Agricultural Technology Adoption by Rural Farmers in Malawi

Case study of a Small Enterprise in Malawi

TU Delft

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by

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Project duration: March 1, 2019 – December 11, 2019
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Abstract

The implementation of new agricultural technologies is considered a key component of Malawi's agricultural development strategy. However, successful technology adoption has proven to be difficult, affecting both farmers and small businesses introducing the technology. With a primary focus on farmers interested in adopting the technology, common factors influencing farmers' adoption habits are determined by conducting interviews and observations. Survey results indicate that from a farmers perspective; market access, information access, education, and affordability are key factors helping facilitate adoption, while lack of these factors hinder adoption. Insight into these factors could provide business knowledge on how to better facilitate technology adoption. For this purpose, literature factors affecting a SME's success are compared with an active agricultural technology company. These factors include experience, communication, management and technology performance. Using both farmers needs and business developmental factors, this study hopes to provide insights for new companies starting a business in a developing country.

Acknowledgement

The experience we had in Malawi as a group and as individuals would not have been possible without the help of a lot of people.

First of all we want to thank the company aQysta for giving us the opportunity to use their company and technology as a base for our case study. Thank you Martin for all the meetings we had with you and helping us out with the contact with the aQysta Malawi office. Secondly we want to thank the aQysta Malawi office for all their help regarding to get around Malawi. Especially Marloes for fixing us a car and a place to stay.

We also want to thank all the farmers for their cooperation and their friendliness. Without them this project would not have been possible. We learned so much from all the farmers, not only with respect to our project, but also in terms of appreciating life and how you can always be there for one another even though you are struggling yourself on whatever issue.

Without the irrigation officers it would not have been possible to find the locations of the farms and talk to them. They have been a tremendous help in guiding us and translating all our interviews.

We want to thank Ria for her hospitality to let us live in her home for almost 2 months. We felt part of the family and very welcome.

Our appreciation also goes out to Ruben who was there most of the time with us. It was nice to have someone to talk to outside of the project every now and then, this gave some very new insights and often directed us towards a better path. Thank you for picking us up from the airport and letting us get to know Malawi those first few days. Also thank you Ruben for providing beautiful pictures of all the farm sites. Thank you for letting us use some of these pictures in our presentation and report.

Last but not least, we want to thank professor Maurits Ertsen for supervising our project and be patient with us. Thank you for all your feedback and narrowing down our scope in order to create a doable research plan.

We have learned so much over the past few months. Not only about irrigation possibilities in Malawi, but even more about working as and in a team, setting goals, changing plans, adjusting to every new situation and experiencing the real “Warm Heart of Africa”. Malawi has a special place in our hearts we will cherish as long as we live. Thank you all for contributing to create this beautiful image of Malawi. It was a pleasure to work with all the people mentioned above.

Contents

1

Introduction

Malawi is primarily an agricultural based economy, employing nearly 80% of the countries' total population (JICA, 2019). Agriculture is the engine of Malawi's economic growth, between 2005 and 2011, more than 80 % of the total exports were agricultural products, which largely contributed to an 5.2% GDP growth rate (Food and Agriculture organization of the United Nations, 2015; World Bank, 2016). Despite this growth rate, Malawi remains one of the poorest countries in the world, with over 50 % of the population living below the world poverty line of 1.90 USD/day and about one quarter is considered 'ultra-poor' (below 1.25 USD/day). Furthermore, the life expectancy in Malawi is relatively low (63 year) (World Bank, 2016). The low life expectancy is mainly due to high prevalence rates of HIV, poor health care, deficiencies in diets, and high infant mortality rates. Approximately half of all children are suffering from acute or severe malnutrition (Food and Agriculture organization of the United Nations, 2015).

The Malawian government is faced with an enormous task to expand the economy, improve healthcare, education, employment and environmental protection. To structure this development, *Vision 2020* was adopted by the Malawian government in 1998. Vision 2020 identifies the importance of smallholder agriculture as a staple to nurse economic growth. Through this vision, the Malawi Growth and Development Strategy (MGDS) was developed. The MGDS aims to develop the agriculture sector as Malawi's economic backbone (Food and Agriculture organization of the United Nations, 2015). The MGDS agricultural goals are to increase productivity, diversify food production, promote commercialization of agriculture among smallholder farmers, while focusing on sustainable land and water utilization. In order to achieve these goals, Malawi hopes to increase agriculture mechanization, promote appropriate technologies, sustainable irrigation, and climate smart land and water management (Malawi Government, 2017).

The majority of farmers in developing countries still make use of traditional farming methods, lowering the relative level of productivity (Muzari, Gatsi, & Muvhunzi, 2012). This means little or no fertilizers and pesticides are being used and most crops are grown under rain-fed conditions. Irrigation is sometimes used but predominantly in an informal smallholder setting, with little or no governmental or technical support. This triggers a discussion on the need to increase productivity in agriculture in Malawi and on specific ways to achieve this aim.

In many studies, the link between the adoption of (new) agricultural technologies and an increase in earnings and employment is disclosed. A clear issue that comes forward in many studies however, is that new agricultural technologies are taken up slowly in the developing world (Bandiera & Rasul, 2003; Kariyasa & Dewi, 2013; Simtowe et al., 2011). According to Loevinsohn, Sumberg, and Diagne (2012), a farmers' decision on the adoption of a new technology are dependent on the characteristics of the technology itself and the collection of a farmers' conditions and circumstances. This decision is often the result of the possible (uncertain) benefits and costs of the new technology (Hall & Khan, 2002). Understanding the factors that are influencing this decision is essential for developers of such technologies, in order for them to be properly adopted in the developing world (Hall & Khan, 2002). In addition, it is crucial that developers of a technology understand the critical success and failure factors that are regulatable within their organization.

This paper will review the factors determining successful adoption of a new agricultural technology by categorizing them into economic factors, technological factors and social factors, observed from a farmer's and developers' point of view. This enables an in-depth review on how each factor influences technology adoption. These categories have again been divided into subcategories. For the adoption of a technology by smallholder farmers, these have been based on the study of (Mwangi & Kariuki, 2015), reviewing factors determining adoption of technology in developing countries. For the adoption of technology and a developer's influence on this, the subcategories are based on a combination of factors that were identified in the studies of (Akande, 2018; Chittithaworn, Islam, Keawchana, & Yusuf, 2011). See figure 1.1.

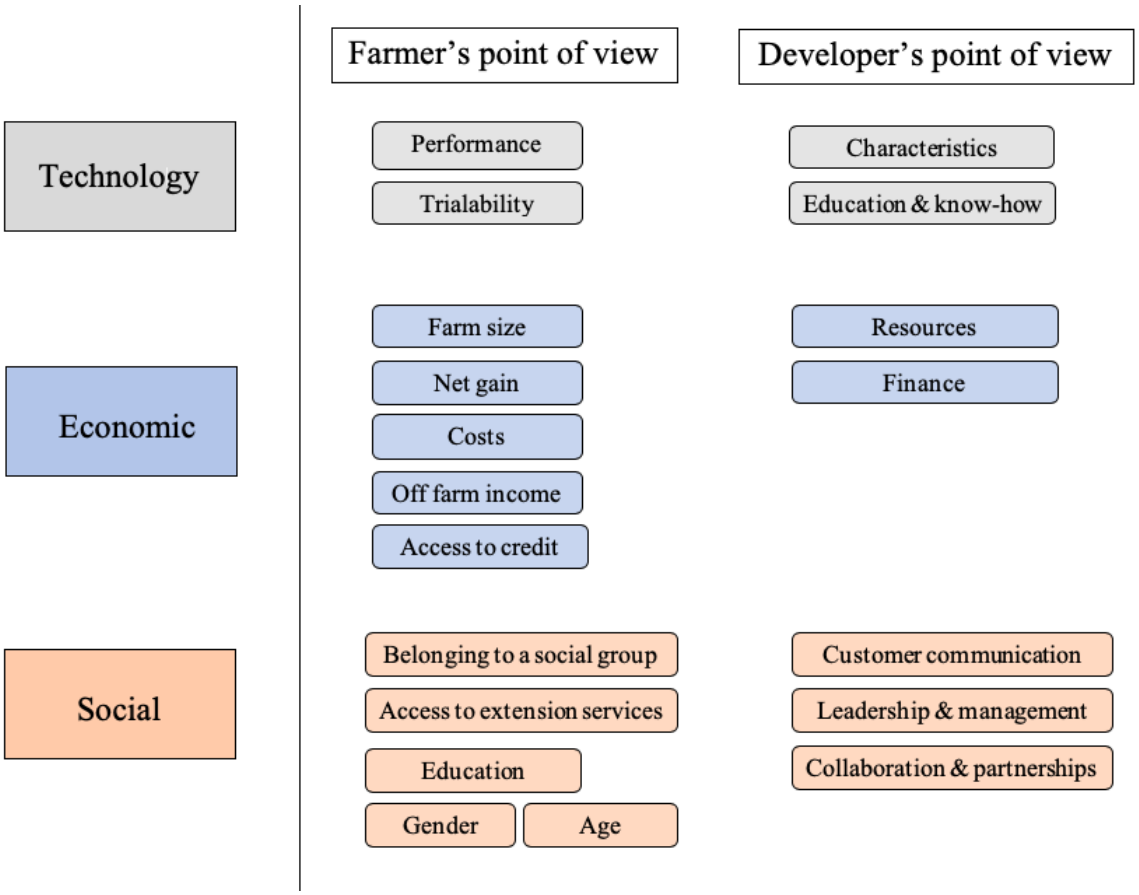

Figure 1.1: Factors determining the adoption of new agricultural technologies

An example of a new agricultural technologies is the Barsha Pump (see figure 1.2), designed by aQysta. It is a sustainable technology that may assist the development of sustainable agriculture world-wide. The hydro-powered pump has the capacity to irrigate plots up to two hectares in size with no operating costs, zero emissions, and simple maintenance (aQysta, 2018). For farmers, this irrigation system can be highly beneficial as there are no recurring costs during the growing season. The pump allows farmers to increase their irrigated plot size, yields, and expand their growing seasons (aQysta, 2018). Currently, the Barsha Pump has been installed in nine rural farming communities across Malawi.

This research aims to provide insight in how these factors influence the adoption of the Barsha Pump for farmers in Malawi. To achieve this, a thorough understanding of the personal background, mindset and the financial means of farmers is needed, as well as an understanding of the resources, strategy, knowledge and communication skills of aQysta. For this purpose, we conducted interviews with farmers and irrigation officers, whereby findings were put into perspective with field observations which led to a further understanding of current farming practises. Furthermore, we spend several weeks with the aQysta office staff and installation teams to observe whether the significant factors mentioned by literature were also factors hindering or assisting aQysta's success in the adoption of the Barsha pump in Malawi.

Figure 1.2: aQysta's Barha pump at work, aQysta (2018)

The objective of this research is to assess which factors influence the successful adoption of the Barsha Pump, and to use this insight to recommend for a more successful technology adoption by smallholder farmers in Malawi.

2

Method

In this study the factors that influence the successful adoption of the Barsha Pump in Malawi are investigated. A qualitative research method was chosen, meaning that research was done through observations and conversational communication. This method was chosen in order to gain insights into the company of our case study and a farmer's rationale on the concept of technology adoption, to explore whether the factors determining the adoption of a technology apply to aQysta and the farmers of our case study. The method will be explained in detail below.

2.1. Interview method

In all interviews with farmers, we used a method of semi-structured qualitative interviews. This method contains open-ended questions that are asked and organized thematically (Schmidt, 2004). All questions generally are the same across every interview, but the order is shaped on what the participants respond. This made every interview different. The guide approach was used to ensure that the same topics are covered in the questionnaire so that the same general information is collected from each interviewee. The guide approach also allows a certain degree of adaptability and freedom in gaining information from the interviewee. Each interview was recorded and during the interview, notes were taken by another person than the interviewer (McNamara, 2006).

When interviewing farming communities (of between 10 and 30 people), only one interview was conducted with an entire community at the same time, which would become the representative interview for that farm. This meant that multiple respondents answered the same questions at the same time. A positive outcome of this strategy was that questions or theorems were brought up by farmers that were not in our questionnaire, but very relevant to explain the content of their situation, which lead to a diversification in questions. Another positive outcome was that observations could be done by looking at respondents' body language during interactions within the group when questions are asked.

Furthermore, in all interviews with farming communities, irrigation officers served as a translator and interpreter to conduct the interviews, as many respondents in the rural communities did not speak English. This leaves room for translators to omit nuances in their translation, for example because they need to summarize the answer since it comes from multiple people, or the interviewees spoke for a long period of time. Encoding the information from the translator and decoding the information from the interviewer are (as in every communication process) a source of noise in any interview. In this research however, several researchers were present during the interview to assess the tone and body language of respondents. The similarities and differences between the assessments could then be used as indication of the reliability of the reporting. Furthermore, a discussion with irrigation officers was performed after the interviews to ensure the overall vision of both the irrigation officer and the researchers. A combination of this could have prevented some of the interpretation errors.

