

BARSHA SUMMIT

A Product Service System for aQysta

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Design of a Product Service System for aQysta

Master Thesis

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LIST OF ABBREVIATIONS

BM	= Business Model
BMC	= Business Model Canvas
EASI-Pay	= (Enabling Access to Sustainable Irrigation)- Pay
GDP	= Gross Domestic Product
iNGO	= International Non-Governmental Organisation
ITP	= Integrated Turbine Pump
NGO	= Non-Governmental Organisation
PSS	= Product Service System
SBM	= Sustainable Business Model
SDG	= Sustainable Development Goals
SPSS	= Sustainable Product Service System
SWOT	= Strengths, Weaknesses, Opportunities & Threats
UN	= United Nations



Preface

This is the final thesis report 'Design of a Product Service System for aQysta'. The research for this thesis on designing sustainable business models was conducted using the company aQysta as a business case. The research took place at Delft University of Technology and partly in Nepal. This report was written in the context of my graduation project for the masters Strategic Product Design at the Delft University of Technology. Starting 18th of February until November 15 2019 I have been busy doing my research and making a final design to implement a sustainable business model in the strategy of aQysta.

The basis of the assignment for this project was set by one of my supervisors, J.C. Diehl. However, during the research it was more defined and shaped to my own preferences, based greatly on the research studies performed. It was only after the desk research that I defined the research question for the project. During the project a lot of data was collected, which caused it to be complex at times. Luckily, throughout the project, both my supervisors, J.C. Diehl and Brian Baldassarre, helped me when I needed it and answered my questions. This way I was able to continue. Besides my two official supervisors, my third supervisor, Juan Carlo Intriago, who is doing his PhD on a topic closely related to this project, also helped me a lot. Especially in the beginning when I was a bit lost and during the field research in Nepal.

Hereby I would like to thank my three supervisors for their great guidance and support throughout this project. They really supported me through the times when I needed it. By being critical and honest when it was necessary, I was able to achieve a result I am satisfied with. Without their necessary feedback, this report would have been way worse.

Also, I want to thank the aQysta team in Nepal very much for their time, help and great hospitality. They made us feel welcome at the office, provided us with a delicious lunch every day and most importantly, assisted us during the field visits through means of translation and guidance. Without their help I would have never been able to complete this project. Additionally, I want to acknowledge my appreciation to all the people who participated in the co-creation sessions. These are the different organisations: Sunfarmer, Renewable World, USAID as well as mr. Lohanee from the Department of Agriculture and of course the farmers in Lele, Ratamata and Manthali.

Also, my friends and families deserve a special thanks as they gave me great words of wisdom and moral support throughout the whole research. Additionally, they listened to me when I wanted to talk about the project (or anything else) which is very wanted during this period of isolation. I want to give special thanks to my friend Minouk, who helped me a lot during the writing process and with the English translation. Also, I want to thank my cousin Kiki, for the time spent on reading and correcting the report.

Furthermore, I would like to thank Delft Global Initiative for the financial support and TU Delft (specifically JC Diehl) for covering my travel expenses for the fieldwork. Last but not least, I want to thank aQysta for allowing me this great opportunity to do this project and work with their local team in Nepal. It was an incredible experience and the project's case was very interesting.

I wish you a lot of fun in reading the thesis report.

Elsbeth Maas
Delft, November 2019



Abstract

For this thesis, the focus is on aQysta's Barsha pump. aQysta is a Dutch start-up that develops hydro- powered water pumps for irrigation purposes. The Barsha pump uses the kinetic energy of water flowing through rivers to pump water to smallholder farmland for irrigation. The pump requires no external power source and all the energy required comes directly from the flow of the river. It is therefore a highly sustainable alternative to the currently used pumps, using fuel or diesel as a power source. These traditional pumps create greenhouse gas emissions and high operating costs for farmers.

The aim of this thesis is to research and design a Product Service System (PSS) around the Barsha pump. Through a thorough desk research, threats and opportunities for the business model were identified. The main complication was identified to be the fact that farmers do not have a desire to use a sustainable pump if the investment costs are high. Therefore, the PSS should solve this matter by making it more affordable for farmers to buy such a pump. As there are no operational costs when using the Barsha, the PSS can focus purely on the overcoming the high initial costs.

Additionally, the opportunity of implementing a PSS for the Barsha pump was critically analysed. The attitude of the customers towards the service system as well as the simplicity of the service system are critical. If the system is too complicated, farmers are reluctant to use this and the chance of aQysta implementing it reduces significantly. Furthermore, the governmental subsidies for agriculture should be taken into account as this is a great opportunity to overcome the high initial costs. However, these subsidies also create a threat as they cause the farmers to be conceited and no longer willing to pay for any form of service or product.

Fieldwork was performed locally in Nepal to gather data and experiences from the different stakeholders: farmers, the government and possible partners. By communicating with people locally, further opportunities and complications were identified. It was verified that farmers are in great need of financial support for covering the upfront costs. Furthermore, it was identified that the farmers desire training about farming and need a connection with the market. A good designed PSS could help by delivering this.

The fieldwork determined the feasibility of a PSS for the Barsha pump and with the gained knowledge two designs were made. The concept design, Barsha Basecamp was validated by aQysta out of which the final design: Barsha Summit derived. A result-oriented PSS, where aQysta is responsible for the whole value chain and offers farmers a guaranteed income.

The conclusion of this thesis is that the ideal PSS, which is one that makes profit and creates impact on society, *does not exist for this case. Also, too many variables exist which makes it too complex to stick to only one business model.* The final design for this thesis is a sustainable business model that works well in theory, but it is yet to be determined whether it will work in practise as well.

Executive Summary

In 2015, the UN created several different Sustainable Development Goals (SDG) that should be achieved by 2030 (UN, n.d.). These goals focus on improving existing issues in our current society. Among these SDGs, are targets that address climate change, poverty and injustice: three hot topics in our current society. These targets are addressed in the goals: **climate action, renewable energy, no poverty and zero hunger** (UN, n.d.).

These SDGs are embedded into aQysta's culture. The company's strategy and value is to provide sustainable products that improve human well-being without compromising the environment (aQysta, 2019). This Dutch start-up has developed **hydro-powered water pumps for irrigation purposes**. The pumps have the ability to increase the profit and crop yield of smallholder farmers in developing countries by means of providing water for irrigation. Thereby, this company addresses the four above mentioned SDGs. Firstly, the pump is completely sustainable by being **powered purely by the flow of water** in, for example, a river. The pumps are therefore a more sustainable alternative to the existing, fuel powered pumps. Secondly, the pump provides water for irrigation which provides the opportunity for farmers to increase their crop yield and thereby increase their income and living standards. However, the initial cost of these pumps are high and therefore unaffordable for those that would benefit most from these pumps (smallholder farms).

This is where the opportunity for this project was identified: designing a (Sustainable) **Product Service System (PSS) for aQysta** to overcome the initial costs for smallholder farmers in Nepal. A good designed PSS improves their access to the use of aQysta's Barsha pump. A Product Service System is a type of Sustainable Business Model that combines services and products and offers them in one single solution to customers. The product in this case is the Barsha pump. The services are the actions performed to enhance the interaction with the product and provide an economic benefit. The system are the regulations and infrastructure required to make the service possible. The intention of a PSS is to sell the use or result of a product rather than the product itself. By allowing farmers to pay for the use of the pump rather than having to buy the entire pump, this method of achieving irrigated land is more attractive.

The Barsha pump is the flagship product of aQysta. It is a spiral pump with a manometric working principle, meaning that the interaction of water and air inside the spiral create a certain pressure that pumps up the water. The pump can deliver a total of 1667 L of water per hour, up to a horizontal distance of 2 km and 20 m vertically. It has an estimated lifespan of about 15 years which justifies the possibility of long-term use of the pump. The pump requires very little maintenance and can therefore easily be used by multiple people without a large risk of it being out of order for a longer period of time. The costs of a new Barsha pump are around €1000, thus making it too expensive for smallholder farmers to afford.



The focus group of this thesis is chosen to be **smallholder farmers in Nepal**. Smallholder farmers are those who would gain most benefit from improved and affordable irrigation methods, due to their small size, limited profit and openness to cheaper alternatives. Nepal relies greatly on agriculture and any method to increase the total capacity can benefit the country as a whole and reduce the poverty rate. Nepal also has multiple flowing rivers, thereby making it a suitable country of study for this thesis.

After performing a SWOT analysis for the current situation of this case study: aQysta, several interesting takeaways were extracted to be used for further fieldwork. The opportunity and threats were the basis for defining the problem for this project.

Stakeholders are an important aspect of the implementation of Barsha pumps. The reason for this is that stakeholders can subsidise (part of) the pump and/or provide help in the communication between the consumers and aQysta. Furthermore, they can provide training on how to operate and maximise the usage and benefit obtained from the pump. It was determined that the most important stakeholders in supporting the business are the government and NGO's. Furthermore, farmers currently obtain their pumps through third parties. It is therefore an opportunity for aQysta to sell their pumps directly to the farmers.

By combining the literature, company and market analysis the main aim of this thesis is to define ***what additions should be made to the current business model of aQysta in order to contribute to more benefits for the smallholder farmers, other stakeholders and aQysta?***

To support this research question, project objectives have been formulated as follows:
1) to identify the barriers for the farmers to overcome in order to create a preference for the Barsha over any other pumping solution.
2) To identify the needs of the farmers regarding a PSS in the context of farming.
3) To determine the relevant stakeholders for the PSS.
All of this, to *4)* ***deliver a higher Barsha-based value proposition to the farmers, by means of a PSS.***

To be able to answer the research question and the supporting project objectives, **fieldwork was performed in Nepal by means of co-creation on local level.** Co-creation is necessary for good PSS design as it is more likely that the final design will meet customers' needs and expectations. Different methods and tools were used for co-creation, amongst others, interviews were conducted and a Q-study was performed. The outcomes of the co-creation were translated into insights. These insights, combined with the insights and takeaways of the analysis were concluded into the *List of Elements* and *Building Blocks*, forming the basis for the PSS Design.
Upon analysis of the research, analyses and fieldwork, an initial design was proposed named the Barsha Basecamp. This design uses the Nepalese government and NGO's as key players in distributing the pumps and provinding the services. It further differentiates between so-called experienced farmers and inexperienced "NEW" farmers. The government focuses on the experienced farmers and the NGOs focus on the new farmers. The NGO's are key in this system as they are able to connect with new farmers and train them in using the pump. For both the experienced as well as the inexperienced farmers, aQysta provides the installation and maintenance, although, for the new farmers this is done in collaboration with the NGO.

After having analysed the effect of the Barsha Basecamp with aQysta, it was determined that the implementation of this model is risky, mainly due to the effect of involving NGO's. It is preferred to collaborate with cooperatives which invest in the future of the system rather only the start-up and installation. Taking into account the feedback of aQysta reagarding advantages and disadvantages of Barsha Basecamp, an improved design was made, named Barsha Summit.

After taking into account the advantages and disadvantages of the Barsha Basecamp, an improved Barsha Summit was designed. Barsha summit is the final PSS design for this graduation project. The main idea behind this design is offering a value-based model to the farmers. This requires aQysta to shift to a result-oriented PSS, taking care of the whole value chain. aQysta 'sells' the result of a guaranteed income to the farmers.

This PSS is challenging as it requires aQysta to shift from a seller's- product-oriented mindset to a service-oriented mindset. Furthermore, the PSS is highly dependent on the financial aid of a third party, in this case the Government. Without the funding and subsidies, this model requires high initial investment,which is something aQysta cannot afford. However, if aQysta cares to create more impact for the local farmers, then this model could be taken into consideration.

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Reading Guide

This report is structured in six main sections. These sections serve as a guideline throughout this report and are all labelled with a different (tone of) colour. All through the report the coloured tabs on the right side will give the reader a guide-line to what section is currently being read. The order of the sections is based on the order of the project structure, shown on the right page.

Section 1 : Setting
In this first part of the report, the project is introduced. It is divided into three chapters., The first part provides an explanation on the relevance of the project. Then some relevant background information is given and last the project brief is presented. In the background information chapter, basic knowledge about aQysta, agriculture and Nepal is given.

Section 2: Analysis
Section 2 aims to give a better understanding on the different analyses that were performed. The first analysis that was done is a thorough literature analysis (2.1 Literature Analysis) of sustainable business models, thus Product-service Systems. The second analysis is the market analysis (2.2), in which the agricultural market in Nepal was analysed. The last chapter of this section (2.3), contains the company analysis of aQysta.

Section 3: Problem Definition
In this section the problem is defined (3.2 Problem Definition) based on the findings of the previous sections. Furthermore, the research questions (3.3 Research Questions) are formulated, followed by an approach to answer these research questions (3.4 Approach)..

Section 4: Field Work
The section Field Work explains what the goal of the field work (4.1 Goal & purpose of field work) was and what methods were used for the co-creation (4.2 Methods for co-creation). After the explanation of the different methods, the outcomes (4.3 Outcomes& Evaluation) are given. Lastly, this chapter contains a conclusion (4.4 Conclusion) which is presented in a List of Elements and as Building blocks to be used for the design of the business model.

Section 5: Concept Design
Using the building blocks, which were introduced in the previous chapter, the first design was made. A description of this model, Barsha Basecamp is provided in 5.1. This model was later validated and evaluated (5.2 Validation & Evaluation) by aQysta.

Section 6: Final Design
In this section the previous design is improved upon by developing a second model for aQysta, based on the validation from the previous chapter. This model is described, amongst others by using a Business model canvas. The section ends with a conclusion (6.3), which gives a final recommendation and answers to the research question(s).

At the end of each chapter and/or section, the conclusions are given along with **takeaways** for the project. These takeaways are put in coloured blocks for easy recognition.

Quick route
Are you in a rush?

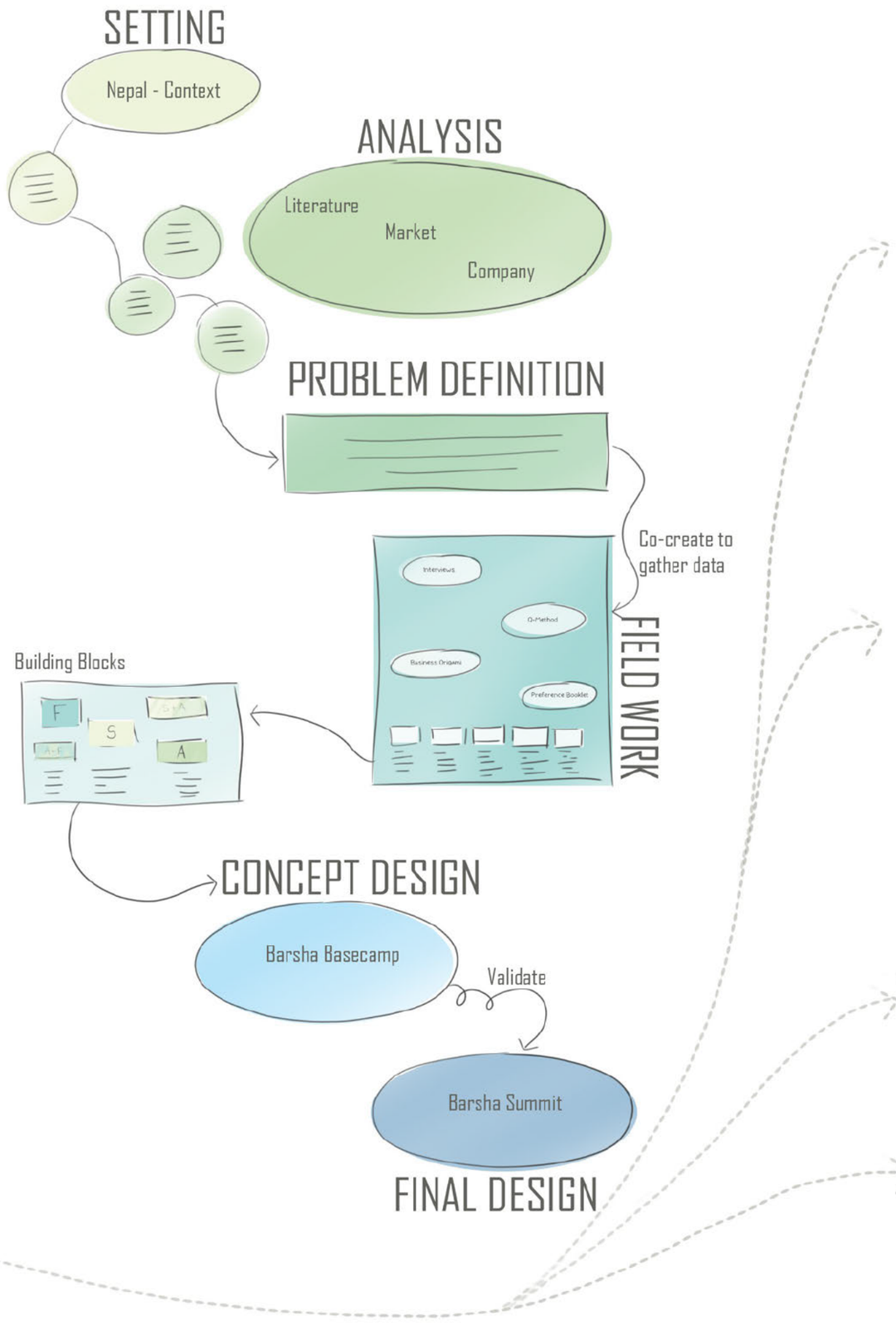
If you want to know about the **project brief** go to page 31.

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If you want to see and read about the first PSS **design** go to page 103.

If you want to know about the **final Design** for aQysta go to page 112.



1. SETTING



This section gives the introduction to basic knowledge required to understand this project. First the relevance of the project is explained. Additionally, relevant background information is given to obtain a full understanding of the scope of the project and its aim. The project brief and the goal of the project are presented and discussed in the last part.

1.1 Relevance

This chapter explains the relevance of the project for aQysta and how it relates back to the sustainable development goals of the United Nations (UN) (Figure 1).

The Sustainable Development Goals (SDG), set by the UN, are goals for achieving a "better and more sustainable future for all" (UN, n.d.). The goals address challenges related to, among others, worldwide climate change, poverty and injustice. The goals are to be achieved by 2030. In order to achieve these goals as a society, many companies strive to implement them in their core business strategy, just like aQysta.

aQysta's mission is '**innovating for impact**' and their products address **four different Sustainable Development Goals.** The relevant goals for aQysta are listed below, where goals numbers 1 and 2 are related to energy and goal numbers 3 and 4 are related to improving people's lives.

Sustainable Development goals :

1. Climate Action
2. Renewable Energy
3. No Poverty
4. Zero Hunger

The temperature of the Earth's atmosphere is ever increasing, causing significant changes to our climate, thereby being the important driver for the UN setting the SDGs. The main cause for this are the CO^2 emissions that have reached a global concentration of over 400 ppm (Our World in Data, n.d.). There is a clear need for change to limit these emissions from increasing even further. Many companies, countries, organisations and individuals are working on making their businesses and lifestyle more sustainable as an attempt to reduce the effect on the climate. However, there is still a lot of work that needs to be done.

aQysta has implemented goals number 1 (Climate Action) and 2 (Renewable Energy) in their core business by making a product that takes immediate action regarding climate change and the use of renewable energy. The Barsha pumps eliminate the use of energy as a whole by using purely the flow of water as an energy source and therefore reducing the harmful greenhouse gasses which are otherwise emitted when using fuelled pumps.

Policy makers in high income countries are attempting to reduce the effect on the climate by implementing laws to limit the greenhouse gas emissions. These laws push companies and other emitters to adapt their business plan and use sustainable routes to achieve the same goal. However, low income countries are more hesitant to this change, mainly due to the financial aspect of sustainable alternatives. As the emissions of greenhouse gasses is also present in these countries, support is needed to stimulate change in these areas of the World.

Regarding the SDGs that improve people's life standard, aQysta addresses 'No Poverty' and 'Zero Hunger'. Agriculture is a big part of the national

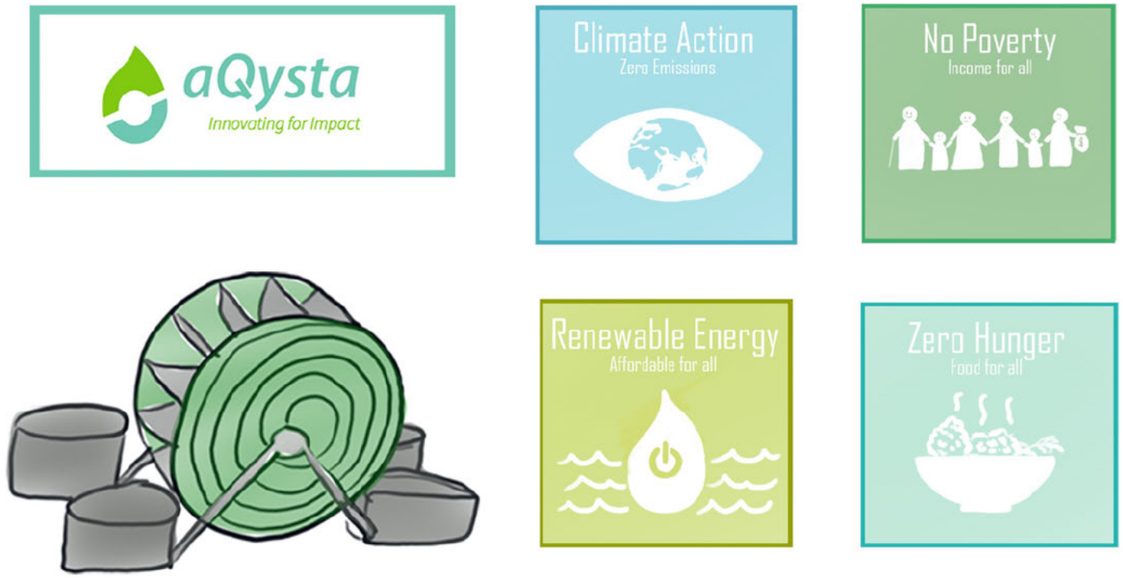


Figure 1: aQysta & Sustainable Development Goals

income of many low income countries. It has been identified that **irrigation increases the production from agriculture.** However, water is required to irrigate land. Low income countries often deal with a scarcity in water supply in, for example, dry season. For this reason, farmers use pumps to transport the water from a source to the farmland. Currently, traditional pumps are used that require fuel or diesel to power the pump. Naturally, these technologies emit greenhouse gasses, contributing to the ever-increasing concentration in our atmosphere.

That is where aQysta identified an opportunity. It combines all 4 SDGs mentioned above, to create sustainable pumps to irrigate farmland. They developed two different pumps, of which the Barsha pump is currently the most widely used pump. This pump uses the energy of flowing water to pump water to farmland, requiring no external power source and thereby emitting no greenhouse gases. This is a completely sustainable alternative to the traditional pumps, using fuel as energy source. The additional advantage to this technology is that it is not only suitable for low income countries but it can be used worldwide. Furthermore, the costs of operation are very limited, creating a huge advantage for farmers. Also, the pumps' power source is reliable , as it runs on hydro-power. The only constraint is that the pump requires a flow of water. That is why the focus is currently on Nepal, where there are a large amount of flowing rivers and irrigation will stimulate the agriculture, contributing to 70% of the nation's Gross Domestic Product (GDP). More on aQysta and their pumps can be found in the company analysis chapter (*2.3, page 58*).

Even though the pumps have no operating costs, they require a large initial investment. This naturally creates a complication for many farmers in developing countries, as financial issues, such as low savings, lack of access to credit/loans, are their main restriction. These farmers have no interest in switching to sustainable alternatives if it requires more money.

That is why the aim of this thesis is to **create a Product Service System (PSS) to seek new business opportunities for aQysta** to implement the Barsha pumps. An PSS can help with making the Barsha pump affordable for all. The target group of this thesis is chosen to be smallholder farmers, due to their need for irrigation. Governmental institutions and Non-Governmental Organisations (NGO) are important stakeholders due to their investment opportunities and possibility to aid in the communication with farmers. To further define the goal and focus of this project, more detailed background information is given in the next chapter on Nepal (the country of focus), the company (aQysta) and a market analysis. Fieldwork is a large part of the process in designing a PSS for this project hence the information provided in this chapter is essential.



1.2 BACKGROUND INFORMATION

This chapter gives a better understanding of the background of the project. First the company aQysta will be briefly introduced. Then background information on agriculture is given and last but not least, the context of Nepal, the country that was visited for the fieldwork, is explained.

1.2.1 aQysta

This part first briefly introduces the company aQysta, that was used as business case for this project.

aQysta is a start-up located in YES!Delft, which is the largest high-tech incubator in Europe. aQysta was founded in 2013 by three engineers from TU Delft, namely: Pratap Thapa, Lennart Budelmann and Fred Henny.
Apart from the three co-founders, the aQysta team consists of employees and partners from different countries of the world. Their main base is in Delft, however, they also have local offices in Kathmandu, Nepal and in Malawi (fig. 2). Nowadays the aQysta team consists of approximately 30 employees. With the help of all employees, aQysta has managed to grow from a small start-up to a successful business in just a couple of years. Their award-winning hydro-powered pump, the Barsha, designed to help farmers near rivers cultivating their land, was the main reason for this success. aQysta is operational in many different countries. Besides Nepal and Malawi, their pumps are used in, among other countries, Spain, Turkey and Indonesia, but they sell their products in even more countries such as Turkey, Colombia, India and Zambia.
The name aQysta was derived from the Quest for Water, or in other words: Quest for Aqua. The two words, aqua and quest combined have formed the name: aQysta (Thapa, 2015). More about aQysta can be found in the company analysis (*2.3, page 58*)

The aim of aQysta is to provide sustainable alternatives for farmers to irrigate their land in an attempt to reduce greenhouse emissions that arise from the use of fuel powered pumps. In order to further indicate the worldwide need for aQysta's products, agriculture and irrigation are defined in detail in the next part. Later on, these are further explicitly explained for Nepal (the country of focus of this project) specifically in chapter 2.2 (*p. 46*). By doing so, the project description and scope will be further defined.

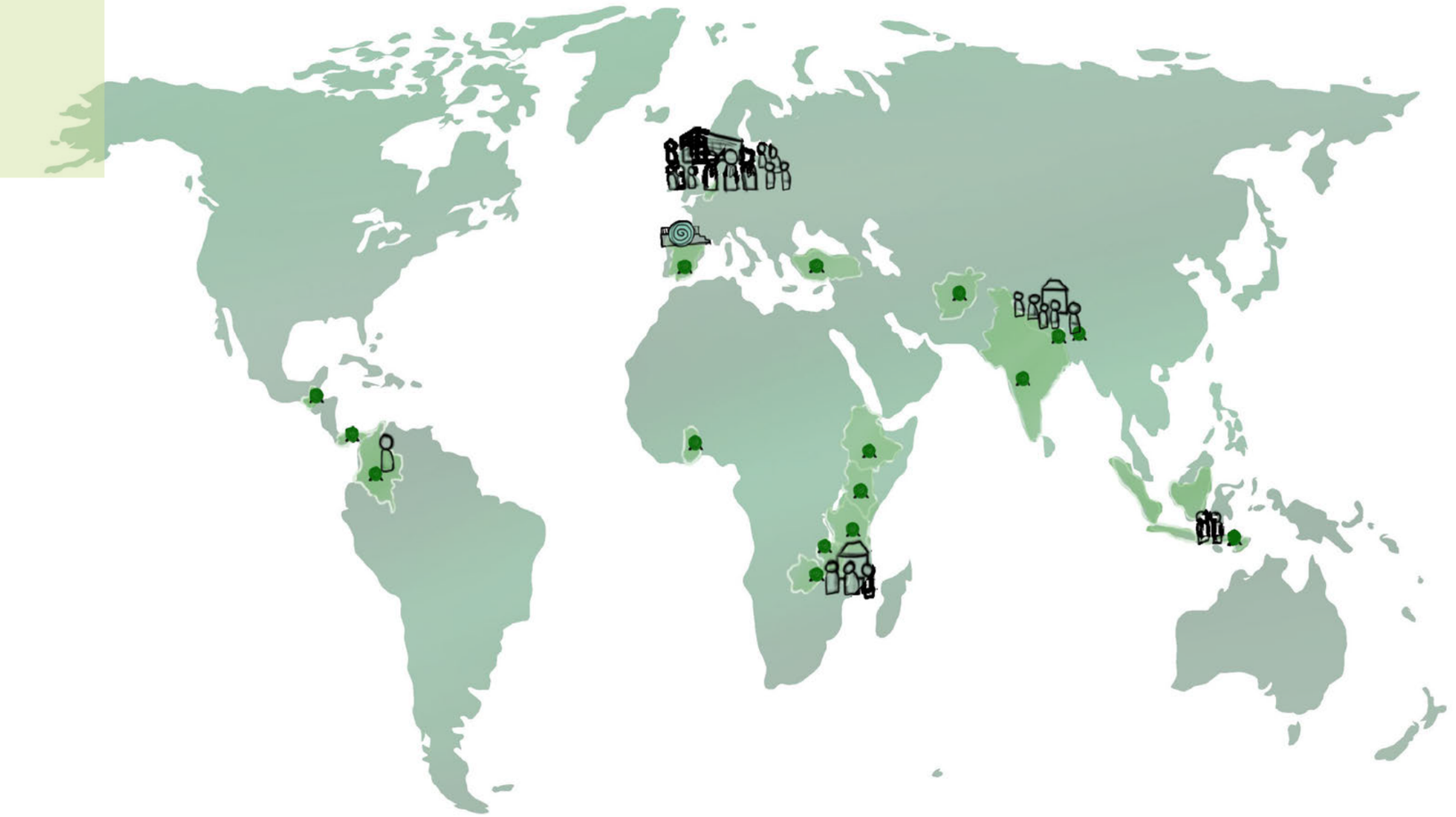


Figure 2: aQysta Installations

1.2.2 Agriculture

This part first explains what is understood to be agriculture ,thus agriculture in general Then small holder farmers are explained, since smallholders in Nepal are the target group for this project.

