSORT7	-0.35	flagged	0.19	
8	QSORT8	-0.31		0.59	flagged
9	QSORT9	-0.70	flagged	0.17	
10	QSORT10	-0.47		0.52	
11	QSORT11	-0.47	flagged	0.24	
12	QSORT12	-0.09		0.76	flagged
13	QSORT13	-0.48	flagged	0.27	
14	QSORT14	-0.61	flagged	0.42	
15	QSORT15	-0.31		0.35	
16	QSORT16	-0.68	flagged	0.24	
17	QSORT17	-0.67	flagged	0.34	
18	QSORT18	-0.34		0.29	
19	QSORT19	-0.49	flagged	0.31	
20	QSORT20	-0.32		0.73	flagged
21	QSORT21	-0.21		0.72	flagged
22	QSORT22	-0.38		0.67	flagged
23	QSORT23	-0.57	flagged	0.24	
24	QSORT24	-0.19		0.55	flagged
25	QSORT25	-0.71	flagged	0.18	
26	QSORT26	-0.65	flagged	0.34	
27	QSORT27	-0.62	flagged	0.30	
28	QSORT28	-0.67	flagged	0.21	
29	QSORT29	-0.59	flagged	0.29	
30	QSORT30	-0.71	flagged	0.15	
31	QSORT31	-0.46		0.47	
32	QSORT32	-0.76	flagged	0.33	
33	QSORT33	-0.27		0.54	flagged
34	QSORT34	-0.28		0.44	flagged
35	QSORT35	-0.70	flagged	0.05	
36	QSORT36	-0.60	flagged	0.06	
37	QSORT37	-0.42		0.57	flagged
38	QSORT38	-0.58		0.49	
39	QSORT39	-0.38		0.49	flagged
40	QSORT40	0.06		0.62	flagged
41	QSORT41	-0.28		0.71	flagged
42	QSORT42	0.04		0.33	
43	QSORT43	-0.33		0.21	
44	QSORT44	-0.30		0.35	
45	QSORT45	-0.75	flagged	0.22	
46	QSORT46	-0.57	flagged	0.27	
47	QSORT47	-0.53	flagged	0.23	
48	QSORT48	-0.50		0.68	flagged
49	QSORT49	-0.66	flagged	0.17	
50	QSORT50	-0.07		0.64	flagged
51	QSORT51	-0.28		0.19	
52	QSORT52	-0.51		0.61	flagged
53	QSORT53	-0.41		0.32	
54	QSORT54	-0.55	flagged	0.40	
55	QSORT55	-0.77	flagged	0.00	
56	QSORT56	-0.39		0.39	
57	QSORT57	-0.69	flagged	0.27	
58	QSORT58	-0.56	flagged	0.35	
%Explained Variance		**26**		**18**	
Total %Explained Variance			**44**		

	Factor 1
	Factor 2
	Unflagged

Factor Characteristics

	factor 1	factor 2
No. of Defining Variables	30	17
Avg. Rel. Coef.	0.8	0.8
Composite Reliability	0.992	0.986
S.E. of Factor Z-scores	0.089	0.118

Composite Q sort for Factor 1

-4	-3	-2	-1	0	1	2	3	4
I can't expand my farm. I don't want to invest.	I have other farming limitations. I don't want to invest.	I prefer a technology that works automatically without human power.	I want it to be cheap to maintain the technology.	I want overall affordable costs.	I want to be able to maintain the technology myself.	My water availability and water source determine my technology choice.	I want the technology to enable me to grow crops that I can eat.	I want the technology to enable me to grow crops that I can sell at the market.
I don't own the land on which I farm. I don't want to invest.	I dont mind watering the crops myself without the use of a technology.	I am happy with my current pumping method. I don't want to invest.	I want my irrigation technology to give me a better status in my community.	I find it important that the technlogy is hard to vandalize or steal.	I prefer technology that I can understand.	I prefer paying through installments over time.	I prefer a technology that has been advocated by the extension officers.	I need external support after implementation.
	It is too expensive. I don't want to invest.	I want support from my community and family.	I don't mind paying fuel to keep the technology working.	I want to have seen the technology before I adopt it.	I want a technology that other farmers have used successfully before I adopt it.	I prefer to use and pay for a technology with a group of farmers instead of individually.	I prefer a technology that can give me a high volume of water.	
		I prefer if the company representatives are Malawian.	I prefer to adopt a more expensive technology but safe on running cost.	I find easy maneuverability important.	I find easy individual operation important.	I want to hear about the technology before I adopt it.		
			I prefer to wait for someone to give me an irrigation technology.	I want to try out the technology before I adopt it.	I prefer a technology that can give me a high pressure.			
				I prefer a technology that uses water efficiently.				

Legend

- Distinguishing statement at P< 0.05
- Distinguishing statement at P< 0.01
- Consensus statement

Composite Q sort for Factor 2

-4	-3	-2	-1	0	1	2	3	4
I dont mind watering the crops myself without the use of a technology.	I don't mind paying fuel to keep the technology working.	I am happy with my current pumping method. I don't want to invest.	I need external support after implementation.	I want a technology that other farmers have used successfully before I adopt it.	I want to be able to maintain the technology myself.	I find easy individual operation important.	I want the technology to enable me to grow crops that I can sell at the market.	I want it to be cheap to maintain the technology.
I don't own the land on which I farm. I don't want to invest.	I have other farming limitations. I don't want to invest.	I want my irrigation technology to give me a better status in my community.	I want to try out the technology before I adopt it.	I prefer technology that I can understand.	I prefer a technology that has been advocated by the extension officers.	I prefer a technology that works automatically without human power.	I prefer a technology that uses water efficiently.	I want overall affordable costs.
	I can't expand my farm. I don't want to invest.	I prefer to wait for someone to give me an irrigation technology.	I prefer if the company representatives are Malawian.	I prefer paying through installments over time.	I prefer a technology that can give me a high volume of water.	I prefer to adopt a more expensive technology but safe on running cost.	I want the technology to enable me to grow crops that I can eat.	
		It is too expensive. I don't want to invest.	I want support from my community and family.	I find easy maneuverability important.	I prefer to use and pay for a technology with a group of farmers instead of individually.	My water availability and water source determine my technology choice.		
			I want to have seen the technology before I adopt it.	I want to hear about the technology before I adopt it.	I prefer a technology that can give me a high pressure.			
				I find it important that the technlogy is hard to vandalize or steal.				

Legend

- Distinguishing statement at P< 0.05
- Distinguishing statement at P< 0.01
- Consensus statement

Distinguishing Statements

Factor 1

Threshold	Z scr.	Q Sort Value	State. No.	Statement
P < 0.0001	-1.31	-2	29	I prefer if the company representatives are Malawian.
P < 0.0001	-1.132	-2	16	I prefer a technology that works automatically without human power.
P < 0.0001	-0.401	-1	9	I prefer to adopt a more expensive technology but safe on running cost.
P < 0.0001	-0.396	-1	3	I don't mind paying fuel to keep the technology working.
P < 0.0001	-0.13	-1	15	I want my irrigation technology to give me a better status in my community.
P < 0.0001	0.005	-1	14	I want it to be cheap to maintain the technology.
P < 0.0001	0.023	0	21	I prefer a technology that uses water efficiently.
P < 0.0001	0.35	0	31	I want to have seen the technology before I adopt it.
P < 0.0001	0.417	0	12	I find it important that the technlogy is hard to vandalize or steal.
P < 0.0001	0.448	0	2	I want overall affordable costs.
P < 0.0001	0.46	1	10	I find easy individual operation important.
P < 0.0001	0.785	2	30	I want to hear about the technology before I adopt it.
P < 0.0001	0.829	2	8	I prefer to use and pay for a technology with a group of farmers instead of individually.
P < 0.0001	0.874	2	1	I prefer paying through installments over time.
P < 0.0001	1.408	4	28	I need external support after implementation.
P < 0.0005	-1.183	-2	24	I want support from my community and family.
P < 0.005	0.539	1	34	I prefer technology that I can understand.
P < 0.005	1.76	4	19	I want the technology to enable me to grow crops that I can sell at the market.
P < 0.01	-0.637	-1	5	I prefer to wait for someone to give me an irrigation technology.
P < 0.01	0.478	1	33	I want a technology that other farmers have used successfully before I adopt it.
P < 0.01	0.996	3	17	I prefer a technology that can give me a high volume of water.
P < 0.01	1.211	3	27	I prefer a technology that has been advocated by the extension officers.
P < 0.05	-1.572	-4	26	I can't expand my farm. I don't want to invest.
P < 0.05	-1.475	-3	6	It is too expensive. I don't want to invest.
P < 0.05	-1.159	-2	4	I am happy with my current pumping method. I don't want to invest.
P < 0.05	0.066	0	32	I want to try out the technology before I adopt it.
P < 0.05	0.184	0	11	I find easy maneuverability important.