2.2. Observation method

In addition, data collection was done through observations. The farm-observations in this research were done in a systematic way meaning that data collection was conducted using particular variables using a pre-defined list, with the purpose of studying the regular behaviour of participants in their normal setting (Angrosino, 2016). During the fieldwork there was collaboration with aQysta's installation and office team. The observations of aQysta's strategies and characteristics were therefore done via participant observation, a method whereby the researcher becomes part of the studied group (McLeod, 2015).

During every visit and every meeting, observations by all our team members were done separately. During all observations, all group members observed the habits, activities and conversations by themselves without discussing these, resulting in a great number of observations from different perspectives.

3

Results

3.1. Factors influencing the successful adoption of the Barsha pump: a farmer's perspective

According to literature there are several key influences defined as having a significant impact on successful technology adoption. In this study, an assumption is made that willingness to adopt is correlated with the farm's self-inquiredness about the technology. Thus, the key factors are often linked to this parameter. The influences have been separated into three categories; social, economic, technical. Using survey and observation data of (n=9) farms in appendix A Farm Visits, a table with the key findings was created. With these key findings, the key factors which are most critical for technology providers beginning to distribute their products in Malawi are determined.

3.1.1. Social Factors

Social factors commonly cited are age, gender, education, service access and social group. From the results, see figure 3.1, several social factors demonstrate an impact on the influence to adopt a technology which often have links to one another.

Age and gender

Commonly cited factors include age and gender as important social factors. From our results, age and gender do not appear to have a clear trend on the likeliness to adopt. The ages of the individual farmers surveyed ranged between 25-55, and in all cases these farmers were interested in the technology and inquired into adopting the technology for their farms. In community farms, the ages varied within the community. Resulting in members of all ages being interviewed and a part of the adoption process.

Gender also does not appear to be a significant factor in the willingness to adopt a technology. Of the five individual farmers surveyed, two were female and three were male. In community farms the genders of the members varied. One exception is farm A.8, in which a female cooperative of farmers collaborated in purchasing the technology.

Education

In all cases, individual farmers had post-secondary education and self-inquired about the potential use of the technology on their farms. The community farms tended to have fewer education and were less likely to approach the technology providers. Which resulted in a 50% approach rate of farmers to the technology provider. Of the two farms that approached, farm A.8 observed the technology being used by a neighbouring farm and farm A.6 self-inquired.

	Farm 1 Collins	Farm 2 Zomba irrigation canal	Farm 3 Dowa	Farm 4 Talitha	Farm 5 Zomba 3 pumps	Farm 6 Rumphi	Farm 7 Mr Innocent	Farm 8 Ntchisi Women	Farm 9 Roseburry
Social									
Age	30	Varied	25-35	45-55	Varied	Varied	40-50	varied	45
Gender	Male	Varied	Male	Female	Varied	Varied	Male	Female	Female
University Education	Yes	No	Yes	Yes	No	Varied	Yes	No	Yes
Access to services	-Close to local markets/city -Governmental services (not used) -Cell Phone / internet -NGOs (not used)	-Limited market access -Governmental services (Used) -NGOs (not used) -Cell Phone / internet (Not used)	-Market access -Cell Phone Internet -NGOs (Collaborated) -Irrigation officers (Collaborated)	-Market access -Cell Phone / internet -NGOs (used) -Irrigation officers (not used)	-Limited market access -Limited cell phone/ internet -Government services (used) -NGOs (used)	-market access -Cell phone/ internet -Governmental services (used) -NGOs (used)	-Market access -Cell phone/ internet -Governmental services (used) -NGOs (Not used)	-Market access -Limited Cell phone/ internet -Government services (used) -NGOs (Not used)	-Market access -Cell phone/ internet -Government services (Not used) -NGOs (used)
Social group	Individual	-Community -Approx. 100 people	Individual	Individual	-Community -Approx. 100 people	-Community -Approx. 100 people	Individual	-Community -Approx. 18 people	Individual
Economic									
Farm size	0.8 ha	1.5 ha	>20 ha	5 ha	20 ha	~1 ha per farm	7 ha	3 ha	2 ha
Expected gain	-Economic growth -Expend farmable land	-non - economic -Starvation prevention	-Testing farm for new technology	-Farm expansion -Economic growth	-Reduced labour -Non-economic growth -Starvation Prevention	-Farm expansion -Labour reduction	-Independent of fuel costs -Create gravity flow -Economic growth	-Independent of fuel costs -Create gravity flow	-Did not need pump. -Better technologies available
Costs	-Use payment over time method -Could not pay upfront	-Could not generate pay - Would require NGO assistance	-Could pay upfront	-Use payment over time method -Could not pay upfront	-Could not generate pay - Would require NGO assistance	-Collective earnings to pay for the pump over time	-Use payment over time method -Could not pay upfront	-Payment over time difficult -Could not pay upfront	-Could pay upfront
Off farm income	-Farming main source -Some livestock	-None	-Alliance One Farm (received support from international company)	-Peanut butter and Potato chip processing -School teacher	-None	-Farming main source -eggs	-Tabaco	-Working on neighbouring farms	-Commercialized sales
Access to credit	No	No	Yes	No	No	No	No	No	Yes
Technical									
Trialability	-Wanted to test -Self-inquired	-Testing was not necessary -Not self-inquired	-Wanted to test -Self-inquired	-Testing was not necessary -Self-inquired	-Testing was not necessary -Not self-inquired	-Testing was not necessary -Self-inquired	-Wanted to test -Self-inquired	-Testing was not necessary -Self-inquired (saw neighbours using it)	-Wanted to test -Self-inquired
Performance	-Yes	-Not applicable	-No, stopped using the technology	-No, unmatched expectations, did not adopt	-Not applicable	-No, wanted to return the technology	-Partially matched expectations	-Partially matched expectations	-Not applicable

Figure 3.1: Summarized observation and survey data from farm visits

Access to services

Access to services is clearly demonstrated as a significant factor in likeliness to adopt a new technology. Both individual and community farms that were located closer to larger cities and major roads had better market access. In all cases, farms with better market access self-inquired about adopting the technology, while in all cases farms with poor market access did not inquire about the technology. Access to information is also significant. Nearly all farms with cell phone and internet access self-inquired about using the technology. Farms without cell phone or internet access did not inquire about the technology. The notable exception to this trend is farm A.8, in which the women inquired about the technology without cell phone or internet access but observed the technology being used in a neighbouring farm. Individual farmers tended not to rely on government services via the District Agricultural Office (DAO) with four out of five farmers not using this service. In all cases, community farms used or relied on the services provided by these DAOs. The use of NGOs was varied. Three out of four community farms used NGOs services to help them farm while two of five individual farms used NGOs services. Of the two individual farmers that used NGOs services, both were women.

Belonging to a social group

The value of belonging to a social group is by Mwangi and Kariuki (2015) mostly attributed to the enhanced social capital allowing for trust and exchange of information and experiences. The benefit of this could be observed on farm A.8, whom were convinced of purchasing the Barsha pump only when they saw the pump at work at the neighbour's farm A.7. Furthermore, social group distinction has demonstrated clear trends among all factors. Whether the farm was an individual or community farm had clear distinctions on likeliness to adopt a technology and is therefore from now on used as a separation method in identifying factors.

3.1.2. Economic Factors

Plot size

Plot size does not appear to be a clear factor in the willingness to adopt the technology. There was a significant variation in the plot sizes of all the farms that ranged from 0.8 hectares to over 20 hectares. Community farmers tended to have larger plots of land, but often only small portions of the land were being actively used for farming due to labour and input limitations. However, individual farmers did tend to grow on a significantly larger plot size when hectares/person ratio is accounted relative to the community farmer.

Expected gain and costs

A clear trend among individual farmers was that they expected the pump to help them grow economically. The method was variant, as farm A.7 wanted to keep the farm the same size but become independent of fuel costs, while other individual farms wanted to use technology to expand their irrigable land to grow more crops. The motives of community farmers differed; in three out of four farms the key motivation was labour reduction. In two out of four community farms, the technology is used to minimize starvation risk. In nearly all cases, farms could not pay the full cost of the technology upfront except for farm A.3 and farm A.9. However, these two farms were among the most commercially successful farms in the country. For the other farms, they all required the payment over time model (2 years). In all cases the individual farmers expected that paying off the technology in two years was manageable. The community farms showed more variance. Farm A.6 expected to be able to pay off the technology in 2 years, farm A.8 expected to pay off the technology in two years but with difficulty. Farm **??** and farm A.5 were unable to generate the income to pay off the technology in two years and would require full assistance from NGOs.

Off farm income and access to credit

The off-farm income varies for both individual farmers and community farmers. However, it does not appear to have a significant impact on the likelihood to adopt a new technology. Farmers that were generating an income often relied on farming as their main source. Farm A.4 was an exception as the farmer was involved

with many NGOs initiatives to produce potato chips, peanut butter and supported her farm growth with a teaching job. Nevertheless, she also was transitioning into making farming the primary source of income.

In Malawi, access to credit was not available in nearly all cases. The exception was farm A.3, which was supported by an international company and farm A.9 which was the primary supplier for the commercial supermarkets in the country.

3.1.3. Technology Factors

Technical results being identified are whether the farmer wanted to try the technology before paying for the pump and whether the performance matched the expectations of the technology.

Trial-ability

Trial-ability was random; some farmers wanted to test the technology before using while others did not feel it was necessary to do so. In cases where farmers did not feel they needed to test the technology, it was often noted that the technology did not match the expectations of the farmer. In cases where farmers wanted to test the technology first, it was more likely to match expectations, or they understood that this technology was not suitable for their plot.

For farmers that did not want to test the pump the pump often did not match the expectations or partially matched expectations. The only exception was farm A.6, in which they pump had an ideal river and flow for maximum performance.

Performance

For farm A.2 and A.5 the performance was not applicable as they were not going to invest into the technology due to limitations in the water source. In many cases, the expectations did not match the expected performance the farmers wanted. One trend in this was that farms who wanted to irrigate more than two hectares of land were disappointed in the performance of the pump, since the pump often was not able to irrigate such a large plot. Often the expectations were too high, leading to disappointment and often replacement of the technology by other technologies.

3.1.4. Concluding Remarks

Using the results of the first farms that inquired about the technology, several clear linkages between the factors are identified and discussed to determine general trends between farmers' likelihood to adopt.

Farms that self-inquired into adopting the technology generally had several key factors in common. They were located near a big street or city that had access to local markets. This allowed them to use their farms as a main income source. These farms viewed the technology as a means to stimulate income generation on their farms via increased plot size and cost reduction, relative to other technologies. The farmers tended to be the individual, more highly educated farmers, with increased access to information services via cell phones and internet. The access of information could explain why farmers were able to learn about this technology and were more likely to inquire. However, these farms generally wanted to test the technology first before purchasing it.

These factors suggest that educated, individual farmers feel that they can take care of themselves, which is reflected in the expected gain, as these farms expected that their farm would expand and grow with the use of the technology. In many cases, the farmers expectations of what the technology's capabilities were did not match their expectations of their previously acquired knowledge of the pump which may be due to errors in information received. In all cases these farmers thought that paying over-time was manageable with less reliance on outside assistance via government employees and NGOs. However, in nearly all cases the individual farmers were only able to adopt the technology because of the ability to pay-over-time, suggesting that the individual farmers' resources were still limited. In cases where the aid of NGOs was used by individual farms, the operators of these farms tended to be women, which may suggest that women were more likely to

search for outside assistance or individual woman are more frequently targeted by NGOs than men.

In general, it was concluded that the combination of education, access to a potential income source, and access to information services are significantly linked to the likelihood to adopt the technology. Often these factors may depend on one another. For example: a farm with potential income sources can afford higher education which allows them to make informed choices about the technology they are adopting.

Community farmers' motivations for self-inquiring had much greater degrees of variation. Both community farms that self-inquired after the pump had access to markets and earned income from their farms. Nonetheless, the farming communities tended to have less disposable income which required collaboration with many members of the community pooling their resources together to pay for the technology. This also suggests that the 'payment over time' method is essential for successful adoption, but with difficulty. The motivations for purchasing the technology is different from individual farmers: community farmers were more interested in labour reduction and starvation prevention than income generation. The community farmers that did not inquire about the technology did not focus on income generation, and thus were completely reliant on governmental services and NGOs to acquire new technologies. These farms generally were less educated, and thus more reliant on outside services as gathering information is more difficult. In almost all cases the community farms thought that paying for the pump would be difficult apart for farm A.6 which had the best market access and information access of the farming communities.

In conclusion, community farmers tended to have less access to resources compared to individual farmers. This could be the reason they were more dependent on governmental services and NGOs as an information source regarding new technologies. The lack of market access in both cases restricted the community farmers from inquiring as they had no income source to adopt new technologies.

3.2. Factors influencing the successful adoption of the Barsha Pump: aQysta's perspective

The characteristics and strategies of small-scale technology developers can have a great influence on the successful adoption of these new technologies in developing countries. However, there is insufficient knowledge on these characteristics and strategies affecting the success/failure of small businesses in developing countries. Which is a critical component of successful adoption of new technologies.