Agriculture is a broad term, which is commonly defined as *the science of the growth of plants and animals as a purpose for human consumption* (Ramprasad, 2016). Agriculture is an umbrella term, covering multiple activities, such as irrigation, cattle farming, organic farming, etc. (King, 2018). Another term that is widely used, which is commonly confused with agriculture, is farming. Farming is the activity or business of growing crops and raising livestock (Venugopal, 2015). It includes all activities of crop cultivation, rearing of cattle etcetera. (Hedge, 2015). Furthermore, "*agriculture involves a community network of people involved in this field, from food scientists and machinery supply stores to the farmers and ranchers themselves"* (Difference Between, 2019). On the other hand, farming is a more individual practice involving an area of land with buildings, which is used to grow crops and/or rear animals for human consumption.

Finally, the definition of irrigation is important for this thesis. Irrigation is a supplement to agriculture and is defined as *the artificial supply of water for agricultural needs*. This water supply *assists the production of crops* (Hedge, 2015) through various systems of tubes, pumps and sprays (CDC, 2016). Rainfall and floods irrigate lands in a natural way but in many cases the fields of land do not receive sufficient rainfall to perform as desired. Due to the limited amount of water received, irrigation allows the soil to recover efficiently and receive the required nutrients in a natural way, allowing the quality of the crops to be maintained. Besides the purpose of cultivation, irrigation is also used for other techniques such as sewage treatment and maintaining landscape (King, 2018).

Market description

Regardless of agriculture as a purpose of growing crops, spices, humans have been cultivating and exchanging for centuries. Agriculture remains to be a vital part of today's industry as it contributes greatly to the total World's GDP (Difference between, 2019). **Worldwide**, there are approximately **330 hectares of land used for irrigation**. The water used for agriculture accounts for approximately 70% of all water withdrawals (Worldbank, 2017) and roughly **75% of the people** living in **rural areas are dependent on agriculture** for their means of living (Ramprasad, 2016). Irrigated agriculture represents 20% of the total cultivated land but contributes to 40% of the total of food produced worldwide, indicating the benefit of irrigation. Thus, water in agriculture plays a significant role in global food security.

It is expected that agricultural production must expand to 70% by 2050 to sustain the estimated increase in world population to over 10 billion people. Given that **irrigated agriculture is at least twice as productive per unit of land,** it allows a more secure crop diversification and it provides an important buffer against the increase in climate variability. Improved soil and seeds will be more efficient when they are matched with improvements in water delivery systems to provide on-demand service (Worldbank, 2017).

Small holder farmers

In this thesis, the agricultural focus is on small holder farmers and not on large commercial farms. Therefore, small holder farmers are defined in detail. According to the Food and Agricultural Organisation of the United Nations (FAO), smallholders are "*small scale farmers, forest keepers, fishers who manage areas varying from less than one hectare to 10 hectares. Smallholders are characterized by family-focused motives such as favouring the stability of the farm household system, using **mainly family labour for production** and using part of the produce for **family consumption***" (FAO, 2012). However, small farms are mainly defined as farms with **less than 2 hectares** (Ha) **of land**. The small farm sizes have significant productivity differences across countries, due to soil quality, technology and irrigation. Generally, small farms in Asia are irrigated, while African and Latin American agriculture is mostly rain fed (Tisdell, 2011; Rapsomanikis, 2015).
In many countries, only 40% of smallholders' incomes is obtained through agriculture. Since agriculture is dependent on climate (e.g. droughts or floods), families seek employment outside the agricultural sector to ensure a year-round income as the earnings from agriculture is not enough to cover basic family needs (Rapsomanikis, 2015).

There are approximately 500 million smallholder farms in the world, sized less than 2 Ha each. These farms operate on 12% of the world's agricultural land (Lowder et al., 2016) and produce 80% of the food that is consumed in Asia and Africa (Bayer, n.d.). As a group, these smallholder farmers are amongst **the poorest and most marginalized people** in the world (ASFG, 2013). A share of their agricultural production is often devoted to self-consumption, hence a higher level of own-consumption usually implies lower revenues (Khalil, FAO, 2016).

The smallholder farmers are on the front-line of dealing with the impact of climate change and hence they play an important role in addressing the challenges of climate change, but also of food security and poverty reduction due to their dependency on scarce natural resources (ASFG, 2013). Therefore, the more assistance offered to these farmers, the more they can help their communities in providing food (Bayer, n.d.).

1.2.3 Nepal

This part focuses on the areas required to perform proper fieldwork in Nepal in a specific perspective for this thesis.

Demographics

Nepal currently has a population of approximately **29.9 million people.** The population density is 203 people per km2 and for this reason Nepal is in the top 50 of most populous countries.
20% of the population lives in urban areas (ca. 6 million), whereas the larger part of the population lives in rural areas (approximately 80%). Although this is a large amount, it has decreased since 1960, when 97% of the population lived in rural areas. This clearly shows how Nepal is growing, but it perhaps also has to do with decreasing living conditions in the rural areas (World population review, 2019).

The health conditions in Nepal are poor, causing a low life expectancy of 70 years (in comparison to 81 in the Netherlands) (World population review, 2019). The main cause of these poor health conditions are due to the lack of drinking water and sanitation. The growing population is placing stress on the available water sources (Kharel, Dhakal, & Poudyal, 2014).

Language & culture

The main language is Nepali and even though most inhabitants of cities are also capable of speaking English, the population in rural areas merely speak Nepali and/or their own local language (Bezemer, 2017).
Nepalese people tend to value hierarchy within their work structure, while also valuing religion, respect and equality. The origin of this cultural aspect is due to the previous presence of the caste system (The longest way home, 2012). On the other hand, they find individualism less important; **they like to work in groups** towards a shared goal and prosperity.
In many Nepali households, women are responsible for water fetching, cooking and washing. This is generally done by a group, since there is a strong need for company in Nepalese culture (Culture of Nepal, 2006). Furthermore, it is part of Nepali culture that men do all the work (business), hence being a working woman in Nepal can be difficult.

Agriculture in Nepal

Agriculture is the biggest sector for employment in Nepal with approximately **65% of the inhabitants being involved in agriculture** and nearly 80% relying on it in some way. It is the main source of food, income and employment. Nonetheless, merely 20% of Nepal's surface, which is approximately 2.8 million hectares (Mha), is currently being used for cultivation (MoAD, 2015; World Bank, 2019). A mere 1.3 Mha of agricultural land has irrigation facilities and most of the used irrigation systems are small and medium-scale (Climate & Development Knowledge Network, 2017). **Farmers have an average of 0.8 Ha** at their disposal (Sharna, 2018). Agriculture dominates the economy, as it is **responsible for 33.1 % of the total GDP of Nepal.** Thus,

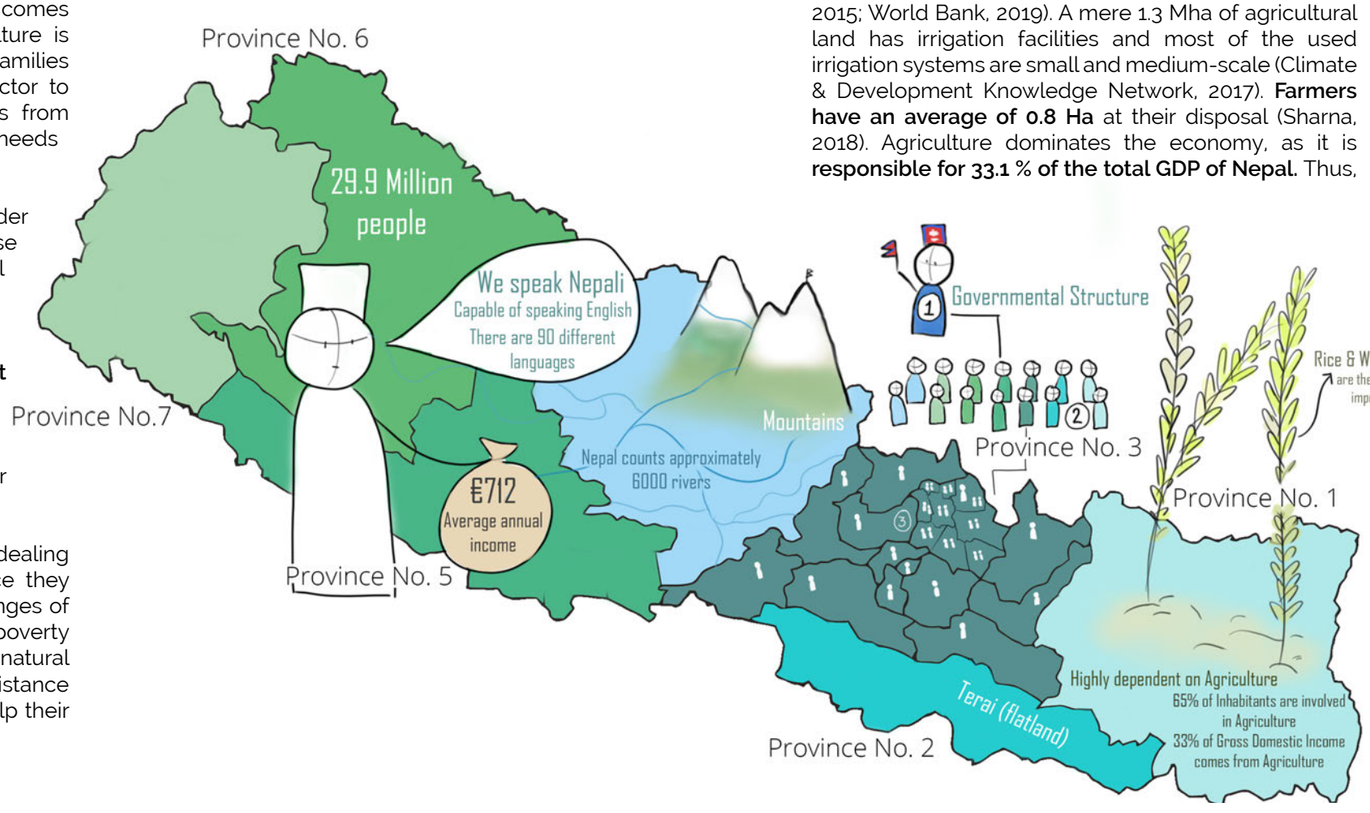


Figure 3 : Nepal context + government structure

this sector is of significant importance for the Nepalese Government (World Bank, 2019). The government is trying to increase agricultural production by providing this sector with subsidies (Savada, 1991).

The largest concentration of land is being controlled by a few people. Many Nepalese make just enough money to sustain themselves by working in other people's fields (Globalgiving, 2019). However, there is currently **not enough production to serve the total population**; food insecurity and malnutrition are very common (Hibbett, 2018). Therefore, agriculture in Nepal is in need of assistance in order to be able to support the local population with stable and efficient production.

Crops

The most important crop in Nepal is rice due to its abundance in Nepal and the daily consumption by inhabitants (Kumar Karki, 2015). Other main crops are grains, such as paddy, maize, millet and wheat (Government of Nepal, 2014) as well as bulbous crops, potatoes, palm seed and spices (CBS, 2013). Every crop has a varied amount of water required for it to grow. For example, for this reason it can be wise to switch between, respectively rice and wheat between the wet and dry season. For the aforementioned reason, organizations help by educating farmers on switching crops between seasons, but also on switching between vegetables that can be cultivated over a shorter timespan (Hibbett, 2018).

The ability to cultivate crops varies due to the presence of different climatic regions of Nepal. Terai, the flat land of Nepal, is the best crop-yielding area, with a sub-tropical climate. This climate supports the production of rice, wheat, barley, oil seeds, jute, tobacco, indigo and even opium. In the hilly areas of Nepal, farmers are able to produce different crops during different seasons. In the summer they can produce rice and maize, while in the winter vegetables, wheat, barley and mustard are grown. The mountainous regions of Nepal have always been difficult for cultivation. Only potatoes, barley and buckwheat are produced here. Therefore, inhabitants in the mountainous areas rely on livestock for food and income from producing yoghurt, cheese and eggs (Hibbett, 2018).

Geographical Characteristics

Nepal is located in the Himalayas and home to many of the World's highest mountains. It is landlocked between China in the North and India in the South, East and West. The total surface area of Nepal is 147,181 km² (World population review, 2019), which is almost 3.5 times larger than The Netherlands.

Nepal is mountainous and is located against the Himalayas to its North-Eastern border. From North to South Nepal the geographical features change from the higher Himalayas with rocky and icy peaks to the lower Himalayas, high mountains and valleys with their more fertile soils of earth and clay. Lastly there are the lower flat regions (called Terai) with their subtropical forests and humid weather (Worldatlas, 2017).

There are approximately **6000 rivers in Nepal**, which accumulate to a total length of 45,000 km. These rivers can be reliable sources of water for irrigation (Water Environment Partnership in Asia, 2018). The Ghaghara is the longest (1080 Km) and also runs through India and China. The Ghaghara river provides Nepal with hydro-electrical power. Bheri is the longest river within the country, with a total length of 264 km. The Bheri river is a source of living for the Bautes people, because of all the fish in it (Worldatlas, 2017).

Climate

A year in Nepal has 5 seasons: summer, monsoon, autumn, winter and spring (Welcome Nepal, 2019). However, due to the recently big effects of climate change, the duration and timing of these seasons is becoming less exact. Additionally, the seasons can be experienced differently depending on the altitude and other geographical features. The changes affect the farmers living in midland (between 1200 and 2000 meters) the most (Dixit, n.d.). The average annual rainfall in Nepal is 1600 mm, which also varies by ecoclimate zones (Welcome Nepal, 2019).

The five different seasons can be roughly divided into four periods:

Summer/ Monsoon : June- September

During the monsoon, the rainy season, 80% of annual rain falls down. The summers in the North of Nepal are mostly cool while in the South mostly experiences tropical climate (Welcome Nepal, 2019). **During this period, most of the agricultural work is performed**. However, the monsoon also causes disturbances. It can wash away nutrients in the soil, causing the land to become less fertile or even cause larger floods.

Autumn/ winter : October- December

In this period the weather is clear and cool as the rainy season has stopped and the winter starts.

Winter/ spring: January – March

In the North of Nepal the winters are severe, while in the South the winters are milder (Welcome Nepal, 2019). **The winter is** also **the dry season**. The dry season can cause rivers to shrink into tiny streams. From an agricultural point of view, this season can be disastrous because **more than 65% of Nepal's agriculture is rain fed** (Dixit, n.d.). Farmers in western midland areas are affected most by this dry season. **In this season irrigation is of great need** for farmers to maintain good production levels.

Spring / Summer / Monsoon :April- June

Between April and June, the dry season changes back into the rainy season. The weather conditions vary the most in this period and many short periods of heavy rainfall occur (Housingnepal, 2013).

Infrastructure

The infrastructure in Nepal is very limited. Most roads are unpaved and in a bad condition, especially in rural Nepal (Worldbank, 2016). A mere 53% of the total road network of 42,000 km are paved roads (Ledesma, 2017; Trading Economics, n.d.). This causes problems with logistics, concerning products to be delivered to and from farmers.

There are several issues with regards to electricity in Nepal. The main concern is that the generation capacity of power at peak hours is too low for the demand and a mere 76% of the population has access to energy. This often causes electricity blackouts for many households (EnDev, 2018). However, nowadays, many places produce spare energy by means of generators running on petrol or diesel. This brings along another complication as these generators are dependent on the availability of petrol, which is not produced in Nepal. Hence Nepal is dependent on its neighbouring countries, India and China, for its fuels.

In order to upgrade the country's infrastructure, the government, private sectors and different international organizations (eg. World Bank) are investing money in the country (Ledesma, 2017; Worldbank, 2016).

Governmental Structure

The government structure in Nepal is quite complex. There is not one centre of power but there are a lot of different ministries, all with their own centre of power. In 2008 Nepal was declared to be a **federal democratic republic**, which ended the 239-year old monarchy. The federalism decentralizes power and authority (Sharma, 2019; Interactions, n.d.). Where previously all power centres were concentrated in the Central Government (centralized state), the **power is now divided over three levels of Government**.

The three levels of Nepal's newest federalist government are : (1) **Central/Federal Government**, (2) **Provincial/State government** and (3) **Local governments.**

1. The central government is located in Kathmandu and is the main government in Nepal. The central government has a president, who is the titular head of the state. Additionally it has a prime minister, who is the chief executive.
2. There are seven provincial governments or state governments (related to the seven provinces shown in figure 3). Each state has a governor and a chief minister.
3. Nepal has 77 districts and within every district there are local governments, with a total amount of 753. All local governments are autonomous and have their own powers as defined by the constitution. Every local government has a mayor and an administrative



officer. For each of the 77 districts there is a District Coordination Committee, undermined to the local governments, which is there to coordinate activities of several local governments (Karki, 2018; Sharma, 2019).

Economy

Nepal is seen as one of the least developed countries in the world and is the **poorest country in South Asia.** Approximately 25% of the population lives below the national poverty line. This group consists mostly of **farmers living in areas which are exposed to risks such as drought and ground infertility** (Trading Economics, 2016). The average GDP per capita is €648, which is comparable to countries such as Mali and Uganda (World Bank, n.d.). The annual GDP of Nepal was €21.8 billion in 2018, which is only a fraction (3%) of the GDP of the Netherlands, namely €735.3 billion. The Gross National Income (GNI) per capita is normally used to get a better understanding of the average salaries. The **GNI per capita in Nepal is €712** relative to € 41,785 in the Netherlands (World Bank, 2017)[2].

Takeaways for the project

From the given background information some takeaways for the project can be drawn:

- For the fieldwork, the biggest complications in communication that may arise are due to language and cultural barriers.

- In Asia, men are predominantly the farm owners, even though there is a large female workforce (Nelleman, 2011).

- It is important for Nepal to increase its agricultural production and hence aQysta and its Barsha pump is highly relevant to the country, because, among other reasons irrigated agriculture is at least twice as productive per unit of land. The design of a Product Service System could make the service of aQysta more suitable to the small production farmers and available for the poorer.

- Providing farmers with education on farming can be a valuable service factor in the final PSS. It can be wise to switch between, for example, rice and wheat between the wet and dry season, respectively. Organizations currently also help by educating farmers to switch crops between seasons, but also to switch to vegetables that can be grown in a shorter period of time (Hibbett, 2018).

- It can be highly relevant for the farmers with no or limited access to fuels and electricity to use the pumps aQysta has developed, which require no use of any source of power.

- It should be kept in mind that the accessibility of remote areas can effect the flow of the value chain of the business model in rainy season. For example, due to bad unpaved and sometimes even flooded roads, farmers can be limited to reach the 'market' to sell their harvest and the other way around; aQysta or another party is limited in reaching the farmers.

- In order to increase the income for farmers the Barsha pump can be highly relevant, especially because it operates with zero additional costs. This would not only benefit the farmers but also the country as a whole by increasing the average income and GDP.

- **Irrigated agriculture is at least twice as productive per unit of land,**

- In general, smallholder farms use ***mainly family labour for production*** *and they use part of the produce for* ***family consumption***"





1.3 PROJECT BRIEF

The project has been introduced in relation to the company aQysta, the definition of agriculture and irrigation and the application to Nepal specifically. In this chapter the project is defined and the goal, the process, stakeholders, deliverables and the project stakeholders are given.

1.3.1 Goal

The aim of the project is to design a (Sustainable) Product Service System to make the use of a sustainable pump for irrigation, the Barsha, more affordable for smallholder farms in Nepal and by this means also more attractive. Currently, the smallholders are not able to buy the Barsha without government subsidies due to its high upfront cost. The PSS should be easy to implement in Nepal, meaning that it does not require a drastic change in farmers' and government's behaviour. Based on aQysta's slogan: "Innovating for impact", the goal is to deliver a business model that creates value for all stakeholders.

The scope of this project is initially to focus on the implementation of a **PSS for the Barsha pump for smallholder farms in Nepal**. The focus for this research remains purely on Nepal and other countries are not analysed in this project. Therefore, these possible modifications for implementation in other countries are also not given, due to time restrictions. Furthermore,the choice was made to focus purely on the installation of aQysta's Barsha pump. aQysta has also developed other pumps, however the Barsha pump has been identified to be the most suitable for smallholder farms in Nepal and is fully developed.

1.3.2 Process

The project is structured as follows. Firstly (1), a thorough background research is done. This research focuses on the context, literature about PSS and business models, on the market and finally on the company aQysta. Using this acquired knowledge, the (2) problem was defined and based on the problem definition the project objective was formulated/ research question(s) were formulated. In order to gather data for answering th
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business models for aQysta, additional information was captured through the means of co-creation workshops and interviews. After finishing the field trip, the gathered information was concluded into (4) a list of requirements and then transformed into a (5) new PSS business model for aQysta. In the end, this model was evaluated by aQysta and in the final recommendations a (6) second design is given together with an advice implementation. Figure 4 pictures the structure.

1.3.3 Deliverables

The final deliverable for the project is a Business model concept, based on PSS principles. This model is going to be the conclusion of the earlier research combined with findings of the field research. The final concept is visualised using a system map and a Business Model Canvas (BMC). It will give an advice for the long-term, including recommendations and an implementation roadmap.

Deliverable 1 : PSS business model (visualised in a system map & BMC)
Deliverable 2: Implementation plan

1.3.4 Stakeholders

Based on the introduction given previously, four main stakeholders were identified. First of all the company **aQysta** is a main stakeholder due to their product: the Barsha pump. They deliver and produce the pump. Secondly, the **farmers** are stakeholders due to the fact that they are the ones that will be using and paying for the use of the pump. Next, the **government** subsidises many of these pumps and it is assumed this will continue in the future. Therefore they have a large influence on the installation and use of these pumps. Finally, non-governmental **organisations** facilitate the communication between farmers and aQysta. Additionally, they help with the full implementation of the product. A more detailed description of the different stakeholders will be given in part 2.3.3.

The original project brief deliverable can be found in

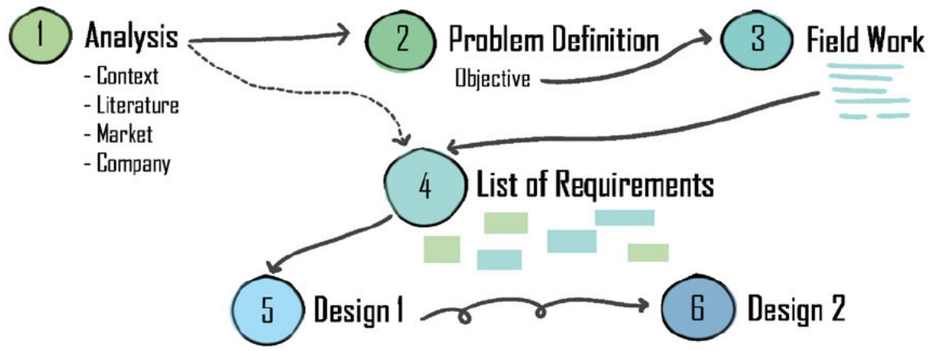
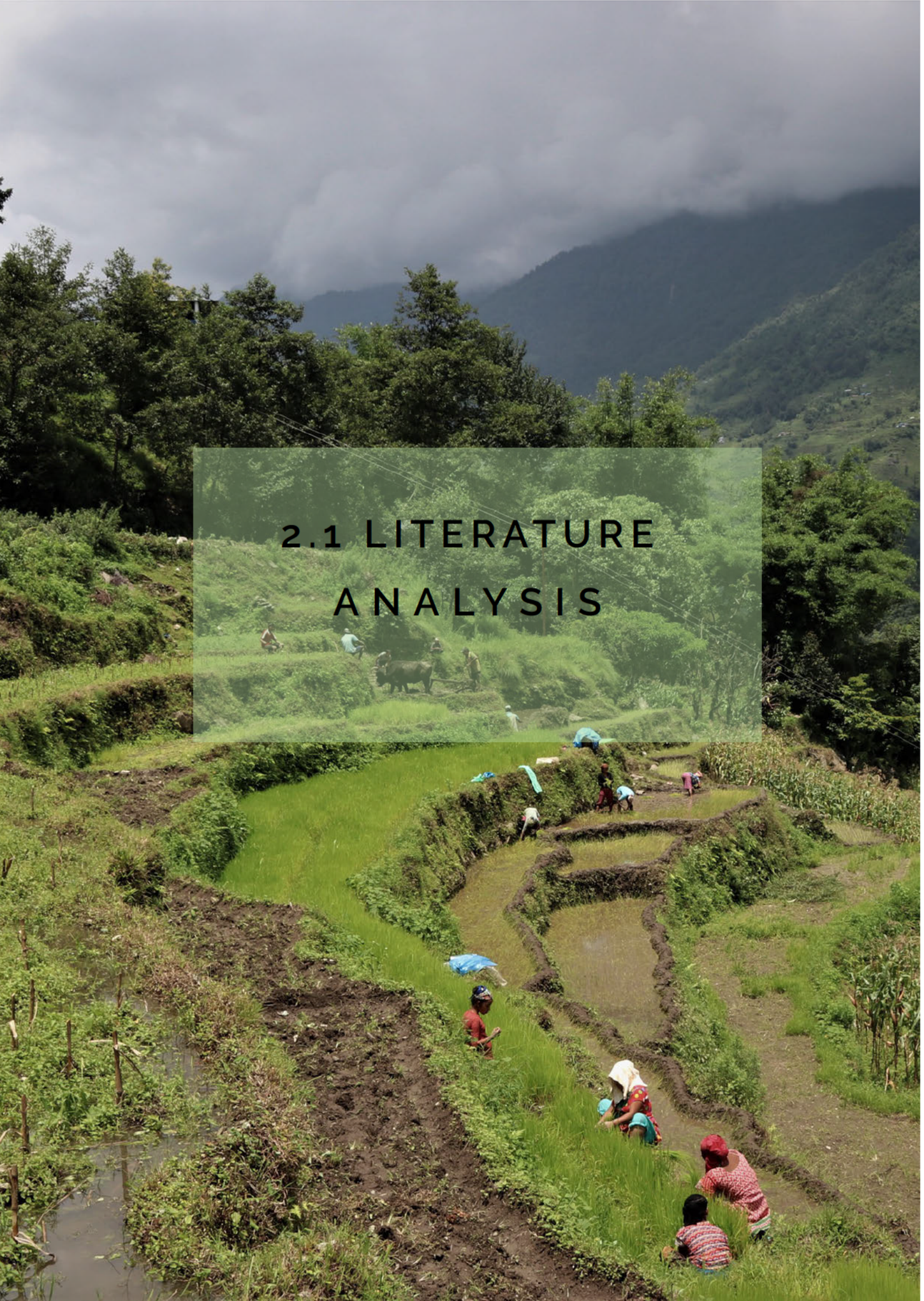


Figure 4: Project Structure

2. ANALYSIS

LITERATURE, MARKET & COMPANY



2.1 LITERATURE ANALYSIS

Sustainable Business Models (SBM)

To attain a better understanding of how to characterize a Product-Service System and implement this in a Sustainable Business Model, it is important to go back to the roots of these concepts. This chapter therefore starts with a definition of these concepts, first describing what a Sustainable Business model is and the overlap with Product-Service Systems. Then the concept of Product-Service systems is described along with a description of design methodologies, the discussed benefits and drawbacks. Subsequently, after generating a definition of (S)PSS, few relevant PSS models for the project are described. Thus the aim of this literature study is to understand and investigate PSSs and their business models.