Factor 2

Threshold	Z scr.	Q Sort Value	State. No.	Statement
P < 0.0001	-1.202	-3	3	I don't mind paying fuel to keep the technology working.
P < 0.0001	-0.912	-2	15	I want my irrigation technology to give me a better status in my community.
P < 0.0001	-0.664	-1	31	I want to have seen the technology before I adopt it.
P < 0.0001	-0.583	-1	29	I prefer if the company representatives are Malawian.
P < 0.0001	-0.241	-1	28	I need external support after implementation.
P < 0.0001	-0.24	0	12	I find it important that the technlogy is hard to vandalize or steal.
P < 0.0001	-0.185	0	30	I want to hear about the technology before I adopt it.
P < 0.0001	0.051	0	1	I prefer paying through installments over time.
P < 0.0001	0.227	1	8	I prefer to use and pay for a technology with a group of farmers instead of individually.
P < 0.0001	0.987	2	9	I prefer to adopt a more expensive technology but safe on running cost.
P < 0.0001	0.997	2	16	I prefer a technology that works automatically without human power.
P < 0.0001	1.053	2	10	I find easy individual operation important.
P < 0.0001	1.26	3	21	I prefer a technology that uses water efficiently.
P < 0.0001	1.579	4	2	I want overall affordable costs.
P < 0.0001	1.931	4	14	I want it to be cheap to maintain the technology.
P < 0.0005	-0.648	-1	24	I want support from my community and family.
P < 0.005	0.06	0	34	I prefer technology that I can understand.
P < 0.005	0.584	1	17	I prefer a technology that can give me a high volume of water.
P < 0.005	1.319	3	19	I want the technology to enable me to grow crops that I can sell at the market.
P < 0.01	-1.046	-2	5	I prefer to wait for someone to give me an irrigation technology.
P < 0.01	0.067	0	33	I want a technology that other farmers have used successfully before I adopt it.
P < 0.01	0.818	1	27	I prefer a technology that has been advocated by the extension officers.
P < 0.05	-1.136	-2	6	It is too expensive. I don't want to invest.
P < 0.05	-0.797	-2	4	I am happy with my current pumping method. I don't want to invest.
P < 0.05	-0.29	-1	32	I want to try out the technology before I adopt it.
P < 0.05	-0.15	0	11	I find easy maneuverability important.

Annex 11.3 – 3-Factor Solution All Participants

Factor Matrix with sorts Auto-Flagged (P < 0.05) & Factor Characteristics

Factor Characteristics

	factor 1	factor 2	factor 3
No. of Defining Variables	21	15	12
Avg. Rel. Coef.	0.8	0.8	0.8
Composite Reliability	0.988	0.984	0.98
S.E. of Factor Z-scores	0.11	0.126	0.141

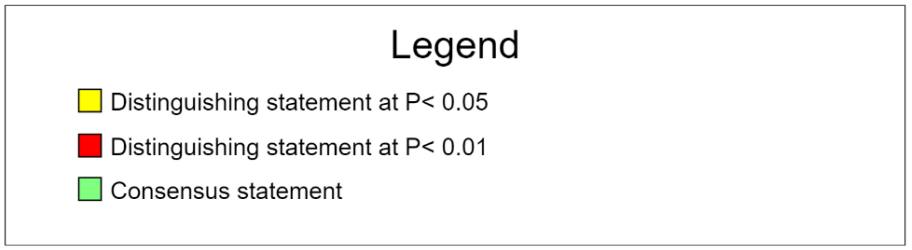
Qsort #	Q-sort	Factor 1		Factor 2		Factor 3	
1	QSORT1	0.22		0.20		0.76	flagged
2	QSORT2	0.20		0.19		0.70	flagged
3	QSORT3	0.24		0.66	flagged	0.26	
4	QSORT4	0.51	flagged	0.29		0.41	
5	QSORT5	0.42		0.59	flagged	0.22	
6	QSORT6	0.59		-0.12		0.62	flagged
7	QSORT7	0.02		0.12		0.57	flagged
8	QSORT8	0.33		0.55	flagged	0.19	
9	QSORT9	0.43		0.07		0.61	flagged
10	QSORT10	0.31		0.45		0.46	
11	QSORT11	0.73	flagged	0.22		-0.12	
12	QSORT12	0.05		0.73	flagged	0.24	
13	QSORT13	0.16		0.19		0.62	flagged
14	QSORT14	0.72	flagged	0.36		0.15	
15	QSORT15	0.53	flagged	0.33		-0.10	
16	QSORT16	0.72	flagged	0.17		0.23	
17	QSORT17	0.70	flagged	0.27		0.26	
18	QSORT18	0.24		0.24		0.29	
19	QSORT19	0.56	flagged	0.26		0.15	
20	QSORT20	0.19		0.67	flagged	0.41	
21	QSORT21	0.19		0.68	flagged	0.24	
22	QSORT22	0.44		0.63	flagged	0.19	
23	QSORT23	0.43		0.16		0.42	
24	QSORT24	-0.02		0.50	flagged	0.43	
25	QSORT25	0.56	flagged	0.09		0.47	
26	QSORT26	0.59	flagged	0.26		0.37	
27	QSORT27	0.64	flagged	0.23		0.25	
28	QSORT28	0.35		0.11		0.67	flagged
29	QSORT29	0.51	flagged	0.21		0.35	
30	QSORT30	0.62	flagged	0.07		0.38	

Qsort #	Q-sort	Factor 1		Factor 2		Factor 3	
31	QSORT31	0.29		0.40		0.45	
32	QSORT32	0.69	flagged	0.24		0.42	
33	QSORT33	0.11		0.49	flagged	0.41	
34	QSORT34	0.55	flagged	0.43		-0.15	
35	QSORT35	0.67	flagged	-0.02		0.29	
36	QSORT36	0.64	flagged	0.00		0.17	
37	QSORT37	0.41		0.51	flagged	0.27	
38	QSORT38	0.67	flagged	0.43		0.19	
39	QSORT39	0.09		0.41		0.58	flagged
40	QSORT40	0.02		0.63	flagged	0.00	
41	QSORT41	0.35		0.68	flagged	0.15	
42	QSORT42	0.08		0.34	flagged	-0.10	
43	QSORT43	0.23		0.16		0.28	
44	QSORT44	0.27		0.31		0.21	
45	QSORT45	0.57	flagged	0.13		0.51	
46	QSORT46	0.56	flagged	0.21		0.26	
47	QSORT47	0.57	flagged	0.17		0.17	
48	QSORT48	0.49		0.61	flagged	0.32	
49	QSORT49	0.57	flagged	0.09		0.38	
50	QSORT50	0.07		0.63	flagged	0.16	
51	QSORT51	0.22		0.15		0.20	
52	QSORT52	0.30		0.53		0.56	
53	QSORT53	0.06		0.24		0.64	flagged
54	QSORT54	0.47		0.33		0.37	
55	QSORT55	0.45		-0.11		0.67	flagged
56	QSORT56	0.19		0.33		0.45	flagged
57	QSORT57	0.33		0.16		0.74	flagged
58	QSORT58	0.41		0.27		0.45	
%Explained Variance		**20**		**14**		**16**	
Total %Explained Variance				**50**			

	Factor 1
	Factor 2
	Factor 3
	Unflagged

Composite Q sort for Factor 1

-4	-3	-2	-1	0	1	2	3	4
I prefer if the company representatives are Malawian.	I want support from my community and family.	I prefer a technology that works automatically without human power.	I find it important that the technlogy is hard to vandalize or steal.	I want to hear about the technology before I adopt it.	I prefer paying through installments over time.	I need external support after implementation.	I prefer a technology that has been advocated by the extension officers.	I want the technology to enable me to grow crops that I can sell at the market.
I don't own the land on which I farm. I don't want to invest.	I can't expand my farm. I don't want to invest.	I prefer to wait for someone to give me an irrigation technology.	I find easy maneuverability important.	I want it to be cheap to maintain the technology.	I prefer a technology that uses water efficiently.	I want to be able to maintain the technology myself.	I prefer a technology that can give me a high pressure.	I prefer a technology that can give me a high volume of water.
	It is too expensive. I don't want to invest.	I have other farming limitations. I don't want to invest.	I prefer to adopt a more expensive technology but safe on running cost.	I don't mind paying fuel to keep the technology working.	I find easy individual operation important.	I prefer to use and pay for a technology with a group of farmers instead of individually.	I want the technology to enable me to grow crops that I can eat.	
		I dont mind watering the crops myself without the use of a technology.	I want to try out the technology before I adopt it.	I want to have seen the technology before I adopt it.	My water availability and water source determine my technology choice.	I want overall affordable costs.		
			I am happy with my current pumping method. I don't want to invest.	I want a technology that other farmers have used successfully before I adopt it.	I prefer technology that I can understand.			
				I want my irrigation technology to give me a better status in my community.				



Composite Q sort for Factor 2

-4	-3	-2	-1	0	1	2	3	4
I dont mind watering the crops myself without the use of a technology.	I can't expand my farm. I don't want to invest.	I want to have seen the technology before I adopt it.	I find it important that the technlogy is hard to vandalize or steal.	I want a technology that other farmers have used successfully before I adopt it.	I prefer a technology that has been advocated by the extension officers.	I want the technology to enable me to grow crops that I can eat.	I prefer a technology that uses water efficiently.	I want it to be cheap to maintain the technology.
I don't own the land on which I farm. I don't want to invest.	I don't mind paying fuel to keep the technology working.	I want my irrigation technology to give me a better status in my community.	I want to try out the technology before I adopt it.	I need external support after implementation.	My water availability and water source determine my technology choice.	I prefer a technology that works automatically without human power.	I find easy individual operation important.	I want overall affordable costs.
	I have other farming limitations. I don't want to invest.	I prefer to wait for someone to give me an irrigation technology.	I prefer if the company representatives are Malawian.	I prefer technology that I can understand.	I prefer a technology that can give me a high volume of water.	I want to be able to maintain the technology myself.	I want the technology to enable me to grow crops that I can sell at the market.	
		It is too expensive. I don't want to invest.	I want support from my community and family.	I prefer paying through installments over time.	I prefer a technology that can give me a high pressure.	I prefer to adopt a more expensive technology but safe on running cost.		
			I am happy with my current pumping method. I don't want to invest.	I want to hear about the technology before I adopt it.	I prefer to use and pay for a technology with a group of farmers instead of individually.			
				I find easy maneuverability important.				