In this study these factors take from Akande (2018); Chittithaworn et al. (2011); Okpara and Wynn (2007) have been divided into seven categories. The (1) characteristics of the technology includes evaluations of the technical feasibility of the technology; the degree of (2) education and know-how of the technology provider relates to in-house knowledge about the technology as well as the level of experience in how to properly implement it; (3) finance could significantly influence the adoption of the technology since, especially in developing counties, financial limitation can be one of the major constraints to adoption; (4) resources is another financial factor that may influence the adoption since a lack of resources may result in improper or delayed installation of the technology; a lack of (5) communication might result in a mismatch between the expectation of the technology developer and the customer; (6) leadership and management influence adoption since bad leadership may lead to bad planning and improper execution of plans; and finally, (7) collaboration and partnerships with other stakeholders (e.g. companies, NGOs, governments) may provide opportunities that could lead to better finance, accessibility of customers and ultimately to better adoption. In this section, AQysta's business strategies are reflected upon these factors.

3.2.1. Social Factors

Part of the factors influencing the successful adoption of the Barsha pump are to be found in the social facet of the company.

Customer communication

Customer communication plays a critical role in the success of a small enterprise. From the interview data could be conducted that most farmers have false expectations considering the capacity and the ability of the pump. These farmers expected the pump to be giving a 20m head pressure over a distance of two kilometres, as was implied on the advertisements. However, in reality, only one of the two can be reached, and only in optimal conditions. As an example, Talita (farm A.4), a female single farmer who inherited the land from her father, was excited about the purchase of the Barsha pump. She learned about the pump from an advert she saw on Facebook and she "expected no challenges" irrigating her whole land with it. The total area of her land is equal to 5 ha, and the highest point of her farm was located at approximately 20 m high (relative to the lowest point) and 100 m far. As her farm is located in Mzuzu, an 8-hour drive from the head office in Blantyre, Talita send a video of her farm and stream to employees of aQysta. After judging the video, they decided to go ahead with the installation. After two days of work, however, the installation team did not succeed in creating a sufficient flow to pump the water all the way to the top of the hill, due to the fact that the pump speed was not nearly high enough to create the hydraulic head needed. It was only possible to irrigate the land nearby the river which was at 5 m vertical distance and 30 m horizontal distance from the river.

Another farmer that came across the same problem was Azibo, a farmer in Dedza see A.9, who had also seen the advert about the Barsha pump on Facebook. He was the owner of a Diesel pump that he was using to pump up water from the river all the way up to his brick reservoir that was located on the highest point on his farm (approx. 15 at vertical distance and 150 m horizontal distance from the river). He used from this reservoir to irrigate the land below applying gravity irrigation. He wanted to substitute the Diesel pump for the Barsha pump, because he said that he did not make any profit anymore due to the high monthly expenses linked to the Diesel pump. We were asked by employees of aQysta to check out his farm. His stream was quite strong, but the reservoir was located too high up and too far away from the river for a Barsha pump to create a high enough speed to reach the hydraulic head. We therefore advised him that the pump would not be suitable for his farm.

Both examples implicate that aQysta's employees either made improper judgements about the feasibility of the pump in the streams of the above mentioned farmers or were untruthful or unclear in their communication towards the farmers considering the feasibility of the pump. Part of this latter issue is related to aQysta's advertisements. All flyers, social media posts, or other type of advertisement state that "the pump can lift water to a vertical height of 20 meters and to a horizontal distance of 2 km". This is however completely depending on the input conditions (depth, width, speed and flow rate) and if and only if all of these variables are optimal this head can be reached. Nonetheless, when all of these conditions are optimal, the lift is either 20 meters high *or* 2 kilometres far, not both.

The farms mentioned above had vertical and horizontal distances of less than 20 meters and 2 kilometres, respectively. This creates a logical motive for these farmers to believe the pump would be able irrigate their fields, judging from the flyers and averts. In the case of Talita A.4, there were employees who had checked out her stream on a video and assured her that the pump would work. While by asking her what her expectations were of the pump, they should have been able to conclude that the pump would not live up to these expectations.

It shows that farmers are not well enough informed by aQysta staff or advertisements on what to and what not to expect from the Barsha pump. This could again partly be caused by lack of education, experience and know-how of aQysta's employees.

Another example of where communication holds the key when it comes to successful adoption of the pump is the lack of explanation to farmers what they could do in preparation of the installation. In the case of farm A.1, sand bags were essential to increase the flow rate in order to reach the needed head. For farm A.4 and farm A.6, the weeds in and near the river needed to be cleared in order for the aQysta installation team to be able to place the pump there and move around the installation site. At farm A.3, large rocks were required to create a plateau to place the pump on, as the river was too deep for the Barsha pump to stand in. In general, every river needs small adjustments to make the pump work optimally, therefore every farmer can and should prepare so the installation can proceed as smooth as possible. However, these prior to installation requirements where never communicated on forehand which meant the installation process took more time than expected.

Leadership and management

Resource management and customer communication, as well as education and technical know-how are often intertwined with communication within the company as well as a company structure. A proper company structure and communication within the company are often direct results of good leadership and management.

aQysta was occupied by one local head manager and two sales and communication managers whom are responsible for the daily tasks. The head manager is in charge of sales of the Barsha pump in Malawi. Frequent miscommunication, and a lack of responsibility made it seem like proper company structure was absent. A tense environment was experienced during observations. The head manager expressed to experience difficulties with delegating tasks to employees. On top of that, employees were not always present during working hours. The judgements on the suitability of the pump at certain locations were performed by the management team. Yet, the lack of technological knowledge and field experience of the management team led to improper judgement calls. This is mainly because the team is not educated in (water)engineering and their absence during installations. By being more involved with the installations, a better understanding of the struggles and problems during installations is created. Another factor lacking the local management of aQysta, is failure in customer follow up, satisfaction and assistance.

Improper resource management was also experienced during the preparations of the installations. Miscommunication led to not all required materials being present at installations. Trucks were not being prepared on time and the installation team was not always aware of the location to be visited. Even though the resources for properly working were present, miscommunication often results in ineffective use of time. The Dutch management team should be aware of the challenges their Malawian colleagues are facing. A clear management structure should be created in which there is room for clear communication within the Malawi department as well as between the Malawian department and the Dutch headquarters.

Collaboration and partnerships

Collaboration with other parties is also identified as a critical factor in the success of aQysta as a developer of a new technology. Partnerships with irrigation officers could be of great importance. The task of irrigation officers is to promote sustainable socio-economic growth through developing efficient and effective irrigation technologies to smallholder farmers in small scale irrigation schemes. They also develop training programs for smallholder farmers to improve capacity building in irrigation (Malawian Government, 2013).

Firstly, this means that irrigation officers have the data on and connection to smallholder farmers A.3, A.5, and secondly they can make the linkage between supply and demand - provided they have heard about the technology. Additionally, irrigation officers would be able to do follow-ups on farms where the Barsha pump is installed to see if it's working and help them re-install the pump after the rainy season. Another benefit of this partnership is that NGOs also contact irrigation officers to gain knowledge of the small farming communities, meaning that this partnership could also create a relation between aQysta and NGOs. We found that aQysta's employees were not in contact with irrigation officers at all, neither did they plan on doing so. This suggests that aQysta is not building the partnerships it could or should in order to enhance the successful adoption of the pump.

UNDP

The company has a beneficial connection with the UNDP which is a great asset improving the affordability of the pump. This collaboration also has roadblocks instituted by governmental policy which does hinder the companies' success. Part of the targets aQysta must reach include selling Water Rights certificates to farmers. These certificates are costly and prove to be a difficult roadblock for the company to reach. Without these targets, the company might lose their funding from the UNDP which places them in a challenging situation. Currently, most farmers do not pay for their water usage, and with limited income, it is difficult to convince them to do so.

NGOs

NGOs often purchase technologies for poorer farms through foreign investment funds. aQysta does not have connections with any of these providers, which would allow them to reach a much greater target customer

group. Smaller rural farms rely on NGOs' assistance for improving their farms. Thus without this collaboration, these farms will not have access to the technology.

Agriculture Trade Fairs

Agriculture trade fairs occur frequently across the country which attracts many local farmers. This creates a space where aQysta can showcase their Barsha pump. Hereby they gain exposure by which more farmers and agricultural officers get familiar with the Barsha pump. By demonstrating a real Barsha pump, farmers become more aware of the operation of the pump, which makes the principle more clear and thereby maybe more interesting to purchase. Since the Barsha pump was often one of the only stands with a physical attribute (the pump itself) or a video on screen present, often a lot of attention was received.

3.2.2. Economic Factors

Proper finance and resources are the major need of most small enterprises in developing countries. As mentioned previously, the company's resources are often limited or mismanaged, hindering the potential success. A lot of strategies to reduce this issue to a minimum have been put into place by both governments and NGOs, such as financial assistance and training programs. However, improper and/or insufficient financial management still plays a key role in company success. (Akande, 2018).

Finance

Finance contributes substantially in the success of a commercial company. In developing countries such as Malawi, a lack of financial resources may lead to challenges involving product sales. Potential customers often cannot pay large expenses upfront 3.1. This is because the pump prices range between 1850000 and 1950000 MwK (2500-2600 USD): amounts for which farmers may need years to generate a sufficient income. To help keep these costs manageable for farmers, the United Nations Development Program (Malawi Government, 2017) sponsors 1000 USD per pump, provided when the company meets certain milestones. The rest of this expense is to be paid for by the farmer. As these remaining costs are still too high in nearly all cases, the company has created a 'pay-over-time' method. This method allows farmers to pay off these costs over a period of 2 years. Creating a possibility for farmers as they now have the opportunity to invest in their future (farm A.1 and farm A.4).

While this 2-year period is essential for farmers to purchase the pump, the company takes considerable risk via large capital investments in transportation and installation costs. For example: costs incurred for one installation (5 days):

- truck rental per day 70 USD
- fuel for 500+ km installations
- 20 USD team costs per day

The risk these costs bring for a (new) company with limited financial resources is large. This is exemplified as farmers may not be able to manage the payments. One example is farm A.11, in which payments for a pump were not made for approximately eight months as the farming community did not want to be responsible for payments. Our visit in July was the only follow-up visitation of a location site within these 8 months since the pump had been installed. Thus, follow-up visits or contact should occur to determine if this is a common occurrence after a certain time since the pump is being installed. If these situations continue to occur, the Small Medium Enterprise (SME) invests substantial amounts for installation without any return.

While the 'pay-over-time' method is essential to sell the pump, receiving payments may be difficult without a proper payment strategy. In the case of farm A.11, there was no follow up from the office for 8 months, which may have extended the problem. This is a major concern, as the enterprise's resources were already stretched thin: eight months without payment should have been recognized and accounted for quickly.

A final consideration is that pumps are imported from an foreign country. The farmers pay with MwK while

the enterprise pays in USD for the pump. The MwK is not always stable as any other currency, which can lead to significantly differing profit margin on a given pump.

Resources

The enterprise is located in Blantyre, they have an office with storage space for the pumps. Customer communication is conducted via information services (Facebook and Whatsapp) which the employees have access to and allows them to contact potential customers. This way of communication has proved beneficial as nearly all farmers learned of the pump via Facebook.

The office was struggling to generate usable cash-flow to solve key resource and supply issues. For example, the office did not possess critical components to ensure their pump worked effectively in the field. These components include sandbags, pipe connectors, sprinklers, and tools to install effectively (A.1 A.3 A.4 A.6). These small limitations, often led to disappointed customers as the pump did not perform as the advertisements indicated. For example, farm A.6 expected sprinklers (that the company did not possess) to be included with the pump. Farm A.1 did not receive sandbags as there was a lack of cash-flow to purchase sandbags (8 USD per bag), which had considerable effects on the farmers' ability to generate income and pay his payments. Lacking resources as a company appears to link to farmers' expectations as shown in the table demonstrated in figure 3.1, which demonstrates again how critical these resources may be.

The company does not own a truck which is required for installations. Thus, they are reliant on truck rentals from neighbouring companies. The rental is costly (70 USD per day) and cuts into the thin profit margins taking away from other areas where resources can be allocated. While currently sufficient due to the small team, this long term this dependency has costly implications. As the company expands, pumps have to be delivered in both Malawi and neighbouring countries, which results in transportation costs being much higher. The trucks can also only stock two pumps for one delivery, which demonstrates how significant these costs are one compared to the cost of a pump (1200 USD).

The lack of cash-flow also meant that the office was unable to conduct proper follow up visits with pumps in the fields. Transport to distant farms A.11 to determine payment issues, giving assistance to farmers having difficulties with pump operation i.e. A.10 was not conducted as the office did not have the cash to make these trips.

Having stretched resources appears to have a negative effect on the customers' satisfaction and company's follow up abilities. These factors can significantly hinder the successful adoption and growth of the technology.

3.2.3. Technology factors

Characteristics

The characteristics are defined as "how well the technology meets the customers' needs". The Barsha pump is a water wheel propelled pump that uses energy of the flow of canals, streams and rivers to pump water from this water source, to a farm. The pump can generate a 20 meter head, which should pump water 2 kilometres distance. The pump is advertised as low-maintenance and easy to use by farmers. To further benefit, the pump does not require any type of electricity or fuel to be operated.