2.1.1 Sustainable Business Models (SBM)

The main aim of this graduation project is to design a new business model for aQysta. Therefore, an explanation of what business models are and a description of different SBM that exist are given in this part.

Definition Business Model

There are multiple ways to define a business model. One definition for a business model is that it is a simplified **way to explain how companies create value** (Aurich et al., 2010). However, it is not as simple as this definition may imply, as a business model consists of multiple elements. Many opinions exist on what the key elements are (Kujala et al., 2010), but according to Osterwalder and Pigneur (2010), the different elements in a business model influence each other and therefore a BM merely makes sense if it contains and operates all these elements. They have also described it in a way that a company could have several business models; '*Business models are representations of companies' strategies, operations and relationships that define their business logic*'. It is a conceptual tool that helps companies to identify, understand, design, analyse and change their business models (Osterwalder & Pigneur, 2010). Moreover, different opinions exist on what elements are key for business models. According to Richardson (2008) it should at least contain a value proposition, a value creation, delivery system and the value capture.

Business Model Canvas

Osterwalder and Pigneur (2010) created the Business Model Canvas (BMC), a commonly used tool to analyse and ideate a business model. It contains the following elements: customer segments, value propositions, distribution channels, customer relationships, revenue streams, key resources, key activities, key partners and cost structure. Customer segments are the different groups of people the company aims to serve and for whom the company creates value. The value proposition defines what value the company is providing and which problems they solve with their offerings. The distribution channels intend to describe how the company communicates their value proposition to its customers. Customer relationships explain what kind of relationships the company has with the different customer segments. Revenue streams are the cash flows coming from the customer segments. Cost structure is the other half of the money flow and includes all the operating costs. Key activities are necessary to run the business. Key resources are the necessary assets to make sure the business model will work. Lastly, the key partners describe the stakeholder network that is necessary to create a working business model (Osterwalder & Pigneur, 2010).
This tool is used in this project for analysing the current business model of aQysta, but also as a tool to explain the final PSS. In the book of Osterwalder and Pigneur (2010), different methods are described for business model generation. These methods include amongst others, customers insights, ideation, visual thinking, prototyping, storytelling & use of scenarios.

Types of Sustainable Business Models

The difference between linear business models (BM) and Sustainable Business models (SBM) is that the **model should not only create value for the involved stakeholders but also for the environment and society** (Baldassarre et al., 2017; Bocken et al., 2013; Donaldson & Preston, 1995; Tyl et al., 2015).
In order to identify the different types of sustainable business models that exist, the archetype model of Bocken et al. (2014) was used (fig. 5). The figure summarizes the eight SBM archetypes and shows a broad range of examples within these archetypes. Short definitions of each archetypes will be given below.

Maximising material and energy efficiency is about achieving more with fewer resources and thus generating less waste, emissions and pollution.
Creating value from waste concerns the reuse of materials and products and turning waste into feedstock for other products.
Substituting with renewable and natural processes refers to the use of non-finite materials and energy sources.
The delivery of functionality rather than ownership archetype is about providing services that satisfy users' needs without the requirement for them to own the physical products.
Adopting a stewardship role means pro-actively engaging with all stakeholders to ensure their long-term health and well-being.
Encouraging sufficiency concerns the solutions that actively seek to reduce end-user consumption.
The re-purpose for society/environment archetype is about seeking to create positive value for all stakeholders in society and environment.
Inclusive value creation relates to sharing resources, knowledge, ownership and wealth creation.
The last archetype, ***developing scale up solutions*** refers to the delivery of sustainable solutions at a large scale to maximize benefits for society and the environment (Bocken et al., 2016).

As shown in the figure, examples of the "***deliver functionality rather than ownership***" archetype are several PSS types. Using this theory, it can be said that **PSS is a specific type of sustainable business model.**

MAJOR INNOVATION TYPES	ENVIRONMENTAL			SOCIAL			ECONOMICAL		
DOMINANT ARCHETYPES	MAXIMIZE MATERIAL AND ENERGY EFFICIENCY	CLOSING RESOURCE LOOPS	SUBSTITUTE WITH RENEWABLES AND NATURAL PROCESSES	DELIVER FUNCTIONALITY RATHER THAN OWNERSHIP	ADOPT A STEWARDSHIP ROLE	ENCOURAGE SUFFICIENCY	REPURPOSE FOR SOCIETY/ ENVIRONMENT	INCLUSIVE VALUE CREATION	DEVELOP SCALE UP SOLUTIONS
INNOVATION THAT FITS THE ARCHETYPES	Low-carbon manufacturing	Circular economy, closed loop	Move from non-renewable to renewable energy sources	Product-oriented PSS – maintenance, extended warranty	Biodiversity protection	Consumer education, communication	Not for profit	Collaborative approaches (sourcing, production, lobbying)	Incubators and entrepreneur-support models
	Lean manufacturing	Cradle-2-Cradle	Solar- and wind-power-based energy innovations	Use oriented PSS – Rental, lease, shared	Consumer care – promote consumer health and well-being	Demand management	Hybrid businesses, social enterprise (for profit)	Peer-to-peer sharing	Open innovation
	Additive manufacturing	Industrial symbiosis	Zero-emissions initiative	Result-oriented PSS – Pay per use	Ethical trade (fair trade)	Slow fashion	Alternative ownership: co-operative, mutual, collectives	Inclusive innovation	Patient/slow capital
	Low-carbon solutions	Reuse, recycle, remanufacture	Slow manufacturing		Choice editing by retailers	Product Longevity	Social and biodiversity regeneration initiatives	Base of pyramid (BoP) solutions	Impact investing/ capital
	Dematerialization (of products/ packaging)	Take back management			Radical transparency about environmental/ societal impacts	Premium branding/ limited availability			Crowdfunding/ sourcing
	Increased functionality					Frugal business			Peer-to-peer lending

Figure 5 : Business Model Archetype model (Bocket et al. , 2014)

2.1.2 Product Service Systems (PSS)

As previously mentioned, a Product-Service system is a type of business model. For this graduation project, the PSS Business model will be used. Therefore, literature research was performed in order to learn the definition, different types, benefits and methods for designing such a model.

(Sustainable) Product Service-Systems

In this part, it will be explained what a Product-Service System (PSS) is and how it is commonly defined. After giving the definition of a common PSS, the transition to Sustainable Product-Service Systems (SPSS) will be given.

One of the first to define a Product-Service System (PSS) were Goedkoop et al. (1999). They defined PSS as **market offerings that combine products and services and present them as single solutions to customers.** As the concept states, PSS is a combination of three elements: (a) products, (b) the service and (c) the system. Products (a) are described as tangible elements that can vary in the degree of technology they comprise. The services (b) are the activities and actions done for others with an economic value, meant to enhance the interaction with the product and the solutions provision. And lastly, the system (c) is defined as the collection of elements including their relations, such as infrastructure, people and regulations needed to deliver the solution (Goedkoop et al., 1999). More simply said it is a **combination of products and services in one single offering** (Morelli, 2002) to fulfil customers' needs. It commonly focusses on offering services, whereby the **product simply becomes the means to provide the offer.** The products are the distribution mechanisms for service supply (Kowalkowski, 2010). However, in contrast to traditional services that are added to products (e.g. warranty), PSS' services should **deliver value to the customer in its use** (Baines et al., 2007). Through this, it **achieves differentiation**. Asset ownership is often not transferred to the customer with PSS, but rather remains in ownership of the company. With PSS it is more **about selling the use, satisfaction or result** of a product, than about selling the product itself. Hence, one of the **main objectives of PSS is to reduce the consumption of products through alternative scenarios of product use instead of buying** (Beuren et al., 2013). Furthermore, in case of PSS the consumer is not always the final user (B2C), but another company can act as a client as well (B2B) (Manzini & Vezzoli, 2003).

When a PSS helps to correct current unsustainable production and consumption trends, it is usually referred to as a Sustainable PSS (Manzini & Vezzoli, 2003). Only a few cases use the term Sustainable Product-service systems instead of PSS. This is because PSSs generally embraces sustainability and it is expected that a well-designed **PSS has a less negative impact on the environment than another business model** (Dornveld, 2012). It supports de-materialization and reduces material consumption (Baines et al., 2007), thus enables a move towards a more sustainable society (UNEP, 2002). However, not all of the systems are that well-designed to actually result in environmental benefits. In order for the PSS to be highly eco-efficient, it needs to be specifically designed, developed and delivered (Vezzoli et al., 2014). Good SPSS design should for example lead to better management of the product's life cycle by decreasing product-related waste or providing solutions that require lower amounts of energy (Beuren et al., 2013). Up until now, there are only few companies that take the whole life-cycle into account (Dornveld, 2012). Mont (2001) was one of the first to include it in the definition of PSSs and describes it as "*systems that have lower environmental impact than traditional business model*". Vezzoli et al. (2014) defined it as "*an offer model providing an integrated mix of products and services that are together able to fulfil a particular customer demand, based on innovative interactions between the stakeholders of the value production system, where the economic and competitive interest of the providers continuously seeks environmentally and socio-ethically beneficial new solutions*". Examples of environmental benefits are reductions in greenhouse gasses, use of renewable resources, efficiency of resources and contextual reduction of environmental and social impact and the systemic level of the innovation (Manzini & Vezzoli, 2003). The sustainability of PSSs depends on whether it is less material intensive compared to previous models and whether actors in the network are aiming to reduce the materialization even more (Tukker, 2004).

Benefits of PSSs

Implementation of PSS has a lot of benefits and can result in positive effects for providers, consumers, environment and society (Baines et al., 2007). In this part different key benefits will be explained.

First of all, as previously highlighted, a PSS can have a **positive impact on society and the environment** if designed well. By selling the use of products rather than the product itself, products are used more efficiently, which will positively influence the consumer good society and reduce mass production. It provides a greater social balance because more people can use the same product while paying less (Beuren et al., 2013). By taking care of the products' end-of-life, the company can recycle materials and resources, thereby reducing product waste. The **lifetime of products can be increased** by this means, because the company can give interim maintenance to the product. For society PSS implementation is beneficial because **new jobs are created since service supply requires manpower** (Baines et al., 2007).

Secondly, for customers the PSS can result in flexible and **more customized solutions** which better meet their needs and fulfil their wishes (Baines et al.,2007; Beuren et al., 2013). It releases them from product

ownership and therefore they do not have the risks and responsibilities anymore. Also the administrative and monitoring tasks are the responsibility of the provider (Baines et al., 2007). Last but not least, with some PSS models, **it makes the products more affordable for the customer** because instead of spending (a big sum of) money at once, there are possibilities to pay off in periods or to pay-per-use. For this reason, consumers are able to use products of high quality, which were not affordable previously.

For the company implementing PSS, there are multiple benefits. First, implementation of PSS can be used as a **competitive strategy**, since well designed PSS business models are **hard to copy** (Mont, 2000). The different service factors of the model combined with the product are not easy to replicate by competitors and thus results in a competitive advantage (Baines et al., 2007). Secondly, PSSs lead to **better relationships with customers**. Instead of the one-time interaction at the sale of the product, the company is able to sustain contact with its customers during the whole product life-cycle. This will lead to improved communication, **better understanding of customers' needs** and thus better value propositions (Reim, Parida & Örtqvist, 2015). The good relationship can influence the loyalty of consumers towards the brand (Beuren et al., 2013), which indirectly leads to another competitive advantage. Furthermore, good client relationships allow companies to co-create with their customers in order to offer improved solutions (Reim Reim, Parida & Örtqvist, 2015).
Also, by remaining the owner of the product, there is a **possibility to monitor the performance of the product** and use this data to improve the delivered product and its value (Sundin et al., 2009). However, there might be some customers sensitive to privacy (Vezzoli et al, 2015). Lastly, it will lead to greater involvement of stakeholders (Baines et al, 2007; Goedkoop et al., 2009) and new type of relation-/ partnerships.

Barriers to adoption

Despite the benefits the implementation of PSS entail many companies still use the more common product-selling business models. This is because barriers exist for PSS adoption and not all companies are aware of the potential value of providing services and PSS. Addressing these barriers can help companies to limit future risks and adopt the PSS successfully (Barquet et al., 2013).

One existing barrier is the fact that there is **lack of well-developed tools and methodologies for the design, creation and implementation of PSS**. The adoption of an effective PSS is more complex than the existing way of selling and delivering the product (Baines et al., 2007), especially when no guidelines are given.

Another barrier that companies face, is the **difficulty of pricing the service**. For each model the pay-off period for initial costs is different, making it difficult to calculate and to rely upon. Additionally, it is not clear how to tax a PSS (Barquet et al., 2013). Furthermore, **PSS models often require long-term investments**, not all companies have the resources to absorb these financial risks. Also, the uncertain cash flows can cause financial barriers for the companies (Mont, 2004[b]).

Therefore, a shift in organisational structure is aquired, when **changing from product selling to service offering.** The delivery of product function **requires a new mindset** for all stakeholders. Changes in a company's organisational structure requires time and money. Since it is not yet clear how to adopt PSS, not all companies are willing to take this risk.

Also, PSS business models are **highly sensitive to the culture** in which it will operate (Wong, 2004), implying tailor-made solutions are necessary for success. In order to do this, companies should keep developing their model to the environment in which it will be provided. This again requires time and money.

Regarding the collaboration with stakeholders there is also a barrier. Working together along the value chain might require stakeholders to share sensitive information and not all parties are willing to share such information (Mont, 2004 a). Also, **finding new partners and building the new stakeholder network could be challenging**. Different parties also means different wishes to address.

From a consumer's point of view there is also a barrier: not everyone is expected to be happy about owner-less consumption and they are not familiar to only pay for the function of the product (Rexfelt and Ornäs, 2009). Consumers might perceive the price of the service too expensive, compared to just the purchase of products (Mont & Plepys, 2008).

PSS in Low income context

According to Baines et al. (2007) PSS can be very valuable for manufacturers based in low income countries. Vezzoli et al. (2015) expect that PSS are especially beneficial for these contexts, because it can help to **overcome high access costs of useful goods and services.** However, limited data on PSS design for this context exists. As said in one of the previous paragraphs, the different cultures for PSS are challenging. It is important to understand the context in which the PSS will be introduced and design suitable strategies accordingly (Vezzoli et al.,2015).

2.1.3 PSS Types

In this part first a general explanation of PSS types is given. Secondly, a selection of valuable cases was made for explaining, understanding and investigating the PSSs and their business models. However, not all of them are related to irrigation systems.

PSSs are generally divided into different subdivisions. Various authors agree that there are three specific sub-divisions, being: **(1) Product-oriented, (2) use-oriented and (3) result-oriented.** All three types satisfy the customers' needs through a unique offering which combines products and services.

A product oriented PSS focusses mainly on selling products, but some extra after-sales services (maintenance, recycling, warranty, etc.) are also included. These added services are meant to guarantee

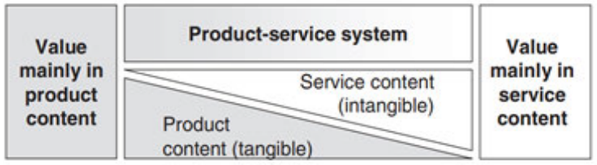


Figure 6 : PSS Types (Tukker, 2004)

functionality and durability of the product. The reason for a company to implement this model is because it can minimise the costs for a long-lasting product and by taking care of end-of-life cycle, the company can have a positive impact on the environment.
The use-oriented PSS are less geared towards selling the product but the product still plays an important role. The company remains the owner of the products, but the use rights are transferred to the customer. For a company this can be interesting because the use of products are maximised and so the materials used to produce it are maximised as well. The result oriented PSS has no predetermined product, but the company and user agree on the delivery of a certain result. The company remains the owner of the product and the user only pays for the result. (Tukker, 2004; Baines et al., 2007). According to different researchers, **result-oriented PSSs have most potential in business and concerning the environment** (Tukker & Tischner, 2006; UNEP, 2002).

Tukker (2004) divided these 3 main categories in 8 different archetypes, visualised in fig. 6.

Product-oriented PSS
Product-related service : The company does not only sell the product, but it also offers services that are needed during the use of the product
Advice & Agreement : In this archetype, a company provides advice on the most efficient use of the product in addition to providing the product itself.

Use-oriented PSS
Product Lease: The product remains to be in the ownership of the company. The user pays a regular fee for using the product. The idea of this model is that the user has unlimited access to the product-use. A great example of this model is Netflix's streaming (service) of movies.
Product Renting/Sharing : The company generally remains the owner of the product and the user pays for the product when using it. This time, the user does not have unlimited and individual access to the product. Taxi companies are an example of the use of this model.
Product pooling: In this model multiple users have access to the product at the same time and pay per use.

Result-oriented PSS
Activity management/outsourcing: In this model activities are outsourced to a third party. An example is the catering service for companies.
Pay per service unit: The user buys the output of a certain product, according to the level of usage. An example of this model is the pay-per-print model from Xerox.
Functional result: In this model, the client pays for an agreed upon result, no matter by what means it is delivered. An example can be selling maximum of harvest loss instead of selling the pesticides (Tukker, 2004).

A quick impression of relevant options for this project within these eight archetypes is visualised in fig. 7 on the next page (Intriago, 2019). As shown, different types are combined and several options are given for add-ons.

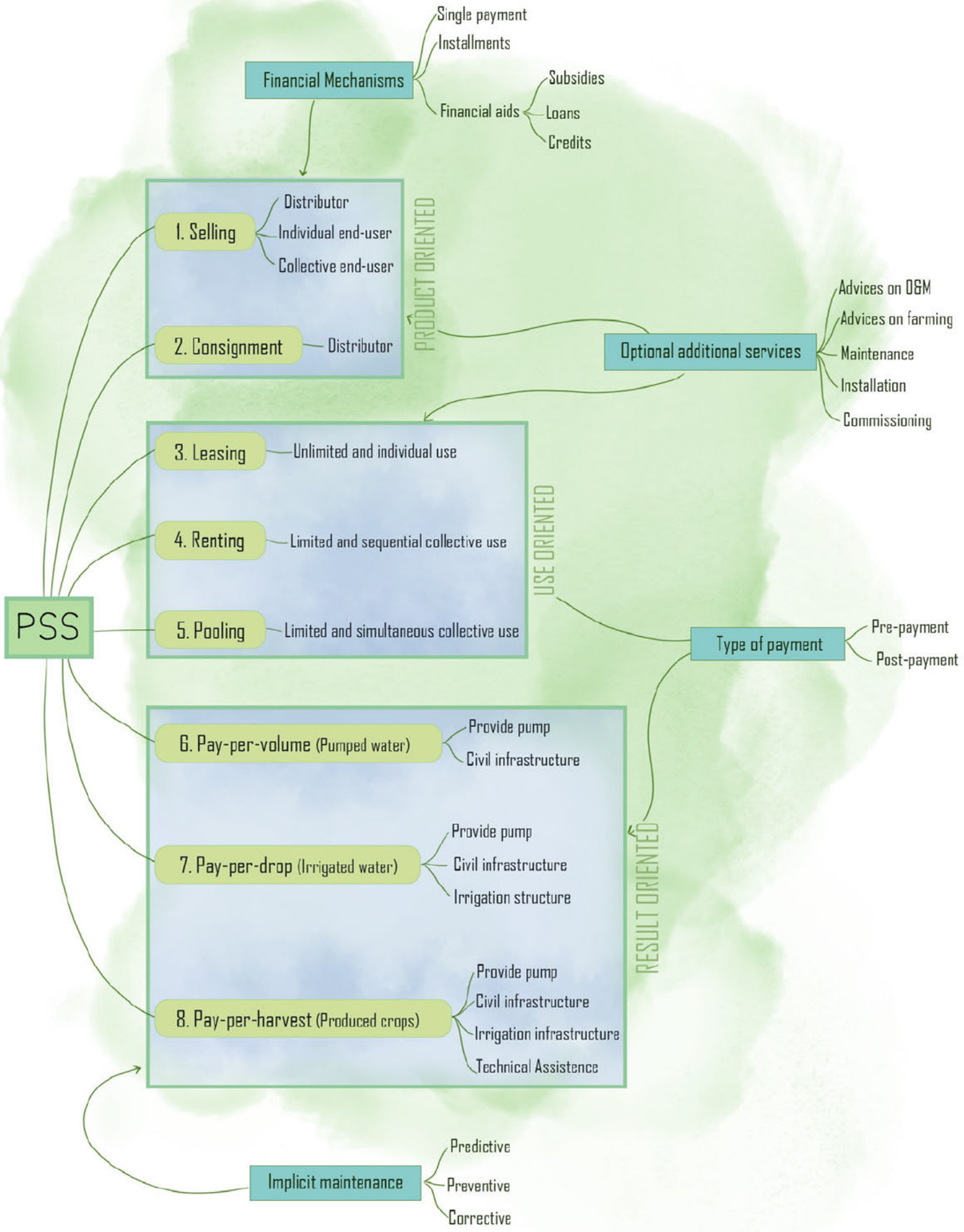


Figure 7: PSS Types with possible add-ons *(Intriago, 2019)*

Type 1 : Pay-Per-Use

Even though this model is already briefly mentioned, it deserves a more in depth explanation as these type of models can be of great relevance for the project. Farmers could buy one pump collectively with the community and pay for each time they use it. If the community invested in the pump, it will get the investment cost back over this period of time. Another option within this model is that the pump is being paid off by the pay-per-use model to aQysta. However, this causes a financial risk for aQysta, as they cover the investment cost and there is no clear indication of when the costs are even. Thought should also be given to the fact that the whole idea of marketing the free operation cost of the Barsha would not be applicable anymore. Integration of a middleman could be of interest here, one that is more specialised in pay-per-use provision, and for example works with digital payment service. In the figure 8 below, a possible pay per use model for the Barsha is drawn.

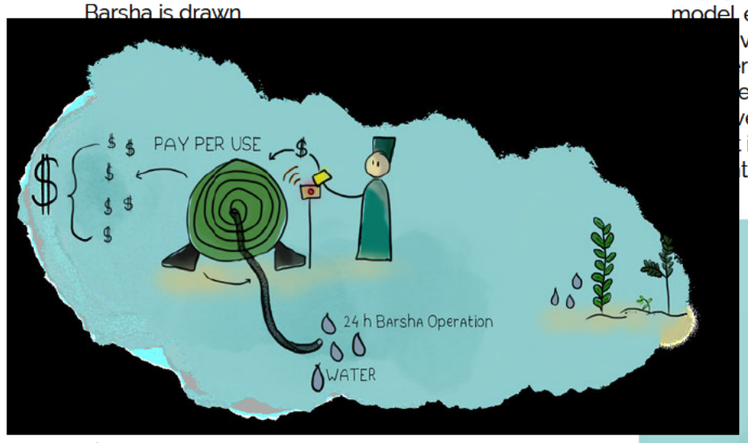


Figure 8 : Pay per use

A famous example of this model in the Netherlands is the OV-Fiets. At approximately 300 train stations travellers are able to rent an OV bike for a fixed price per 24 hour use. The only thing necessary for making use of this service system is ownership of an OV-chipcard. By means of this card (and credit on it), you pay for the bike when returning it to the station.
Another interesting example of a pay-per-use PSS which is more related to the project, is Claro Energy (more explanation can be found in the competitor analysis p. 54). They found that not all people had the resources to buy pumps, so they implemented the irrigation as a service system, where the users could pay per use with a pay-as-you-go card. The solar pump system is placed on movable trolleys (figure 9), so that it can reach broad range of farmers.



Figure 9: Claro Energy's movable Trolley

Type 2 : Pay Per Result

Another type that was already briefly explained is the pay-per-result PSS. Because of the fact that it is said to be the **most promising type**, this model requires additional attention and explanation. Furthermore, this model is interesting to evaluate, since aQysta incorporated such a model in Indonesia; pay-per-harvest, named EASI-Pay (Enabling Access to Sustainable Irrigation).

The EASI-Pay model was generated to match with the cash-flow of the farmers and breaks the barrier to pay for the upfront costs of the Barsha pump. The model enables farmers to pay for the solution, rather ving the pump away for free. Within this model, r involved party (who bought the pumps) helps e farming and the selling of the crops. Part of the vest is consumed by the farmers and the other is sold on the market. Then, after selling, a small t is profit for the third party, for providing the

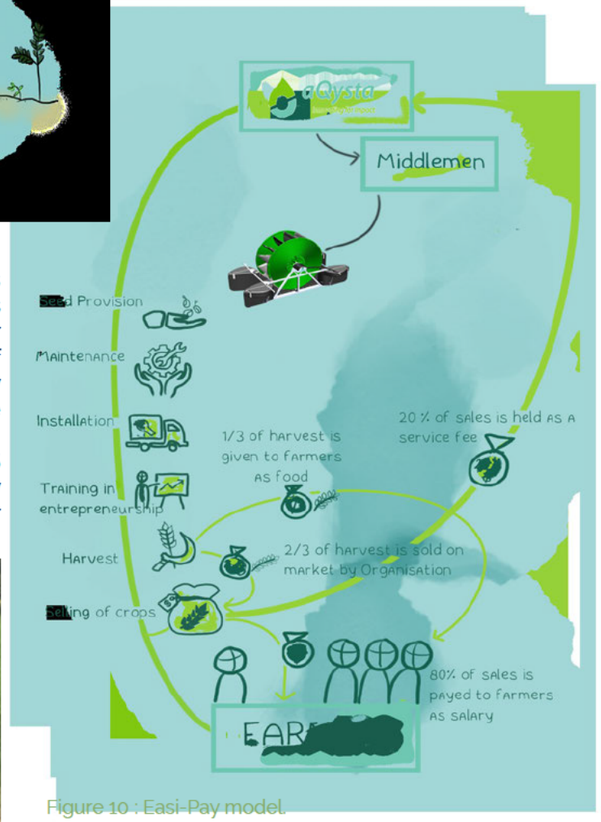


Figure 10 : Easi-Pay model

service and to get money in return for their investment in the Barsha pump. The remaining sum of money is for the farmers to provide them with an income. It is expected that with this model, the Barsha pump would be paid off in three to four years (Knowledge4food, 2017). The model is visualised in figure 10. In this specific model, there is no risk for aQysta, because the organisation takes care of the service and pays for the pumps at the start.

Type 3 : Micro-credit

The micro-credit model is a whole other type of model relative to the eight archetypes. The basic idea of this model is to cover upfront cost for any kind of product. An organisation, often a NGO, supported and supervised by a bank, provides a loan to a consume and they can start paying back the loan when they star making profit. The loan gives them the opportunity t make an investment needed for starting a business.
Involving organisations that provide micro-credits in th stakeholder network of this project can be relevant. could help cover the large upfront cost of the irrigatio pump and furthermore teaches farmers to handl money carefully (compared to a subsidy model). I most cases, people who apply for micro-credits, shoul have a clear business plan for how to make profit i order to assure they can pay back the borrowed money See figure 11 for an explanatory drawing.

For example, a success story of micro-credits is th story of Annika, a seamstress from South Africa. Thank to micro-loans, she started a successful business i making traditional skirts for woman from the region. She used the loan to buy fabric, a sewing machine and also to pay for school fees for her four children. This is only one of many success stories thanks to micro-credits (Kimmons, 2018).