Legend

- Distinguishing statement at P< 0.05
- Distinguishing statement at P< 0.01
- Consensus statement

Composite Q sort for Factor 3

-4	-3	-2	-1	0	1	2	3	4
I dont mind watering the crops myself without the use of a technology.	I have other farming limitations. I don't want to invest.	I don't mind paying fuel to keep the technology working.	I prefer to adopt a more expensive technology but safe on running cost.	I prefer to use and pay for a technology with a group of farmers instead of individually.	I want a technology that other farmers have used successfully before I adopt it.	I want the technology to enable me to grow crops that I can eat.	I prefer paying through installments over time.	My water availability and water source determine my technology choice.
I don't own the land on which I farm. I don't want to invest.	I can't expand my farm. I don't want to invest.	I am happy with my current pumping method. I don't want to invest.	I want my irrigation technology to give me a better status in my community.	I need external support after implementation.	I prefer a technology that has been advocated by the extension officers.	I want overall affordable costs.	I find it important that the technlogy is hard to vandalize or steal.	I want the technology to enable me to grow crops that I can sell at the market.
	It is too expensive. I don't want to invest.	I prefer a technology that can give me a high pressure.	I prefer to wait for someone to give me an irrigation technology.	I find easy maneuverability important.	I want to be able to maintain the technology myself.	I want to have seen the technology before I adopt it.	I want to hear about the technology before I adopt it.	
		I prefer a technology that works automatically without human power.	I prefer if the company representatives are Malawian.	I want it to be cheap to maintain the technology.	I want to try out the technology before I adopt it.	I prefer technology that I can understand.		
			I want support from my community and family.	I prefer a technology that uses water efficiently.	I find easy individual operation important.			
				I prefer a technology that can give me a high volume of water.				

Legend

- Distinguishing statement at P< 0.05
- Distinguishing statement at P< 0.01
- Consensus statement

Distinguishing Statements

Factor 1

Threshold	Z scr.	Q Sort Value	State. No.	Statement
P < 0.0001	1.7	4	17	I prefer a technology that can give me a high volume of water.
P < 0.0005	1.44	3	27	I prefer a technology that has been advocated by the extension officers.
P < 0.0001	1.37	3	18	I prefer a technology that can give me a high pressure.
P < 0.0001	1.18	2	28	I need external support after implementation.
P < 0.01	0.88	2	8	I prefer to use and pay for a technology with a group of farmers instead of individually.
P < 0.05	0.59	2	2	I want overall affordable costs.
P < 0.0001	0.56	1	1	I prefer paying through installments over time.
P < 0.005	0.48	1	21	I prefer a technology that uses water efficiently.
P < 0.05	0.37	1	34	I prefer technology that I can understand.
P < 0.01	0.31	0	30	I want to hear about the technology before I adopt it.
P < 0.0001	0.17	0	3	I don't mind paying fuel to keep the technology working.
P < 0.0001	0.01	0	31	I want to have seen the technology before I adopt it.
P < 0.05	-1.32	-3	24	I want support from my community and family.
P < 0.0001	-1.56	-4	29	I prefer if the company representatives are Malawian.

Factor 2

Threshold	Z scr.	Q Sort Value	State. No.	Statement
P < 0.0001	2.13	4	14	I want it to be cheap to maintain the technology.
P < 0.0005	1.68	4	2	I want overall affordable costs.
P < 0.0001	1.32	3	21	I prefer a technology that uses water efficiently.
P < 0.0001	1.25	3	10	I find easy individual operation important.
P < 0.05	1.2	3	19	I want the technology to enable me to grow crops that I can sell at the market.
P < 0.0001	1.04	2	16	I prefer a technology that works automatically without human power.
P < 0.0001	0.88	2	9	I prefer to adopt a more expensive technology but safe on running cost.
P < 0.001	0.43	1	17	I prefer a technology that can give me a high volume of water.
P < 0.0001	0.19	1	18	I prefer a technology that can give me a high pressure.
P < 0.05	-0.03	0	28	I need external support after implementation.
P < 0.01	-0.07	0	34	I prefer technology that I can understand.
P < 0.0001	-0.1	0	1	I prefer paying through installments over time.
P < 0.01	-0.14	0	30	I want to hear about the technology before I adopt it.
P < 0.0001	-0.82	-2	31	I want to have seen the technology before I adopt it.
P < 0.01	-0.88	-2	15	I want my irrigation technology to give me a better status in my community.

Factor 3

Threshold	Z scr.	Q Sort Value	State. No.	Statement
P < 0.0001	1.74	4	23	My water availability and water source determine my technology choice.
P < 0.0001	1.33	3	1	I prefer paying through installments over time.
P < 0.0001	1.13	3	12	I find it important that the technlogy is hard to vandalize or steal.
P < 0.0001	1.09	3	30	I want to hear about the technology before I adopt it.
P < 0.05	0.95	2	2	I want overall affordable costs.
P < 0.0001	0.88	2	31	I want to have seen the technology before I adopt it.
P < 0.05	0.79	2	34	I prefer technology that I can understand.
P < 0.005	0.68	1	33	I want a technology that other farmers have used successfully before I adopt it.
P < 0.0001	0.52	1	32	I want to try out the technology before I adopt it.
P < 0.05	0.36	0	28	I need external support after implementation.
P < 0.005	-0.02	0	21	I prefer a technology that uses water efficiently.
P < 0.001	-0.2	0	17	I prefer a technology that can give me a high volume of water.
P < 0.001	-0.38	-1	5	I prefer to wait for someone to give me an irrigation technology.
P < 0.0001	-1.02	-2	18	I prefer a technology that can give me a high pressure.

Annex 11.4 – 4-Factor Solution All Participants

Factor Matrix with sorts Auto-Flagged (P < 0.05) & Factor Characteristics

Qsort #	Q-sort	Factor 1		Factor 2		Factor 3		Factor 4	
1	QSORT1	0.16		0.13		0.67	flagged	0.42	
2	QSORT2	0.06		0.14		0.56	flagged	0.50	
3	QSORT3	0.26		0.62	flagged	0.31		0.12	
4	QSORT4	0.62	flagged	0.23		0.45		0.13	
5	QSORT5	0.44		0.57	flagged	0.24		0.16	
6	QSORT6	0.41		-0.15		0.38		0.66	flagged
7	QSORT7	0.13		0.04		0.63	flagged	0.05	
8	QSORT8	0.24		0.55	flagged	0.14		0.29	
9	QSORT9	0.08		0.08		0.27		0.85	flagged
10	QSORT10	0.13		0.44		0.31		0.51	
11	QSORT11	0.50		0.27		-0.33		0.50	
12	QSORT12	0.05		0.71	flagged	0.30		0.09	
13	QSORT13	0.04		0.15		0.49	flagged	0.44	
14	QSORT14	0.70	flagged	0.34		0.11		0.27	
15	QSORT15	0.46	flagged	0.35		-0.15		0.20	
16	QSORT16	0.70	flagged	0.15		0.17		0.30	
17	QSORT17	0.53		0.27		0.09		0.53	
18	QSORT18	0.40		0.18		0.40		-0.07	
19	QSORT19	0.64	flagged	0.23		0.20		0.08	
20	QSORT20	0.10		0.65	flagged	0.37		0.32	
21	QSORT21	0.08		0.68	flagged	0.19		0.29	
22	QSORT22	0.36		0.62	flagged	0.15		0.29	
23	QSORT23	0.55	flagged	0.10		0.47		0.10	
24	QSORT24	0.09		0.44		0.53	flagged	0.00	
25	QSORT25	0.40		0.07		0.28		0.56	flagged
26	QSORT26	0.38		0.26		0.16		0.59	flagged
27	QSORT27	0.41		0.25		0.03		0.60	flagged
28	QSORT28	0.15		0.08		0.46		0.63	flagged
29	QSORT29	0.33		0.21		0.16		0.54	flagged
30	QSORT30	0.55	flagged	0.04		0.26		0.42	
31	QSORT31	0.24		0.37		0.40		0.32	
32	QSORT32	0.55		0.22		0.25		0.54	
33	QSORT33	0.09		0.45		0.41		0.20	
34	QSORT34	0.55	flagged	0.44		-0.14		0.10	
35	QSORT35	0.77	flagged	-0.07		0.29		0.14	
36	QSORT36	0.75	flagged	-0.04		0.20		0.07	
37	QSORT37	0.44		0.48		0.30		0.16	
38	QSORT38	0.63	flagged	0.42		0.14		0.30	
39	QSORT39	0.14		0.35		0.61	flagged	0.17	
40	QSORT40	-0.01		0.63	flagged	0.04		0.04	
41	QSORT41	0.20		0.69	flagged	0.07		0.36	
42	QSORT42	0.08		0.35	flagged	-0.07		-0.01	
43	QSORT43	-0.06		0.19		0.04		0.58	flagged
44	QSORT44	0.00		0.34		-0.01		0.54	flagged
45	QSORT45	0.49		0.09		0.39		0.46	
46	QSORT46	0.49	flagged	0.19		0.17		0.34	
47	QSORT47	0.43		0.18		0.02		0.42	
48	QSORT48	0.38		0.60		0.24		0.40	
49	QSORT49	0.31		0.10		0.12		0.66	flagged
50	QSORT50	0.07		0.61	flagged	0.21		0.06	
51	QSORT51	0.11		0.15		0.10		0.29	
52	QSORT52	0.38		0.46		0.61		0.17	
53	QSORT53	0.06		0.17		0.63	flagged	0.24	
54	QSORT54	0.31		0.32		0.22		0.49	
55	QSORT55	0.29		-0.15		0.45		0.60	flagged
56	QSORT56	0.21		0.28		0.46	flagged	0.19	
57	QSORT57	0.37		0.08		0.72	flagged	0.29	
58	QSORT58	0.31		0.25		0.33		0.42	
%Explained Variance		**15**		**13**		**12**		**15**	
Total %Explained Variance				**55**					