Malawi is a country with many rivers, which in theory allows the pump to be used in many different locations around the country. However, Malawi's rivers are seasonal, being largely fed from the heavy flowing rainy season, gradually decreasing during the dry season. This poses a problem for the Barsha pump, as it requires steady optimal flows throughout the pump's operation period. To ensure the pumps consistent operation, the river flow must maintain an ideal velocity and depth for the pump. As the flow diminishes, the flow must be constantly adjusted to meet the velocity needs for the pump to be operational. Damming the river may require resources that the farmer does not have access too. In one case on farm A.1, the pump was not operating for over one month during critical moments in the growing season as the farmer did not have the resources or knowledge to dam the river during this time. Other farms, including farm A.3 and farm A.6, also found that the challenge of constantly having to readjust the pump made the technology inconvenient to

use. In nearly all cases (farms A.3, A.6, A.4, A.7), the pressure supplied by the pump did not reach the product design characteristics of providing low pressures at distances greater than 200 meters. The reason for this could be because the river, which was used to test the characteristics of the pump, led to better performance than in practise. These technical obstacles limit the effectiveness of the pump in many Malawian situations. After damming the river of farm A.1, the pump performed optimally, but its required distance was only 100 meters, instead of the advertised two kilometers. Therefore, the effectiveness of the pump with an optimal river flow is still unknown.

In many cases, the pump is attractive to farmers as it removes the dependence on reoccurring fuel costs according to farm A.7 and farm A.8 matching technology adopters needs in the country as fuel is costly matching a common demand.

Education and know-how

Technical knowledge within the company can contribute to a company's successful development. This knowledge prepares the company to handle technical challenges, managerial decisions, and operational planning. The aQysta team consists of an office staff with three employees and an installation team with two employees.

Two of the installation team employees have a technical school diploma with a general school education. To prepare for pump installations, the team was educated with a course specifically on the installation of the pump. This background helped prepare the team with equipment preparation and mechanical issues during installations. This allowed the installation team to construct the pumps with no difficulty.

We found that many farmers do not know what it takes to make optimal use of the pump, e.g. adjust their river stream pattern in order to create the optimal flow, or attach a sprinkler or built a reservoirs to make use of the water pumped up during the night. However, the installation team members were also not prepared to make the proper adjustments to the river flows to maximize the pumps' efficiency (A.1 and A.3). When aQysta's employees also do not know how to show the farmers how to properly operate the pump, it will have serious effects on the implementation and resulting performance and of the pump. One key factor that was not considered was the ability to swim. Many installations required from the installation team to have the skills to swim to get the pump in place at farm A.4 and farm A.6, a skill both installation team members did not possess.

Furthermore, from multiple conducted interviews such as with farm A.4 and farm A.6, the farmers were unsure of what to do if the pump stopped working. An important characteristic of technology of the Barsha Pump is the fact that maintenance is low and if necessary, that it is simple. This is only a benefit when farmers are educated by aQysta's employees to fix the pump if something were to go wrong. We estimate that these knowledge gaps will have a significant impact on the acceptance of the pump. One of the first seven adopters, farm A.8, adopted the pump because of observing a neighbour using the pump. Other farmers stated that neighbours were interested in seeing how the pump performs at farm A.3 and farm A.4. If the farmers are not trained to use the pump correctly, the pumps acceptance has much greater risk of failure. The installation team is the only source of knowledge for farmers that are adopting the pump. It is critical that these employees are able to teach the farmers the necessary skills to operate the pump.

The office team coordinates sales, installation planning, and installation preparation from the Blantyre location. The potential rivers are often examined via a video sent by the farmer of interest. The video must contain footage of the river flow and an overview of a large part of the river, and information about the size or height of the to-be irrigated land. However, there are still many occasions in which the installation team travels long distances to discover that the river flow does adequately meet the needs of the customers A.4, A.3, A.6 or that the farmers' expectations of the pump were mismatched with the pumps capabilities. These effects indicate that the office team is unaware of capabilities of the product, assessment methods, and communication methods are poor. This could be due to lack of experience or education on these requirements. The office team is not educated on irrigation or water engineering, which creates a possible gap in background knowledge when it comes to fluid mechanics or pump efficiency. This gap is highlighted, as the office members have not been present at installations, resulting in a lack of experience in judging the feasibility of the pump for a given scenario. That too could explain the false expectations of farmers when considering the Barsha pump, as the office might not provide proper river assessment with respect to Barsha pumps' suitability and capability. The lack of experience and education results in limited knowledge transfer to customers

in using the pump to its optimal potential. An example of this inexperience is highlighted in farm A.1 in which the office offered assistance in building a reservoir, but lacked the knowledge to do so, resulting in a non-operational pump during critical phases of the growing season.

3.2.4. Concluding Remarks

The findings in this research on success and failure factors of aQysta are widely supported throughout literature. Section 4.2 implies that possible conclusions for making aQysta a bigger success as a business presented in this research could also be suitable for other small businesses in developing countries.

These factors are also observed in aQysta as it begins to develop its business. For aQysta, the teams were often inexperienced for their respective roles without any proper training measures in place. This inexperience has major implications across other cited problems which include resource allocation, communication, and collaboration. These inefficiencies have also resulted in many farmers being disappointed about their product, not paying payments, and not having an understanding of the intended performance.

aQysta has developed several models that help farmers adopt the technology. By creating pay-over-time models and collaborating with UNDP, the pump is more accessible for farmers to use. This model starts a good foundation for the technology to gain a foothold in the country. The model does come with risks as farmers must be happy with the performance to ensure that they will make payments. Since this is critical to the company's success, the company should pay close attention to providing proper training through installations, supplying correct information regarding performance margins, and choose locations in which the pump works close to optimal. It can be made easier by further collaboration with irrigation officers, as they can provide valuable assistance in the field. The irrigation officers also have the network to introduce new customers for which the pump could be beneficial.

4

Discussion

4.1. Key factors influencing farmers likeliness to adopt a new agriculture technologies in Malawi

4.1.1. Social

In summary, the key social factors discussed in this study are age, gender, education, social group, and access to services. The results of our study show that age and gender do not appear to be critical factors for technology adoption. In contrast, Mwangi and Kariuki (2015) found that age can be considered as a determinant as older farmers are assumed to have gained more knowledge and experience to evaluate the technology while younger farmers are typically less risk-averse and more willing to adopt new technologies. This suggests that in our results most farms inquiring about the technology would be younger farmers. Which does not align with the results. A possible explanation for this contrast could be that the main target group of this study were farmers that inquired about the technology. Which could suggest that older farmers already evaluated the risk and were still willing to adopt this technology. As for gender, a study by Doss and Morris (2000) found no significant association between gender and the probability to adopt new technologies. They concluded that technology adoption decisions were more reliant on the access to resources, rather than gender which aligns with the results of this study.

Education, access to services, and social group were critical components on whether the farmer was willing to adopt the technology. According to Mwangi and Kariuki (2015), the education level of a farmer increases the ability of the farmer to process and use information, which allows them to make open, rational decisions when analyzing the benefits of the technology. This aligns with Sinja et al. (2004) who found that increased understanding of technologies and their benefits leads to an increasing probability to adopt.

The results show that access to cell phone and internet services had a significant influence on whether the farmer inquired about the technology. This could be explained by Mwangi and Kariuki (2015), who state that acquisition of information allows the farmer to learn of the existence and effective use, which could facilitate adoption. This agrees with education being a significant factor, as farmers with the access to information educate themselves about new technologies A.1, A.4. Furthermore, from the results can be concluded that community farms which are reliant on government services and aid from NGOs did not inquire about the technology. Technology adoption in these communities was completely dependent on governmental services and NGOs supplying the technology to them A.2, A.5. This agrees with Sinja et al. (2004), who states that using extension services helps facilitating adoption in smallholder farms and Mwangi and Kariuki (2015), which state that farmers are usually informed about the existence and benefits of new technologies through extension agents. One notable example of the importance of social group is observed in farm A.8, in which the farm did not have education or information access, but observed the technology being used by a neighbouring farm which facilitated their own adoption of the technology. According to the results, market access is a critical factor in whether technologies are adopted. This is supported by the study of Uaiene, Arndt, and

Masters (2009), which observed that the greater the distance between a farm and markets, the smaller the likelihood that the farmer is willing to adopt a new technology. The results show that these farms feature lower education levels, information access, and economic potential, which negatively affects adoption probability.

4.1.2. Economic

The economic factors discussed in this research include farm size, expected gain, costs, off-farm income, and access to credit. In this study, farm size did not appear to be a significant factor in whether a farmer would adopt the new technology or not. Individual farmers tended to have a higher plot-to-person ratio compared to community farmers. However, the farm sizes from this study showed a significant size distribution between all farms. Uaiene et al. (2009) identified a positive correlation between farm size and technology adoption while Mwangi and Kariuki (2015) suggest that there is a negative influence as small farm sizes may have incentive to adopt a technology that helps minimizes labor or utilizes land better. In the results, many farmers wanted the technology so they could expand the agricultural producing land which aligns with Bonabana-Wabbi (2002), who suggest that the likelihood of technology adoption is best explained by the proportion of total land area suitable to the new technology. This statement also matches the expectations of the farmers in which several farmers were disappointed the technology did not expand the irrigatable land as they expected. That may suggest that farmers were adopting a technology based on the benefit it provided relative to their farm size rather than the size itself.

In many cases off-farm income is suggested to play a key role in whether a farm would adopt the technology. In these results, off-farm income did not appear to play a significant role in farmers willing to adopt the pump, as these farmers used farming as their primary income source. According to Diiro (2013), off-farm income is expected to provide farmers with capital to invest into productivity enhancing technologies. Mwangi and Kariuki (2015) suggest that off-farm income is reported to act as a substitute for borrowed capital in places where credit markets are missing or dysfunctional. From the farmers surveyed in this research, the correlation between credit access and off-farm income did not match literature studies as farmers were adopting without credit and off-farm income. In the farmers' survey, credit access appeared to be limited, thus it may be a constraining factor, this cannot be deduced from these results as the farmers surveyed generally self-inquired about the technology. This effect could be explained by the 'payment over time' method which acts as a form of credit, providing the farmers with more confidence in adopting the technology.

This effect would also explain how the barriers which large upfront costs have in technology adoption, is overcome in the results of this study. Mwangi and Kariuki (2015) state that the cost of the technology is a constraint to adoption of the technology. Meinzen-Dick and Di Gregorio (2004) go further, stating that technologies with a high investment cost structure with smallholders should be avoided as the farmers lack the necessary resources to adopt. This aligns with our results which determine that the farmers were able to adopt the technology because of the aforementioned 'payment over time' method rather than paying a large upfront cost.

4.1.3. Technology

The technical results we categorized on the ability of the farmer to test the technology before using the technology and whether the performance of the technology matched the expectations. The results suggest that the majority of highly educated individual farmers wanted to test the technology before fully committing to its adoption. While community farmers did not need to test the technology before using it. Mwangi and Kariuki (2015) state that the trialability to which a potential adopter can tryout something on a small scale first before adopting it completely, is a major determinant in technology adoption. This has appeared to be the case in Malawi for the individual farmers who were given a trial period before starting their payments while deciding if the technology met their expected performance needs. Communities did not express the need to try the technology, which could be because NGOs often donated the technology (or part of the technology) to help them with starvation prevention. This means they did not have to dedicate personal resources to adopt the technology which may explain why testing was not has important for them.

In nearly all cases where the pump was adopted by the farm, the expected performance did not match the

expectations of the farm. Mwangi and Kariuki (2015), determined that farmers perception about the performance of the technologies significantly influences their decision to adopt them. Sinja et al. (2004) found that it is important that farmers perceive the technology as being consistent and being suitable for the circumstances. This aligns with our study as changing rivers and performance were given as reasons why farms A.3 and A.6 did no longer want to use the technology and why farm A.4 did not adopt the technology.

Thus, to improve the technology adoption by farmers, it is crucial that developers of new technologies understand the needs of farmers by fitting in the technology to the farmers resources, knowledge, and needs.

4.2. Factors influencing the success of aQysta in Malawi

Currently, the company has struggled to gain a solid foothold in the country. In this discussion, the main factors influencing the growth of aQysta Malawi are discussed.

4.2.1. Social

The key social factors within a developer's scope discussed in this study are customer communication strategies, leadership management skills and collaboration & partnerships. A study conducting research to the business development needs of small businesses, concluded one of the major needs for the growth of SMEs were more effective communication skills, leadership and management skills and a higher level of collaboration and partnerships (Chittithaworn et al., 2011). This was also concluded in the research of Robertson (2003), stating that the success of small businesses in developing countries depends crucially on training and knowledge of employees and their ability to engage in training programs.