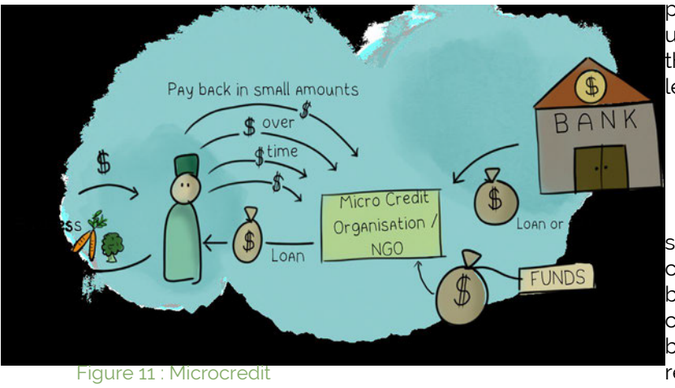


Figure 11 : Microcredit

Type 4 : Impact Investing

Another interesting financing model is impact investing. However, differing from micro-credit, this model provides credit to other organisations instead of to individuals. Impact investing companies are organisations which amongst other things could finance micro-credit organisations (Global Impact Investing Network, n.d.).
However, only for organisations and companies that create social or environmental benefits, such as aQysta (Pandit & Tamhane, McKinsey, 2018). Impact investment often allocates capital to challenges and projects focussing on sustainable agriculture, renewable energy and micro-finance (Global Impact Investing Network, n.d.).
Applying for impact investments could be of relevance, to overcome the financial risk of pay-per-use models. Pay-per-use models require large capital and aQysta does not have the financial resources to overcome these investment costs as they need their resources for

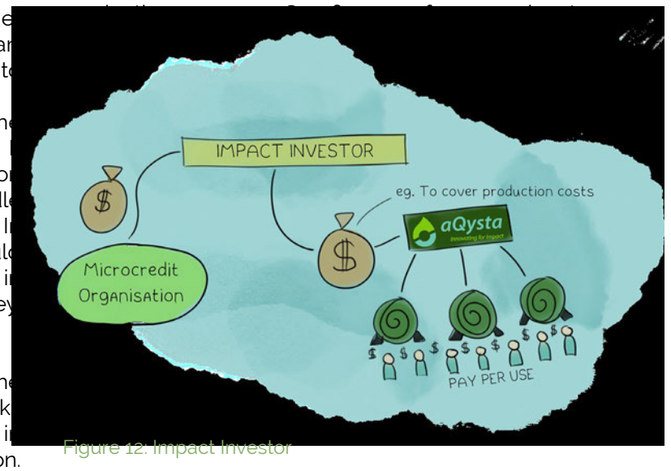


Figure 12: Impact Investor

Type 5 : Lease-to-own

This model differs from the leasing archetype, because the aim of the model is to shift the ownership after a period of time. When the leasing period starts, the user has unlimited access to the product. However, the lessee could also choose not to purchase the leased item after the leasing period expires (Business Dictionary, n.d.). This model is relevant to consider because it could help bridging large upfront costs as the user is able to pay off the initial cost through evenly spread periodic fees.
Another benefit of the Lease-to-own model over the standard leasing model, is that the consumer will feel commitment towards the product since he/she will be the eventual owner. According to Tukker (2004), consumers of leasing models can have careless behaviour towards products because they do not feel related to the product as it remains in ownership of the provider.
Different options occur within this model, for example, products can shift in ownership after an agreed period of time with the monthly fees, this takes away the financial risks for the provider. Another possibility is to reduce the periodic fee but after a period of time, the user can choose to pay an additional amount to shift the ownership. Even within these examples, a lot can be done with adjusting the fees according to added services. Especially since aQysta (2019) mentioned not to 'sell' second-hand pumps, agreements on shift in ownership should be made.
A context in which lease-to-own models are often implemented is real-estate. Often, one can pay a non-refundable fee for agreeing on the leasing option for a period of three years with the option to buy the building when the leasing period ends, for a pre-negotiated price. Then you would pay a monthly lease amount and after three years you have the option to purchase the building (Kimmons, 2018).

2.1.4 Co-creation & PSS Design Methods

In this part, the importance of co-creation with end users is explained. Additionally, the way in which co-creation relates to a PSS design is analysed. Later, some guidelines for designing PSS Business models are given since there is no clear and validated methodology for PSS design yet.

Co-Creation for PSS Design

In the literature, it is often mentioned that it is important to involve customers, end-users and others from the stakeholder network in the design process of PSS design because they should be satisfied with the final delivery (Beuren et al., 2013). Together with these stakeholders, the **value proposition of the model should be co-created** (Vezzoli et al., 2015).

Previous research has proved that participation of consumers in the early stage of creation and during the use of PSS had a positive impact on the final deliverable (Morelli, 2002; 2006; 2009). According to Luiten (2001), successful, competitive and sustainable solutions are rarely provided by a single company. Thus involving several stakeholders in the process is important. By involving customers in the early phase of the process, the company can identify their needs and design the PSS based on these needs and in that way the **final design is more likely to meet end-users' expectations**. Also, good relationships with stakeholders are important for an effective PSS and therefore, relationship management and involving them as much as possible is key (Mont, 2000; Manizini, 2001; Luiten, 2001).

According to Nambisan (2002) and Von Hippel and Katz (2002), there are three forms of how the customer can co-create : (1) CIS – Customer involvement as an information source, (2) CIC – customer involvement as co-developers and (3) CIN – customer involvement as innovators. With CIS, the company gathers input from the customer and applies it to develop products which meet their needs. These inputs can be gathered through interviews, surveys or focus-groups. For CIC, the customers and the company develop the product together and the customers are involved either in the idea generation and/or in the evaluation process (Marilungo et al., 2016). With CIN, the customers design their own products/service and the company adopts the idea.

Customer/stakeholder involvement should occur during the whole product cycle, from involving them during the PSS creation phase by considering the needs and ideas to using the enabled data during PSS use phase. In the end, **after the design is finished, the co-creation should continue** and the service should be tested with key customers to keep searching for potential improvements (Marques et al., 2013).

PSS Design Methodologies

As explained in the previous paragraph, PSS Design is a *"participatory design process and users need to be allowed to participate in as many design activities as possible"* (Tran & Park, 2014).

Designing a PSS is more complex than designing a product (Geng et al., 2010); companies must move from product thinking to system thinking (Manzini et al., 2001). The process of PSS design has become very complicated because both products and services should be included (Muto et Al., 2015) and service development involves more human factors. Hence, there is not a clear method to follow for designing the PSS yet. Some researchers made attempts to develop a methodology or a framework to support the PSS development, however there is a lack of evidence for the completeness of the tools and methods (Baines et al., 2007). Most models need further development in order to facilitate wide implementation of PSS.

According to Baines et al. (2007) many of the methodologies have a clear heritage in **Lean Product development** because of customer involvement, identifying customer's value and continuous improvement. The PSS design cycle is one of the important factors of PSS design because markets change and thus customer's needs and requirements (Meier & Völker, 2010). As for Morelli (2006), the **PSS design process should contain all of the following elements: (1) identification of stakeholder/actor network, (2) possible PSS-scenarios and defining actors' role. (3) Definition of the PSS requirements and the logical organisational structure of the PSS and lastly (4) the tools to represent the PSS in all of its components.** Multiple methods were uncovered during literature research (e.g. PROSECCO, COSUP, PSS Design Kernel, BMC + SPSS characteristics, MEPPS Handbook) but none of them seemed relevant for the project. The methods are either not complete enough, they require too much time or they are not related to the low-income context.

2.1.5 Conclusions

This literature analysis explained that a Product-Service System is a type of Sustainable Business Model. A PSS is a combination of products and services in one single offering. It allows companies to enhance competitiveness, create a positive impact on the environment and create more valuable solutions for the end-users. Besides this, the implementation of a PSS has many more benefits. However, some barriers are still obstructing wider implementation

Also, as aforementioned, the uniqueness of the innovation does not lie in the technology, but in the systematization of the technology (Manzini & Vezoli, 2003). Involving different stakeholders in this system could help create a more unique model. However, partnership models also have the risk of being dependent of the performance of the different parties. For the realisation of a competitive advantage, the addition of services to the product can increase market share and customer satisfaction (Beuren et al., 2013).

Takeaways for the project

From the given literature analysis some takeaways for the project can be drawn:

- First of all, it should be kept in mind that the Sustainable Business model should not only create value for aQysta and the involved stakeholders, but also for the society and the environment. In case of a PSS, the model should deliver value to the customer in its use. Thus, the final design should create value to all parties during the whole cycle.

- An objective of a Product Service-System is to reduce the consumption of products by offering alternative use scenarios instead of buying. This can be challenging since aQysta has a seller's mindset. An opportunity that arises when aQysta remains owner is that they can monitor the performance and usage of the pump.

- The PSS is highly relevant for this project because a PSS makes it possible for consumers to use the high quality Barsha pump which beforehand was not affordable.

- PSS lead to better relationships with customers, because the offerings are more customized and often require direct contact with the service provider. This improved relationship provides a competitive advantage and is therefore something that should be taken into account accordingly.

- Since determing the way of pricing is difficult for the service offering, extra consideration is required when estimating the price for the designed PSS for this project. Moreover, the often required long-term investments for PSS design have to be considered carefully when giving recommendations to aQysta.

- aQysta is currently a product-selling focussed company, so the transition to a service-offering model will be challenging. This requires a new mindset for aQysta.

- Aforementioned, PSSs are highly sensitive to the culture in which they will operate (Wong, 2004). This means that the final design cannot simply be copied and implemented in other countries. aQysta should carefully evaluate each country before implementing the business model.

- In the different types of PSS that were evaluated, some interesting characteristics and options were already highlighted. These options, e.g. considering a micro-credit organisation as a middleman instead of subsidies or in combination with a subsidy, will be taken into account when designing the final PSS business model. Furthermore, it will be kept in mind that result-oriented PSSs have most potential in a business concerning the environment.

- As stated, no specifically relevant PSS design methods for this project were found. However, knowledge was gained and elements of different methods can be used to develop the final PSS model. Furthermore, stakeholder involvement is identified to be especially important in designing this PSS. Co-creation should be performed, as it is necessary for good PSS design. By doing co-creation, the final design is more likely to meet customers' expectations by offering more customized solutions.

- After the finalization of the design, the co-creation should continue. This is something to keep in mind for the final design; to keep involving the users.





2.2 MARKET ANALYSIS

Agriculture & Irrigation in Nepal

This chapter analyses the agricultural and irrigation market in Nepal. This was already briefly described in the context analysis in the introduction, but in this part more specific details are given. A description of the market is presented, along with a description of the target group. Furthermore, different irrigation methods are explained. In the second part a competitor analysis was performed in order to understand the competitive landscape in Nepal for aQysta.

2.2.1 Agriculture & Irrigation in Nepal

In this part, agriculture in Nepal is highlighted and researched. The focus of this part is on the market size of smallholder farmers in Nepal (Target group) and the current situation regarding agriculture in Nepal. Secondly, different irrigation methods are described.

Agriculture is the biggest sector for income and work in Nepal, with nearly **80% of inhabitants relying on it** in some way. It dominates the economy, as it is responsible for **33,1% of the total GDP of Nepal** (World Bank, 2019). However, it is becoming less and less popular among youngsters for employment (Lohanee, 2019; Dulal, 2019). The government is aiming at increasing the agricultural production by, for example, providing farmers with funds (Savada, 1991; Lohanee, 2019). A mere **20% of Nepal's surface, 2.8 MHa, is cultivated and only 1.3 MHa has irrigation facilities** (MoAD, 2015; World Bank, 2019).

Target group : Smallholder farmers in Nepal

Since many people are reliant on agriculture in one way or another, the market size of agriculture is large. The target group for this project is not the entire agriculture sector, but is limited to **smallholder farmers in Nepal**. As mentioned before, smallholder farms are *farms with less than 2 Ha of land*. In this part, this group is analysed in more detail. In figure 13 a persona is given.

There are many **smallholder households** in Nepal, namely approximately **2.7 million** (Rapsomanikis, 2015) with a total of more than 13.8 million farmers (Subedi, 2017). Most of these small farms are family farms. Nearly five family members work on the household farm and **more than half of the food consumed by the family is produced on** these **family farms**. The reason for high family labour is because the wages are relatively high for hired staff; the wage for farm workers is roughly $4.6 per day. In the family farms, **women provide essential labour in smallholder farms in Nepal**. There are 1.4 women working in smallholder farms in comparison to one man each day (Fontana & Paciello, 2009; Rapsomanikis, 2015). Besides the normal farm work and unpaid household work, women are generally responsible for collecting water and fuel. **The value of the produced food, makes up about 33% of the entire family budget**. Often, smallholders are net consumers; in Nepal the average smallholder farmers allocate 26% of the budget to food purchases. Spending more than half of their budget on food means there is not much money left for other purchases. Data suggests that generally only 3% of the budget is spent on durable goods (for example a fridge, a television, etc.) and a mere 3% is spent on education (Rapsomanikis, 2015).

Most of the smallholder households own their house. About 32% have proper toilets, 8% has access to running water and 27% has electricity. Most of the houses (70%) are built with bricks, but only 12% have a non-dirt floor (Rapsomanikis, 2015). Most of these houses are **remotely located**. The lack of well-paved roads in Nepal, make it somewhat difficult to reach these areas. On average, it **takes 11 minutes for a smallholder to travel to a paved road**. During monsoon it becomes even more challenging because of the landslides and the floods that occur. Due to these poor transport facilities, it is tougher to sell the products on the market, for which on average **only 5% of the production is sold.** In less remote areas, approximately 12% of the production is sold on the market. Additionally, prices are often higher in remote areas. The price of rice in can be almost 3 times higher in comparison to the prices in Terai, which is the most productive agricultural zone in the country and also called 'the food basket of Nepal' (Lohanee, 2019; Rapsomanikis, 2015; The State of Food Insecurity in the World, 2013). This **limited**



Figure 13: Persona target group

access to markets, cause smallholders to annually receive an income of only $256, which is only 5% of the average annual income. Other constraints that withhold the smallholders from the market are that sales through different market channels often require the farmers to have greater management and logistic skills and a more steady supply. However, participation in the market would result in positive outcomes for farmers, as it can facilitate technology adoption and exchange of information. For example, only 20% of the smallholders use improved seeds due to a limited access to innovation (Rapsomanikis, 2015). This can be improved by the exchange of knowledge between different farming parties/communities.

In terms of land, the average **size of smallholdings is 0.8 Ha** (Sharna, 2018), **of which 67% is irrigated** (compared to 94% of land farmed in larger farms). However, due to their hard work and intensified family labour, **smallholders generate more than two times as much as other farmers in terms of revenue per hectare** ($2576 compared to $1016). Considering crops, 36% of small farmers' production is rice and both wheat and maize account for 24%. It is challenging for smaller farms to access credit to buy livestock due to the fact that **banks are often reluctant to loan** to them due to the poor collateral and the lack of information. Nevertheless, most of the animals throughout Nepal are kept by smallholder farmers. In Nepal, **76% of the livestock is owned by smallholder farmers.** According to Mr. Lohanee (Deputy Director General Department of irrigation), landlord ownership is not that common anymore in whole of Nepal. In Terai it is still common, however in mountainous and hilly areas it is very rare these days and most farmland is owned by the farmers themselves or rented directly from the government.

Current situation regarding irrigation

Currently, only about one third of the agricultural land in Nepal is irrigated and **two-thirds still depends on the rainfall.** In a country that contains 6,000 rivers, this situation seems strange. According to Thapa (2018), this is "Ironic in a country with 6,000 rivers". This is because most of the farmers cannot easily access the irrigation facilities (Chaudhary, Kathmandu post, 2017). This lack of irrigation facilities, creates a necessity for pumps. Furthermore, the **majority still uses pumps that are harmful for the environment**, like diesel pumps and electricity powered pumps. As there is a chronic lack of fuel and electricity within Nepal, these pumps are also harmful for Nepalese society.

Another important factor regarding the irrigation in Nepal, are the governmental subsidies. Because agriculture is an important sector in Nepal, **irrigation is seen as a service and the government allocates a yearly budget for it**. Local governments help to finance pumps up to 95% of the price. Lately, a new law related to sustainability was introduced. This law states that governments are not allowed to subsidise environmentally harmful pumps, e.g. diesel pumps, anymore (Dulal, 2019). However, the main reason for not financing these pumps is mostly related to financial issues. Diesel for example, has to be imported and is therefore extra costly for the country (Lohanee, 2019).

Irrigation methods

Irrigation is considered to be one of the most important and effective assets. It generally improves the household's livelihood and welfare of smallholders (Araujo et al., 2019) and **leads to significant increases in yields.** Land productivity is highly dependent on access to water and irrigation, since **irrigated land is twice as productive as rain-fed land** (Hussain & Hanjra, 2004). Rain-fed farming is the natural application of water to the soil. However, since rainfall is dependent of the climate and the season, it is not constant and therefore difficult to rely on (CDC, 2016). For the plants to grow, an adequate and consequent water supply is important. Therefore, when rainfall is not sufficient, extra water should be received through irrigation. Furthermore, proper irrigation also allows the growth of more diversified crops all year round (Rapsomanikis, 2015). The amount and duration of irrigation depends on the type of soil, type of crops and season of sowing (Ebix Smartclass, 2017).

As previously mentioned, irrigation can be performed using different methods. Since humans have invented agriculture, different methods of irrigation have been developed. Therefore, this section allows the reader to obtain a better understanding of different irrigation methods together with their advantages and disadvantages. Besides the different irrigations systems, the water sources also vary. Irrigation water can come from groundwater, through springs or wells, rivers, lakes, surface water or other sources (CDC, 2016). When deciding what method should be used and what best suits the local circumstances, these factors should be taken into account (Brouwer, FAO, n.d.).

Traditional methods

The most traditional forms of irrigation are rarely used nowadays. These methods are mostly cost effective, but very time consuming. Thus these methods have been replaced with modern techniques. However, a few of these methods are described briefly below.

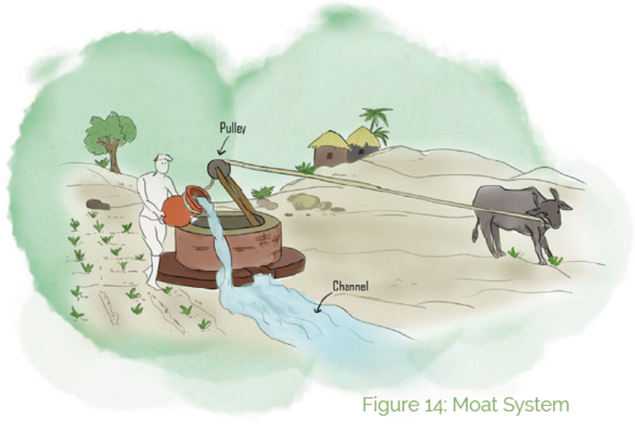


Figure 14: Moat System

Manual Irrigation

Through this method, water is distributed across land through manual labour and watering cans (CDC, 2016). The water is brought from the water source to the plants with buckets. Obviously, this method is very labour intensive. This technique is however still used to irrigate small plots of lands close to a water source.

Moat System

In this system, water is drawn from a well or water source by a bucket attached to a rope. The rope is put over a pulley and fixed to an animal. When the animal walks away from the well, the water lifts and is emptied into a channel, through which the fields are irrigated (fig. 14). This method is one of the cheapest and simplest alternatives (Ebix Smartclass, 2017).

Rahat System

The Rahat system involves two wheels; one placed vertically over the water source and the other is placed horizontally on the ground surface. A bunch of buckets is fixed to the first wheel and an animal (ox, cow, buffalo, etc.) is tied to the other wheel. As the animal walks , the wheel moves in a circular motion. This motion sets the other wheel with the buckets in motion,drawing water from the water source and irrigating the fields through a channel (fig. 15) (Ebix Smartclass, 2017).

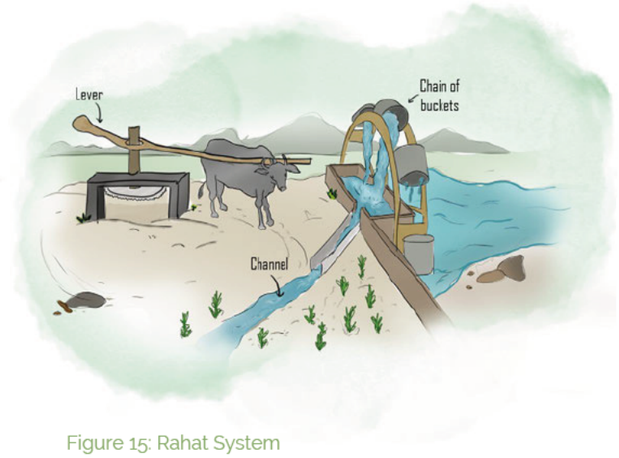


Figure 15: Rahat System

Surface Irrigation

Lately, the previously described methods of irrigation have been replaced with modern ones. These more sophisticated methods are more efficient in irrigating larger areas of land. One of the commonly used modern methods is surface irrigation. **Surface irrigation is when the water is distributed by gravitational flow to the surface of the field** (Brouwer, FAO, n.d.). There are three types of surface irrigation: Basin irrigation, furrow irrigation and border irrigation. These will be explained below in respective order.

Basin Irrigation

With basin irrigation, the entire field is flooded. A basin is a flat area of land, surrounded by low bunds. The bunds make sure the water does not flow to the neighbouring fields (fig. 16). In general, this method is suitable for crops that can stand in water for longer periods (e.g. 12-24 hours), like rice (paddy fields). Trees can also be grown in the middle of a small basin (Brouwer, FAO, n.d.).

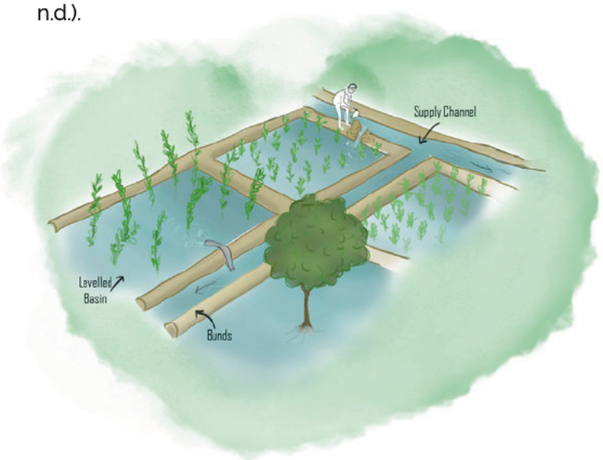


Figure 16: Basin irrigation

Furrow Irrigation

With furrow irrigation, water is fed into small channels (furrows), hence the name. The furrows carry the water down the land slope between the crop rows. The crops are mainly grown on the ridges between the furrows. Irrigated water flows from the field channel into the furrows, by opening the bank of the channel (fig. 17). This method is suited for crops that cannot stand in water for long periods of time , such as tomatoes, cabbages and corn (Brouwer, FAO, n.d.).

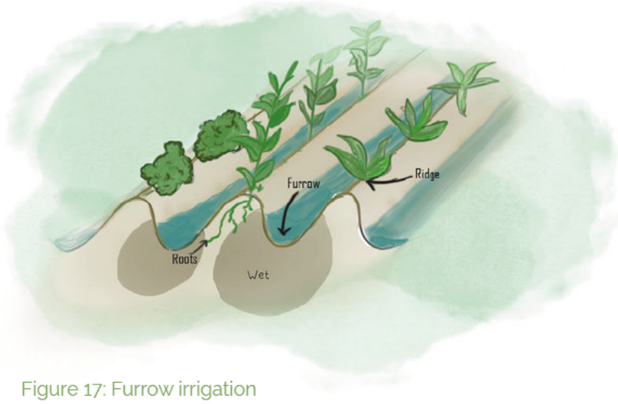


Figure 17: Furrow irrigation

Border Irrigation
When using the border irrigation technique, water is fed into strips of land (borders). The borders are separated by bunds allowing a sheet of water to flow down the slope of the border. Water can be fed by opening up the channel bank with small outlets or by means of siphons (fig. 18). Suitable crops for border irrigation are closely packed growing crops (e.g. alfalfa) (Brouwer, FAO, n.d.).

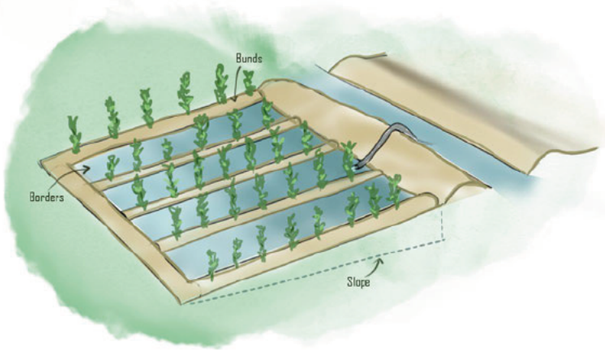


Figure.18: Border Irrigation

Modern methods
Other commonly used modern methods are sprinklers and drip irrigation. Both of these are relatively **costly** (€ 10 - €2722), but they **require little time and labour** (Ebix Smartclass, 2017). These methods help to use water in an economical manner.

Sprinkler irrigation
With sprinkler irrigation, water get sprinkled on the crops as if it is raining. This method is realized by overhead sprinklers from a central location in the field or from sprinklers on moving platforms (fig. 19) (CDC, 2016). With the help of a pump, water is pumped through a pipe system and then sprayed through rotating sprinkler heads to deposit on the crops (Brouwer, FAO, n.d.). This technique is mainly used in uneven lands, where water is not available or scarce (Ebix Smartclass, 2017). A basic sprinkler can already be purchased for a price of about €10. However, the price of a more advanced sprinkler system can be up to €2500.

Drip irrigation
In a drip irrigation system, water is conveyed under pressure through a pipe system to the fields, where it drips slowly through the drippers onto the soil (Fig. 20). This dripping occurs drip by drip and is deposited close to the crops or at the root zone of the crops (Brouwer, FAO, n.d.). This method is the **most efficient irrigation method**, because the immediate root zone of the plant is wetted and **no water is wasted** (Ebix Smartclass, 2017). However, because of the efficient technology, this method is really costly to implement, it can cost from US $ 300 up to $ 3000 ((€272 - €2722) per acre, depending on what is included and soil quality (Chu, MIT News, 2017; Improvement, n.d.). Drip irrigation is **mostly used for fields with poor water availability** (Ebix Smartclass, 2017).