	Factor 1
	Factor 2
	Factor 3
	Factor 4
	Unflagged

Factor Characteristics

	factor 1	factor 2	factor 3	factor 4
No. of Defining Variables	12	11	9	11
Avg. Rel. Coef.	0.8	0.8	0.8	0.8
Composite Reliability	0.98	0.978	0.973	0.978
S.E. of Factor Z-scores	0.141	0.148	0.164	0.148

Composite Q sort for Factor 1

-4	-3	-2	-1	0	1	2	3	4
I prefer if the company representatives are Malawian.	It is too expensive. I don't want to invest.	I find easy maneuverability important.	I prefer a technology that uses water efficiently.	My water availability and water source determine my technology choice.	I prefer technology that I can understand.	I want the technology to enable me to grow crops that I can eat.	I prefer a technology that can give me a high pressure.	I want the technology to enable me to grow crops that I can sell at the market.
I don't own the land on which I farm. I don't want to invest.	I dont mind watering the crops myself without the use of a technology.	I want support from my community and family.	I want my irrigation technology to give me a better status in my community.	I need external support after implementation.	I want overall affordable costs.	I want to hear about the technology before I adopt it.	I prefer a technology that has been advocated by the extension officers.	I prefer a technology that can give me a high volume of water.
	I have other farming limitations. I don't want to invest.	I prefer to wait for someone to give me an irrigation technology.	I want to try out the technology before I adopt it.	I want a technology that other farmers have used successfully before I adopt it.	I find easy individual operation important.	I prefer to use and pay for a technology with a group of farmers instead of individually.	I want to be able to maintain the technology myself.	
		I can't expand my farm. I don't want to invest.	I am happy with my current pumping method. I don't want to invest.	I prefer paying through installments over time.	I want to have seen the technology before I adopt it.	I don't mind paying fuel to keep the technology working.		
			I prefer a technology that works automatically without human power.	I want it to be cheap to maintain the technology.	I prefer to adopt a more expensive technology but safe on running cost.			
				I find it important that the technlogy is hard to vandalize or steal.				

Legend

- Distinguishing statement at P< 0.05
- Distinguishing statement at P< 0.01
- Consensus statement

Composite Q sort for Factor 2

-4	-3	-2	-1	0	1	2	3	4
I don't mind paying fuel to keep the technology working.	I have other farming limitations. I don't want to invest.	I want to have seen the technology before I adopt it.	I want to try out the technology before I adopt it.	I prefer to use and pay for a technology with a group of farmers instead of individually.	I prefer to adopt a more expensive technology but safe on running cost.	I want the technology to enable me to grow crops that I can eat.	I prefer a technology that uses water efficiently.	I want it to be cheap to maintain the technology.
I don't own the land on which I farm. I don't want to invest.	It is too expensive. I don't want to invest.	I want my irrigation technology to give me a better status in my community.	I want support from my community and family.	I need external support after implementation.	My water availability and water source determine my technology choice.	I prefer a technology that works automatically without human power.	I find easy individual operation important.	I want overall affordable costs.
	I dont mind watering the crops myself without the use of a technology.	I can't expand my farm. I don't want to invest.	I prefer if the company representatives are Malawian.	I prefer paying through installments over time.	I prefer a technology that can give me a high volume of water.	I want to be able to maintain the technology myself.	I want the technology to enable me to grow crops that I can sell at the market.	
		I prefer to wait for someone to give me an irrigation technology.	I find it important that the technlogy is hard to vandalize or steal.	I prefer technology that I can understand.	I want a technology that other farmers have used successfully before I adopt it.	I prefer a technology that has been advocated by the extension officers.		
			I am happy with my current pumping method. I don't want to invest.	I find easy maneuverability important.	I prefer a technology that can give me a high pressure.			
				I want to hear about the technology before I adopt it.				

Legend

- Distinguishing statement at P< 0.05
- Distinguishing statement at P< 0.01
- Consensus statement

Composite Q sort for Factor 3

-4	-3	-2	-1	0	1	2	3	4
I dont mind watering the crops myself without the use of a technology.	It is too expensive. I don't want to invest.	I can't expand my farm. I don't want to invest.	I want my irrigation technology to give me a better status in my community.	I want to try out the technology before I adopt it.	I find it important that the technlogy is hard to vandalize or steal.	I prefer to use and pay for a technology with a group of farmers instead of individually.	I prefer paying through installments over time.	I need external support after implementation.
I don't own the land on which I farm. I don't want to invest.	I want support from my community and family.	I am happy with my current pumping method. I don't want to invest.	I prefer a technology that can give me a high pressure.	I find easy individual operation important.	I prefer a technology that uses water efficiently.	My water availability and water source determine my technology choice.	I prefer a technology that has been advocated by the extension officers.	I want the technology to enable me to grow crops that I can eat.
	I prefer a technology that works automatically without human power.	I don't mind paying fuel to keep the technology working.	I prefer to wait for someone to give me an irrigation technology.	I want it to be cheap to maintain the technology.	I prefer technology that I can understand.	I find easy maneuverability important.	I want the technology to enable me to grow crops that I can sell at the market.	
		I have other farming limitations. I don't want to invest.	I prefer to adopt a more expensive technology but safe on running cost.	I want to have seen the technology before I adopt it.	I want to hear about the technology before I adopt it.	I want overall affordable costs.		
			I prefer if the company representatives are Malawian.	I want a technology that other farmers have used successfully before I adopt it.	I want to be able to maintain the technology myself.			
				I prefer a technology that can give me a high volume of water.				

Legend

- Distinguishing statement at P< 0.05
- Distinguishing statement at P< 0.01
- Consensus statement

Distinguishing Statements

Factor 1

Threshold	Z scr.	Q Sort Value	State. No.	Statement
P < 0.001	2.04	4	19	I want the technology to enable me to grow crops that I can sell at the market.
P < 0.0001	1.78	4	17	I prefer a technology that can give me a high volume of water.
P < 0.0001	1.61	3	18	I prefer a technology that can give me a high pressure.
P < 0.0001	0.72	2	3	I don't mind paying fuel to keep the technology working.
P < 0.05	-0.08	0	12	I find it important that the technlogy is hard to vandalize or steal.
P < 0.05	-0.87	-1	16	I prefer a technology that works automatically without human power.
P < 0.005	-0.89	-2	11	I find easy maneuverability important.
P < 0.005	-1.43	-4	29	I prefer if the company representatives are Malawian.

Factor 2

Threshold	Z scr.	Q Sort Value	State. No.	Statement
P < 0.0001	2.2	4	14	I want it to be cheap to maintain the technology.
P < 0.0001	1.83	4	2	I want overall affordable costs.
P < 0.0001	1.42	3	21	I prefer a technology that uses water efficiently.
P < 0.05	1.22	3	10	I find easy individual operation important.
P < 0.0001	1.07	2	16	I prefer a technology that works automatically without human power.
P < 0.05	0.84	1	9	I prefer to adopt a more expensive technology but safe on running cost.
P < 0.05	0.13	1	18	I prefer a technology that can give me a high pressure.
P < 0.01	-0.2	0	34	I prefer technology that I can understand.
P < 0.005	-0.29	0	30	I want to hear about the technology before I adopt it.
P < 0.05	-0.55	-1	12	I find it important that the technlogy is hard to vandalize or steal.
P < 0.0001	-0.78	-2	31	I want to have seen the technology before I adopt it.

Factor 3

Threshold	Z scr.	Q Sort Value	State. No.	Statement
P < 0.0001	1.89	4	23	My water availability and water source determine my technology choice.
P < 0.0001	1.53	4	12	I find it important that the technlogy is hard to vandalize or steal.
P < 0.01	0.92	2	1	I prefer paying through installments over time.
P < 0.05	0.82	2	31	I want to have seen the technology before I adopt it.
P < 0.05	0.67	1	14	I want it to be cheap to maintain the technology.
P < 0.05	0.59	1	20	I want the technology to enable me to grow crops that I can eat.
P < 0.005	0.2	0	27	I prefer a technology that has been advocated by the extension officers.
P < 0.05	-0.42	-1	16	I prefer a technology that works automatically without human power.
P < 0.05	-0.57	-1	3	I don't mind paying fuel to keep the technology working.
P < 0.01	-0.6	-1	28	I need external support after implementation.
P < 0.0001	-1.29	-3	18	I prefer a technology that can give me a high pressure.
P < 0.05	-1.67	-3	26	I can't expand my farm. I don't want to invest.
P < 0.05	-1.74	-4	6	It is too expensive. I don't want to invest.

Factor 4

Threshold	Z scr.	Q Sort Value	State. No.	Statement
P < 0.0001	2.25	4	28	I need external support after implementation.
P < 0.01	1.49	3	1	I prefer paying through installments over time.
P < 0.0005	0.75	2	11	I find easy maneuverability important.
P < 0.005	0.49	1	12	I find it important that the technlogy is hard to vandalize or steal.
P < 0.005	0.34	1	30	I want to hear about the technology before I adopt it.
P < 0.05	0.31	1	13	I want to be able to maintain the technology myself.
P < 0.05	-0.36	-1	18	I prefer a technology that can give me a high pressure.
P < 0.0001	-0.64	-1	9	I prefer to adopt a more expensive technology but safe on running cost.
P < 0.05	-1.33	-3	16	I prefer a technology that works automatically without human power.