Regarding customer communication, the results show inadequate customer communication having a significant impact on the approval of the technology. This results in poor expectation management and inadequate preparation for technology use. The lack of communication also caused farmers to have much higher expectations of the capabilities of the pump than what was actually possible, resulting in dissatisfaction. This is supported by (Akande, 2018), stating that effective customer communication skills are one of the most important factors in developing and maintaining the interest and trust of a (potential) consumer for SMEs in developing countries. Communicating effectively the proper usage, expectations, and operating techniques would better prepare the farmers for operating their pump. After a customer purchases a pump it is also important that communication is maintained. For example, aQysta did not maintain communication with their customers leading to a pump being unused and unpaid on the side of the road A.11.This was supported by Chittithaworn et al. (2011), who concluded that successful businesses were generally likely to spend more time communicating with customers. It was also observed that the advertisements for aQysta's Barsha pump contained misleading information suggesting the pump's performance far exceeds its actual abilities, resulting in disappointed customers.

Literature describes collaboration with partners as a factor for success (Chittithaworn et al., 2011). Temtime and Pansiri (2004) studied the success and failure factors of small business in Botswana and found that "poor use of external advisers by small business owners/managers' is a major problem affecting (SME) development". In this aspect, aQysta has found mixed success. The company has built good collaboration with the UNDP which allows them to reach a larger customer base with more affordable pricing. This should contribute to the success of the company on the long term. At this time, aQysta has not built collaboration with NGOs and irrigation officers. However, these could have a great influence on the adoption rates of smallholder farmers. This corresponds to our finding that the incorporation of irrigation officers in the selling and sustainable use of the pump is a critical factor influencing the success of aQysta. For many customers, irrigation officers are the only means of acquiring knowledge about the pump. Making use of this service will also ensure that the aQysta office does not have to travel long distances to ensure proper pump operation, decreasing the strain on their resources as well as connecting with new farms more easily. Additionally, the services of irrigation officers can support aQysta in helping farmers to operate their pump successfully, as well as to allocate resources to other critical components affecting the successful adoption of the pump.

The leadership and management structure at the office is not experienced enough to handle standard problems occurring in this business field. Okpara and Wynn (2007) observed that people who were running busi-

ness without training or experience were often too impatient to learn and gain experience from an experienced individual. This aligns with our observations as the local aQysta team did not possess the technical knowledge to properly advise farmers on the pumps' capabilities, whether it be preparation procedures, pump operation, and location feasibility. The management structure also did not recognize important duties such as customer follow up, satisfaction, and assistance when promised. These habits even persisted when the company was not receiving incomes from the customers, indicating that something was not correct. This form of mismanagement has added to resource strain, as money was spent on costly installation trips to unsuitable locations as well as delays in payments from the customers.

With proper guidance within the company, the team would be better prepared to handle these challenges, make informed decisions and have effective communication and thereby potentially better chances at success.

4.2.2. Economic

The critical economic factors discussed in this research are finances and resources. Very little research is conducted about financial payment methods success and failures in sub-Saharan Africa. aQysta is implementing a relatively new 'payment over time' model to Malawi. This mode of payment is new to Malawi, and provides farmers with opportunities that were not present historically, making the technology more desirable than competing pumps. This method is a key to the company's success in the country. The initial adoption of the pump 3.1 depended on this mode of payment to adopt the pump. Without this model in place, it would be very difficult for farmers to purchase the pump. This mode of payment does come with significant risk. Paying over-time allows the farmers time to test the pump before paying for the pump in full. This test period occurs after the company has dedicated significant resources into the delivery and installation. For this reason, it is critical that the pump is operating as expected so farmers have incentive to continue making payments for the pump. This links with other parameters of AQysta's service on the installation, training, and communicating with the farmer. It is essential that AQysta provides these services to minimize the risk of missed payments.

After generating the income, the methods in which the company obtains and allocates resources is also essential to a successful endeavour. Okpara and Wynn (2007) states these main struggles are often misused in various business operations such as marketing, operations, and inventory management by poorly trained management teams. This problem has also been observed at the AQysta office. Many critical resources (sandbags, sprinklers, pipe connectors, etc.) were not kept in stock, or provided to the customers, even though they were essential to the pumps successful operations. Resources were spent on costly cross-country trips that generated zero net gain. Allocating limited resources to these unsuccessful operations also limited the success of following operations. Resources were not allocated to proper training and management to ensure effective sales to customers. Proper training in resource management will help the staff be better prepared to manage customer expectations, while allowing investment into other aspects, such as acquiring technical knowledge for the team.

4.2.3. Technology

The technology factors discussed in this research include the education and know-how of the employees and the characteristics of the Barsha pump technology. In this study, education and know-how is identified as an important factor of limitation in the success of aQysta as a company. The office team lacked field experience and background education, which made it difficult for them to assess efficacy of the pump or to assist farmers. That education and know-how of employees is an important factor determining the success of developers is in line with the research of McPherson (1991); Parker (1995) studying the micro-and small-scale enterprises in Zimbabwe and Kenya. They found that companies with educated employees are growing relatively more rapidly. The study of Robertson (2003), studying the role of training and skilled labour in the success of businesses in developing economies, also emphasized the need for education specifically directed on the technology of interest. He stated the importance of tailored programs for employees, since each technology has a different learning requirement. He also concluded that "economic development has generally proceeded from prior investments in the education and skills of a workforce". This is in many ways an unpleasing message for many businesses in developing countries, as some of them have array of urgent issues

and very limited resources. He therefore suggests that the help of governments or multinational corporations is needed to facilitate and determine types of training in order to achieve development of small businesses in developing countries (Robertson, 2003).

The characteristics of the technology determine the successful adoption of the pump. The pump is attractive to many farmers in Malawi as it removes the dependence on reoccurring fuel costs, maintenance costs and labour are low, and the technology is easily understandable. Studies on performance related to other technologies were not conducted, which could be an area for further research. The technology is currently undergoing testing in several sites across the country to determine its success for these rivers and farmers. However, it is critical that the technical requirements are meeting the farmer's needs. Follow-up meetings with farmers using the pump must be conducted to determine the happiness with the operations of the pump. Currently, the majority of installation sites have experienced mismatched expectations which suggest that information given, usage, or expectations are disassociated from reality.

The Barsha pumps are currently made in Europe but looking into opportunities for local production might be interesting. This will create more local jobs and knowledge and the local production requires less transportation costs and emissions. Additionally, at the moment only once in a couple of months new pumps can arrive. Localized production will ensure a more frequent delivery of Barsha pumps. However, still the quality of the pump should be guaranteed and should be the same as the current pumps manufactured abroad.

4.3. Methodological limitations and suggestions for further research

The number of interviewees (n=9), is small which is too small of a survey to derive statistical correlation. To generate a statistical analysis, it is recommended to have at minimum 10 observations per variable. And in the case of more than 3 variables, a minimum of 30 respondents. This implies that the clear statistical trends cannot be identified.

The first 6 farms that wanted to adopt the technology were surveyed. This is interesting as it can identify trends among these farmers that already planned on adopting but it does not provide information on farmers that did not approach the company. This could lead to bias, for example, we could derive from the results that individual farmers always had the capacity to adopt the technology. This would be incorrect, as we did not interview individual farmers that may have not had this capacity. This can be extended to farming communities as well. We did not choose communities at random, they were introduced to us by irrigation officers which may have personal reasons for using these farms as interview sites. Using these farms as strict guidelines for farmers in Malawi is not factual, but may provide insights into first adopter characteristics. To surpass this limitation, greater populations must be surveyed that inquire into the pump.

User habits were not observed after long periods of time. Hence it is difficult to conclude success of the pump itself. This would require future research and follow-up interviews with the farmers surveyed. Therefore the benefits of this technology are still unknown in Malawi. While early adopters struggled with expectation and performance optimization this does not imply that the technology work correctly. In certain situations, we have noticed the pump had a significant impact in expanding an individual's farm. This farmer was independent and educated which allowed him to use the pump to its best usage demonstrating a clear potential of the technology. There was no time for proper training of farmers which could shown better expectation results.

For further research, aQysta has a large list of potential customers that have signed up for more information at agriculture trade fairs or have inquired about purchasing a pump but have not made the commitment yet. These farms are located across the entire country and would be a valuable resource as each of these farmers has considered adopting a new technology. Using this list, a full statistical survey can be generated with full comparisons to literature features for successful adoption in Malawi. A study of this magnitude gain build upon the information generated in this study.

4.4. Implications

Implication on further research and how the results of this study can be used for company policy and practise is elaborated on in this section. The results gave insight in farmers' expectations of the technology versus the technology's actual performance. For many farmers, the Barsha pump is desired to (partially) replace manual irrigation and thereby reduce labour intensity, as well as to make gravity irrigation possible. Optimally, the latter could be done in combination with a reservoir installed at the highest elevation point of the farm plot. Using the pump to transport water in this way will reduce the labour intensive manual bucket transportation. However, this is not advertised. Showcasing farmers that gravity flow becomes more convenient in combination with the use of a reservoir might aid in bridging the gap between farmers' expectations of the technology and its actual performance. Next to the use of a reservoir, the performance of the pump is highly dependent on the flow of the river, which changes seasonally, and on the level of know-how on how to optimally install and adjust the pump accordingly. When not properly addressed, the lack of training may also lead to disappointment of customers. Using these insights to prevent misleading advertisements may enhance technology adoption.

Furthermore, both community and individual farms proved to be able to pay back the pump in two years, although certainly not upfront. For aQysta this shows that the payment over time method is crucial in facilitating the adoption of the pump. Even more so for community farms, since they were found to have less financial resources than individual farmers, were overall less educated and more dependent on NGOs and governmental services. Recognizing which type of farmer groups are more dependent on outside aid may be relevant for government and NGOs in adjusting their policy in the right direction to enhance technology adoption. As for aQysta, this insight may be used to understand for which farmers' it may be more feasible to collaborate with both NGOs and irrigation officers.

Lastly, without proper collaboration with irrigation officers, aQysta's resources will be stretched too thin. Many farmers are unable to make their own adjustments to the pump during the frequent season changes. With pumps located throughout the entire country, aQysta does not have the man-power to assist farmers with these adjustments. Collaboration with irrigation officers that can provide insight to farmers minimizes aQystas resource input, allowing them to allocate resources to other operational costs.

4.5. Beyond our scope

The results and its implications mentioned in the previous sections gave rise to subjects which could require further study but were beyond the scope of this research. These are subjects regarding further possibilities of using a reservoir in combination with the Barsha Pump, and the effect of using the Barsha Pump on downstream water availability.

The main purpose of installing a reservoir in combination with using the Barsha Pump is having a buffer for irrigation. However, if the reservoir is big enough, not all of the water stored in the reservoir is required for irrigation, which gives way for using the water for other purposes as well. Frequently, villagers have to walk to the nearest river for bathing and doing laundry, which for some communities may take two to four hours a day. Bringing the water source closer to their homes may therefore save time and effort. Furthermore, shifting these activities to people's homes may reduce river water pollution with detergent chemicals. To further study the extra benefits the pump may be provide, studies can be conducted on the change in farmers habits after acquiring the technology.

Besides storing water for washing and bathing, a reservoir could also be transformed into a fish pond, enabling fish farming. This provides another source of income for farmers, which potentially provides them with more financial security[A]. However, although the willingness to invest and put effort in building a reservoir seemed to be present, a lack of financial resources is often the main reason why farmers could not build a reservoir in the first place [A.1]. How to overcome this barrier with possibly, aid from NGOs or government facilities was not further researched.

This study concludes that farmers believe they are able to pay for the pump. Follow-up studies could be done to determine the capabilities the farmers have in doing so. During the course of the research, preliminary tests suggest that in theory farmers are able to make a considerable expansion to their farms and therefore

profit margins B.1. However, each farmer's situation differs in practice. The results from further study could indicate the feasibility of the pay over time method while indicating whether improved credit access could have sustainable success.

Lastly, the effect of transporting substantial amounts of water from a river to a nearby plot or reservoir may negatively affect water availability downstream. Especially at the end of the dry season, when water levels are decreased tremendously compared to the wet season, constant uptake of water from a river will most likely influence farming practices downstream. The outcome may have implications on irrigation water restrictions determined by local governmental institutions. However, further research is required to fully understand this effect.

5

Conclusion

In this study, factors influencing the successful adoption of a new agricultural technology in developing countries are reviewed, with combined focus on both the farmers' and business' perspective. This research aims to provide insight in how these factors specifically influence the adoption of the Barsha Pump for Malawian farmers. Gaining insight into these key factors could be insightful for both governments and enterprises looking to develop such technologies in the developing world.

Results indicate that key factors influencing farmer adoptions are market access, information access and education. Farmers with these characteristics appear to be more likely to inquire and adopt a new technology. Rural farmers who lived relatively further away from cities tended not to have these characteristics and were found to be more dependent on governmental institutions and NGOs for technology access. Although Malawian farmers with these characteristics were likely to adopt the technology, economically, it was not manageable for them to pay the costs upfront. aQysta recognized this issue, and thus created payment over time models to make technology adoption possible for these farmers. The performance of the technology however did not always match the farmer expectations, which often still lead to disappointment on the farmers' side. These performance deficiencies result from Malawi's constantly changing seasonal river flows which require constant maneuvering of the technology. Surveyed farmers were not adequately trained or resourced to handle the rivers' alteration. For a successful adoption, clear communication, training, and expectation management is of great importance. The most successful adoptions were at farms where the farmer was being aware of the characteristics of the Barsha pump and its working at his/her particular farm upfront of the purchase.