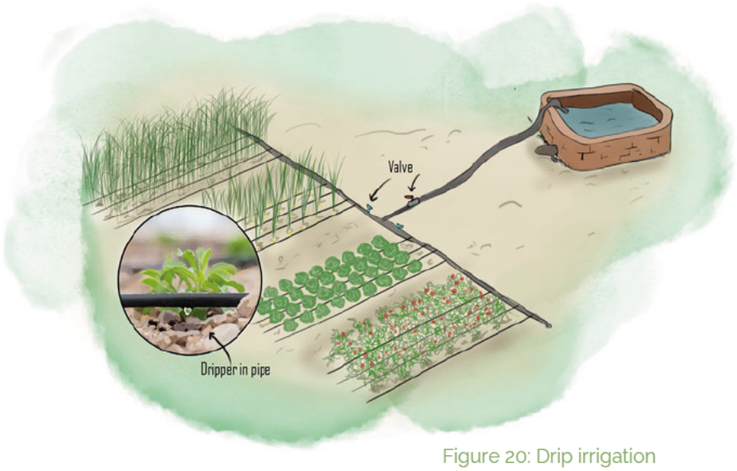


Figure 20: Drip irrigation

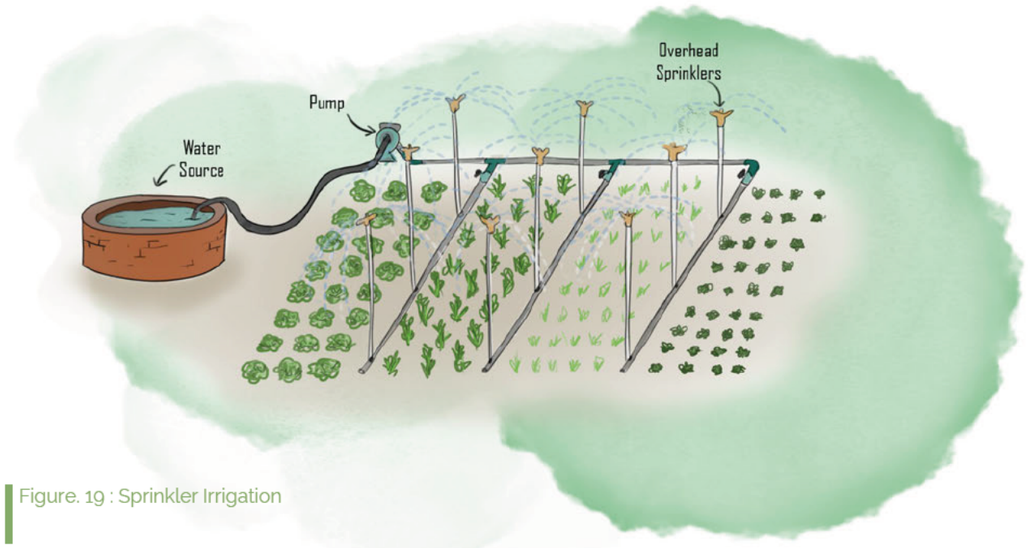


Figure. 19 : Sprinkler Irrigation

2.2.2 Competitor Analysis

To understand which pumps already exist on the market and to know more about the actual competitors for aQysta, these different pumping technologies are analysed in this part.

Among others, these technologies are (bio)fuel based, electricity powered, human powered, solar powered and there are also a few hydro powered. Some of them are direct competitors, others indirect. For each competitor the relevance for aQysta is mentioned. The Barsha pump and other pump technologies from aQysta are not described in the text below since they are no competition. These technologies are described in the Product portfolio part of the company analysis (p. 60).

Furthermore, during field research it has been observed that many farmers work with **water ponds** (fig. 21). These work parallel to the water pumps, as they use the pumps to fill the ponds. Also, it works to collect water from rainfall. Investment costs of these ponds are relatively low when it is just a pit with a canvas in it. The price rises when the pond is build out of concrete.

Fuel powered pumps

The first pump technology is the fuel powered pumps. This type is one of the **main competitors** of the Barsha pump. There are two types of fuel powered water pumps, namely the **petrol pump and the (bio) diesel** pump. An advantage of both of these types of pumps are that they can **run on any water source available** (e.g. a well, pond, river, etc.).



Figure 22 : Petrol Pump

Petrol Pumps
The petrol pump is relatively cheap, with a price range of €120 to €275 for different versions and brands. Another advantage of this pump is the small size and its weight. Furthermore, the pump can be installed anywhere to work and is independent of the location.
One of the disadvantages of the pump is that it can only pump up to seven meters in height and approximately 25 m horizontally. Also, the pumps have a short life span of only four years (Get Involved, 2016). Lastly, even though the pumps are relatively cheap to purchase, operation costs are relatively high. It uses approximately 1 L fuel per hour to pump 30000- 48000 L (Indiamart, 2019; Toolsvilla, 2019), which costs around 110 NRs (€ 0.85) (KTM 2 Day, 2019). Furthermore, the fuel deliveries are also unreliable in rural areas. During field research it was seen that in many cases, pumps are not owned by farmers, which means they have to pay-per-use.



Figure 21: Water pond as reservoir

The prices for usage are between 400 NRs and 600 NRs (ca. €4) per hour. Furthermore, maintenance costs are high. Lastly, the pump has a negative effect on the environment as it emits large amounts of CO^2.
The main reason for this pump to be identified as a competitor of aQysta is due to the widespread implementation and knowledge of this technology. Additionally, due to the cheap purchase costs and the ease of use, this pump has been accepted by many farmers (Nedersticht, Bom, Diik, 2013).

Petrol pump

Water pressure : 30,000-48,000 L/h
Pumping distance : Vert. 7 m - Hori. 25 m
Lifespan : 4 years
Operation costs : approx. € 0,85 - €4/ h
Cons : Negative for environment, High operation and maintenance costs
Pro's : Works with any water source, high water pressure, cheap purchase price
Purchase price : €197,50 on average



Figure 23: Petrol pump

(Bio) Diesel Pumps
The (bio) Diesel pumps have a purchasing price of €250 - €1000. However, the investment cost of a diesel pump can increase greatly when a well needs to be dug, in case the water source is underground. Depending on the geographical features of the area, the costs can amount to between €160 - €1350 (iwmi, 2019). The pumps are able to pump about 2500 L per minute, which is 150,000 L per hour. The exact fuel usage per hour is not known, but it requires large amounts of diesel to pump these quantities of water. This makes the operational costs for this pump high. According to the green-serve Ventures Limited (2017), small farmers spend approximately €450 on fuel annually. During the fieldwork it was found that people pay 400-600 NRs (€3.2-4.8) per hour of usage. It was not clear if these costs were solely diesel pump usage costs or also the costs for the pay-to-use service. In many cases the pumps are rented by the community and individual farmers can use it in turn, allowing a pay-to-use system. The renting costs of these pumps are extremely high, but sometimes this is the only solution for farmers as they cannot afford the upfront costs of these pumps.
Most of the diesel pumps are able to pump to heights of 16 m (Prem Engineering, 2019). The diesel pumps have a life expectancy of almost 8 years, however they require a high amount of maintenance. Due to the ease of use, this pump is seen as a luxury product. Like the petrol pump, the diesel pump is very harmful for the environment as it emits a large amount of CO^2 during its use. According to Lohanee (2019), **people care more about the user friendliness than the environmental impact.** For this reason the diesel pumps are seen as a big threat. Even though these pumps are no longer subsidised by the government, it is already widely used (approximately 31,000 pumps only in the Terai region (CBS,[29]..)). Furthermore, if people have their own purchasing power, they are likely to purchase the diesel pump rather than a more sustainable alternative, mainly due to the widespread knowledge of this pump. Additionally, this pump is often chosen over the pumps powered by electricity (another main competitor), because of the poor supply of electricity in farming areas (Shah, T; Singh, O.P.; Mukherji, A, 2006).

Diesel pump

Water pressure : 150,000 L/h
Pumping distance : Vert. 16 m
Lifespan : 8 years
Operation costs : approx. €4/ h
Cons : Negative for environment, High operation and maintenance costs. Relatively high purchase price
Pro's : Works with any water source, high water pressure
purchase price : €250 -€1000



Figure 24: Diesel pump

Solar powered pumps

Another important competitor for aQysta, are the solar powered pumps. Like the Barsha, and in contrast to the fuel powered pumps, they support sustainable agriculture. In Nepal this is a widely used solution, because many (international) NGO's are funding these pumps. Amongst this technology, there are many different types and brands. A few of these are discussed briefly, in the case that they have an interesting business model or use a somewhat adapted technology. The others are generalised and described as one technology; Solar pumps.



Figure 25 : (Bio) Diesel Pump

Solar Pumps
Solar pumps pump ground water to the surface or pump water from other water sources. Most solar systems work together with electric water pumps, but rather than using normal electricity, the electricity is provided by the sun through solar panels. A great advantage of this system over the normal electric pumps is that it is more reliable, since Nepal faces many electricity black outs. However, because it works on solar energy, it does not work 24h per day and the pressure of the pump is low when days are, for example, cloudy.
On average, solar pumps can pump up to 40 m vertically, 2 km horizontally and suck up the water from a depth of 7 metres or from a distance of 7 m to any water source (Green-serve Ventures Limited, 2017).
Also, solar pumps require little maintenance so the operational costs are low. However, solar pumps are expensive. According to the Get Involved group, every pump costs around €10,000. Other sources (ICIMOD, n.d.) mention a price of US$ 3800 (ca. €3400), which is still expensive, but relatively cheaper. According to the SELF research (2008), the initial cost of solar pumps is paid off after two years since there are almost no operational costs. Most solar powered pumps are able to pump 18,000-30,000L per day (750-1250 L/h), depending on the hours of sun and its strength.
Thus, a great advantage of solar powered pumps is that, as soon as the pump is paid off, there are no extra operational cost. Additionally, the pump is sustainable and has no negative impact on the environment. Disadvantages of these pumps are that they are expensive initially and only work effectively when the sun is out with a clear sky. While solar water pumps

Solar pump

Water pressure : 750 - 1250 L/h
Pumping distance : Vert. 40 m - Hori. 2 km
Lifespan : 20- 25 years
Operation costs : Almost zero
Cons : Operation limited by sunlight and very high initial costs
Pro's : Harmless for environment, little maintenance required
purchase price : €3400-€10.000



Figure 26 : Solar pump

also offer clean and cost-effective irrigation to farmers, the Barsha pump is cheaper and easier to maintain by comparison, it saves 70 percent of irrigation cost throughout its lifetime.

Sun Farmer
SunFarmer Nepal is a company based in Kathmandu. It is a solar energy company and one of their products is a solar energy system for electric water pumps. This company works with a three year rent-to-own service to cover the high initial costs of solar pumps, making this company interesting for this research (Sunfarmer Nepal, 2016; Get Involved, 2016). SunFarmer's irrigation model allows the farmers to pay for the solar energy in an affordable monthly amount. They work together with agricultural cooperatives who help to collect the monthly fees. They also provide long-term maintenance services (SunFarmer Nepal, 2019). Since March 2014, they managed over 100 of these projects throughout Nepal (Get Involved, 2016). Besides this model, they also tried and are still trying different other models with the vision to provide the best opportunity to the farmers (Paul-Bossuet, 2017).

Claro Energy
Claro Energy is a company based in India. Since their launch in 2011, they have installed 8000 solar systems throughout India (Claro Energy, n.d.) . This company is not seen as a direct competitor of aQysta, but more as a source of inspiration. Claro Energy works with a low-cost pay-per-use irrigation system. For this project, they have installed 5 fixed solar systems and 50 trolley systems (figure 27), which are being used for irrigation and shared among 30-40 farmers per day and a total of 900 farmers. Farmers can activate the pumps with a pre-paid card system. Claro Energy has 12 professionals available to provide technical assistance and to give training to farmers (Powering Agriculture, 2019).

Gham Power
Gham Power is a Kathmandu based company, providing solar water pumps to local farmers. They are the first to use a data-driven approach for agriculture in Nepal. The pumps are integrated with built in 'Smart Meters" to track live data about water and farming patterns. With these outputs, they can enhance the cropping practices of the farmers. Besides the "Smart Meters", Gham Power also provides a pay-as-you-go financing service to overcome the upfront costs of the pump. The repayment should be done over a period of three years. Farmers are able to pay with mobile money, so that nobody is in charge of physically collecting the money. The product is available in 20 districts of Terai (Gham Power, 2019).

Others
Other organisations that provide Solar powered pumps work with subsidies to facilitate an easy accessible technology for the farmers. They work together with the government and other stakeholders, such as Village Development Committee (VDC), Municipality and District Agriculture Development Office (DADO). In this way they can provide the pumps at an affordable price. It was also mentioned that an initiative exists where the farmers could use the pumps for 50 NRs per hour (Bhusal, LI-BIRD, 2018).

Electricity powered pumps

Another main competitor is the irrigation pump powered by electricity. This system, together with the diesel pumps, is widely used in Nepal. Main reason for this is because they are cheaper (5,000-125,000 NRs ; €40-1,000) (Nepkart, 2019; Wikiwater, n.d.) and easier to use, since it does not need to be installed in a river. This type of pump can work with different types of water sources (wells, ground water, ponds, rivers, canals), whereas the Barsha pump only works with streaming water (from a canal or a river). Depending on the variant (thus the horsepower) of the pump, it can deliver 4 to 190 L water per minute (240-11.400 L/h) (Electric Water Pump Guide, n.d.). However, bigger pumps, can, according to Water & Waste Water Treatment (WWT), even manage flows of 16,500 L per minute , with a maximum head of 85 m (WWT, 2017). A drawback of electric pumps is that they depend on electricity, which is not always available in Nepal and also not free. This pump also has high maintenance costs, however once installed, maintenance is not required often.



Figure 27 : Claro Energy (PV-Tech, n.d)

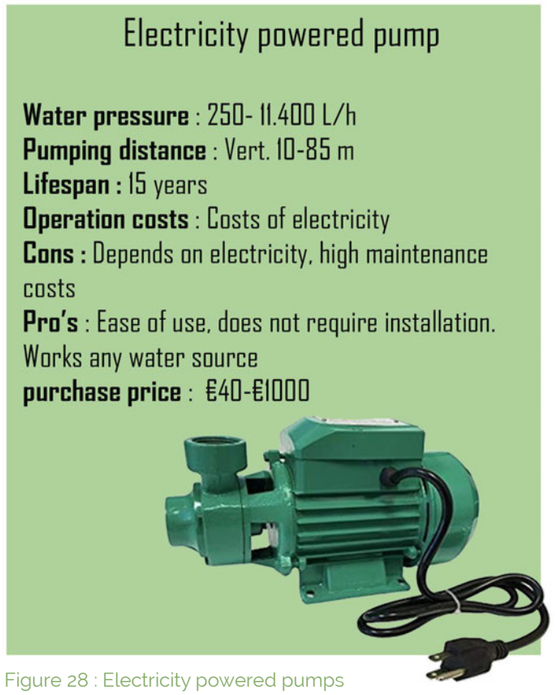


Figure 28 : Electricity powered pumps

Wind powered pumps

Another natural source of energy is wind. Although it is not commonly used in Nepal, there is at least one company selling windmill water pumps: Krishna Grill and Engineering (Get Involved, 2016). Another more famous windmill water pump is the Poldaw. It is quite expensive, ca. €1,800, but it can pump water from depths up to 140 m. The Poldaw pumps only require simple annual maintenance, and materials can be bought locally (Poldaw, n.d.; Tribology, n.d.). These windmill pumps are no direct threat to aQysta. However, the technology is taken into account since the input is a renewable energy source and therefore a sustainable technology.

Hydro powered pumps

The last type of pump to discuss are hydro powered pumps. In a country with 6,000 rivers, hydro powered pumps can be of great value. There is no direct competitor in Nepal that works with similar hydro powered spiral technology. However, other types of hydro powered pumps exist. Among them is the so called the RAM pump, working with a different technology.

Hydraulic RAM pump
The basic working principle of hydraulic RAM pumps is the presence of height differences to build up a pressure within the pump. Basically, water enters the pump, the pressure builds up and when the pressure is high enough, the water is pumped out. It can pump up to 100 m vertically (Papa pump, n.d.). Depending on the size and other features, prices of RAM pumps can vary between €1,650 and €6,000. Also depending on size of the pump, they can pump between 90,000 and 230,000 L a day (3760 -9580 L/h) (Get Involved, 2016). A clear disadvantage of this technology is the high upfront costs, however, the ability to pump up to heights of 100 m is a great advantage.

Papa pump
One of these RAM pumps used in Nepal is the Papa Pump. Together with the NGO Renewable World, they provide sustainable irrigation solutions. Renewable World connects the farmers to "Collection Centres", which are financial institutions that provide trainings in farming. They fund 30% of the upfront costs and advise

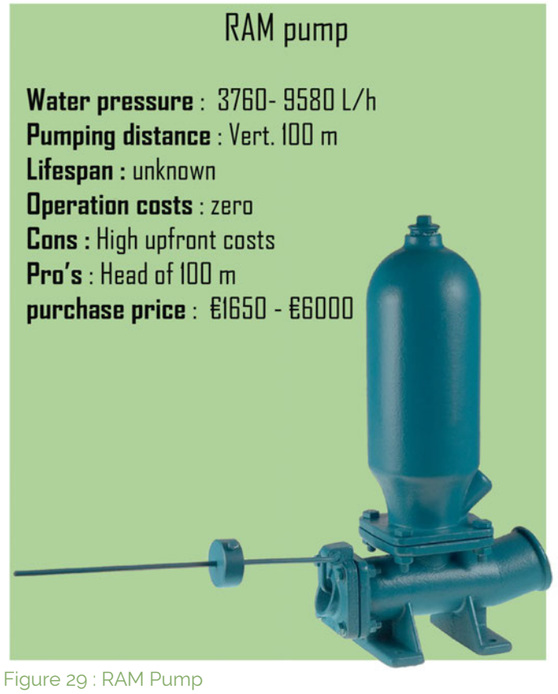


Figure 29 : RAM Pump

the farmers to pay 20% themselves and get the other 50% through government subsidies. More details of this model are explained on p. 92 in the outcomes of the interview with Renewable World.

Human powered pumps

Lastly, there are a few other ways to get water to the field. One of them is of course carrying the water from the river to the farm. However, the reason for designing other pumps is so that this method can be avoided. With taking up to 5 hours a day it is very time consuming and this leaves little time for other jobs. Another method could be to just collect rainfall in buckets. The advantage of this method is that the water could also be used for drinking purposes. However, the disadvantage is of course that it is very unreliable, because it is weather dependent. Besides this very labour intensive and time consuming alternative, there are also some other human powered pumps. A few of them are already explained in the traditional irrigation methods parts (p. 48). Another human powered method, is the bicycle pump (USAID, 2015). Simply said, farmers need to cycle the bike to pump up water. Even though it is a cheap and effective solution, it is still time consuming as you cannot do anything else when you are on the bike. All of these human powered pumps are not seen as competitors, but because the operation of the Barsha also needs some manual labour (placing it in river), it can be useful to compare with what farmers are familiar with.

2.2.3 Conclusions

First of all, small farms are described because they are the end users of the Barsha pump, i.e. the target group for this project. A small farm is a farm with less than two Ha of land. In Nepal, there are approximately 2.7 million of these farms. Most of them are family farms, containing on average 5 people working on the farms. Agriculture is the biggest sector of income in Nepal, hence this sector is of great importance. Unfortunately it is becoming less popular amongst youngsters to work in this sector. This causes a problem because even more products have to be imported. For a country with no natural raw materials, the own food production is very important. Therefore it is important to see how these youngsters can be motivated in any way. Governments are already trying this by reserving large budget for this sector.

Currently, only one third of the agricultural land in Nepal is irrigated. This results in a large need for irrigation pumps. Preferably, this should be sustainable ones. The Barsha pump is not suitable in all cases since sometimes the farms are not located close enough to rivers. Working with (local) government is a really important factor in Nepal, as they have annual budgets to allocate to different projects. Furthermore, it can be helpful and a competitive advantage that the fuel powered pumps are no longer subsidised by governments. However, most of farmers have no interest in a positive environmental impact and care more about the financial aspect of the pump.

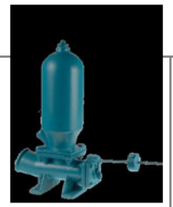
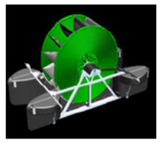
						
	Petrol Pump	Diesel Pump	Solar Pump	Electricity powered Pump	RAM Pump	Barsha Pump
Water pressure	30.000 -48.000 L/h	150.000 L/h	750 - 1250 L/h	250 -11.400L/h	3760 - 9580 L/h	1667 L/h
Pumping Distance	Vert. 7 m - Hor. 25 m	Vert. 16 m	Vert. 40 m - Hor. 2 km	Vert. 10-85 m	Vert. 100 m	Vert. 20 m - Hor. 2 km
Purchase Price	€120- €275	€250- €1000	€3400- €10.000	€40- €1000	€1650- €6000	ca. €1000
Operation Costs	ca. €0,85 -€4 /h	ca. €4 /h	~€0	Electricity costs: ca. €0,07 /h	€ 0	€ 0
Lifespan	4 years	8 years	20-25 years	15 years	unknown	15 years
Pro's	Works with any water source. High water pressure. Cheap purchase price	Works with any water source. High Water pressure	Harmless for environment. Little Maintenance required	Works with any water source. Ease of use; does not require installation.	Head of 100 m. Harmless for environment	Harmless for environment. Almost no maintenance required
Con's	Harmfull for environment. High operation and maintenance costs.	Harmfull for environment. High operation and maintenance costs. Relatively high purchase price.	Operation limited by sunlight. Very high initial costs.	Depends on electricity. High maintenance costs.	High upfront costs	High upfront costs. Only operates with water flow with min. Of 1 m/sec

Figure 30 : Competitor Analysis overview

Finally, the previously explained pumps, stated as real competitors, are put together in a table (fig. 30) for easy comparison. The Barsha pump and its characteristics is also put in the table so that the characteristics of the competitors can be easily compared. As can be seen in the table, the petrol pump and Diesel pump can deliver the highest water pressure. The petrol pump is able to pump as much water in one hour as the Barsha does in 24 hours.
However, the Barsha has a higher vertical head than both the fuel powered pumps. However, compared to the other sustainable pumps (solar and RAM), Barsha stays behind regarding its vertical pumping distance.
Last, it can also be seen that the life expectancy of the solar pumps is longer than Barsha's lifespan. On the other hand, Barsha pump does have a longer lifespan than both the fuel powered pumps.

Takeaways for the project

From this analysis on the market some takeaways for the project can be drawn:

- **Involving youngsters in any way**, could be an interesting thing to take into account when designing the business model. This might help in getting government subsidies, since the government cares about this.

- The remote locations and difficulties for farmers to reach local markets are interesting to consider. Selling the products should be something farmers can rely upon, as it represents their income. It could be of great value to **link farmers to the market** and make contracts for steady incomes.

- The Barsha pump is not suitable in all cases since sometimes the farms are not located close enough to rivers. In such situations, it can be interesting to **work together with a NGO** that provides different sustainable solutions, to **provide a sustainable solution for all farmers**.

- Also, there might be cases where Barsha is suitable, but **farmers do not have enough funds to invest**. This could be something that can be overcome with a new business model design.

- Currently, only 5% of the production of smallholders is sold. This is mainly due to poor transport facilitations, but also because there is lack of knowledge on how and where to sell harvest. This limited access to the market cause smallholders to receive an income of €233 annually only.

- Farmers clearly need help with covering the upfront costs, need **training about farming** and connection with the market. PSS could help by delivering this.

- Participation in the market would result in positive outcomes for farmers, as it can facilitate technology adoption and exchange of information. For example, only 20% of the smallholders use improved seeds due to a limited access to innovation (Rapsomanikis, 2015). This can be improved by the **exchange of knowledge between different farming parties/communities.**

- Regarding irrigation methods, it can be interesting to **create package deals** where farmers 'receive' drip systems or sprinklers in addition to the Barsha pump. By **providing them with a complete solution**, farmers are more likely to have a profit. However, in order to offer such package deals, aQysta should collaborate with **different stakeholders.** Furthermore, prices would be higher, so that should be bear in mind.

- Drip irrigation is the most efficient irrigation method, because no water is wasted. In case off offering the complete package, this one would suit best, due to efficiency.

- Finally, competitors should not be forgotten. As mentioned previously, it could be interesting to **work parallel with other (sustainable) pumps**, so that aQysta, or another party, could always offer a solution for irrigation. This will still be profitable for aQysta, since in particular cases the Barsha is the best option. For example, if both solar pumps and Barsha would be suitable, Barsha is cheaper, easier to maintain and operates 24/7.





2.3 COMPANY ANALYSIS

Strategy & Mission

The business case for this project is the company aQysta. A company analysis is performed in this chapter to get a better understanding of the company, their strategy and the different products they offer. The general features of the company are already discussed in the introduction. In this chapter the focus is more on the company's strategy and their product portfolio. Last but not least, the mode of operation of aQysta in Nepal is discussed along with their current business model.

2.3.1 Strategy & Mission

In this part the strategy and mission of aQysta are discussed in addition to the opportunities that arrive from them.

aQysta strives to offer a solid value proposition to their customers while creating a positive impact on the world (aQysta, 2019). This means that the **sustainable products they produce should improve human well-being without compromising the environment.** Their value of sustainability is not limited to reducing emissions but also focuses on the impact on lives and thereby hoping to further develop the less-developed areas of the world by encouraging irrigation for farms.

This is why aQysta has decided to design pumps that provide water for irrigation in less developed areas in order to improve these communities' farming standards. By doing this, they hope to **improve the living standards** in those areas, by **increasing the farmers' incomes**. By developing hydro-powered pumps, the energy from flowing waters is used to power the supply of water to the customers (Global Innovation Exchange, n.d.). aQysta has developed different pumps, which will be explained in the next part; Product Portfolio.

The Barsha pump, which is the main focus of this thesis, has been sold in 19 different countries. The Barsha pump is unique in that it allows the **use of small volumes of water in a cost-effective manner**. Efforts are made to scale up the production of this pump to allow a more optimized use of the pumping system, however this has not been implemented yet (aQysta, 2019).

The Barsha pump has been effective up to now because of the strategy of aQysta. Due to their technical knowledge and wide network in the 12 countries, of which the main country of interest is Nepal, they have been able to **implement approximately 300 Barsha pumps.**

However, aQysta's mindset is also the cause of different complications. An example is the financing of the pump. The pumps are expensive for the farmers (the target group of the pumps), causing aQysta and the farmers to **rely on the investment of external parties**. This is fairly difficult, which in effect, reduces the installation opportunities for aQysta. The communication of aQysta has also proven to cause complications for their business, as their way of addressing stakeholders has been less effective (T. van der Gragt, n.d). Their values are clear to the customers and external parties; however, the stakeholders are often left in doubt about the strategy and value proposition. Furthermore, it was noticed that aQysta has no clear mission and/or vision statement. This is often used by companies for communicating their strategy.

EASI-Pay & Farm incubator.

As mentioned before, aQysta is already experimenting with certain PSS business models, namely the EASI-Pay (pay-per-harvest) model (Food & Business, n.d.) but also a farm incubator model. The Farm incubator model was only briefly piloted in Nepal, on a farm owned by aQysta, in Lele. Within this model, aQysta was responsible for **providing the farmer with salary and all required inputs for farming.** The Barsha was only used by the farmers, meaning that it was still in ownership of aQysta. Furthermore, aQysta had the responsibility to sell the harvest in the market. Thus, aQysta took all risks concerning finances and market, so that the farmer could fully focus on farming.
The aim of this pilot was to enable smallholder farmers to shift to commercial farming, whom before were not able to because they did not have the financial aids. The idea was that after a few years, the farmer would be experienced enough to buy the farm and grow even bigger (aQysta, n.d.[1]). Unfortunately, the farmers never came to the point where they were able to purchase the farm and the new inhabitants of the farm did not make use of the Barsha. Hence, the Barsha pump was removed in July.

The EASI-Pay model was already explained in the Literature Analysis on page 41. This pay-per-harvest model is implemented for three years now in Sumba, Indonesia, in about 10 villages. A NGO (Max Waingpu) bought the pumps from aQysta. If desired, the use of the pay-per-harvest service, the pumps are able to be repaid within 4 years (Food & Business, n.d.). It is not clear yet, if the NGO aims to let the farmers pay off the pump. Currently, the pumps remain in ownership of the NGO and the idea is that the farmers only pay for the service.

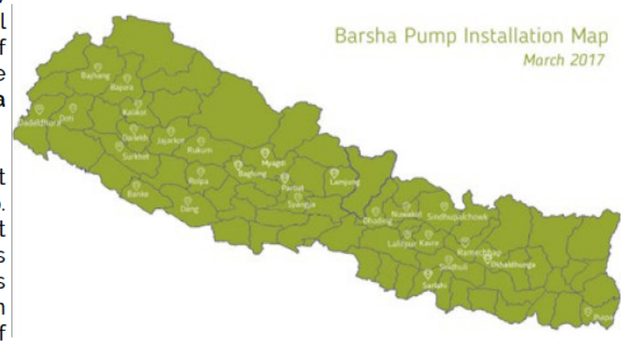


Figure 31: Overview of installed Barshas 2017

2.3.2 aQysta's Product Portfolio

In order to get a better understanding of the products aQysta offers and the differences between these, this part discusses the portfolio of the products. As this thesis focuses on the Barsha pump, the other pumps will be compared and related to this pump. The technical aspects of each pump are briefly mentioned. At the end of this part an overview of the three pumps is given by means of a comparison table.