Annex 11.5 – 5-Factor Solution All Participants

Factor Matrix with sorts Auto-Flagged (P < 0.05) & Factor Characteristics

Qsort #	Q-sort	Factor 1		Factor 2		Factor 3		Factor 4		Factor 5	
1	QSORT1	0.12		0.12		0.66	flagged	0.50		0.22	
2	QSORT2	0.11		0.12		0.54		0.61	flagged	0.16	
3	QSORT3	0.29		0.66	flagged	0.28		-0.08		0.18	
4	QSORT4	0.29		0.24		0.46		-0.02		0.55	
5	QSORT5	0.09		0.53		0.21		0.23		0.51	
6	QSORT6	0.54		-0.16		0.41		0.43		0.32	
7	QSORT7	0.07		0.08		0.63	flagged	0.00		0.10	
8	QSORT8	0.38		0.57	flagged	0.12		0.07		0.15	
9	QSORT9	0.67	flagged	0.09		0.28		0.53		-0.05	
10	QSORT10	0.25		0.42		0.28		0.51		0.17	
11	QSORT11	0.44		0.20		-0.32		0.35		0.48	
12	QSORT12	0.14		0.74	flagged	0.25		0.00		0.02	
13	QSORT13	0.25		0.17		0.48	flagged	0.37		0.02	
14	QSORT14	0.29		0.29		0.11		0.21		0.71	flagged
15	QSORT15	0.16		0.29		-0.16		0.22		0.51	flagged
16	QSORT16	0.28		0.09		0.17		0.25		0.72	flagged
17	QSORT17	0.44		0.23		0.09		0.39		0.51	
18	QSORT18	-0.24		0.13		0.38		0.22		0.57	flagged
19	QSORT19	0.07		0.17		0.19		0.16		0.71	flagged
20	QSORT20	0.23		0.66	flagged	0.33		0.24		0.09	
21	QSORT21	0.22		0.69	flagged	0.15		0.21		0.07	
22	QSORT22	0.33		0.62	flagged	0.12		0.15		0.32	
23	QSORT23	0.23		0.11		0.48		-0.03		0.49	
24	QSORT24	-0.11		0.45		0.49		0.13		0.16	
25	QSORT25	0.67	flagged	0.11		0.30		0.15		0.21	
26	QSORT26	0.66	flagged	0.28		0.17		0.22		0.22	
27	QSORT27	0.63	flagged	0.25		0.04		0.26		0.28	
28	QSORT28	0.50		0.10		0.47		0.39		0.06	
29	QSORT29	0.72	flagged	0.26		0.18		0.06		0.11	
30	QSORT30	0.60	flagged	0.06		0.29		0.04		0.38	
31	QSORT31	0.21		0.36		0.38		0.28		0.25	
32	QSORT32	0.47		0.19		0.26		0.37		0.51	
33	QSORT33	0.18		0.48	flagged	0.38		0.11		0.06	
34	QSORT34	0.24		0.41		-0.16		-0.01		0.53	flagged
35	QSORT35	0.34		-0.08		0.32		-0.05		0.69	flagged
36	QSORT36	0.36		-0.03		0.23		-0.18		0.63	flagged
37	QSORT37	0.41		0.52		0.28		-0.13		0.30	
38	QSORT38	0.34		0.38		0.13		0.18		0.61	flagged
39	QSORT39	0.16		0.39		0.59	flagged	0.08		0.10	
40	QSORT40	-0.11		0.60	flagged	-0.01		0.20		0.10	
41	QSORT41	0.21		0.65	flagged	0.02		0.35		0.24	
42	QSORT42	0.24		0.39	flagged	-0.08		-0.26		-0.04	
43	QSORT43	0.20		0.14		0.02		0.62	flagged	0.01	
44	QSORT44	0.22		0.29		-0.03		0.57	flagged	0.06	
45	QSORT45	0.47		0.09		0.40		0.24		0.40	
46	QSORT46	0.56	flagged	0.22		0.18		-0.03		0.32	
47	QSORT47	0.70	flagged	0.22		0.05		-0.07		0.20	
48	QSORT48	0.18		0.55		0.21		0.47		0.47	
49	QSORT49	0.59	flagged	0.10		0.13		0.38		0.20	
50	QSORT50	-0.08		0.59	flagged	0.16		0.21		0.17	
51	QSORT51	-0.05		0.08		0.08		0.51	flagged	0.26	
52	QSORT52	0.32		0.51		0.59		-0.04		0.28	
53	QSORT53	0.29		0.24		0.63	flagged	0.03		-0.04	
54	QSORT54	0.56	flagged	0.35		0.22		0.17		0.18	
55	QSORT55	0.48		-0.14		0.48		0.39		0.21	
56	QSORT56	0.21		0.31		0.45	flagged	0.07		0.16	
57	QSORT57	0.34		0.13		0.73	flagged	0.09		0.28	
58	QSORT58	0.42		0.26		0.33		0.21		0.22	
%Explained Variance		**14**		**13**		**12**		**8**		**12**	
Total %Explained Variance			**59**								

	Factor 1
	Factor 2
	Factor 3
	Factor 4
	Factor 5
	Unflagged

Factor Characteristics

	factor 1	factor 2	factor 3	factor 4	factor 5
No. of Defining Variables	10	11	7	4	9
Avg. Rel. Coef.	0.8	0.8	0.8	0.8	0.8
Composite Reliability	0.976	0.978	0.966	0.941	0.973
S.E. of Factor Z-scores	0.155	0.148	0.184	0.243	0.164

Composite Q sort for Factor 1

-4	-3	-2	-1	0	1	2	3	4
I don't own the land on which I farm. I don't want to invest.	I want support from my community and family.	I am happy with my current pumping method. I don't want to invest.	I want to have seen the technology before I adopt it.	I prefer technology that I can understand.	My water availability and water source determine my technology choice.	I prefer to use and pay for a technology with a group of farmers instead of individually.	I want the technology to enable me to grow crops that I can eat.	I need external support after implementation.
It is too expensive. I don't want to invest.	I prefer if the company representatives are Malawian.	I dont mind watering the crops myself without the use of a technology.	I want a technology that other farmers have used successfully before I adopt it.	I want overall affordable costs.	I prefer a technology that uses water efficiently.	I find it important that the technology is hard to vandalize or steal.	I prefer a technology that can give me a high volume of water.	I prefer a technology that has been advocated by the extension officers.
	I don't mind paying fuel to keep the technology working.	I can't expand my farm. I don't want to invest.	I prefer to adopt a more expensive technology but safe on running cost.	I want to try out the technology before I adopt it.	I want to be able to maintain the technology myself.	I prefer paying through installments over time.	I want the technology to enable me to grow crops that I can sell at the market.	
		I prefer to wait for someone to give me an irrigation technology.	I prefer a technology that works automatically without human power.	I want it to be cheap to maintain the technology.	I want my irrigation technology to give me a better status in my community.	I find easy maneuverability important.		
			I have other farming limitations. I don't want to invest.	I want to hear about the technology before I adopt it.	I prefer a technology that can give me a high pressure.			
				I find easy individual operation important.				

Legend

- Distinguishing statement at P< 0.05
- Distinguishing statement at P< 0.01
- Consensus statement

Composite Q sort for Factor 2

-4	-3	-2	-1	0	1	2	3	4
I don't mind paying fuel to keep the technology working.	I have other farming limitations. I don't want to invest.	I want to have seen the technology before I adopt it.	I prefer technology that I can understand.	I need external support after implementation.	I prefer a technology that has been advocated by the extension officers.	I want the technology to enable me to grow crops that I can sell at the market.	I prefer a technology that uses water efficiently.	I want it to be cheap to maintain the technology.
I don't own the land on which I farm. I don't want to invest.	It is too expensive. I don't want to invest.	I want my irrigation technology to give me a better status in my community.	I find it important that the technology is hard to vandalize or steal.	I prefer to use and pay for a technology with a group of farmers instead of individually.	My water availability and water source determine my technology choice.	I prefer a technology that works automatically without human power.	I want the technology to enable me to grow crops that I can eat.	I want overall affordable costs.
	I dont mind watering the crops myself without the use of a technology.	I can't expand my farm. I don't want to invest.	I want support from my community and family.	I prefer paying through installments over time.	I want a technology that other farmers have used successfully before I adopt it.	I want to be able to maintain the technology myself.	I find easy individual operation important.	
		I prefer to wait for someone to give me an irrigation technology.	I prefer if the company representatives are Malawian.	I want to hear about the technology before I adopt it.	I prefer a technology that can give me a high volume of water.	I prefer to adopt a more expensive technology but safe on running cost.		
			I am happy with my current pumping method. I don't want to invest.	I find easy maneuverability important.	I prefer a technology that can give me a high pressure.			
				I want to try out the technology before I adopt it.				