Common factors hindering a successful adoption in literature also appeared frequently in AQysta's initial deployment in the country. Key literature deficiencies in training and management, resource planning and communication were also prevalent in aQystas start up efforts. The team struggled to train and communicate issues effectively to the farmers. This can stem from lack of experience and technical knowledge in the office and installation teams. In the farmers survey it was observed that many of the first adopters were not satisfied with the performance of the pump which stems from these issues. This study highlights the importance of clear communication and training with farmers to facilitate positive impressions of the pump. Proper training and usage in the business can translate to proper usage in the field. The most successful implementations occurred at farms where the farmer was aware of the pumps characteristics, and was using the pump optimally for his situation. aQysta proved to be very good in creating a manageable financial solution by recognizing farmers' economic limitations, but were sometimes short of technical knowledge and communicative skills.

Mistakes hindering the success of small market enterprises in developing countries are commonly shared. Recognizing and understanding the factors influencing successful companies in developing countries is essential to ensure long-term growth of this project. By challenging itself to communicate, use and manage resources, and structure itself effectively, the company could increase the probability for successful technology adoption while meeting customers expectations.

5.1. Group work

As a team of five students with different backgrounds and different expertise it was interesting to see how a project in a country as Malawi came together. There was a mutual goal as described in section 1: Introduction. However different visions and ideas were often a reason to sit together and listen to each other, both to understand and to gain insight in other people's perspectives around the same topic. We are confident to say that this project would not have been a success without any of the team members. Every member contributed in a different way to target our goal. Individually we gained a lot of experience in working as a team, and about working in less-developed countries with in particular Malawi. We are thrilled and thankful we got the opportunity to do this research and experience the Warm Heart of Africa.

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A

Farm visit summaries

A.1. Farm 1: Collings Bema, Michiru Road, Blantyre

Interview

Social

Why do you need the pump?
The pump will help me expand the amount of crops I can grow. Using watering cans is a lot of work, with the Barsha pump I can water much more crops every day.

How did you find the Barsha pump?
I saw the advertisement for the Barsha Pump on Facebook, and then contacted aQysta.

How did you learn to become a farmer?
My father was a farmer, I first went to university and then my father died. I decided to take over his land and start farming. I also do a lot of research on how to grow different crops on the internet.

How has communication worked with aQysta?
aQysta has been good, however I am still waiting for money to purchase plastic for my fish farm. Aqysta offered to pay for the plastic for

Financial

Where do you sell your crops?
I currently sell most of my crops at the local market, and sometimes to Roseburry farms. Ruth comes when she needs more of a certain crop. My lettuce I will sell to Ruth. I am looking for more businesses to sell too so I can always know how much I can sell. I am selling to CrossRoads Hotel but I am hoping to sell too the supermarkets.

What are the difficulties selling crops?
"It is very difficult trying to sell crops to the supermarkets, I need more money for higher quality seeds and fertilizer so my quality is good enough for the markets. I am trying to grow different crops to try find a commercial market, like watermelons as they are easier to sell.

How will you pay for the pump?
"I don't have to pay yet because aQysta is allowing me 3 months before I have to start paying, but the pump hasn't worked for the past 1.5 months. So I think this will allow me to extend this period. If I can expand my farm and grow more, I will be able to pay the payments for the pump over the 2 year period."

Technical

Why do you need the pump?
The pump will help me expand the amount of crops I can grow. Using watering cans is a lot of work, with the Barsha pump I can water much more crops every day.

How did you find the Barsha pump?
I saw the advertisement for the Barsha Pump on Facebook, and then contacted aQysta.

How did you learn to become a farmer?
My father was a farmer, I first went to university and then my father died. I decided to take over his land and start farming. I also do a lot of research on how to grow different crops on the internet.

How has communication worked with aQysta?
aQysta has been good, however I am still waiting for money to purchase plastic for my fish farm. Aqysta offered to pay for the plastic for me, which will help me use the pump all the time.

Observational Results

Social Observations

Personal (gender, age group) Male. Age 30

Education: Collins is a passionate farmer, spends much time reading research and growing techniques of various crops and experiments with their success in outdoor conditions. He recognizes that certain farming techniques are the future of proper horticulture development (Greenhouses, hydroponics etc) and hopes to earn income from his farm to build to this level of technology.

Social Standing: Collins is a well-respected farmer in the community. He has several farmers from the near by village working at his farm. When he first came to the community, he had several occurrences of theft, but since he has become a member of the community this has stopped. Many children come to his field and play during the day. People seem to respect him because he is working very hard to build his farm.

Access to external extension services: Collins is well informed of the extension services available to him, however, he is quite independent and able to work on his own. He has contacted external vendors and commercial markets to build his customer base and has the mobility to contact the necessary people. He has internet access as well which he used to find the Barsha Pump and to learn about farming.

Economic Observations

Farm size: Collins farm is about 0.8 ha, but he also has a much larger plot that is not currently being used as it is too far from his water source for buckets. During the rainy season he grows maize on the further reaches of his farm.

Expected gain: Collins hopes to make his farm a commercial success. He is looking to run his farm for a profit and expand to be a supplier of commercial vendors. The pump is a way for him to expand his farm and returning to his farm several weeks later showed a massive increase in production capacity. Collins wants to use the pump's 24/7 capabilities to farm fish which he also expects to make a good profit. Collins wants the pump so that he can consistently sell his produce at high quality to commercial vendors who require consistent quality and quantity. At this time, Collins has mentioned that it is difficult for him to grow at this quality as he does not have enough money for high quality seeds or fertilizers, but he hopes that after several harvests with the Barsha Pump that he can start using high quality inputs to improve his yields.

Costs: Collins does not have enough money to purchase the pump up front and hopes to pay for the pump when he harvests his crops. For example, the pump was non-operational for over a month as he did not have 8 euros available to purchase sandbags and aQysta promised to supply him. Not having this upfront cash really effected his ability to earn money. External income: Collins sole business is farming. He does sell some milk from a cow and raises pigs, but this is only a small portion of his income which he uses to buy seeds and fertilizer.

Technical Observations

Expectations: Collins expects that the pump can irrigate his entire farm with the Barsha Pump. This agrees with aQystas advertising of irrigation size 2 ha with 20 m head. His farm geography also is suited well for the Barsha Pump. Collins is also understanding of the work required for the pump to operate properly, this includes re-aligning the river to adjust flows and seasonal variance in performance.

Performance: Collins farm is a perfect example of the pump working as is intended. The pump allowed him to expand his field capacity significantly, as over a period of a single month his farms production nearly tripled in size relative to the previous 5 years. Using the pump's 24/7 capabilities Collins will use the pump to build a fish pond, and build storage basins around his farm to minimize the walking required with water cans. We did not see the performance of the pump deeper into the dry season which would be very beneficial information to determine the long-term potential of the pump in Malawi.

Trialability: Collins requested to be a demo farmer for aQysta, this allowed him a 3-month trial period in which he could use the pump. At the time of our visits Collins was happy with the performance and is intending to carry forward in paying for the pump. He did not need to see the pump in use before he used it. Collins enjoyed being the first farmer to use the pump, and it added a prestige factor to his farm.

A.2. Farm 2: Zomba Farm, Irrigation Canal

Interview

Social

Why do you need the pump?
-Not relevant for this farm, the water source was very limited flow through a small gravity canal

How did you find the Barsha pump?
-not relevant

How did you learn to become a farmer?
"Anyone from the community who is willing to work can use a plot of land from the chief. We learn the farming methods from our parents and the community."

How has communication worked with aQysta?
-not relevant

Financial

Where do you sell your crops?
"We don't sell the crops here; all the food is for consumption and even then, it is not always enough. Sometimes when we grow, we sell some of the excess on market days so we will bring our extra tomatoes to the market."

What are the difficulties selling crops?
-not relevant

How will you pay for the pump?
-Not relevant

Technical

What is your current irrigation method?
"We are using watering cans and gravity irrigation. Last year the gravity irrigation canal was built, so we flood our fields below the canal and use the watering cans above the canal"

Do you expect there to be any challenges with your irrigation

“Last year we did not grow enough food, so we had a very hard year with hunger. The irrigation officers and government came to help us grow beans and maize. This year we are hoping to have a bigger harvest to prevent hunger. During the dry season the river runs dry so we can not grow during the whole year.’

Observational Results

Social Observations

Personal (gender, age group) Farming community with a large variety of genders and ages. Both men and women were working on the farm together as a community.

Education: The community were uneducated with minimal access to education. Much of the community was illiterate. Not all the children could afford to go to school. Irrigation techniques and strategies were passed down through the community, and only rainfed irrigation was used until 1 year ago.

Social Standing: This was a large community with over 20 families using the plots to grow their land. The chief owned the land and the farmers were able to use a plot from the chief. The village was quite rural without access to outside markets.

Access to external extension services: The community experiences some very bad years so the governments got involved with the community. The irrigation officers helped the farmers build a gravity irrigation canal which allowed them to expand their crop sizes to alleviate starvation risk. The government also supplied the farm with seeds and fertilizers. One year ago, the farm only grew tomato’s, onions, and maize. With the governments help they received seeds for beans and potatoes to diversify their crops. The farm didn’t have much knowledge of irrigation technology outside of the advice given to them by irrigation officers.

Economic Observations

Farm size: The farm was quite large, however, only about 1.5 ha was being used by the community. This is because the water source was limited, and during the dry season runs dry. Thus, for large portions of the year the farming output was only attributed to rain-fed irrigation.

Expected gain: The farmers were using the gravity canals to expand their plots. This was for the sole purpose of preventing hunger. If extra income could be achieved by selling their crops this would be used to help the children go to school, not to expand their farm.

Costs: Did not have money to purchase new technology. If a new technology is used, it must be supplied by the NGO’s.

External Income: No external income. The farmers were not commercially minded. They were expanding their fields and planned to separate growing beans from maize. However still for personal use. I asked why, they don not keep they beans in the maize and just grow more beans to sell and they were not sure why. However, once the suggestion was made, they thought it was a good idea and would allow them to send children to school. In general, this farm needed much external support in order to succeed in the long term.

Technical Observations

Expectations: The farmers were very poor, any additional information or gifts they thought were very helpful. During the interview they asked us for any advice or help we can offer to help improve their livelihoods. The Barsha Pump was not a technology that could be implemented at this farm as the water source was not adequate.

Performance: not relevant

Trialability: not relevant

A.3. Farm 3: Commercial mega farm, Dowa - Interview with Irrigation Engineer

Interview

Social

Why do you need the pump?
“This farm is being used as a testing farm for new irrigation technologies. Alliance one and Pyxus are working together with NGO’s to determine technology applications in Malawi”

How did you find the Barsha pump?
“I was seeing on facebook the advertisements for the Barsha Pump and I personally thought the technology looked really interesting, so I asked Mark Lytton (Head of Project) to bring the Barsha Pump here and test its capabilities.”

How did you learn to become a farmer?
“My parents were farmers, but I went to university to study water resource management. At first I was doing Wash Projects but I found that not interesting, so I switched towards farming. This has been a really become a passion of mine. Since then I want to become a part of the future growth of farming in Malawi”

How has communication worked with aQysta?
“We spoke with aQysta on the phone and they sent a us a pump, communication has been good”

Financial

Where do you sell your crops?
“80% of the crops from this farm are sold on the local markets, 10% to supermarkets and 10% to our store in Lilongwe. We hope to sell 100% to hotels and supermarkets because the prices are better than the local markets.”

What are the difficulties selling crops?
“At certain points of time there is much oversupply, during this period the prices are very low and it can be quite difficult to cover your costs. However, with a good irrigation system high value crops can always be grown which should give reasonable margins”.

How will you pay for the pump?
"The pumps will be paid for by the alliance one program and NGO’s"

Technical

What is your current irrigation method?
“On the farm we are using all different types of technologies including Solar, Diesal all connected to drip irrigation systems.”

What do you expect the biggest challenges to be with the Barsha Pump?
“We will be testing the pump here to see how it performs, The biggest challenge is that in many rivers there may be not enough water and then the Barsha will not work.”

How big is the plot you want to irrigate?
“We will be testing the pump on a 2 ha plot about 300 m away from the river. The crops will be used for horticulture products that we hope to see to our commercial store in Lilongwe.”

Why did you choose this pump?
“I really liked how the pump was sustainable, and had no operational costs. This might make it a very good technology for Malawian farmers. This is why I personally hope the pump works well.”

Observational Results

Social Observations

Personal (gender, age group) The farm was being run by a team of 6 irrigation engineers. The personal we worked with were all male in the 25-35 age range.

Education: The irrigation engineers working at the farm were all university educated in agriculture, agro-business and water resource management. They were all very knowledgeable about irrigation and were well informed about the benefits and uses of the different irrigation technologies.

Social Standing: The company was a very well developed company relative to other farmers in the country. This is because they were heavily involved in the tobacco industry. This allowed them to have more resources which they invested in new technologies, testing farms, and in Malawian farming development. Although they were currently offering their services for free, they are going to start charging as it is important for farmers to invest into their farms to succeed. They had many villages working and living on their farms which also elevated their status.