The water delivery by the pumps depends greatly on the location of the pump. This also includes the hydro-power which may or not be present at that location, which in effect impacts the irrigation of the fields (Lawrence et al., 2018). This therefore requires the addition of technical complements in order to be competitive with the traditional fuel powered pumps. aQysta has developed* three pumps: the Barsha pump, the Hypump and the Integrated Turbine Pump (ITP) (aQysta, 2017), that could compete against these traditional pumps. Each pump is explained now.

**ITP has not been developed yet, but is in concept phase.*

Barsha pump

The Barsha pump is thus far the most widespread pump aQysta has developed. It has been sold in 12 countries so far. Barsha means rain in Nepalese, which was the country were the Barsha was inspired. Co-owner Thapa's parents were hard working farmers in Nepal, having to fetch water by hand at all times. With the idea of improving the livelihood of his parents (and many other farmers), in mind, the Barsha originated. The technology consists of a set of twin spiral pipes, driven by the kinetic energy of the water stream by means of a waterwheel. The spirals act as volumetric pumps that lift water through the so-called manometric principle (Young, 1807; Technology Exchange Lab, n.d.). In figure 32 it is shown where the water enters (and the names of the parts). The pump is powered purely by the flow of the river or canal itself (aQysta, 2017) and therefore, no external power source is required to enable this process. The Barsha is able to pump the water up to 20 m in height and up to 2 km in horizontal distance. It is able to irrigate up to 2 Ha of land at a time (aQysta, n.d.). Due to the maximum power that can be generated in the pump, a maximum of 40,000 litres per day can be delivered (Sangam Ventures, 2018). This is comparable with what an average Diesel pumpset can deliver in one hour.

The Barsha is fixed to the ground in the flowing river or canal. The water enters one side of the hosepipe and the wheel obtains kinetic energy from the water pushing against the 14 paddles, causing the wheel to rotate. The (manometric) working principle of a spiral pump is that the combination of air pressure and water inside the spiral generate a gravitational force (Intriago et al., 2019). This force pushes the water (and the air) upwards, hence allowing the water to exit the hosepipe at its other end (S. Chaudhary, G. Ram Sinkemana, 2017). The end of the hosepipe is placed near the land for irrigation.

However, consequently, the water pumping power depends greatly on the flow that is present in the river/canal and therefore it also heavily depends on the location (Manzano-Agugliaro, Taher, Zapata-Sierra, Juaidi, & Montoya, 2017). The river or canal requires to flow at a rate that is greater than 0.3 m3/s (equal to 1 m/s in speed) (S. Chaudhary, G. Ram Sinkemana, 2017). Apart from the technical aspects, the social, economic and environmental aspects are also relevant in determining



Figure 32 : The Barsha pump

the location of the pump (Butera & Balestra, 2015).
A limitation of this pump is that it handles small volumes, making it mainly applicable for small farming purposes. However, efforts are being made to scale this pump up to larger volumes to optimize the costs and the performance of the pump (aQysta, 2019). Nonetheless, the small volumes allow the pump to be independent and provide sufficient water for irrigation of smallholder farms.

The pump has no operating costs, as it requires no energy or labour and thereby reduces the costs by 70% relative to traditional pumps. Therefore, the only costs are the initial investments and the related maintenance. The Barsha pump is also more affordable than other sustainable alternatives, such as solar pumps (Sangam Ventures, 2018). As the government has subsidised a large amount of Barsha pumps, customers have been able to buy it at a huge discount. As the lifetime of the Barsha pump is around 15 years and it requires very little maintenance, the farmers have sufficient payback time and no/little costs (aQysta.com, 2019). Through the use of the Barsha pump, customers have been able to increase their annual income by 3.5-4 times (Sangam Ventures, 2018).

There are roughly 10 villages that currently use the Barsha pump with the pay-per-harvest model in Indonesia. By using these pumps, the farmers were able to practise their agricultural techniques even during the dry season. Additionally, the Barsha pump allowed the farmers to increase their income. More specifically, the farmers increased their income by 8-13% (Food & Business, n.d.). By providing the farmers with more specific trainings and explanations on the usage of the pump, this can be increased even further (Food & Business, n.d.). Due to the portability of the pump, it enables sustainable business models, such as the EASI-Pay model implemented in Indonesia or another sharing service, by relocating it nearer to different farms.

To summarize, the Barsha pump is a very effective, small volume pump that increases the income of farmers greatly due to the absence of operating costs. It has been implemented widely through Nepal and other countries and has proven to be very beneficial for farmers, especially with a pay-per-harvest service.

HyPump

The HyPump (fig. 33) is the second hydro-powered pump that aQysta has designed. It is the bigger brother of Barsha. The purpose of this pump is primarily to deliver pressurized water for drip systems. Just like the Barsha pump, the HyPump is a spiral pump which, again, functions purely on the flow of water and requires no extra supply of energy (aQysta, n.d.). The first HyPump has recently been installed in Llíria, Spain.

The volumes of the HyPump are larger than those of the Barsha pump, making it suitable to serve 20 Ha of land at a time (aQysta, n.d.). Additionally, it is expected that the pump will be able to supply water at a rate of 6 liters per second, which accumulates to a total of 500,000 L per day. The vertical height the pump is capable of reaching is 35 m and a horizontal distance of 3.5 km (aQysta, n.d.).
The purchase costs are expected to be much higher than those of the Barsha. However, the operation costs for farmers are reduced greatly, just as with the Barsha pump. Similar to the Barsha, the costs for farmers are estimated to be reduced by 70% in comparison to traditional pumps (Cordis, n.d.). Withal its effect is larger, as larger areas can be irrigated through the use of the HyPump.

The main differences between the HyPump and the Barsha pump are the volume of the pump and the fact that the HyPump is stationary and cannot be moved.
The greater volumes of the HyPumps, make them interesting to consider for a PSS in the future for collective use. However, when the project started, the HyPump was not implemented yet. Hence, the Barsha was more suitable for this project.

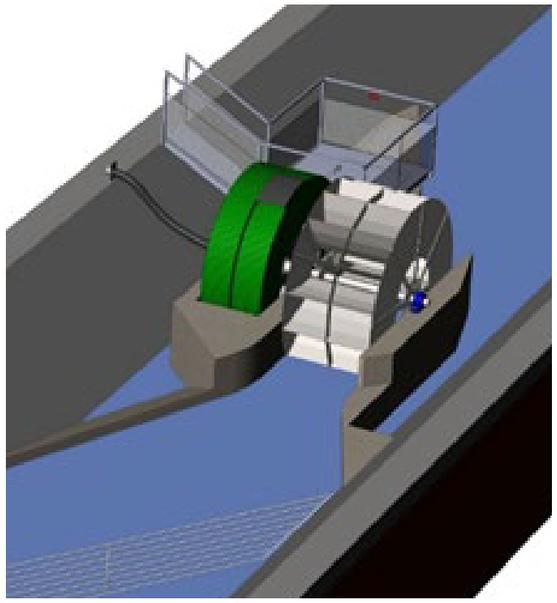


Figure 33: Render of the HyPump

Integrated Turbine Pump (ITP)

The Integrated Turbine Pump is the third pump type aQysta has designed in collaboration with the Comillas University in Spain (M. Ertsen, J.C. Intriago, 2018). Just like the other two pumps, no additional energy is required to supply farmers with water for irrigation. The pump has a similar structure and is made from a wheel.

The pump is similar to the previously described pumps but it combines a turbine, generating energy and a

pump, to pump the water, hence the name of "integrated turbine pump". By adding a turbine, the pump is able to elevate the water to heights greater than 20 m, which is the limiting height of the Barsha pump. It is therefore more powerful than the Barsha pump (aQysta, 2019).

The ITP is expected to be slightly more expensive than the Barsha pump and the HyPump, which causes it to be less suitable for individual use for smallholder farmers. A small increase in costs can already have a serious effect on the farmer's income (M. Ertsen, J.C. Intriago, 2018). Just like the HyPump, the ITP is stationary and cannot be moved. The even higher investment costs of the ITP and the fact that infrastructure is required, make it still an interesting case for PSS implementation. However, due to the fact that this pump is not developed yet, it was chosen to focus on the Barsha pump for this research project.

The three pumps are put together in one table (fig.34) for easy comparison.

2.3.3 aQysta in Nepal

In this part the current way of how aQysta is doing business in Nepal is analysed. The different stakeholders that are involved are described. Secondly the current structure is explained by means of strategy map and a business model canvas. Last, this chapter is concluded with a SWOT-analysis.

aQysta has hired Nepalese local people to ensure an enhanced communication within the country. The team currently consists of six employees, of which most are employed as technical staff. Also, most of aQysta's marketing and communication is done from the local office in Nepal. As their knowledge of the country and the people is also more accurate, this is a great benefit for aQysta and the success of their business. Sometimes it can be challenging working together from stations in different countries, due to different time zones but also due to cultural aspects. On the other hand, this international context is also interesting to work in. Also it could be wise to broaden the team, with employees spread over the country, as now, the team is often occupied with field visits in far remote regions of the country. Although it might be nice to have work related field trips now and then, it can be very time consuming, with traveling times over 16 hours.

Stakeholder analysis

As mentioned in the literature analysis, according to Morelli (2006) the PSS design process should at least contain an identification of stakeholders. Hence, the different stakeholders for aQysta are identified. They are discussed below and visualised in figure 35 along with their relationships.

The stakeholder network that is discussed here evolves around the Barsha pump in Nepal. The Barsha involves four main stakeholders but also other important parties exist in the network. The stakeholders are identified as organisations or individuals that help the company in the form of a financial support or in the form of physical help. The network exists of every party that ensures the

	Barsha Pump	HyPump	Integrated Turbine Pump
Price	ca. €1000	*unknown*	*unknown*
Size	ca. 1,5 m	ca. 4 m	*unknown*
Pumping distance	20 m vertically, 2 km horizontally	35 m vertically, 3,5 km horizontally	> 20 m vertically
Water pressure	40,000 L per 24 h	500,000 L per 24 h	*unknown*
Estimated lifespan	15 years	25 years	*unknown*
Ha of Land	2 Ha	20 Ha	*unknown*
Required water flow	1 m per sec	*unknown*	*unknown*
Operation costs	€ 0	€ 0	€ 0
Stage of development	Improved Design	First working model	Conceptual Stage
Nr. of installations	ca. 300	1	0
Nr. of countries installed	19	1	0

Figure 34: Overview of the three pumps

farmers are able to use and/or purchase a Barsha. The four main stakeholders are aQysta (Headquarters and Nepal team), the government, the distributor and the farmers.

1. aQysta : For the existence of the Barsha, aQysta is of course the most important party. The headquarters in Delft are responsible for the design and the technical knowledge of the pump. Also, they take care of the supply chain. The local team in Nepal is responsible for the sales of the pump. This is mostly done by doing demonstrations for local governments. Also, the technical staff of aQysta's local team is constantly trying to improve the Barsha's performance. Last, in some cases, the team also installs the pumps and provides maintenance when necessary.
2. Nepalese Government : In 2015, the Nepalese government bought 200 Barsha pumps to facilitate farmers throughout the country with water for irrigation at a discounted price. The government has subsidised the pumps in great amounts. Only 10-15% is left to be paid by the farmers (Securing Water for Food, 2017). Nowadays, aQysta mostly relies upon these local governmental subsidies, as they have annual assigned budget for agriculture and thus irrigation. Often, the local government also selects and reaches the final users, the farmers.
3. Distributors : aQysta selects one distributors per country. The Nepalese distributor is NAF Seeds and they are trained by aQysta to assemble the pump.
These distributors aim to show local farmers how the pumps are used and what the benefit is for them (Securing Water for Food, 2017). In exchange for their services, the distributors obtain exclusive rights within the country.
4. Farmers : The final users of the Barsha are smallholder farmers. In most cases, aQysta is not in direct contact with the farmers and all the communication is done through NGO's and distributors. The farmers purchase the pump through the stakeholders, for which there are three ways for the farmers to do so. First, aQysta can sell the pump to the NGO, which then sells it to the farmer. The second option is that the farmers buy it for a discounted price from the government, which has bought it from aQysta in bulk. Last, the farmer buys it from aQysta through the distributor.

Other important stakeholders that exist in the network are **governmental development organisations**. The current governmental organisations that are helping

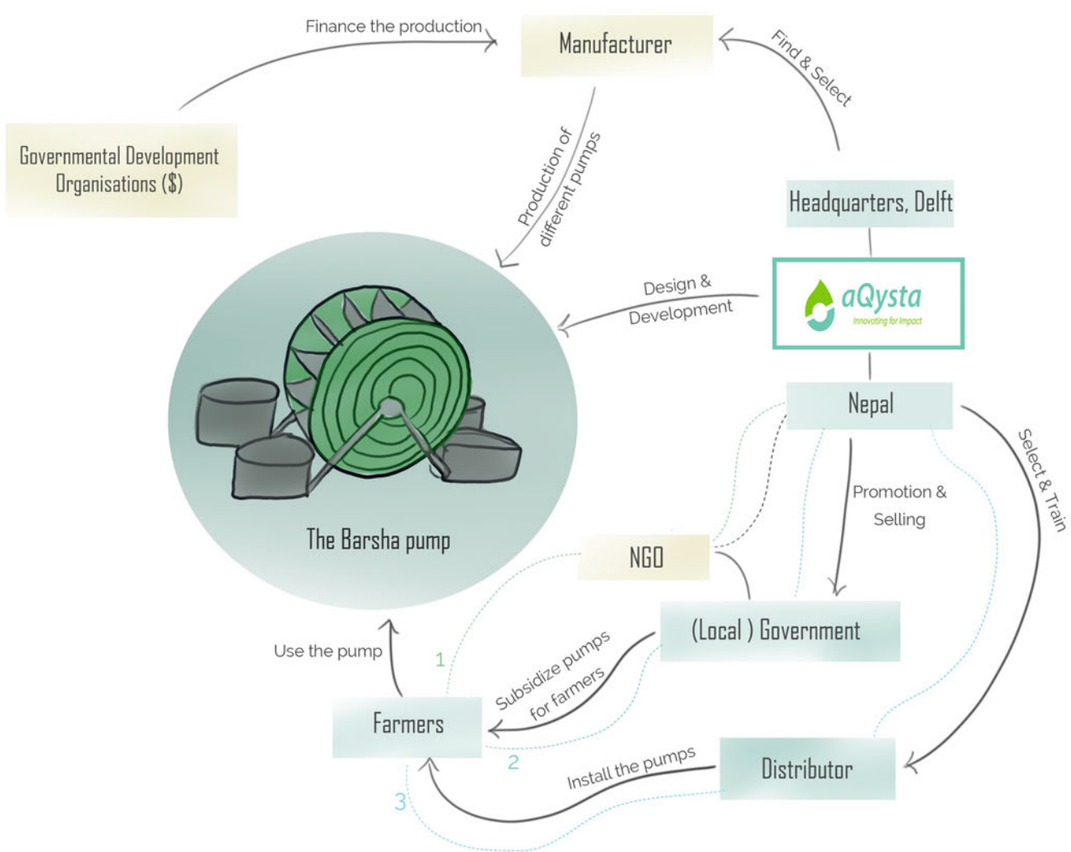


Figure 35 : Stakeholder map

aQysta with the development of the Barsha (and the other pumps) are the Dutch Ministry of Foreign Affairs, United States Agency for International Development (USAID) (K. Unger Baillie, USAID, 2014) and Swedish International Development Cooperation Agency (SIDA). These kind of organisations invest in aQysta under the circumstance that aQysta meets certain set goals. The grant from these organisations comes from the joint programme called Securing Water for Food (SWFF) (Holland, 2014). The programme organised a challenge to produce more food from less water, of which aQysta, amongst other innovative projects, managed to be awarded with a grant of $500,000 (Securing Water for Food, n.d.). Which resulted in the implementation of five demonstration pumps, benefiting at least 300 people (Securing Water for Food, 2017). Additionally, aQysta has won the Climate-KIC innovative clean-tech venture award in 2014, resulting in a grant of €40,000 along with directed coaching (R. Marvasti, 2014).
Furthermore, **Non-Governmental Organisations (NGO's)** have supported aQysta by helping in making contact with farmers. They do not provide any financial aid but they guide in making local contact with customers (buyers).
The last parties that are involved in the network are the different **manufacturers**. The parts of the Barsha pump are manufactured in different countries.

Current Situation

To explore opportunities, it is important to understand the current situation and to determine in what areas/ sectors improvement is needed. Therefore, the current situation was mapped using a business model canvas, value proposition canvas and a basic system map. In this part, the current system map is visualised (fig. 36).
As shown in the visualisation, aQysta has its main office in Delft. From there, they have contact with different local teams, among them Nepal. Currently, most of the production is still outsourced from different countries. Especially the spiral has a complex design and patent. The only one able to manufacture the spirals now is a German company focussed on injection moulding. However, together with aQysta, they are now trying to produce the spiral with help of blow moulding, as that would make the production costs way cheaper. In the future, aQysta aims to outsource the production of the spiral to China or India. Main reason for this is to make the product cheaper. Transportation costs will be less (if also assembled in Asia) and labour costs are also less. However, currently, the spiral is still produced in Germany. After production, it is transported to Delft. Other parts, paddles, floaters etc. are already mainly produced in Asia (India) or simpler parts even locally in different countries. Nowadays however, most parts are sent to Delft, from where it is all put together and sent to the preferred countries. This obviously needs improvement and aQysta is working on making this production cycle more efficient. As for now, the pumps are sent to Nepal in bulk, based on the demand. Once arrived in Nepal, they are distributed to the different order locations. aQysta employees will be in place to install the pumps. However, in previous cases, when sold through distributor, the distributor took care of installation.
Regarding the promotion of the pumps, aQysta employees talk with Provincial governments to try to let them invest in the Barsha. This year, this approach has led to success and Barsha was incorporated in two of the seven province's budgets. This success will however lead to new problems when service is needed, as they are both located at least 8 hours from Kathmandu. Ideally there should be a trained person in these provinces to serve the farmers when for example maintenance is needed.
There are only a few cases in which the sales went directly through aQysta and farmers. aQysta was approached by the 'customers' because they heard about it. However, in most cases, another party was always involved.

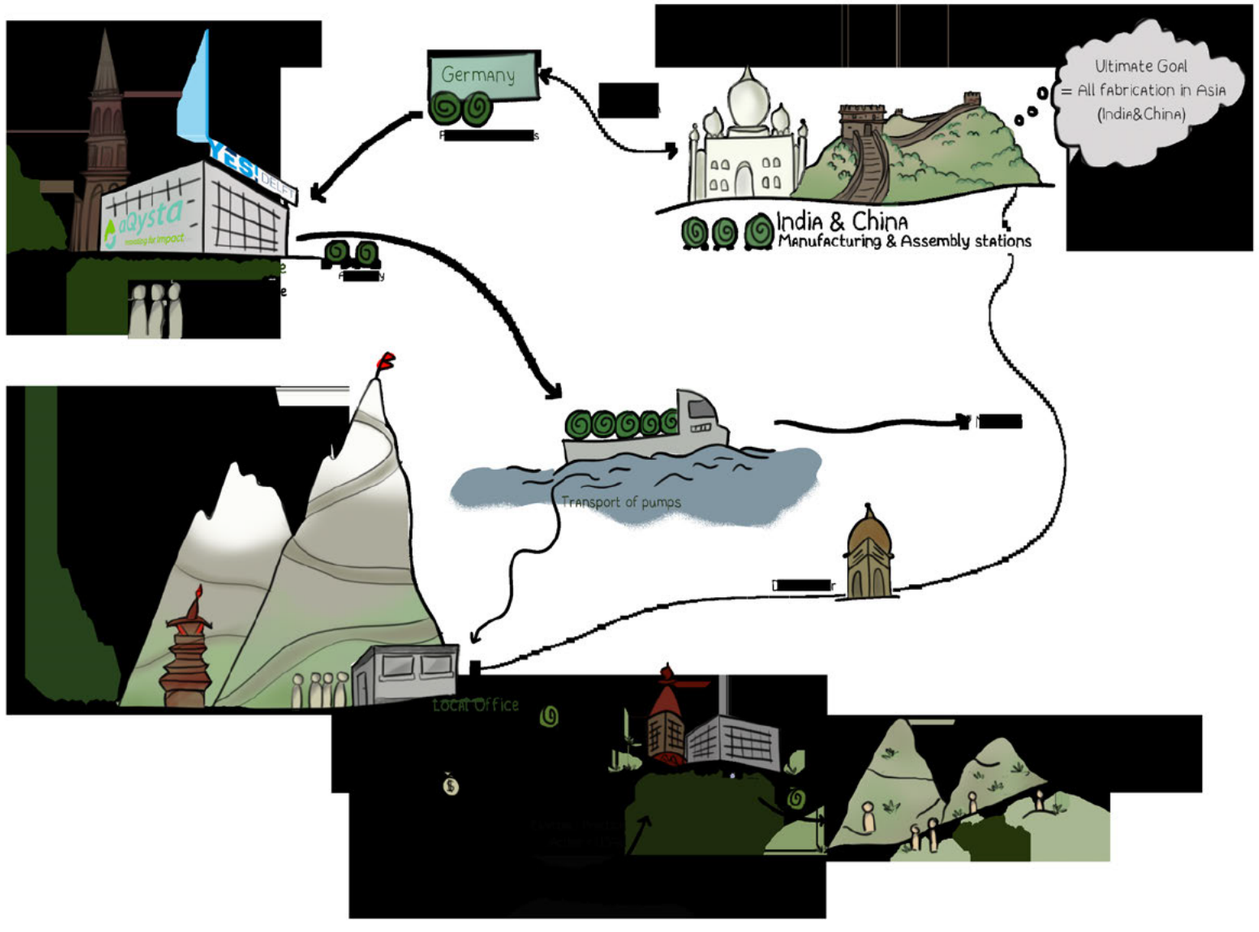


Figure 36 : System map of current situation

Current Business Model

The aim of this project is to give advise for new business opportunities, creating more impact by implementing the Barsha pump. Therefore, it was analysed how aQysta is doing now, hence the current business model of aQysta was reviewed. A simple way to visualise the business model of a company, is by use of the Business Model Canvas of Osterwalder and Pigneur (2010). The basic BMC was adapted to the adapted sustainable version, implementing People, Planet and Profit. In figure 37 the current business model of aQysta is visualised. This knowledge was mostly gained during the field work in Nepal.

As can be seen in the canvas:
1. Customer segments: aQysta creates value for smallholder farmers in Nepal, who are the end users of the Barsha pumps. This can either be individual use or collective use by a community. Other important customers are the local Governments and (non-governmental) organisations.
2. Value propositions: aQysta provides the farmers with a sustainable irrigation pump with zero operation costs. For the planet this is valuable because the Barsha does not require energy or fuel and therefore has no CO^2 emissions.

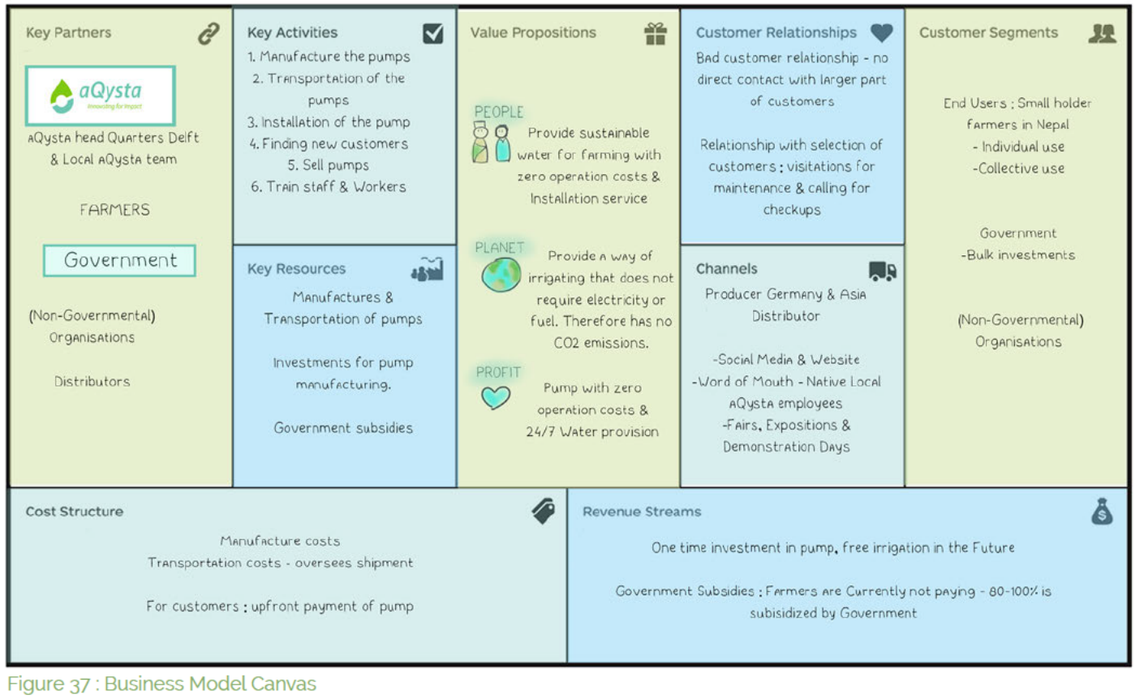


Figure 37 : Business Model Canvas

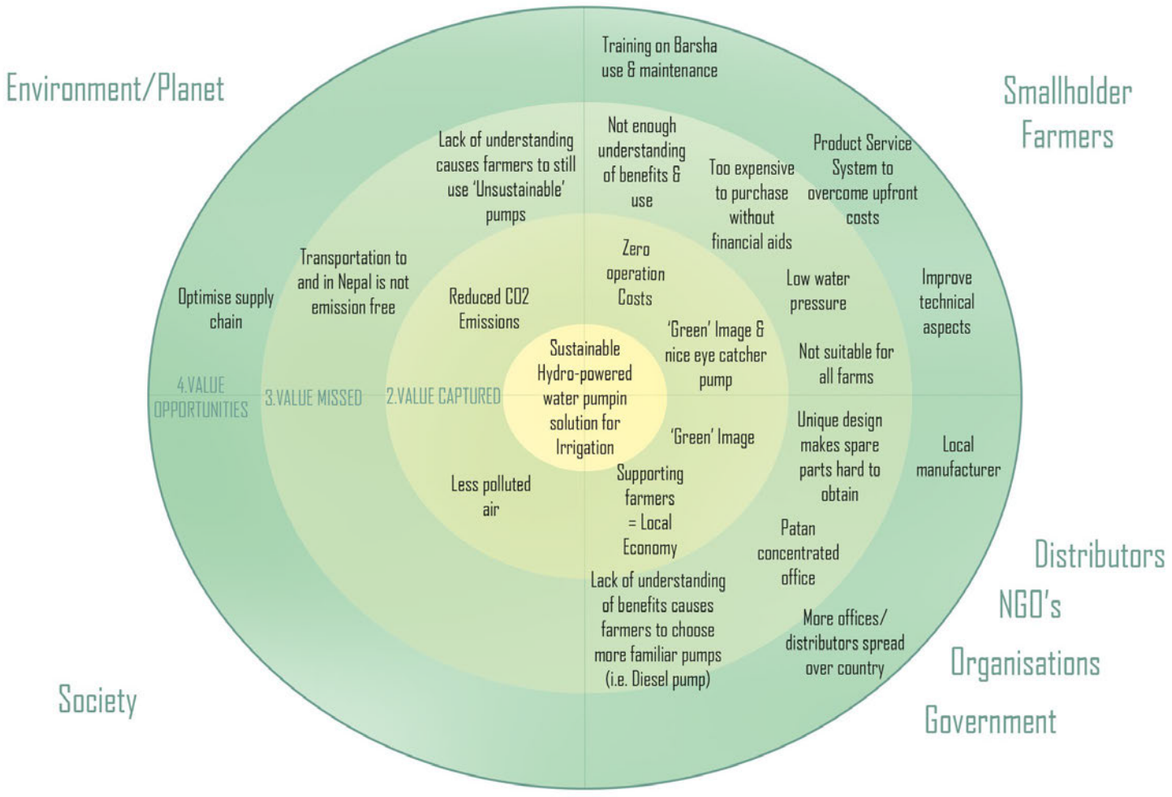


Figure 38 : Value map for aQysta

3. Channels: Different parts of the Barsha are produced in different countries. The green spirals are made in Germany and the floaters, paddles and metal parts are produced in China. From there, they are shipped back to Delft, where the pumps are assembled for the greater part. The next step is to collect the (half) assembled pumps with the remaining parts and prepare them for shipment to Nepal. From there, the larger amount is picked up by the distributor and only few are kept by aQysta at the local office.
As for promotions: the customers, thus farmers and governments, are currently reached through means of word of mouth, presentations, meetings, fairs, expositions and demonstration days. Furthermore aQysta is active on social media and has an up to date website.
4. Customer Relationships: Overall aQysta has almost no contact with the larger amount of their customers, as their sales went via other parties. Only in few cases, aQysta has contact with their customers when visiting them when maintenance is required. Also, aQysta is trying to collect contact details of farmers that use the Barsha.
5. Revenue streams: Currently farmers do not pay, because they get the pump subsidized for 80 up to 100%., therefore the government subsidies are important revenue. The aim is to let them pay once, for free irrigation in the future.
6. Key Resources: To deliver the value proposition, aQysta requires to be able to manufacture and ship the pumps. For this, investments are necessary. Furthermore, for the current business structure, the government subsidies are a necessity, since the farmers cannot afford to pay the price of the Barsha.
7. Key Activities: aQysta's key activities are to provide and sell the pumps. Therefore they have to manufacture and transport the pumps, hire and train their staff and find new customers. For this the local team organises meetings and demonstrations.
8. Key Partners: The key partners in the current business model are first the farmers, as they are the end users of the product. The second partner is the government of Nepal, especially the different local governments, because the current model is highly dependent on them allocating their budget for Barsha subsidies. Also, different organisations are key partners, because they can act as middlemen between the government and the farmers, by providing the farmers with necessary service. The last key partner is the distributor. In the past, aQysta did business with a distributor, Naf Seeds, located in Kathmandu. It is not clear if this relationship still exists nowadays, since they had no contact in the last year.
9. Cost Structure: The main costs for aQysta are the costs regarding manufacturing, transportation and shipment.