Legend

- Distinguishing statement at P< 0.05
- Distinguishing statement at P< 0.01
- Consensus statement

Composite Q sort for Factor 3

-4	-3	-2	-1	0	1	2	3	4
It is too expensive. I don't want to invest.	I prefer a technology that can give me a high pressure.	I am happy with my current pumping method. I don't want to invest.	I want my irrigation technology to give me a better status in my community.	I prefer to use and pay for a technology with a group of farmers instead of individually.	I want to be able to maintain the technology myself.	I want to try out the technology before I adopt it.	I want the technology to enable me to grow crops that I can sell at the market.	My water availability and water source determine my technology choice.
I don't own the land on which I farm. I don't want to invest.	I can't expand my farm. I don't want to invest.	I prefer if the company representatives are Malawian.	I prefer a technology that works automatically without human power.	I prefer to adopt a more expensive technology but safe on running cost.	I want overall affordable costs.	I want to hear about the technology before I adopt it.	I prefer technology that I can understand.	I find it important that the technology is hard to vandalize or steal.
	I dont mind watering the crops myself without the use of a technology.	I don't mind paying fuel to keep the technology working.	I want support from my community and family.	I prefer a technology that can give me a high volume of water.	I find easy individual operation important.	I prefer paying through installments over time.	I want to have seen the technology before I adopt it.	
		I have other farming limitations. I don't want to invest.	I prefer to wait for someone to give me an irrigation technology.	I prefer a technology that has been advocated by the extension officers.	I want a technology that other farmers have used successfully before I adopt it.	I want the technology to enable me to grow crops that I can eat.		
			I need external support after implementation.	I prefer a technology that uses water efficiently.	I want it to be cheap to maintain the technology.			
				I find easy maneuverability important.				

Legend

- Distinguishing statement at P< 0.05
- Distinguishing statement at P< 0.01
- Consensus statement

Composite Q sort for Factor 4

-4	-3	-2	-1	0	1	2	3	4
I can't expand my farm. I don't want to invest.	I am happy with my current pumping method. I don't want to invest.	I prefer a technology that can give me a high pressure.	I want to be able to maintain the technology myself.	I want support from my community and family.	I want it to be cheap to maintain the technology.	I find easy maneuverability important.	I prefer paying through installments over time.	I prefer a technology that has been advocated by the extension officers.
I dont mind watering the crops myself without the use of a technology.	I prefer a technology that can give me a high volume of water.	It is too expensive. I don't want to invest.	I have other farming limitations. I don't want to invest.	I prefer a technology that uses water efficiently.	I prefer to use and pay for a technology with a group of farmers instead of individually.	I need external support after implementation.	I want the technology to enable me to grow crops that I can sell at the market.	I want overall affordable costs.
	I want to try out the technology before I adopt it.	I don't own the land on which I farm. I don't want to invest.	I want to have seen the technology before I adopt it.	I find it important that the technology is hard to vandalize or steal.	I prefer to wait for someone to give me an irrigation technology.	I prefer technology that I can understand.	My water availability and water source determine my technology choice.	
		I prefer a technology that works automatically without human power.	I want a technology that other farmers have used successfully before I adopt it.	I prefer if the company representatives are Malawian.	I want the technology to enable me to grow crops that I can eat.	I find easy individual operation important.		
			I want my irrigation technology to give me a better status in my community.	I want to hear about the technology before I adopt it.	I don't mind paying fuel to keep the technology working.			
				I prefer to adopt a more expensive technology but safe on running cost.				

Legend

- Distinguishing statement at P< 0.05
- Distinguishing statement at P< 0.01
- Consensus statement

Composite Q sort for Factor 5

-4	-3	-2	-1	0	1	2	3	4
I don't own the land on which I farm. I don't want to invest.	I want support from my community and family.	I prefer to wait for someone to give me an irrigation technology.	I find it important that the technology is hard to vandalize or steal.	I prefer to adopt a more expensive technology but safe on running cost.	I want overall affordable costs.	I want to be able to maintain the technology myself.	I prefer a technology that can give me a high volume of water.	I want the technology to enable me to grow crops that I can sell at the market.
I prefer if the company representatives are Malawian.	I dont mind watering the crops myself without the use of a technology.	I find easy maneuverability important.	I want my irrigation technology to give me a better status in my community.	I want it to be cheap to maintain the technology.	I prefer technology that I can understand.	I want to hear about the technology before I adopt it.	I don't mind paying fuel to keep the technology working.	I prefer a technology that can give me a high pressure.
	It is too expensive. I don't want to invest.	I can't expand my farm. I don't want to invest.	I prefer a technology that works automatically without human power.	I prefer a technology that uses water efficiently.	I find easy individual operation important.	I want the technology to enable me to grow crops that I can eat.	I prefer a technology that has been advocated by the extension officers.	
		I have other farming limitations. I don't want to invest.	I am happy with my current pumping method. I don't want to invest.	I prefer paying through installments over time.	My water availability and water source determine my technology choice.	I prefer to use and pay for a technology with a group of farmers instead of individually.		
			I want to try out the technology before I adopt it.	I want a technology that other farmers have used successfully before I adopt it.	I want to have seen the technology before I adopt it.			
				I need external support after implementation.				

Legend

- Distinguishing statement at P< 0.05
- Distinguishing statement at P< 0.01
- Consensus statement

Distinguishing Statements

Factor 1

Threshold	Z scr.	Q Sort Value	State. No.	Statement
P < 0.0001	0.53	1	15	I want my irrigation technology to give me a better status in my community.
P < 0.0005	1.96	4	28	I need external support after implementation.
P < 0.01	-0.11	0	10	I find easy individual operation important.
P < 0.05	0.23	0	32	I want to try out the technology before I adopt it.
P < 0.05	0.8	2	12	I find it important that the technlogy is hard to vandalize or steal.

Factor 2

Threshold	Z scr.	Q Sort Value	State. No.	Statement
P < 0.0001	1.15	2	16	I prefer a technology that works automatically without human power.
P < 0.0001	2.26	4	14	I want it to be cheap to maintain the technology.
P < 0.0005	1.39	3	21	I prefer a technology that uses water efficiently.
P < 0.005	-0.3	-1	34	I prefer technology that I can understand.
P < 0.05	-0.29	0	32	I want to try out the technology before I adopt it.
P < 0.05	-0.04	0	8	I prefer to use and pay for a technology with a group of farmers instead of individually.
P < 0.05	0.84	2	9	I prefer to adopt a more expensive technology but safe on running cost.

Factor 3

Threshold	Z scr.	Q Sort Value	State. No.	Statement
P < 0.005	0.93	2	32	I want to try out the technology before I adopt it.
P < 0.005	1.57	4	12	I find it important that the technlogy is hard to vandalize or steal.
P < 0.01	0.17	0	27	I prefer a technology that has been advocated by the extension officers.
P < 0.01	0.98	3	31	I want to have seen the technology before I adopt it.
P < 0.05	-0.87	-2	3	I don't mind paying fuel to keep the technology working.
P < 0.05	-0.72	-1	28	I need external support after implementation.

Factor 4

Threshold	Z scr.	Q Sort Value	State. No.	Statement
P < 0.0001	-1.24	-3	17	I prefer a technology that can give me a high volume of water.
P < 0.0005	0.47	1	5	I prefer to wait for someone to give me an irrigation technology.
P < 0.005	-0.32	-1	13	I want to be able to maintain the technology myself.
P < 0.005	0.28	1	3	I don't mind paying fuel to keep the technology working.
P < 0.01	0.85	2	28	I need external support after implementation.
P < 0.05	0.22	0	24	I want support from my community and family.
P < 0.05	1.57	3	1	I prefer paying through installments over time.

Factor 5

Threshold	Z scr.	Q Sort Value	State. No.	Statement
P < 0.0001	1.7	4	18	I prefer a technology that can give me a high pressure.
P < 0.005	-0.96	-2	11	I find easy maneuverability important.
P < 0.005	1.23	3	3	I don't mind paying fuel to keep the technology working.
P < 0.05	0.32	1	31	I want to have seen the technology before I adopt it.

Annex 12 – Predefined 3 factors (expert, commercial, smallholder)

Factor Matrix & Factor Characteristics

Qsort #	Q-sort	Factor 1		Factor 2		Factor 3	
1	QSORT1	0.22		0.20		0.76	X
2	QSORT2	0.20		0.19		0.70	X
3	QSORT3	0.24		0.66	X	0.26	
4	QSORT4	0.51	X	0.29		0.41	
5	QSORT5	0.42	X	0.59		0.22	
6	QSORT6	0.59	X	-0.12		0.62	
7	QSORT7	0.02		0.12		0.57	X
8	QSORT8	0.33		0.55	X	0.19	
9	QSORT9	0.43	X	0.07		0.61	
10	QSORT10	0.31	X	0.45		0.46	
11	QSORT11	0.73	X	0.22		-0.12	
12	QSORT12	0.05		0.73	X	0.24	
13	QSORT13	0.16		0.19	X	0.62	
14	QSORT14	0.72	X	0.36		0.15	
15	QSORT15	0.53	X	0.33		-0.10	
16	QSORT16	0.72	X	0.17		0.23	
17	QSORT17	0.70	X	0.27		0.26	
18	QSORT18	0.24	X	0.24		0.29	
19	QSORT19	0.56	X	0.26		0.15	
20	QSORT20	0.19	X	0.67		0.41	
21	QSORT21	0.19	X	0.68		0.24	
22	QSORT22	0.44	X	0.63		0.19	
23	QSORT23	0.43		0.16	X	0.42	
24	QSORT24	-0.02		0.50	X	0.43	
25	QSORT25	0.56	X	0.09		0.47	
26	QSORT26	0.59	X	0.26		0.37	
27	QSORT27	0.64	X	0.23		0.25	
28	QSORT28	0.35	X	0.11		0.67	
29	QSORT29	0.51	X	0.21		0.35	
30	QSORT30	0.62	X	0.07		0.38	