Access to external extension services: The farm is owned by a large world-wide company, with extensive resources. They did not depend on local institutional infrastructure like irrigation officers as their team was equally knowledgeable about irrigation. They worked together with NGO's to improve Malawian farming, and had more access then traditional farmers.

Economic Observations

Farm size: The farm is massive, 100's of hectares. Much of the farm was not used for growing, but the areas were the Barsha were going to be used was for about 2 hectares.

Expected gain: The farm hopes to act as an advisory company to farmers in Malawi. Therefore, they were testing different technologies in a Malawian context to determine their potential in the Malawian market. The Barsha pump was one of the technologies tested. In the long term the farm hopes to expand and be a supplier for commercial and export markets in the region.

Costs: -not relevant

Technical Observations

Expectations: Henry hopes that the pump proves to be a good technology for farmers in Malawi. The pay as you harvest model will make the pump accessible for Malawian farmers which is why testing this pump may be very beneficial. There is some concerns that Malawian rivers are not stable enough for the pump, which will make the investment not worth it.

Performance: At this point we were not able to see the performance of the pump. I later asked Henry about how the pump performed and he stated they stopped using it as the river flow was too low to supply adequate water to the farm."

Trialability: "The farm was using the pump as a testing ground for future recommendations for farmers. They did not use the pump as a trial version."

A.4. Farm 4: Talita, Mzuzu district, Nkhata Bay area

Interview

Social

Why do you need the pump?
"I hope to expand my farm to a much greater size, right now we are using water cans near the water source but I hope to irrigate all the plots on this farm I want my farm to grow so that my sons can also farm on this

land”

How did you find the Barsha pump?
“I was seeing on facebook the advertisements for the Barsha Pump and I thought this pump would be a life changing pump for our farm”

How did you learn to become a farmer?
“My dad was a farmer, and I first was a teacher at school but when my husband passed away I could not teach and raise my children. Being a farmer was more convenient with raising kids. I learned a lot from my dad, and I study how to farm from the internet”

How has communication worked with aQysta?
“I spoke with aQysta on the phone to order the pump and sent a video of my stream. aQysta sent an invoice and asked me to come up with a financial payment plan for the pump. I am very happy that aQysta allows us to pay overtime as this is really empowering for us. I can now look at my business in a different way as something I can invest in”

Financial

Where do you sell your crops?
"All crops are sold in the local markets. None are sold to the businesses. I want to start making potato chips that I can also sell in the supermarkets, but I need certification first. I am also using my ground nuts to make peanut butter that I am selling in the markets.”

What are the difficulties selling crops?
“In the markets there is a lot of theft and it is a struggle to always get paid. People quickly disappear in the crowd, but if I had a supermarket to sell too the money would be guaranteed”.

How will you pay for the pump?
“I would not be able to pay the upfront costs, but because aqysta provides a payment over time model I am able to time payments with harvests.”

Technical

What is your current irrigation method? “Currently I am using buckets to irrigate my plot from a gravity canal, but it is really hard labor to properly water the field”

Do you expect there to be any challenges with the Barsha Pump? “I do not expect any challenges with the pump”
How do you expect the pump help you?

“The pump will allow me to grow much more products, and use much more of the land than I am using now. I also want to be able to use the pump on my fathers land as well.”

How big is the plot that you want to irrigate “In total the farm is about 7 hectares. 5 hectares are from me and 2 from my father”

Observational Results

Social Observations

Personal (gender, age group) Talita was a 50 year old women with a very entreprenurial mindset.

Education: Talita was university educated, and a teacher at the local school. For her, education is really important as she has worked to insure that all her children were also going to school. She was always investigating new opportunities for growth by learning how different types of equipment worked on the internet.

Social Standing: She was respected in her community. She was to be the first one to have a Barsha Pump, and the surrounding farmers were waiting to see the success at Talita’s farm before investing themselves. She was also working together with people in the village on NGO’s development business which including manufac-

turing peanut butter and potato chips. Access to external extension services: Talita takes full advantage of the external services available for her. She applied for new initiatives such as the potato chip machine, and the peanut butter manufacturing machine. She finds the opportunities on the internet through global development agencies and takes the initiative to become a part of these development programs. Using the internet she also found the Barsha Pump and wanted to immediately use the pump on her farm.

Economic Observations

Farm size: Her farm was 5 hectares and her father lived next door with an additional 2 hectares which she helped him operate.

Expected gain: She wanted to grow more maize and potatoes. Currently the farm was not being fully used as it was too difficult to water with watering buckets, however Talita was a visionary and expected that the pump could irrigate her entire property and her fathers. She was planning to grow more potatoes to expand the amount of potato chips she could make, she was buying potatoes from her neighbours but wanted to grow them all herself. She wanted the pump so she could buy more land from the surrounding farmers and supply her children with land as well.

Costs: She was unable to pay the upfront costs of the pump her self, but with aQysta's offer to pay over a 2 year period was very empowering for her. She expected to pay this with her harvests. She was clearly capable of making an income as she was able to afford expensive university education for all 5 of her childrens.

Technical Observations

Expectations: Talita's expectations was very misguided. Her farm was between 100-200 meters away from the water source, with atleast 10 m elevation gain. By aQysta advertisement this should be sufficient, however the pressures were much too low to irrigate the plot. And irrigating 7 hectares was definitely not possible. She watched one advertisement and immediately assumed that this pump was the full solution for her farm. She was very excited for the pump and was telling her entire surrounding community about the pump. When asked if she expected any challenges she did not expect any.

Performance: Unfortunately the pump did not work as planned as the pressure was much to low to irrigate her plots. At later contact we learned she purchased a solar pump.

Trialability: -not applicable

A.5. Farm 5: Community farm using solar, treadle and diesel pump, Zomba district- Translated

Interview

Social

Why do you need the pump?
-See technical discussion

How did you find the Barsha pump?

-not relevant for this interview How did you learn to become a farmer?
-See observations

How has communication worked with aQysta?
-not relevant for this interview

Financial

Where do you sell your crops?
"They are only producing crops for eating, and haven't grown any crops for sale. Right now they are running out of food during the year because with their field we can not grow enough for all our families.

What are the difficulties selling crops?
"If they had more money for fertilizer they would be able to grow more crops to begin to sell. But because we have not enough fertilizer inputs we can not.

How did you pay for the pumps you have?
"NGO's have given us first the treadle pump and diesel pump. The diesel pump was very expensive so now we were given a solar pump to use by NGO's."

Technical

What is your current irrigation method? "We are mostly using the solar pump(have diesel, treadle) for watering our crops. If someone is using the solar pump sometimes we might have to use watering cans so our crops don't die".

Have there been any struggles with your current irrigation method "The pump has been a big help, but we are still struggling because of the inputs. We also have pests in our crop that lower our yields. If we had fertilizer and pesticide we could grow more. With diesel it goes very fast, but its very expensive so we usually just use solar."

How have the pumps helped you? "Using the watering cans is very labour intensive, it is not possible to use watering cans over the whole field as it takes too much energy. The water also dries up faster with a watering can than with a solar pump, with solar we can apply enough water on the crops. We still have low production because we don't have enough fertilizer and inputs"

Why did you choose this pump? "They did not choose, ngo gave the pumps to them"

Observational Results

Social Observations

Personal (gender, age group) Large community with a variety of ages. Mostly women were working on the fields, the men were sitting in the village center.

Education: Community was uneducated, much of the community was illiterate, without much access to information. They required help from outside sources like the irrigation officer and NGO's to improve their farming techniques.

Social Standing: This was a large community, that generally seemed neat and organized. Not very commercially minded. Access to external extension services: The community worked frequently with irrigation officers and EPA officers. They also had a lot of contact with NGO's and were given diesel pump, solar pump and treadle pumps in previous years. They were using the institutional network with government assisstance.

Economic Observations

Farm size: 15 ha with many families living on the farm

Expected gain: The technology for these farmers was most considered valuable because it decreased the amount of labor involved. This gave more time for activities and energy saving. Economic gain was not considered.

Costs: -not applicable

Technical Observations

Expectations: These farmers expected the pumps to be given to them, to help mae there lives easier. In many cases it worked as labor was decreased. But expectations were high for anything new that 'could' help.

Performance: The pumps allowed them to water more land and grow more food. This was better than in previous years, however, there was still much progress to be made.

Trialability: -not relevant

A.6. Farm 6: Rhumpi

Interview

Social

Why do you need the pump?
Conventional pumps which need fuel cost more money in the long term. Since there is a fast flowing river relatively close to the desired to be irrigated fields, the Barsha Pump would be suitable to use. The alternative would be manual irrigation which requires significantly more maintenance.

How did you find the Barsha pump?
A farmer from the farming community had seen a movie of the Barsha Pump on Facebook and showed it to the village chief. He then contacted aQysta.

How did you learn to become a farmer?
He has inherited the land and skills of his father, who also was the chief of the village. The farming profession was passed down many generations.

How has communication worked with aQysta?
Not relevant for this interview.

Financial

Where do you sell your crops?
Most of the time crops are sold once a week at local markets.

What are the difficulties selling crops?
No difficulties arise in selling them.

How did you pay for the pumps you have?
The profits gained by selling crops goes to the individual farmer and part of this profit is paid to the community. The collective earnings are then used to pay back the pump in 2 years. Next to selling crops, the community also makes money by selling eggs and they want to start producing and selling goat cheese.

Technical

What is your current irrigation method? Currently, all irrigation is done by either gravity flow or manual irrigation.

Have there been any struggles with your current irrigation method Manual irrigation is labour intensive and gravity flow cannot be applied to fields at a higher elevation than the river. For a large fraction of the field, the latter was the case. A solution would be to buy a conventional petrol/diesel pump.

How have the pumps helped you? The Barsha Pump provides irrigation water for fields that are at a higher elevation which normally needed to be irrigated manually. Replacing manual irrigation will lower the labour intensity and more time will be available for activities next to irrigation.

Why did you choose this pump? The fact that there is a fast flowing river next to the field that needs to be

irrigated makes the Barsha Pump an appropriate pump. AQysta also recommended to use the pump in combination with a reservoir so the field can be irrigated by gravity flow.

Observational Results

Social Observations

Personal (gender, age group) Chief Molongoti was about 40 years old. The community consisted of people from all different ages.

Education: Chief Molongoti is the chief of the farming community. It seems like he and the other farmers of the community are well educated and have financial ambitions.

Social Standing: Chief Molongoti was very well respected in the community. What was noticeable was that the chief had a different appearance than most of the other villagers. He seemed less willing to work along with the installation of the pump. It seemed also that they did not expect the people with the most prestige to work.

Access to external extension services: People in the village were well aware of different NGOs that are engaged in agricultural projects, and thus also from which development projects they could expect aid. The farm had the government install an irrigation system, and students from Australia provided soil moisture content sensors so the farmers could irrigate to maximize efficiency. Also, They almost all have a cell phone and access to internet.

Economic Observations

Farm size: The farm size of chief Molongoti is about 1.5 ha while the average farm size of the other villagers is about 1 ha.

Expected gain: Being able to reduce the amount of labour on the field that was going to be irrigated by the Barsha Pump, gives room for labour on other plots, leading to a possible expansion of the farm. This is expected to lead to an increased income.

Costs: Chief Molongoti seemed convinced that the community would be able to buy off the pump in two years when farmers in the community were putting their resources together.

Technical Observations

Expectations: He expected the technology to reduce the amount of labour needed to irrigate the plots that had a higher elevation than the nearby river, making it impossible to use gravity fed irrigation for these field without a pump. He expected the pump to be able fully irrigate the desired plot and for the pump to be operational up till the end of the dry season.

Performance: After installing the pump, it seemed to be able to irrigate the entire plot with a proper flow velocity.

Trialability: Wanting to test the technology before implementation was not crucial in wanting to adopt the technology. There was a strong believe the pump would work.

A.7. Farm 7: Mr Innocent, Ntchisi district

Interview

Social

Why do you need the pump?
He has a need for a more reliable irrigation system. He always used a petrol pump but this often broke down

and it requires a substantial amount of money for fuel. His field has a gradual slope which makes it perfect for gravitational irrigation. The Barsha Pump could in this case be used to pump up water to a reservoir at the highest elevation of his fields after which fields can be irrigated by gravity flow.

How did you find the Barsha pump?
He first saw the pump working because a friend send him a message about it on WhatsApp. This led him to the Facebook site after which he was “admired” by the pump.

How did you learn to become a farmer?
He has inherited the land and skills of his father, who used to be a farmer. He used to be a taxi driver but is now more content as a farmer.

How has communication worked with aQysta?
He contacted aQysta via Facebook and the communication has been good.

Financial

Where do you sell your crops?
Crops are mostly sold in his own store, on local markets and are sold to vendors who come to pick it up at the farm. Tabaco on the other hand is sold on auction floors in the capital of Malawi, Lilongwe.

What are the difficulties selling crops?
Competition can be pretty tough which causes his profit margins to be fairly low. To also compete for more high quality crops, higher quality seeds are necessary which are too expensive. For the auction in Lilongwe also a substantial entry fee is needed.