SWOT- Analysis

SWOT

To determine threats and opportunities for aQysta, regarding their current business model, a SWOT analysis was done. Using this technique, a clear overview of aQysta's Strengths, Weaknesses, Opportunities and Threats can be drawn (fig. 39), which forms a perfect conclusion of this chapter.

Strengths
- With the current business model there is **no financial risk.** aQysta has a 100% payment guarantee because of the government budget allocations.
- The bulk investments (ca. 10 Barshas at once) by the governments, mean that more pumps are installed, so **big sales** at once.
- With the current model, in some cases aQysta already offers the farmers **technical service**, such as installation and maintenance. So besides just product offering, aQysta is already somewhat familiar with providing service to their customers.
- **No hassle** for aQysta when the pump is sold through middlemen. This saves aQysta a lot of time, since they don't have to find customers and install the pumps.
- The relatively **large amount of installed Barshas** in Nepal. For that matter, aQysta is on the good path considering the Sustainable Development Goals.

Weaknesses
- Innovating for impact...? Not really.. With this model aQysta just delivers the pump to the farmers. If they really want to create impact, they should offer a complete package, taking care of the whole value chain.
- Due to the large bulk sales that went via third parties, aQysta has no clue where all the pumps are located and whom are the users. aQysta has **no customer relationship**. Often vice versa clients don't know whom to contact.
- The Barsha pump has its own weaknesses, One of them is that it has **low water pressure**, especially compared to the known Diesel pump.
- The **current supply chain** of aQysta is also a weakness. The production is done in too many different countries, always shipping back to the Netherlands and then reallocating it back to its final destination.
- **Lack of local distributors**

Opportunities
These complications naturally come paired with opportunities for the company. To explore opportunities, the value mapping model (fig. 38) was used (Bocken et al., 2013). These are listed below, in accordance with the findings from Get Involved (Get Involved, 2016) and also other opportunities were identified.



Figure 39 : SWOT Analysis

- The **Government subsidies** create an opportunity for aQysta. The existence of this system offers the opportunity for aQysta to sell multiple pumps at once. This is a good and secure revenue stream.
- Another opportunity lies within having **multiple distributors in Nepal**. Having distributors spread over the country, will save aQysta time as they do not have to travel to far places anymore to deliver spare parts.
- **Offering services** to customers is another opportunity for aQysta. Taking care of whole value chain will lead to better customer relationship and so they would stay closer to their slogan 'innovating for impact'.
- The supply chain is currently oversees, thus on world level. The opportunity lies in having the **supply chain on country level**, thus a local manufacturer. This change would create impact. Furthermore, it can **improve the local economy** by creating jobs and financing local enterprises/businesses (SSIR, 2018).
- There is also space for improvement, regarding the **performance of the Barsha.** If the Barsha would deliver higher water pressure it would help 'beating' the Diesel pumps. Or by **improving the durability of the Barsha**, aQysta could gain more profit out of their goods.. A way to improve this lifetime is by allowing the replacement of specific parts of the pump, to support maintenance and renovation of the pump, generating a longer durability. By using a business model in which the pump can be rented, the durability would also be increased.
- Another opportunity lies in aQysta's business model. The business model can be improved by allowing the **possibility of sharing the pump** with multiple farmers, or to implement a "lease" plan by pay per use, for example (Get Involved, 2016). This way the pump allows immediate use and the pump is used more efficiently by different parties (Desikan, 2016).
- **aQysta's communication** allows room for improvement, especially considering the target group (T. van der Gragt, n.d). Most of the communication is currently provided through the internet. However, internet is not always available in the more rural locations. A wider method of communication can improve the living standards in Nepal and thereby increase the sales of aQysta.

Threats

- Most of aQysta's products are funded by external parties (such as the government and the Securing Water for Food program). The government has subsidized 200 pumps, but this is also one of the threats for aQysta. As the **government is** young and **unstable**, **relying on funds** provided by the Nepalese government can therefore be risky (Department for International Development, n.d.).
- The **bad infrastructure** in Nepal forms a threat to farmers as well as to aQysta. The travel distances can be very large and therefore time consuming. The traffic conditions should not be a limiting factor for the transportation and implementation of the pumps. In addition to that, the weather plays a large role because the traffic can be even worse in times of monsoon.
- The **oversees manufacturing and assembly** in Delft form another threat to aQysta. It is not only time consuming to ship the parts and pumps from one country to another, but also very expensive.
- aQysta wants to create impact by providing water for food to the farmers. However, by just leaving the pump at the farmer, it sometimes happens that the farmers have no clue where and how to sell their crops. So besides eating their own harvest, the farmers do not know how to generate income with the harvest.
- When the pump is sold through middlemen, there is **no link between aQysta and the pump**. aQysta has no idea where the pump is installed and the farmers do not know where to ask questions about its use and maintenance. This can cause farmers to go back to previously used pumps.
- Same thing happens because there are **no local distributors**, except the one in Kathmandu. Local handymen are not familiar with the Barsha and the **spare parts are not easy to purchase**. This means that as soon as the Barsha has a defect and there is **no link between the farmer and aQysta**, the pump will be left broken.
- The **subsidy system** also forms a threat to aQysta, as subsidies can lead to **careless behaviour**. The farmers experience the installation of the Barsha as a gift: something they did not had to pay for. This can cause that the pumps are neglected when they are broken. Furthermore, the subsidy system makes it hard to create a sustainable business model where the farmers do have to pay. As they already know that they can also receive the pump as a gift, then why would they pay?
- The widely used **fuel powered pumps** form a threat as well. This competitor has a much higher water pressure. The high pressure of this pump, that is widely used and therefore known, makes the performance of the Barsha pump valueless. This makes it even harder to enthusiasm farmers for the use of Barsha.

Takeaways for the project

From this company analysis some takeaways for the project can be drawn:

- The expected lifespan of a Barsha is 15 years. For a PSS this is positive, as it gives the farmers sufficient time to pay off the pump. A great advantage of the Barsha is that during its use there are (almost) no additional costs.

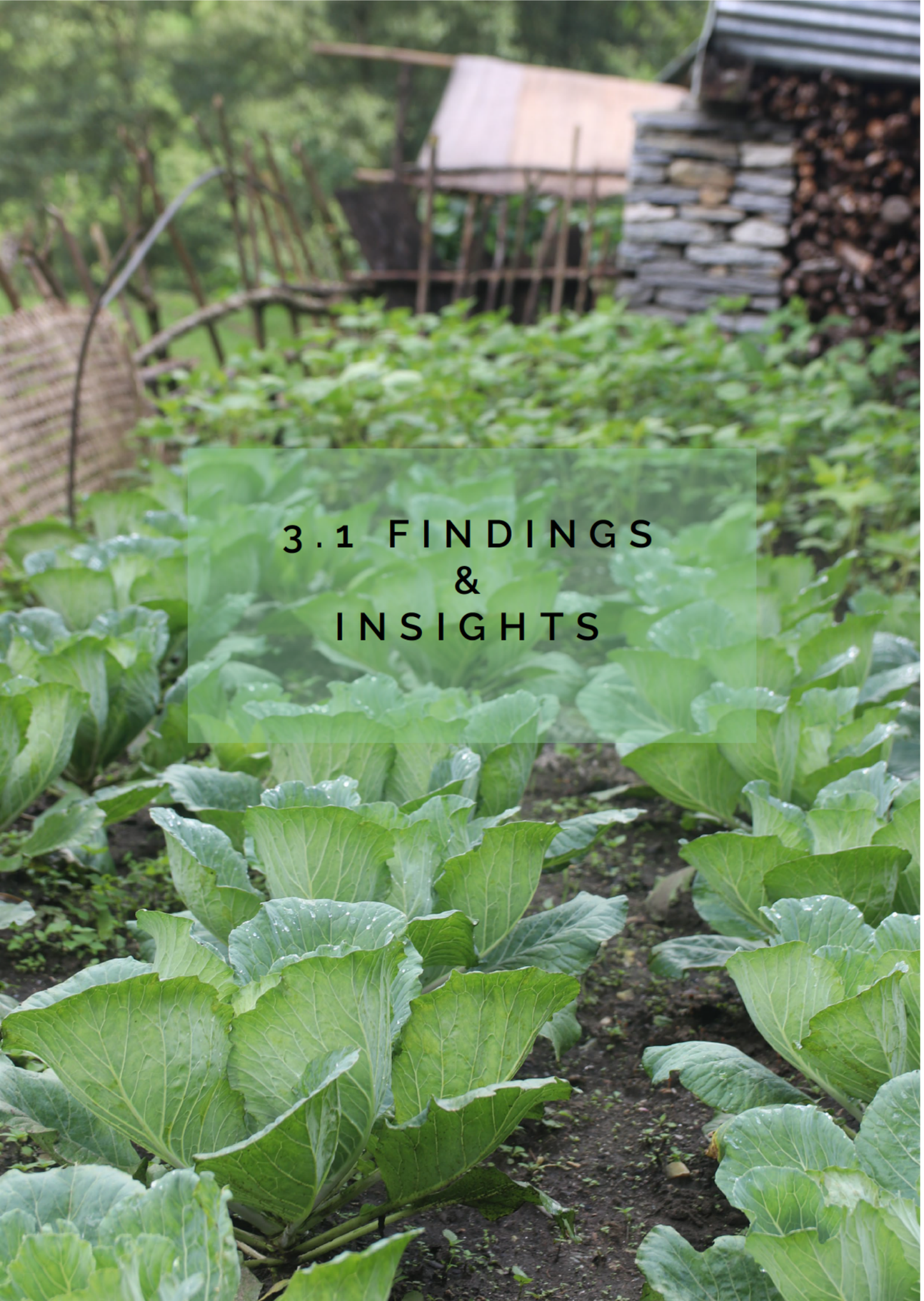
- For this research the stakeholders from the current network should be contacted for fieldwork. The NGO's are important as they can support a good stakeholder network by having close relationships with local farmers. The government is interesting to get a better understanding of the structure.

- Currently the farmers can obtain a Barsha through three different ways. All these methods work, but it would be more efficient if the farmers were able to buy the pump from aQysta directly rather than having to rely on third parties.

- In the SWOT analysis the opportunities for aQysta within the scope of the project are mentioned. One of these is offering services, so a PSS would be great opportunity for aQysta. Other opportunities will be taken into account for the PSS design for this project.

- Really important is to implement the **subsidy system**, but also to think of alternatives for this.

3. PROBLEM DEFINITION



In this section the problem will be defined. First, the relevant findings will be listed respectively to the foregoing chapters. These findings will lead to the problem definition. Using the problem definition as a starting point, the research questions and objectives derived along with an approach.

3.1 Findings & Insights

In this chapter, the insights and some takeaways from the previous chapters that are relevant for the problem definition and approach, are summarized. Firstly, the insights from the background information (section 1), followed by the literature analysis and the market analysis. Lastly, the findings of the company analysis are mentioned.

In the **Background Analysis** it was found that:
- The business and *government structure* of Nepal creates a *unique context*. However, this means that the final model should be adapted when aQysta would like to implement it in other countries.
- The *bad infrastructure* of Nepal should not be ignored, as it is of importance in reaching the farmers for maintenance or transportation of the pumps. The other way around, it can also be a limiting factor for farmers trying to reach the market.
- The *differences in climates and geographical features* can cause farming strategies to differ per region.
- *Cooperation with the Nepalese government* might be difficult since the *structure is unstable* and there are no clear national rules and agreements. This means that once an agreement is made with one province, the other six are not automatically on board as well. They have their own rules and structure. This could mean that a different strategy, thus business model, is needed for each province or even district.

In the **Literature Analysis** it was found that:
- A *PSS adds value to products* and gives more options for customized solutions for individual needs. But in order to create value with the PSS model, analysis of customer needs should be done.
- An objective of a Product Service-System is to *reduce the consumption of products* by offering alternative use scenarios instead of buying. This can be challenging since *aQysta has a sellers' mindset*.
- *Most effective PSS involve government-led investments*, such as subsidies (Vezzoli et al., 2015). However, this readily available subsidies also cause a barrier to PSS adoption because customers are less likely to pay for something they could also get subsidized.
- *PSSs are highly sensitive to the culture* in which they will operate (Wong, 2004). This means that the final design cannot simply be copied and implemented in other countries. aQysta should carefully evaluate each country (and perhaps even the regions) before implementing the business model.
- Since determining the way of *pricing is difficult for the service offering*, extra consideration is required when estimating the price for the designed PSS. Moreover, the *often-required long-term investments for PSS* design have to be considered carefully when giving recommendations to aQysta.
- No specifically relevant PSS design methods for this project were found. However, knowledge was gained and elements of different methods can be used to develop the final PSS model. Furthermore, *stakeholder involvement* is identified to be especially important in designing this PSS. *Co-creation* should be performed, as it is necessary for good PSS design. By co-creating the final design is more likely to meet customers' expectations by offering more customized solutions.

In the **Market Analysis** it was found that:
- The target group, smallholder farmers in Nepal are amongst the poorest of the world, with an average annual income of $256. This group of *smallholder farmers is in great need of financial support*.
- Agriculture is the biggest sector in Nepal and probably therefore the *Nepalese Government subsidises pumps* for irrigations, as it is seen as a public service. The Nepalese Government has not been stable in the past, so it should be kept in mind that the *subsidies* for agriculture *are not infinite*.
- The subsidies are naturally a great advantage for farmers, (and for aQysta as investors), but unfortunately this also means that pumps running on fuel or electricity are funded. For this reason *many Nepalese farmers still use* these *unsustainable pumps*. These pumps have a negative impact on the environment, whereas in contrast, if farmers would use the Barsha or solar-powered pumps, the impact on the environment would be reduced.
- *The Diesel pump* not only forms a threat to the environment, but also to aQysta. It is the most widely used pump in Nepal and has a greater water pressure than the Barsha. It is challenging to convince farmers of Barsha's benefits. To them, the financial benefits might be important but they do not really care about the environmental benefits.
- The *Barsha pump's performance is limited* and therefore not suitable in all cases since sometimes the farms are not located close enough to rivers.
- Only 5% of the production of smallholders is sold. This is mainly due to poor transport facilitations, but also because there is *lack of knowledge on how and where to sell harvest*.

Finally, in the **Company Analysis** it was found that:
- The *current business model of aQysta is not* as *efficient* as it could be. There is room for improvement, especially considering the *supply chain*. Furthermore, aQysta has no mission - and/or vision statement. This could be a means to communicate the strategy and goal for the future.
- *aQysta wants to create impact* as they want what the client needs/wants (Thapa, 2019). Their goal is to help farmers grow more crops and thereby have a higher turnover. However, with their current model, aQysta is just providing the pumps. By just leaving the

pump at the farmer, it sometimes happens that the farmers have no clue where and how to sell their crops. Therefore, besides eating their own harvest, the *farmers do not have the knowledge to generate income with their harvest.*

- Due to the large bulk sales that went via third parties, aQysta has no clue where all the pumps are located and whom are the users. aQysta has *no customer relationship*. Often vice versa clients don't know whom to contact. Additionally, a lack of customer relationship can lead to unawareness of the customers needs. aQysta has no clear image of the farmers' needs and wishes.
- The Barsha pump has *low water pressure*, especially compared to the widely known and implemented Diesel pump. This makes it even harder to enthusiasm farmers for the use of Barsha.
- There is a *lack of local distributors*. Local handymen in the other provinces are not familiar with the Barsha and the *spare parts are not easy to purchase*.
- The *subsidy system* also forms a threat to aQysta, as subsidies can lead to *careless behaviour.* Furthermore, the subsidy system makes it hard to create a sustainable business model where the *farmers do have to pay*, as they already know that they can also receive the pump as a gift.

Takeaways for the design phase are not mentioned here as they do not per se influence the problem definition. However, these takeaways will be taken into account for the final design. Therefore, they will be repeated and implemented in the list of elements and used for the Building Blocks (page 99)





3.2 PROBLEM DEFINITION & RESEARCH QUESTION

Problem Definition & Research Question

In this chapter, the problem is defined based on the findings from the previous sections that were mentioned in the foregoing chapter. Secondly, the research question and objectives for this project are formulated.

Problem Definition

The problem that exists for the current situation will now be explained from four relevant perspectives, namely for: (1) farmers, (2) for Nepal, with a perspective of the Nepalese government, (3) for aQysta and last for (4) the planet (fig. 40)

Farmer:

- In case of no subsidies, the farmer still has to pay the upfront cost (of the Barsha), whilst for most farmers it is hard to save money for big investments such as this one.
- Farmers are often not experienced enough to create a profitable income with farming. Bad infrastructure and the lack of knowledge makes it hard to connect with the market to sell their crops.
- It might be difficult to learn how to farm differently with other ways of water provision (less volume, spread over whole day etc.)

Nepal and its Government:

- The current agricultural production is not enough to feed the country. Yet, also agriculture becomes less popular among youngsters.
- More products (vegetables/ fruits) are currently imported than exported, which causes Nepal to remain one of the poorest countries in the world.
- The operation of the widely used fuel powered pumps also require import of fuels, whereas the use of pumps operating on renewable energy, do not require any import.
- The current use of electricity powered pumps for irrigation is also not beneficial for the country because Nepal faces a chronic lack of energy.

aQysta:

- For farmers it is logical to go for a familiar type of pump, with more pumping power and flow rate, instead of choosing for a more innovative and sustainable pump, such as the Barsha. The fact that farmers are not familiar with this new type of technology (the Barsha) makes it difficult to convince them of the benefits.
- aQysta is a hardware provider with no experience in service provision, yet they want to create more impact. Changing from a sellers'- product oriented mindset to a service oriented mindset is challenging.
- The current subsidy system of the government creates an opportunity as well as a threat for aQysta. On one hand it creates a steady revenue stream but on the other hand it causes the farmer to be careless regarding the Barsha.

Planet:

- The pumps that are currently widely used operate on either fuel or electricity. Unfortunately, this means that they have a negative impact on the environment.

Research Question

Using this problem definition as a starting point, the research question for the project was formulated :

What additions should be made to the current business model of aQysta in order to contribute to more benefits for the smallholder farmers, other stakeholders and aQysta?

Project Objectives

Now that the problem is defined and the research question is formulated, the project objectives are given to describe the aims and outcomes that are intended to be achieved within this project.

1) To identify the barriers for the farmers to overcome in order to create a preference for the Barsha over any other pumping solution.

2) To identify the needs of the farmers regarding a PSS in the context of farming.

3) To determine the relevant stakeholders for the PSS.

And finally, the main objective :

4) **To deliver a higher Barsha based-value proposition to the farmers, by means of a PSS.**

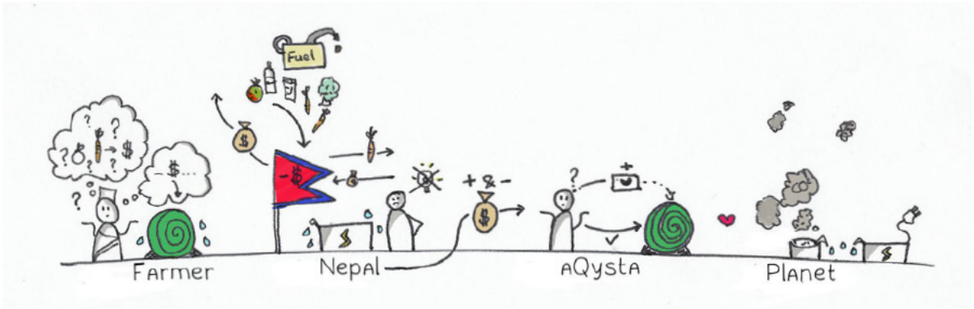


Figure 40: Problem visualisation



3.3 APPROACH

Approach

In this chapter the chosen approach for delivering the project objectives and answering the research question is explained. As fieldwork is important for this project to collect the necessary data, the goal of the fieldwork is also explained.

Project approach

If a PSS design is based on external and internal inputs, it is more likely to represent the customers' value perspective (Marques et al., 2013). Therefore, it is valuable to do **field research in Nepal to co-create** with customers and possible partners to identify their needs and values and to gather data about sustainable business models used in the context. Knowledge of the needs of the different stakeholders is critical for developing ideas for the new PSS.

After the field research is finished, the outcomes can be concluded. This data will be used as 'elements' to start developing designs for the final PSS model. This data, combined with relevant takeaways of the analysis section, is concluded in the "*List of Elements*" (page 97). The different elements that are listed are used as a source of inspiration for options within the PSS design. Furthermore, the findings from the analysis and fieldwork that are critical for the design, thus requirements for the design in order to be valid, are concluded as "*Building Blocks*" (page 99) for the design. The requirements that are mentioned are literally the building blocks, thus the minimal basis to start the design. From here, the elements from the List of Elements can be used to adjust, supplement and improve the concept design.
As soon as the concept design is finished, it should be validated with aQysta. An improved version, based on this validation, should be made. This second design serves as the final design for this project. The final design is accompanied by advice on how to implement it.

Goal and purpose of the Fieldwork

The main goal of the field work is to collect empirical data for a validated PSS design in order to answer the research question (*What additions should be made to the current Business model of aQysta in order to contribute to more benefits for the smallholder farmers, other stakeholders and aQysta?*).
To make the goal more specific, it is subdivided in 3 questions:

- *With Whom to verify?*
- *What to verify?*
- *How to verify?*

The first two will be answered in this chapter in order to get a better understanding of the purpose. In section 4 (Field work) the third question (*How to verify?*) will be answered.

With whom to verify?
The first question we ask ourselves is: *with whom do we verify?* As there are many parties involved, co-creation is the way to go.

Co-creation is an interactive process for generating value, based on collaboration between a company (offering a product or service) and end-users or other relevant stakeholders (SURE-Farm, n.d.). Co-creation is an important element of this research study and for PSS design in general (Meier & Völker, 2010). This is because involving stakeholders in the design and development process of the PSS helps in truly fulfilling customers' needs. In order to deliver the project objectives and answer the research question, data is collected through different co-creation methods and tools. These different methods will be explained carefully in the next section: Field work.

Co-creation is usually done with important partners and final users. The final users are smallholder farmers in Nepal and therefore it is necessary to go to Nepal to perform field research and co-create at a local level. Furthermore, it needs to be determined who might be relevant stakeholders to involve in the final PSS for aQysta. The stakeholders with whom co-creation is performed are not necessarily 'candidates' for involvement, but the collected data is used for the determination of the stakeholders.

The parties who are involved in the co-creation for this study are:
- The **Nepalese government** who play a big role in financing irrigations solutions.
- **NGOs or other organisations** that could help with providing the services to the farmers.
- **Organisations with sustainable business models** as a source of inspiration and to learn about their experiences.
- **Smallholder farmers**, because they are the final users of the Barsha and the target group for the service-based model. These can be farmers that currently use and/or own a Barsha, as well as previous users or other farmers (non Barsha-users), because they are potential users.
- The **local aQysta team** since they are ones that will start implementing the newly designed strategy.

Figure 41 shows how the different stakeholders are involved in the co-creation process.

As co-creations sounds like an ideal solution, it is important to also be aware of the challenges. A challenge could be working with local farmers. If this has never been done before, there will be several pittfalls for both sides, which need to be tackled. For example, the cooperation of the participants might be limited if they are not awarded. In order to perform, it can be advised to follow examples from others organizing co-creation workshops at a local level (SURE-Farm, n.d.).

With Whom to verify?	What to verify?	How to verify?
Smallholder farmers	Needs, Wishes & Thoughts regarding finances, farming, services, etc.	CO- CREATION through means of :
Government	Insights on the current governmental structure and the subsidy system	- Interviews - Surveys - Q-methodology - Business Origami - Preference booklet
NGO's	Insights on current strategies and learn from their experiences. Discover if there is a possibility for partnerships	
Organisations (with sustainable business model)	Learn from experiences and obtain insights and inspiration for the PSS design.	
aQysta	Understand the current business model (with its limitations) and discover possibilites for the PSS design.	

Figure 41: Co-creation

What to verify?

After defining with whom the verification is taking place, it is important to find out *what* ***has*** *to be verified*. In order to do so, the aim is to identify the following:

- What are the barriers for the farmers to overcome in order to prefer the Barsha over other pumping solutions (such as: emotional barriers, financial barriers & operational constraints, preferences)?
- What are the needs of the farmers regarding a PSS in the context of farming (such as: the preferred services, what kind of payment model, individual vs. collective use)?
-Who are and can be the relevant stakeholders for the PSS?

In order to perceive an answer to these questions, it is important to start with analysing the different sustainable business models via talking to organisations. By learning from their experiences, it is known 'what works' and 'what does not work'. Since providing service is a new playing field for aQysta, all insights regarding service models can be of great value. Insights can be for example about different payment structures (pay-per-use, how to collect money, etc.).

After the analysis of existing models, the different needs of involved parties need to be determined. This can be either the needs and wishes of the end users, regarding irrigation pumps and service preferences, or the wishes of other parties regarding possible partnerships.

Once everything is clear, this brings us to the main objective: *To deliver a higher Barsha based-value proposition to the farmers, by means of a PSS.*



4.FIELD WORK



4.1 METHODS FOR CO-CREATION

The aim of this section is to explain the fieldwork. It starts with an explanation of the different methods that are used for co-creation. After this, the outcomes of the different sessions will be elaborated. Lastly, all findings and insights from the fieldwork will be concluded into a list of elements and a list of requirements, called the building blocks.

In this chapter the focus is on explaining How to verify?. To get answers to the research questions, five co-creation tools and activities will be used during the field work; Interviews, surveys, Q-methodology Business origami and the Preference booklet. The different methods that are used for the co-creation will be explained carefully below.

4.1.1 Interviews

As mentioned, one of the goals for the field work is to analyse the needs of different stakeholders. This can be done through direct contact in form of interviews or through (market) surveys (Marques et al., 2013). The first methods to be described are therefore interviews, followed by surveys.

Description & Procedure

The type of interviews that are being held, are Qualitative semi-structured interviews. Many insights can be derived from having interviews with the users and the different (possible) partners. It is important that the interviewee feels comfortable when doing this, so nothing should be too forced. The interview should be more like a conversation instead of an interview.