Qsort #	Q-sort	Factor 1		Factor 2		Factor 3	
31	QSORT31	0.29	X	0.40		0.45	
32	QSORT32	0.69	X	0.24		0.42	
33	QSORT33	0.11	X	0.49		0.41	
34	QSORT34	0.55	X	0.43		-0.15	
35	QSORT35	0.67	X	-0.02		0.29	
36	QSORT36	0.64	X	0.00		0.17	
37	QSORT37	0.41		0.51		0.27	X
38	QSORT38	0.67		0.43		0.19	X
39	QSORT39	0.09		0.41		0.58	X
40	QSORT40	0.02	X	0.63		0.00	
41	QSORT41	0.35	X	0.68		0.15	
42	QSORT42	0.08	X	0.34		-0.10	
43	QSORT43	0.23	X	0.16		0.28	
44	QSORT44	0.27	X	0.31		0.21	
45	QSORT45	0.57	X	0.13		0.51	
46	QSORT46	0.56	X	0.21		0.26	
47	QSORT47	0.57	X	0.17		0.17	
48	QSORT48	0.49		0.61		0.32	X
49	QSORT49	0.57	X	0.09		0.38	
50	QSORT50	0.07	X	0.63		0.16	
51	QSORT51	0.22	X	0.15		0.20	
52	QSORT52	0.30		0.53		0.56	X
53	QSORT53	0.06		0.24	X	0.64	
54	QSORT54	0.47	X	0.33		0.37	
55	QSORT55	0.45	X	-0.11		0.67	
56	QSORT56	0.19	X	0.33		0.45	
57	QSORT57	0.33		0.16	X	0.74	
58	QSORT58	0.41		0.27		0.45	X
%Explained Variance		20		14		16	
Total %Explained Variance				50			

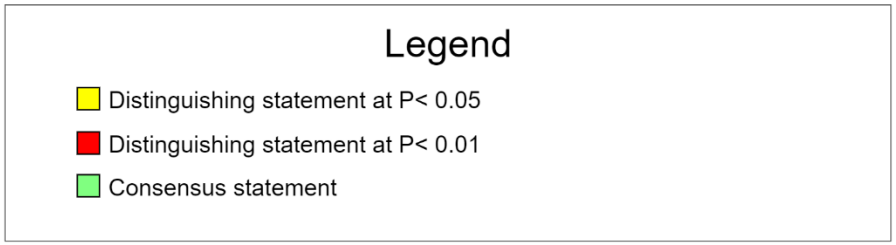
Labeled Smallholder
Labeled Commercial
Labeled Expert

Factor Characteristics

	factor 1	factor 2	factor 3
No. of Defining Variables	41	8	9
Avg. Rel. Coef.	0.8	0.8	0.8
Composite Reliability	0.994	0.97	0.973
S.E. of Factor Z-scores	0.077	0.173	0.164

Factor 1 - Labeled Smallholder farmer

-4	-3	-2	-1	0	1	2	3	4
I can't expand my farm. I don't want to invest.	I dont mind watering the crops myself without the use of a technology.	I am happy with my current pumping method. I don't want to invest.	I want my irrigation technology to give me a better status in my community.	I prefer technology that I can understand.	I prefer paying through installments over time.	I prefer a technology that can give me a high pressure.	I prefer a technology that can give me a high volume of water.	I want the technology to enable me to grow crops that I can sell at the market.
I don't own the land on which I farm. I don't want to invest.	It is too expensive. I don't want to invest.	I prefer to wait for someone to give me an irrigation technology.	I find it important that the technology is hard to vandalize or steal.	I want to hear about the technology before I adopt it.	My water availability and water source determine my technology choice.	I prefer to use and pay for a technology with a group of farmers instead of individually.	I need external support after implementation.	I prefer a technology that has been advocated by the extension officers.
	I prefer if the company representatives are Malawian.	I want support from my community and family.	I prefer to adopt a more expensive technology but safe on running cost.	I want a technology that other farmers have used successfully before I adopt it.	I find easy individual operation important.	I want to be able to maintain the technology myself.	I want the technology to enable me to grow crops that I can eat.	
		I have other farming limitations. I don't want to invest.	I want to try out the technology before I adopt it.	I find easy maneuverability important.	I prefer a technology that uses water efficiently.	I want overall affordable costs.		
			I prefer a technology that works automatically without human power.	I don't mind paying fuel to keep the technology working.	I want it to be cheap to maintain the technology.			
				I want to have seen the technology before I adopt it.				



Factor 2 - Labeled Commercial farmer

-4	-3	-2	-1	0	1	2	3	4
I don't mind paying fuel to keep the technology working.	I dont mind watering the crops myself without the use of a technology.	I have other farming limitations. I don't want to invest.	I prefer to use and pay for a technology with a group of farmers instead of individually.	I find it important that the technology is hard to vandalize or steal.	I want the technology to enable me to grow crops that I can sell at the market.	I find easy individual operation important.	I want overall affordable costs.	I want it to be cheap to maintain the technology.
I don't own the land on which I farm. I don't want to invest.	I find easy maneuverability important.	I prefer to wait for someone to give me an irrigation technology.	I want to have seen the technology before I adopt it.	I want a technology that other farmers have used successfully before I adopt it.	I prefer a technology that has been advocated by the extension officers.	I prefer a technology that can give me a high volume of water.	I want the technology to enable me to grow crops that I can eat.	I prefer a technology that works automatically without human power.
	It is too expensive. I don't want to invest.	I want my irrigation technology to give me a better status in my community.	I prefer a technology that can give me a high pressure.	I want to try out the technology before I adopt it.	I want to be able to maintain the technology myself.	My water availability and water source determine my technology choice.	I prefer to adopt a more expensive technology but safe on running cost.	
		I am happy with my current pumping method. I don't want to invest.	I prefer if the company representatives are Malawian.	I prefer paying through installments over time.	I want to hear about the technology before I adopt it.	I prefer a technology that uses water efficiently.		
			I can't expand my farm. I don't want to invest.	I want support from my community and family.	I need external support after implementation.			
				I prefer technology that I can understand.				

Legend

- Distinguishing statement at P< 0.05
- Distinguishing statement at P< 0.01
- Consensus statement

Factor 3 - Labeled Expert

-4	-3	-2	-1	0	1	2	3	4
I don't own the land on which I farm. I don't want to invest.	It is too expensive. I don't want to invest.	I prefer if the company representatives are Malawian.	I prefer to wait for someone to give me an irrigation technology.	I prefer a technology that can give me a high volume of water.	I prefer to use and pay for a technology with a group of farmers instead of individually.	I find it important that the technology is hard to vandalize or steal.	I want overall affordable costs.	My water availability and water source determine my technology choice.
I dont mind watering the crops myself without the use of a technology.	I want my irrigation technology to give me a better status in my community.	I have other farming limitations. I don't want to invest.	I prefer a technology that works automatically without human power.	I prefer to adopt a more expensive technology but safe on running cost.	I find easy individual operation important.	I prefer a technology that has been advocated by the extension officers.	I want the technology to enable me to grow crops that I can eat.	I want the technology to enable me to grow crops that I can sell at the market.
	I can't expand my farm. I don't want to invest.	I am happy with my current pumping method. I don't want to invest.	I don't mind paying fuel to keep the technology working.	I find easy maneuverability important.	I want to hear about the technology before I adopt it.	I want to have seen the technology before I adopt it.	I prefer paying through installments over time.	
		I prefer a technology that can give me a high pressure.	I need external support after implementation.	I want it to be cheap to maintain the technology.	I want to be able to maintain the technology myself.	I prefer technology that I can understand.		
			I want support from my community and family.	I prefer a technology that uses water efficiently.	I want a technology that other farmers have used successfully before I adopt it.			
				I want to try out the technology before I adopt it.				

Legend

- Distinguishing statement at P< 0.05
- Distinguishing statement at P< 0.01
- Consensus statement

Distinguishing Statements

Factor 1

Threshold	Z scr.	Q Sort Value	State. No.	Statement
P < 0.005	1.37	4	27	I prefer a technology that has been advocated by the extension officers.
P < 0.0005	1.23	3	28	I need external support after implementation.
P < 0.0001	1.07	2	18	I prefer a technology that can give me a high pressure.
P < 0.05	0.78	2	2	I want overall affordable costs.
P < 0.05	0.33	0	34	I prefer technology that I can understand.
P < 0.01	-0.07	0	3	I don't mind paying fuel to keep the technology working.
P < 0.05	-0.1	0	31	I want to have seen the technology before I adopt it.
P < 0.0001	-0.11	-1	15	I want my irrigation technology to give me a better status in my community.
P < 0.005	-0.16	-1	12	I find it important that the technology is hard to vandalize or steal.
P < 0.005	-0.19	-1	9	I prefer to adopt a more expensive technology but safe on running cost.
P < 0.05	-0.42	-1	32	I want to try out the technology before I adopt it.
P < 0.005	-0.88	-1	16	I prefer a technology that works automatically without human power.
P < 0.005	-1.27	-2	24	I want support from my community and family.
P < 0.01	-1.33	-2	7	I have other farming limitations. I don't want to invest.
P < 0.0001	-1.48	-3	29	I prefer if the company representatives are Malawian.

Factor 2

Threshold	Z scr.	Q Sort Value	State. No.	Statement
P < 0.0001	1.84	4	14	I want it to be cheap to maintain the technology.
P < 0.0001	1.31	4	16	I prefer a technology that works automatically without human power.
P < 0.001	1.14	3	9	I prefer to adopt a more expensive technology but safe on running cost.
P < 0.05	1.12	2	10	I find easy individual operation important.
P < 0.001	0.75	1	19	I want the technology to enable me to grow crops that I can sell at the market.
P < 0.0001	0.5	1	28	I need external support after implementation.
P < 0.0001	0	0	1	I prefer paying through installments over time.
P < 0.05	-0.2	0	24	I want support from my community and family.
P < 0.0001	-0.45	0	34	I prefer technology that I can understand.
P < 0.0001	-0.48	-1	8	I prefer to use and pay for a technology with a group of farmers instead of individually.
P < 0.05	-0.53	-1	31	I want to have seen the technology before I adopt it.
P < 0.05	-0.57	-1	18	I prefer a technology that can give me a high pressure.
P < 0.0005	-0.67	-1	26	I can't expand my farm. I don't want to invest.
P < 0.01	-0.88	-2	15	I want my irrigation technology to give me a better status in my community.
P < 0.0001	-1.34	-3	11	I find easy maneuverability important.
P < 0.0001	-1.56	-4	3	I don't mind paying fuel to keep the technology working.