How did you pay for the pumps you have?
He expects to be able to pay off the pump in the next 2 years solely by the sales of his crops.

Technical

What is your current irrigation method? The Barsha Pump is currently only being used.

Have there been any struggles with your current irrigation method The main struggle with the Barsha Pump is that he is now using it without a reservoir. To prevent water spillage a reservoir is needed. However, due to financial limitations it is not possible to build a reservoir at the moment. His main struggles with his prior diesel pump was that it is unreliable and it costs substantial amount of money.

How have the pumps helped you? The pump will aid in becoming independent of fuel costs and will make gravity fed irrigation suitable.

Why did you choose this pump? He has also looked into buying a solar powered pump. A reason why he is more interested in the Barsha Pump instead is because a solar pump requires more maintenance and is highly dependent on the amount of sun hours .

Observational Results

Social Observations

Personal (gender, age group)

Education: Mr Innocent is well aware of what is going on in the agricultural sector in Malawi and uses his critical mindset to explore the possibilities for the expansion of his farm.

Social Standing: Mr Innocent is a farmer with an entrepreneurial mindset. He owns a large farm and is looking to expand and diversify his crops. It seemed like his workers respected him because of it.

Access to external extension services: It appears that Mr Innocent is well aware of which external services are available to him, and which irrigation technologies are available and might be suitable for his plot. This is

reflected in the fact that he contacted aQysta on his own initiative.

Economic Observations

Farm size: Mr Innocent's farm size is 30 ha out of which 7 ha is used for crops. Most of the land was inherited from his father.

Expected gain: Mr innocent's goal is to keep expanding his farm, until he has enough capital to start investing in other ventures such as building a lodge for tourism. The Barsha Pump could aid in speeding up this process due to the increase in farming capacity because of the use of a reservoir.

Costs: It seems like Mr Innocent has the resources to pay off the pump in (less than) 2 years. However, he did show to have some difficulties in acquiring sufficient money to build a reservoir.

Technical Observations

Expectations: Mr innocent expected that the pump could irrigate the plot size which was mentioned on advertisements. The furthest he would have to pump the water was about 300 meters with a 10 meter head.

Performance: In order for the pump to work as efficient as possible, the flow rate of the water should be as high as possible. This was the case for Mr Innocent's pump. It was installed underneath a small waterfall which made the pump rotate at a fairly high speed. Still, with this almost "optimal" set-up, the pump could not irrigate the furthest plots of his field, i.e. 300 meters away from the source with a pressure head of 10 meters.

Trialability: He wanted to test the technology before fully putting it to use.

A.8. Farm 8: Ntchisi women group, Ntchisi district

Interview

Social

Why do you need the pump?
To replace current irrigation technologies and to be able to irrigate a bigger plot size.

How did you find the Barsha pump?
The farming community is also working on other plots to earn extra money. They saw the Barsha Pump being used at one of these farms.

How did you learn to become a farmer?
Farming knowledge has been passed down for generations.

How has communication worked with aQysta?
The communication between the farmer group and aQysta has been good. No issues have arisen.

Financial

Where do you sell your crops?
Crops are sold on local markets.

What are the difficulties selling crops?
The group is dependent on vendors coming to the farm and buying the crops. They are not trained to look for market opportunities. They recognized that this is one of their shortcomings.

How did you pay for the pumps you have?
They plan to pay off the pump in 2 years. However, the group is financially not stable. The costs of fertilizer, seeds and livestock expenses are too high.

Technical

What is your current irrigation method? Currently, a petrol pump and the Barsha Pump are being used to irrigate their fields.

Have there been any struggles with your current irrigation method One of the current struggles with the Barsha Pump is that the hoses which are attached to the pump are not long enough and they had to attach another hose to it manually. However, due to leakage the pressure of the water is not sufficient to pump the water at the desired elevation. No major issues have arisen with the use of the petrol pump. However, the costs of the fuel were found too high and an alternative cheaper technology would be preferred.

How have the pumps helped you? On the long term, the pump will save fuel costs and, when used in combination with a reservoir, it makes gravity flow possible.

Why did you choose this pump? To become independent of the high fuel expenses and since they have a plot with a big slope, they wanted to build a reservoir to make gravity fed irrigation more suitable.

Observational Results

Social Observations

Personal (gender, age group) The group consisted of about 18 people, who were predominantly women and varied in age.

Education: Interviewed farmers did not have a university degree.

Social Standing: A community of about 18 people which were working on a farm owned by two guys. Although they were working very hard, there did not seem to be a risk of starvation.

Access to external extension services: The group had market access since vendors were picking up their crops and were selling them at the street and on local markets. They also seemed to have limited access to internet and cell phones. Furthermore, the access to governmental services in the form of irrigation officers was used. Irrigation officers even were willing to provide them with cement to help the community build a reservoir.

Economic Observations

Farm size: The total farm size is around 6 ha out of which 3 ha is used for growing crops.

Expected gain: They expect the pump to be able to replace a substantial amount of their plot which is now down manually. Saving this time gives room to work on other sites of the plot and ultimately should lead to more yield and thus higher income.

Costs: The community seemed very willing to invest in the technology and seemed confident to back off the pump in two years.

Technical Observations

Expectations: They expect the pump to be able to pump water up to the top of their plot into a reservoir. From their the stored water can be used to irrigate by use of gravity flow.

Performance: The pump was working properly although not till the point where they wanted to build a reservoir. Also, the hose was not sufficiently long so they attached a smaller hose to it which resulted in water spillage and a decreased flow velocity.

Trialability: Wanting to test the technology before implementation was not crucial in wanting to adopt the technology. There was a strong believe the pump would work.

A.9. Farm 9: Roseberry Farms, Blantyre District

Interview

Social
Why do you need the pump?
-Not relevant

How did you find the Barsha pump?
-not relevant

How did you learn to become a farmer?
I received training from a program out of South Africa. They trained 100 farmers there. And now they often will come to my farm to offer training to other Malawian farmers.

How has communication worked with aQysta?
-not relevant

Financial
Where do you sell your crops commercially or also to street markets?
"Not to street markets, Roseberry farms does not grow for market but to market. I dont plant seeds unless I have talked to a shop. They tell me what they need, and we come to an understanding. We always grow for a market.

What are the difficulties selling crops?
"For many farmers the difficulty lies in the fact that they cannot grow consistent qualtiy or supply. For example, now everyone grows tomatos and there is tomatos rotting all over the place because they grew to market and not for market. Do not grow unless you know where to sell them. PLus they need quality, they need to be trained. There is no expertise of horticulture. Horticulture is a science. The subsistence farmers do not grow using science.

How did you pay for this operation?
"I was given funding by the Malawin Innovation Challenge Fund." The grants are only 50% of the funding. I have to supply the rest. Through the program they give milestones, and once you reach the milestones they will match your claims.

Technical

What is your current irrigation method?
I currently use drip irrigation outside, and in the greenhouses I use hydroponics.

Have there been any struggles with your current irrigation method
"Yes we have a challenge with clogging in the hydroponics lines, each line has to be individually tested to check if its not clogged.

How do you expect the pump help you?
-not required

Why did you choose this method?
We had bacteria root in our greenhouses, my advisors from south africa told me the only solution was to implement hydroponics. So now we grow into buckets and plastic bags.

Observational Results
Social Observations
Personal (gender, age group)
Female, 45-55

Education:
University education in the United State in finance.

Social Standing:
Individual farmer with much access to UNDP grants, and funding. She is the largest Malawian supplier to the major supermarket chains in Malawi supplying 8.6% of Shoprites stock.

Access to external extension services:
Ruth has full access to cellphone, internet, and uses NGOs to help fund her projects. She is continuing further to develop projects in greenhouses etc.

Economic Observations
Farm size:
3 hectares growing (12 total)

Expected gain:
She wants to help the Malawian people. But her current technology is being used to help further grow crops locally in Malawi rather than imported.

Costs:
She has the finances to pay upfront for small technologies, for larger projects such as greenhouses she works together with NGOs to supply this.

Technical Observations

Expectations:
She is well aware of what technologies performances are capable of. She claims that the only way to grow commercially is to maintain consistency and quality, which is only done by greenhouse. Not by outdoor growing.

Performance:
The technology must be able to grow consistent quality and supply.

Trialability:
Must try before using.

A.10. Farm x1: Commercial farmers Rodney and his wife Missy, Zomba

We went to Rodney's house in the city Zomba and from there he drove with his motor cycle to his farm (20 min). They thus live in the city, use tap water there, and drive up to the farm a few days a week. He wanted to bring his wife as she is the manager of the farm and he valued her opinion. He is also a carpenter and primary school teacher. His wife is a secondary school teacher. They have inherited this farm a few years ago and thought it would be a waste not to use it, so they do it now as a side job with the goal to make profit. They like farming. He already had a Diesel pump irrigating the area closest to the river. We went to his farm to check whether the flow in the river nearby his farm was suitable for a Barsha pump, to irrigate the area higher up w.r.t. the river. The flow was adequate, however not for the area he wanted to irrigate. We advised him to build a reservoir halfway and fill this with water generated by the Barsha pump, and from there he could irrigate higher up using the Diesel pump. He would think about it. They grew all sorts of crops (rip, mustard, tomato, onion, maize, beans, cabbage) the woman was exploring the markets and was looking into selling to restaurants and hotels as well. Right now they did not have to sell anywhere. Remarks:

- They like farming a lot, more than their other jobs
- She is in charge of the farm and he listens to her
- When they had to fill in the puzzle they both filled in other things and she criticized what he filled in. When they got into a discussion, she could argue her choices better and he was sometimes unable to explain why he chose what; seems she had it better thought through.

A.11. Farm x2: Community farm, Domasi, Zomba district

The Barsha pump at this location was installed 8 months previously. The community claimed the pump was not being used as they are still waiting for pipes to connect to the pump. Which according to the company was provided at installation. The pump was clogged by sticks and leaves, also one of the anchors was not secured on the river bank anymore. Hence, the pump was not in the most optimal place.. The community also did not pay off any costs yet, as they did not arrange a payment plan with the community. Remarks:

- The SME has not contacted the farmers about the payment or delivery of the pipes. The office also does not seem to know about this issue (new management team since installation).
- There was no communication from the community to the SME about the situation
- Not clear where they want to irrigate.
- Stream was in a concrete channel, which makes the stream relatively stable in terms of water level and velocity. This is an advantage for the working of the pump.
- The pump was later returned to the head office.

A.12. Farm x3: Checking suitability of pump for Mr Azibo, Dedza.

Mr Azibo used to be an agricultural officer at the Ministery, but mentioned he needed "an early retirement" and therefore he started farming. He inherited the land of his father. He had a Diesel pump but the weekly costs of the pump were so expensive that he cannot make anymore profit and therefore he was looking into other irrigation techniques. He found the advert of the Barsha Pump online, and therefore we came to his farm to check it out. Sadly however, his river was not flowing fast enough for what he wanted, namely to pump the water all the way from his river to his reservoir (150 m further, 15 m higher) so from there on out he could use gravity irrigation. He was disappointed and his next step is looking into the solar pump.

B

Agronomist Interview

B.1. Interview Henry - Lilonwe District

Henry is the agronomist based near Lilongwe we spoke with to determine the GMA.

Interview Henry

What percentage of your harvest is sold in the local market, or supermarkets, businesses?

80 Percent local market,10 percent supermarkets,10 percent supply to canteen and restaurant. targeting 100% Supply to hotels and supermarkets because prices are better than local market

Do you keep your plot size per crop constant? YES

Have you considered expanding certain crops?

Yes,mostly with onions and cabbage because inorder to attain a better profit you are suppose to have good plant population.

Have you searched for other selling locations? Yes For a main distributor? No

How often do you lose your entire harvest due to weather, bad crops?

one cant really know how often weather is uncertainity, with good management you can control bad crop,so yes maybe not that often one loses entire crop.

Do you sell to a middleman distributor? No Do you act as a middleman? No,but in some situation where you are suppose to supply a certain quatity but you dont have enough so you act like middleman to cover your shortfall

What are the main challenges you face selling crops? the prices are not good at some point in time so it become a challenge to cover for your cost

Can you reuse seeds from the crops or do you always have to buy new? Always buy

Other Notes:

with a good system of irrigation one can produce high value crops of good quality that gives reasonable margin/ha and ofcourse with the quality selling cannot be a challenge.

Agronomic Calculations for Select Crops						
Crop	**Yield (kg)**	**$/(kg or unit)**	**Income ($)**	**Costs ($)**	**Margin ($)**	**Plot Size (ha)**
Beans	2500	0.82/kg	1726	648	1079	1
Cabbage	7288	0.27/unit	2013.15	840.80	1172.35	0.25
Cucumber	3750	0.60/kg	2235.10	471.32	1763.78	0.25
Green Mealie	13333	0.07/cob	882.98	195.10	687.88	0.25
Red Onions	16000	0.46 / kg	7417.22	2086.77	5331.15	1
Watermelon	17500	0.66 / kg	11589.40	1059.88	10529.53	0.5

Figure B.1: Potential profitability