Factor 3

Threshold	Z scr.	Q Sort Value	State. No.	Statement
P < 0.0001	2.06	4	23	My water availability and water source determine my technology choice.
P < 0.0001	0.78	2	31	I want to have seen the technology before I adopt it.
P < 0.05	0.77	2	34	I prefer technology that I can understand.
P < 0.01	0.41	0	17	I prefer a technology that can give me a high volume of water.
P < 0.005	0.35	0	9	I prefer to adopt a more expensive technology but safe on running cost.
P < 0.05	0.08	0	21	I prefer a technology that uses water efficiently.
P < 0.01	-0.24	-1	5	I prefer to wait for someone to give me an irrigation technology.
P < 0.001	-0.31	-1	16	I prefer a technology that works automatically without human power.
P < 0.01	-0.55	-1	3	I don't mind paying fuel to keep the technology working.
P < 0.0001	-0.71	-1	28	I need external support after implementation.
P < 0.05	-0.75	-1	24	I want support from my community and family.
P < 0.05	-1.12	-2	18	I prefer a technology that can give me a high pressure.
P < 0.01	-1.51	-3	15	I want my irrigation technology to give me a better status in my community.
P < 0.005	-1.92	-4	22	I dont mind watering the crops myself without the use of a technology.

Annex 13 – Overview of varying & inconsistent smallholder farmer definitions

Author(s) & Article	Definition of smallholder	Other words used for smallholder
Botha & Treurnicht, 1997 ***Converting South African State extension services: A sustainable development framework***	Botha and Treurnicht identify four categories of farmers: fully commercial farmers, emerging commercial farmers, land reform beneficiaries and household food security farmers.	emerging commercial farmer, land reform beneficiary, household food security farmer
Catling & Saaiman, 1996 ***Small-scale farmers and growers in the Western Cape: the challenge of providing appropriate extension services***	a "historically disadvantaged individual or group having access to land which normally supports a small or medium agricultural enterprise.	/
Chirwa, 2007 ***Sources of Technical Efficiency among Smallholder Maize Farmers in Southern Malawi***	"The smallholder sector is divided into three categories: net food buyers, intermediate farmers and net food sellers. Net food buyers are those farmers with less than 0.7 hectare who cannot produce food to satisfy their subsistence needs given the technology they use and who thus remain dependent on off-farm activities. Intermediate smallholder farmers are those with land holding between 0.7 and 1.5 hectares who produce just enough for their survival but have very little for sale. Net food sellers are those farmers with land holdings of more than 1.5 hectares who produce more than their subsistence needs for survival during the year."	/
Chirwa & Matita, 2012 ***From Subsistence to Smallholder Commercial Farming in Malawi: A Case of NASFAM Commercialisation Initiative***	It draws its membership from smallholder farmers who usually cultivate less than 1 hectare of land, producing 60 percent food and 40 percent cash crops and use a hand hoe as their main tool for farming activities.	smallholder subsistent farmers, small-scale farmers
DAFF, 2012 ***A framework for the development of smallholder farmers through cooperative development***	In general terms smallholder only refers to their limited resource endowment relative to other farmers in the sector. Smallholder farmers are also defined as those farmers owning small-based plots of land on which they grow subsistence crops and one or two cash crops relying almost exclusively on family labour.	small-scale, resource poor and peasant farmer
Eicher, 1990 ***Agricultural development in the Third World***	Identifies smallholders as relying mainly on family labour to produce food, livestock, and export crops for both domestic and international markets.	/
Denison et al., 2016 ***Smallholder irrigation entrepreneurial development pathways and livelihoods in two districts in Limpopo Province***	"The term smallholder by name recognises the characteristic of small(er) farm size, and is typified by partially-developed links with the larger economic system. … Factors that describe smallholders and allow differentiation from the commercial sector include scale, purpose of farming, contribution of agriculture to incomes, use of family labour, mechanisation, capital intensity, and financing ability."	home-food gardeners

Fanadzo et al. 2010 ***Overview of smallholder irrigation schemes in South Africa: Relationship between farmer crop management practices and performance***	"There is no standard definition of a smallholder, but the term is generally used in the South African context for producers who are black and otherwise distinct from the dominant (and white dominated) large-scale commercial sector. No clear distinctions can be drawn between categories such as smallholder, small-scale, subsistence, communal or emergent ..."	small-scale farmer, resource-poor farmer, peasant farmer, food-deficit farmer, household food security farmer, land-reform beneficiary, emerging farmer
Rapsomanikis, 2014 ***The economic lives of smallholder farmers***	"There is no unique and unambiguous definition of a smallholder. Often scale, measured in terms of the farm size, is used to classify farmers into small and large." "The middle-size farm is determined by ordering farms from smallest to largest and choosing the farm size at the middle as the threshold to identify smallholders and other farmers in each country. This means that half of the total land is cultivated by smallholders, and the other half by other farmers."	subsistence farmers
Harrison & Chiroro, 2016 ***Small-scale irrigation in Malawi : challenges and opportunities***	"small-scale farming operated on plots of less than a hectare and concentrating on food crops."	small-scale farmer, smallholder
IDH, 2015 ***From Smallholder to Small Business***	"A smallholder farmer is generally defined as farming seven hectares or less, although this may differ per crop and country. Other indicators that determine whether a farmer is a smallholder are market orientation, labour input, level of income and type of farming system."	
Machethe et al., 2004 ***Smallholder Irrigation and Agricultural Development in the Olifants River Basin of Limpopo Province: Management Transfer, Productivity, Profitability and Food Security Issues***	"Smallholder farmers are defined here to include black farmers ranging from those whose main source of livelihood is nonfarm activities (those where farming constitutes only a minor source of their livelihood) to those whose livelihood is derived mainly from farming. Some of these farmers are poor while others are not."	small-scale farmer, resource-poor farmer, peasant farmer, food-deficit farmer, household food security farmer, land-reform beneficiary, emerging farmer
Hassan & Nhemachena, 2008 ***Determinants of African farmers' strategies for adapting to climate change: Multinomial choice analysis***	"African smallholder farmers typically cultivate part of their own farmland for at least one staple food crop."	/

Annex 14 – Comparison of the predetermined and automatic 3-factor solution

Comparing the predefined analysis trajectory with the automatic 3-factor solution can give us insight in whether our determined groups definitions actually have similar sorting behavior. In Table 49 below we compare the predetermined labeling with the automatic 3-factor solution:

		Automatic labeling - 3 factor solution				
		Factor 1	Factor 2	Factor 3	Unflagged	**Total**
Predetermined labeling - 3 factors	Labeled SF	20	9	5	7	**41**
	Labeled CF	0	4	3	1	**8**
	Labeled EX	1	2	4	2	**9**
	Total	**21**	**15**	**12**	**10**	

Table 49 – Predetermined 3 group labeling versus automatic 3-factor solution

When we compare of the statistical data of the two analysis trajectories below in Table 50, we find higher Mean Standard Deviation (STD) for the raw factor scores for the predefined grouping compared to the automatic 3-factor solution. We also find higher factor score correlations compared to the automatic 3-factor solution. This indicates that the factors are in fact more similar and as Brown (1996) emphasizes factors should not be highly correlated because the higher factors are correlated, the fewer distinctions there will be between the different factors known as distinguishing statements. These differences are not surprising, because the PCA method mathematically seeks for the least number of factors which can account for the most amount of variance of the Q-sorts. The comparison, however, illustrates that the predetermined labeling indeed does not embrace the variety as well as the automatic *flagging* alternative.

		Predetermined labeling - 3 factors			Automatic flagging - 3 factor solution			
		Labeled SF	Labeled CF	Labeled EX		Factor 1	Factor 2	Factor 3
# Participants defining Factor		41	8	9		21	15	12
Mean STD for RAW factor scores		1.73	1.63	1.52		1.56	1.60	1.54
Factor score correlations	Labeled SF	-	0.60	0.70	Factor 1	-	0.65	0.67
	Labeled CF	0.60	-	0.65	Factor 2	0.65	-	0.57
	Labeled EX	0.70	0.65	-	Factor 3	0.67	0.57	-
Average Factor score correlations				**0.65**				**0.632**

Table 50 – Statistical comparison between the predetermined labeling 3-factor solution and the automatic flagging 3-factor solution.

Conclusion & Discussion

It is clear from the results that the predefined groups did not sort the statements in one characteristic way. This in turn means they had different drivers that guide their adoption of WTTs. The group showing the greatest variety in sorting behavior is the SF group. This group of participants automatically *flagged* to all three different factors. Where 20 SF participants loaded on factor 1, respectively 9 and 5 participants loaded on factor 2 and 3.

Also the predefined CF loaded different factors. Interestingly none of the CF participants loaded on factor 1, the factor with most of the SF. The CF, however, dispersed evenly over factor 2 and 3.

The predefined group where one might expect consistent sorting behavior, the experts educated to perform irrigation support services, also loaded significantly on all 3 factors.