As soon as an interview is planned, brief research is done to prepare few (5 to 10) questions. Especially the interviews with organisations (NGO's, Government, etc.) should be prepared and structured in order to get the most out of it. The prepared questions are meant as starting point for the conversation and as food for thought for when the discussions seems to end. The interviews with farmers are harder to steer into the right direction, since there is always a narrator involved. In those cases, it is up to the narrator to keep the conversation going and up to the researcher to have questions ready and respond to the translations spontaneously if necessary.

Furthermore, spontaneous conversations, for example with aQysta employees, are likely to occur. This kind of meetings are not prepared, but many insights can be derived from conversations like these and it is therefore important to always carry a notebook.

Expected Outcomes

The interviews are being done with several parties, so it is expected to get different outcomes from different stakeholders. When doing interviews with other organisations and NGO's, it is expected to get more insights on different business models that exists (in Nepal). Furthermore these interviews can validate data that was already gathered through desk research.
The interviews with the government are planned to attain a better understanding of the governmental structure in Nepal.
For the interviews with the farmers, the aim is to get answers to questions such as:
- *How much water do they need for their farm to perform well?*
- *To what kind of payments are they used?*
- *What are their needs regarding farming?*

Last but not least, out of the interviews with aQysta employees it is expected to get more insights on their current business model and mode of operation.



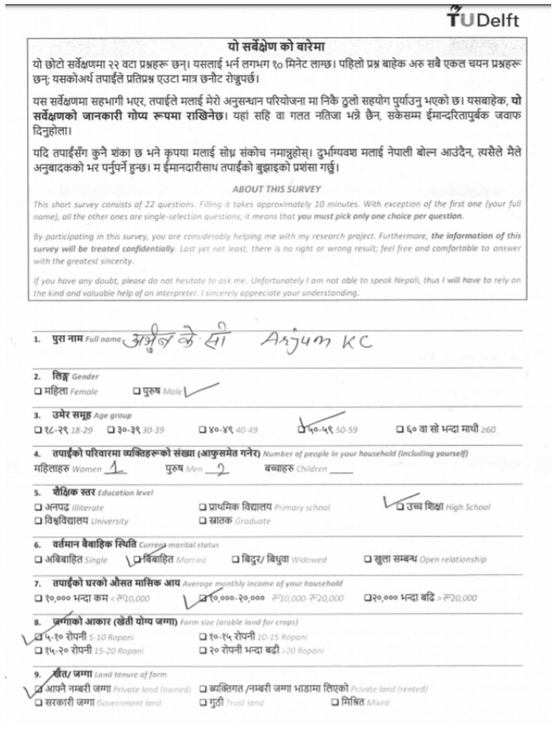
4.1.2 Surveys

Description & Procedure

To gather general data (age, income, etc.) from the farmers, surveys are used. The surveys are prepared by Juan Carlo Intriago (2019) and consist of 21 multiple choice questions and one open question for the name of the respondent. The surveys have an introduction and are translated into Nepali. The translation is both for those farmers who can read and to make it easy for the translator (fig. 42).
The questions on the survey are about the respondents age, family/Housing situation, their income, level of education and their farming experience (with the Barsha).

Expected Outcomes

Expected outcomes of survey are more insights on the target group; small holder farmers. This data is also used to create a persona, in which eventually can be used in scenario to explain the final business model.



TUDelft

यो सर्वेक्षण को बारेमा

यो छोटो सर्वेक्षणमा २२ वटा प्रश्नहरू छन्। यसलाई भर्न लगभग १० मिनेट लाग्छ। पहिलो प्रश्न बाहेक अरु सबै एकल चयन प्रश्नहरू छन्; यसकोअर्थ तपाईले प्रतिप्रश्न एउटा मात्र छनौट रोज्नुपर्छ।

यस सर्वेक्षणमा सहभागी भएर, तपाईले मलाई मेरो अनुसन्धान परियोजना मा निकै ठुलो सहयोग पुर्याउनु भएको छ। यसबाहेक, **यो सर्वेक्षणको जानकारी गोप्य रूपमा राखिनेछ**। यहां सहि वा गलत नतिजा भन्ने छैन, सकेसम्म ईमान्दारितापुर्वक जवाफ दिनुहोला।

यदि तपाईसँग कुनै शंका छ भने कृपया मलाई सोझ संकोच नमान्नुहोस्। दुर्भाग्यवश मलाई नेपाली बोल्न आउँदैन, त्यसैले मैले अनुवादकको भर पर्नुपर्ने हुन्छ। म ईमानदारीसाथ तपाईको बुझाइको प्रशंसा गर्छु।

ABOUT THIS SURVEY

*This short survey consists of 22 questions. Filling it takes approximately 10 minutes. With exception of the first one (your full name), all the other ones are single-selection questions, it means that **you must pick only one choice per question.***

*By participating in this survey, you are considerably helping me with my research project. Furthermore, **the information of this survey will be treated confidentially**. Last yet not least, there is no right or wrong result; feel free and comfortable to answer with the greatest sincerity.*

If you have any doubt, please do not hesitate to ask me. Unfortunately I am not able to speak Nepali, thus I will have to rely on the kind and valuable help of an interpreter. I sincerely appreciate your understanding.

1. पुरा नाम *Full name* अर्जुन के.सी. Arjun KC
2. लिङ्ग *Gender* ☐ महिला *Female* ☐ पुरुष *Male* ✓
3. उमेर समूह *Age group* ☐ १८-२९ *18-29* ☐ ३०-३९ *30-39* ☐ ४०-४९ *40-49* ✓ ५०-५९ *50-59* ☐ ६० वा सो भन्दा माथी *>60*
4. तपाईको परिवारमा व्यक्तिहरूको संख्या (आफुसमेत गनेर) *Number of people in your household (including yourself)* महिलाहरु *Women* 1 पुरुष *Men* 2 बच्चाहरु *Children* ___
5. शैक्षिक स्तर *Education level* ☐ अनपढ *Illiterate* ☐ प्राथमिक विद्यालय *Primary school* ✓ उच्च शिक्षा *High School* ☐ विश्वविद्यालय *University* ☐ स्नातक *Graduate*
6. वर्तमान वैवाहिक स्थिति *Current marital status* ☐ अविवाहित *Single* ✓ विवाहित *Married* ☐ विदुर/ विधुवा *Widowed* ☐ खुला सम्बन्ध *Open relationship*
7. तपाईको घरको औसत मासिक आय *Average monthly income of your household* ☐ १०,००० भन्दा कम *< रू10,000* ✓ १०,०००-२०,००० *रू10,000-रू20,000* ☐ २०,००० भन्दा बढि *> रू20,000*
8. जग्गाको आकार (खेती योग्य जग्गा) *Farm size (arable land for crops)* ✓ ५-१० रोपनी *5-10 Ropani* ☐ १०-१५ रोपनी *10-15 Ropani* ☐ १५-२० रोपनी *15-20 Ropani* ☐ २० रोपनी भन्दा बढी *>20 Ropani*
9. खेत/ जग्गा *Land tenure of farm* ✓ आफ्नै नम्बरी जग्गा *Private land (owned)* ☐ व्यक्तिगत /नम्बरी जग्गा भाडामा लिएको *Private land (rented)* ☐ सरकारी जग्गा *Government land* ☐ गुठी *Trust land* ☐ मिश्रित *Mixed*

Figure 42: : Survey with Nepalese translation

4.1.3 Q-Methodology

Description & Procedure

The Q-methodology is a method used to get a systematic overview of different perspectives and attitudes towards a topic (Cairns, 2012). According to Brown (1980) it is not about the quantity of the study, but about '*the representation of different points of view on the topic of study*'. During a Q-study, the participants are asked to arrange the different Q-statements on basis of their (individual/collective) agreement and disagreement. The participants are forced to have an opinion, by providing the participants with a pyramid shaped framework, in which they have to (dis)agree with a statement in a certain amount (Jedeloo & Van Sta, 2016). For example, they can only strongly disagree (-4) with two statements, whereas they can/have to be neutral towards 8 statements (Fig. 43). If possible, the participants are asked to explain their choices.

Before this tool can be used, statements need to be made and printed on statement-cards. This was done in Delft by Juan Carlo Intriago, who created 38 statements (see appendix C, page 151) related to the Barsha pump and some to farming in general. Because language is a barrier, the statements are not only translated into Nepali but each one is also supported by a visual (fig. 44), in order to get the most out of it.

During this study, the participants were first asked to agree, disagree or feel neutral with/to the statements. As soon as all 38 statements were divided over three piles (agree, neutral and disagree), they had to choose two statements from the agreement pile, with which they agreed most (+4). From here, they had to choose three with which they also fully agreed (+3), but a bit less than the first two statements, and so on until the pile was finished. Same was asked to do for the pile of disagreement. Then, they have to fill the remaining spots in the framework with the neutral cards. As soon as all cards are placed, the participant has to review the table and where necessary, shuffle and rearrange some statement cards until it fully represents the participants vision towards the topic.

Expected Outcomes

When writing the statements for this study, naturally it was already decided on which topics different perspectives were desired. For example, participants' vision regarding ownership of Barsha (Statement: *It is more convenient for me to make use of the Barsha pump without being the owner*).

The outcomes of Q-studies can be derived from free software. This software analyses the data on similarities, groups and clusters. In case there are some similarities amongst groups, this means there is a shared view. Using these outcomes, different perspectives towards the topics can be drawn (STEPS Centre, n.d.).



Figure 43: Q-Study framework



Figure 44: The Q-statement cards

4.1.4 Business Origami

Description & Procedure

A tool that is used during some of the interviews to support the communication, is a slightly adapted version of Business origami. By making use of movable objects, it allows people to communicate possible interactions between different stakeholders for different settings. This tool is especially useful for communicating service designs (McCullin, Universele Ontwerpmethoden, n.d.). The adapted version consists of magnets that represent different artefacts (money bags, services, crops, etc.) and stakeholders (NGO's, aQysta, Farmers, Government) (Fig. 45). Together with a whiteboard and coloured markers, a business model/strategy map can easily be visualised and adapted (because of the moving parts). By drawing arrows, participants are able to draw the different interactions that exist. Because of small scale (a3) whiteboard, this session could take place anywhere, as it can be taken along easily.

During three interviews, this tool was used to understand the current business model of the organisation and to discover possibilities within their model.

Expected Outcomes

The expected outcome of this tool is to get insights on current systems of other sustainable organisations, which can be used as a source of inspiration for the final PSS design for aQysta. Furthermore, visualising the different sustainable business models is a good practise for the visualisation of the final design, which can be a complex task.
Besides these physical outcomes, another outcome is that when bringing such a prepared tool to a meeting, it automatically shows that you are prepared, which can positively influence the interviewees attitude and collaboration.

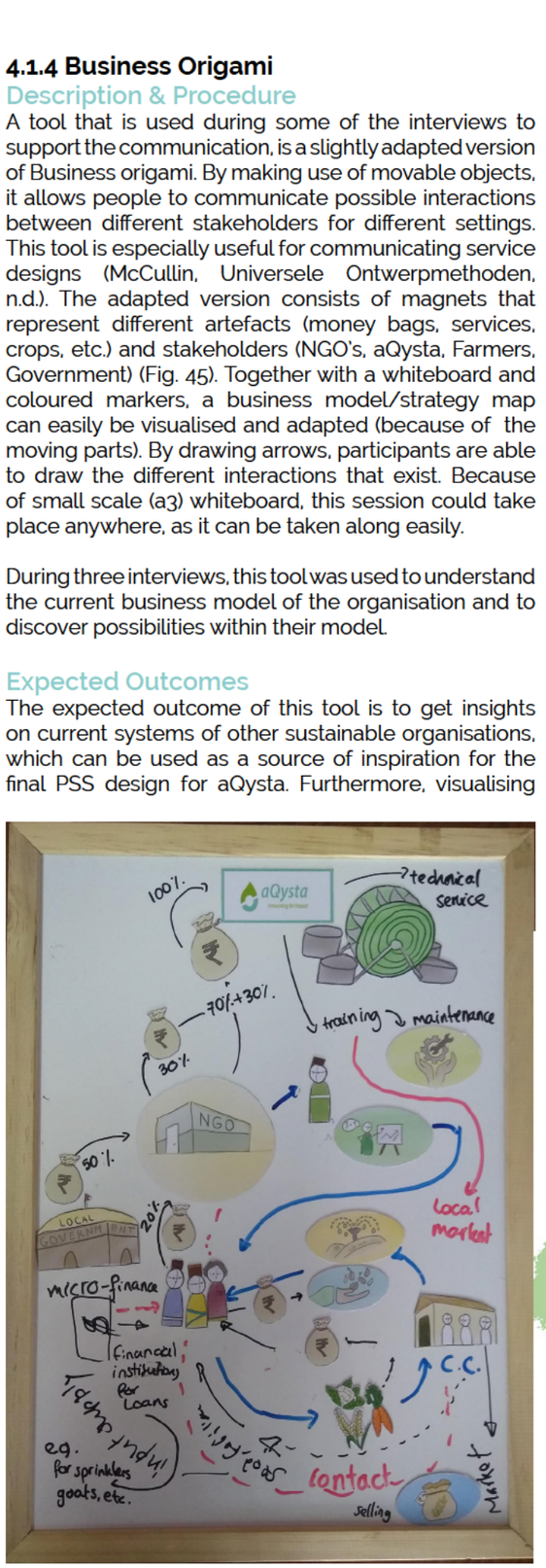


Figure 45 : Result of a session using Businessorigami

4.1.5 Preference Booklet

Description & Procedure

The last tool that was used during the field research is the so called Preference Booklet (fig. 46), inspired by team Across' EG Toolkit (2012). The preference booklet consists of two booklets that can be turned like a calendar. This booklet was specially made to perform with the farmers on site. The aim is to see what services are preferred. The adapted version of this tool for this project, has two rounds. In the first round the participants have to choose between two offerings. This is repeated multiple times. For example, they have to choose between installation service or seed provision, after that they have to choose again between installation and another service. In this way it can be seen which one they prefer over another. For this it is important to have the different services in opposite order on both piles. After making their decision, the participants have to explain why they chose one service over the other. In this way, all services are compared to each other and the reason behind the preference is given. All the preferences are noted on a sheet of paper by the researcher, along with the reasoning. On this sheet, the services are already visualised, so the preferred service only has to be checked.
The second round is quick, because the farmers only have to choose one preferred service. They start with the upper two pages, thus the first services and choose the one they prefer the most. This one stays on top, and the other service is turned. Now the farmer has to choose again and so on until the most preferred service remains.
This 'method' can take place anywhere where the participant feels comfortable, as it only requires the booklet and an annotation sheet for the researcher. On picture 47 you can see how the setting of this session looked like.

This tool is a fun and quick way to discover the preferences of the farmers. However, to get the best out of it, the booklet should be improved as soon as one new optional service is discovered and another one can be removed. Also the order of services can influence the second round of this tool. Therefore, the services should be arranged carefully. This makes the method time consuming regarding preparation.

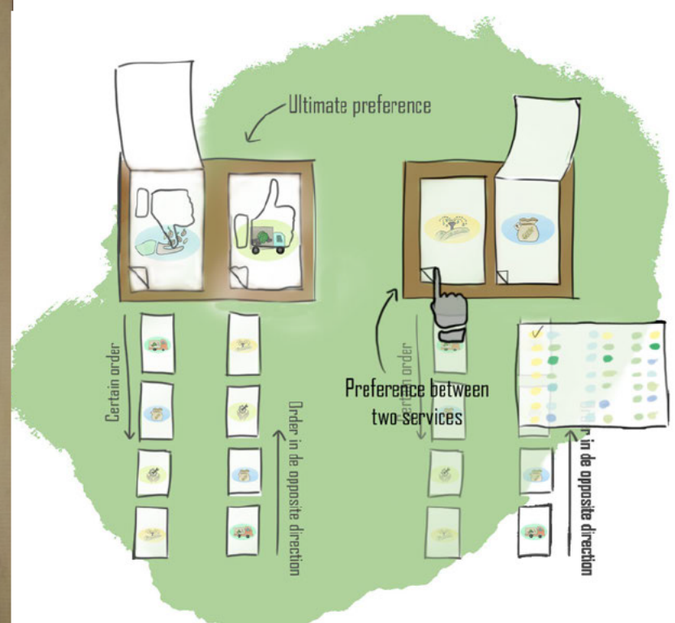


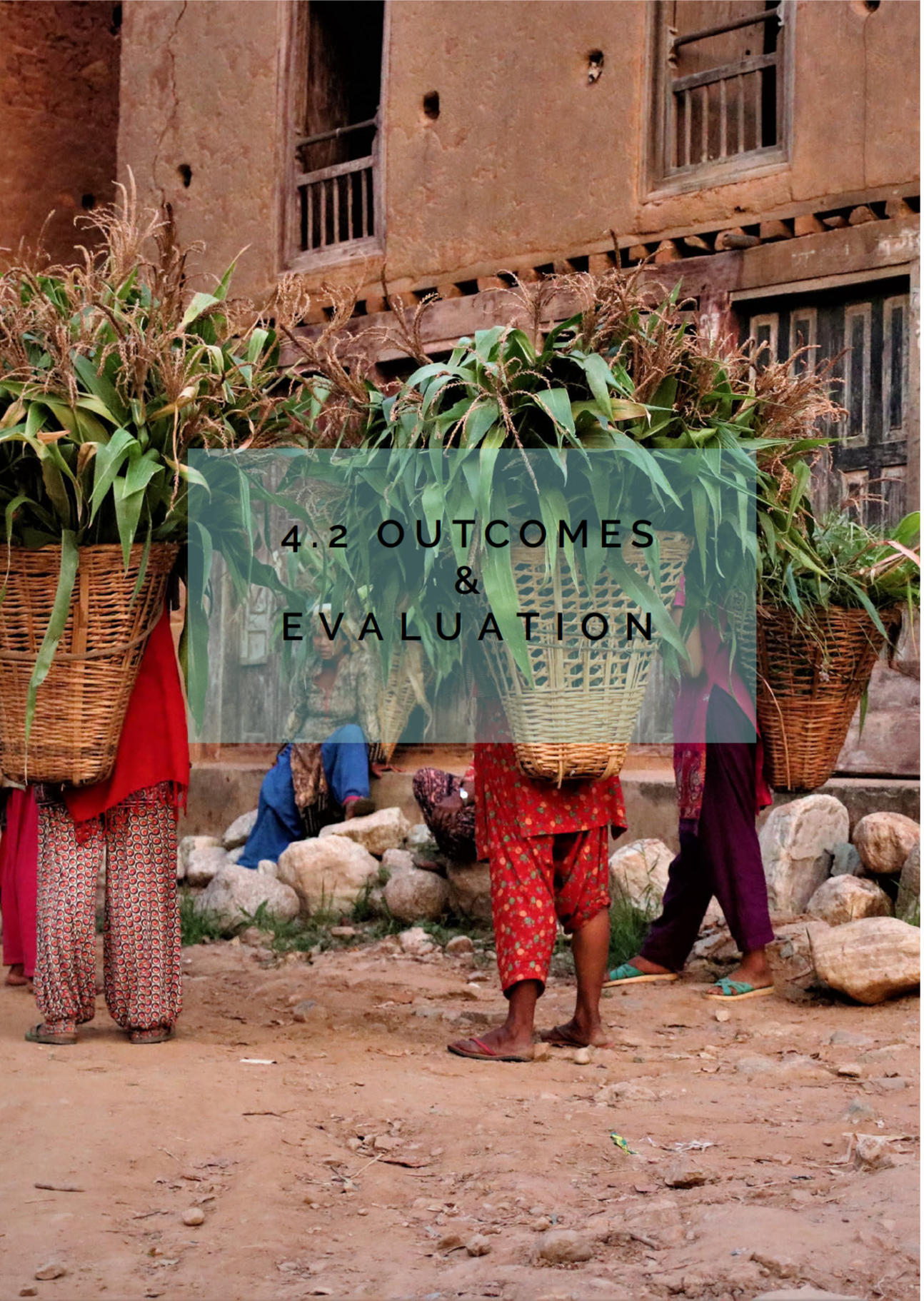
Figure46 : Preference booklet



Figure 47: Preference Booklet study

Expected Outcomes

The expected outcome of this tool is a clear overview of what services the farmers prefer over another, with the reasoning behind it. This overview with preferences can be valuable for the final PSS, as services are an important factor for the model. With the knowledge of the needs of the farmers regarding the services, it can be easier to make choices between one service over another whenever necessary.



4.2 OUTCOMES & EVALUATION

4.2 Outcomes & Evaluation

In this part the relevant outcomes are discussed. The complete interviews, surveys, data sets and outcomes can be found in appendix B- J. After naming the relevant outcomes, each of the used tools and the quality of its outcomes is being evaluated.

Outcomes Co-creation

In this part the outcomes of the co-creation are described. It will be described as a whole; so what can be concluded out of the triangulation of the different methods. Several questions are formulated to structure the different insights in a clear matter. Lastly, some remaining insights, that did not clearly answer any question, are listed.

The fieldwork is used to verify different things and the outcomes of the study therefore give answer to the following questions :

1. What are the** experiences with the Barsha pump **from (current) users?

Unfortunately, only four farm-visits took place, out of which only two farmers were Barsha users. However, valuable insights were obtained (by talking to aQysta employees as well) and those are listed below:

- Irrigating with the Barsha requires a different strategy, as the water output is spread over 24 hours and keeps coming.

- Therefore, the Barsha does not match with all types of crops, padi-fields for example, are not suitable as they require lots of water.

- The Barsha pump truly increases income, thanks to the zero operation costs.

- If the pump has a defect, it can be too much effort to let it be repaired, due to the long distances and hard to obtain spare parts.

- Most farmers are hesitant at first, due to the unknown and thus new technology. However, after the pump is being used for a period of time, almost every user is very satisfied with the result.

- Out of the Q-study there was agreement upon the understanding that once the Barsha is installed, it saves a lot of labour.

- Farmers agreed that the Barsha pump can improve the quality of lives and helps better than other pumps in growing more cash crops and with the increase of the agricultural production in general (Q-study outcome).

- Farmers also agreed upon that the Barsha does not allows a straightforward operation. The operation and maintenance of Barsha are not suitable without first having a proper explanation and training.

- During these sessions we learned that Nepali people are very sceptical. Even though they can see the success of Barsha, they still complain that they wouldn't pay for it because it doesn't give enough flow. Prefer to pay 600 rupees per hour of usage for diesel pump.

- Some feel that the existing irrigation infrastructure of the farmer has to be modificated for the barsha operation.



Figure 48: Farmers in Ratamata filling in the Survey

These limitations result in hesitant for users at first, but when users experience the pump in practise, users are content with the results. The results emphasize the importance of convincing users of the positive outcomes of the pump. The first impression of users is not likely to be correct. The change user's opinion can be explained by the knowledge gap, they are not familiar with the new technology.

2. What is their vision towards different services?

Since providing service is a new playing field for aQysta, all insights regarding service models can be of great value. Several visions towards services were identified.

- It was found that the vision towards services highly depend on the level of experience of the farmer, hence what services are required. For example, more experienced farmers already have their connections for, in example, obtaining seeds and already have a sprinkler system installed. This leads to a different vision on desired services.

- After receiving a funded pump, sometimes farmers had no clue what to do with their crops, which caused them to stop farming for commercial purposes. They suddenly had too many crops for self-consumption and they had no connection with the market where they could sell it. It would therefore be valuable to not only train the farmer for better yields, but also to connect them to the market.

- The results of the interviews also show that there is a positive tendency observed towards training of a new farmer. A training program to learn farming should at least consist of one-week lesson program. Often training only last for one day and farmers mentioned that that was pointless. Furthermore, occasional check-up would also be desirable. In this way, they could ask questions after a period of farming and learn from possible mistakes.

- By means of the preference booklet, it was clear that farmers would not even consider choosing another option over the installation service. It makes sense, because without installation, the pump will not work. And as soon as Barsha is installed, it is really easy to maintain and use.

- During the Q-study it was identified that few farmers are not interested at all in having entrepreneurial training, to start a successful farming business.

- Some farmers outed that they are willing to pay an extra fee to have additional extra technical assistance (such as irrigation advices). However, others felt the complete opposite. So this is something that can only be seen by means of a pilot.

Regarding financial aid, several visions were identified:
- It was clear that financial aid is necessary, since farmers experience trouble with it. So any service in the field of financial aid is highly accepted by the farmers.

The outcomes indicate that farmers clearly need help with covering the upfront costs, need training about farming and connection with the market. PSS could help by delivering this.

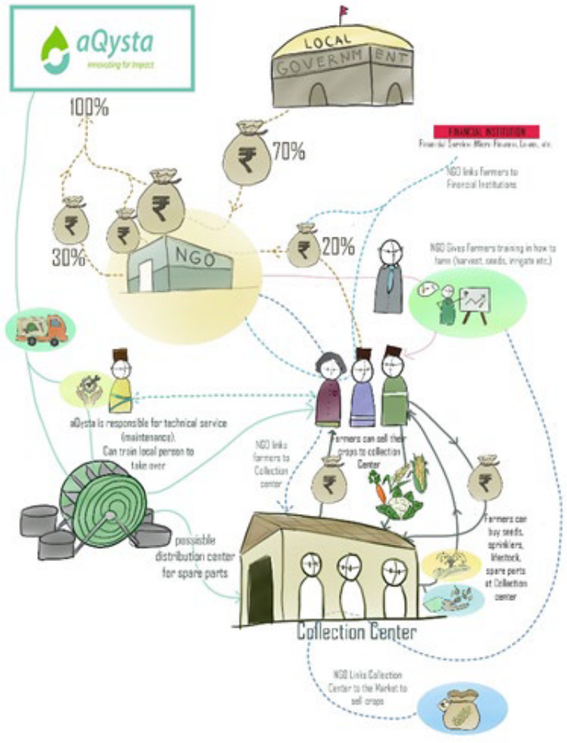


Figure 49: Visualisation of the result of Businessorigami

3. What payment model (PSS) would work best for the farmers & what do they prefer?

-One answer to this question was obtained from interviews with Sunfarmer and Practical Action. In general it can be stated that the farmers prefer a model where they do not have to pay. They rather wait for a period of time for a subsidised solution

- Farmers actually even expect the government to pay 75 up to 100% of the purchase costs. They are used to this system and therefore farmers are reluctant to buying a pump themselves.

- Even though the farmers prefer not to pay at all, they do often accept the hourly wage they have to pay for the use of the Diesel pump. They however complain that it is expensive, but they use it anyway. So there could be an option in implementing such a pay per use model for the Barsha, but over a longer period of time (e.g. 24 h) as it has a lower hourly water output. If this price is then way lower than the hourly wage of the Diesel pump, it can be an attractive option.

- It is a good idea to let farmer pay for the pump, this will help them with connection to financial institute for loans. They can purchase a pomp with a combination of getting subsidy and keeping a part of the purchase amount left to pay. The most important effect of purchasing a pump in this way is that farmers take control and that they feel responsible. (business origami) However, letting them pay is challenging, because why would farmers pay for a pump if they can get it for free.

Another insight regarding the financial behaviour of farmers was:
- Although there is not a lot of money to invest (several times farmers needed an extra job besides farming to have enough income), they would invest in the farm, since this is the main source of their income.

Furthermore, it was researched to what kind of payments the farmers are used.
- Mobile payments work. Many Nepalese initiatives where you can put credit on an account, by which means you can easily pay for services if the service provider works with such a method.

4. What are the barriers for potential users to become actual users?

There are several barriers identified for potential users to become actual users:

-The sessions showed that Nepali people are very sceptical. Even though they can see the success of Barsha, they still complain that they wouldn't pay for it because it doesn't give enough flow. This scepticism makes it challenging to enthusiasm the farmers about the positive features of the Barsha. The new and unfamiliar technique of the Barsha combined with this scepticism creates a serious barrier.

- Furthermore, a drawback of a pump powered on hydro-power, is that it is dependent of the current of the water. During dry season, when there is less water in the river, the water flow decreases and so will the water output of the Barsha be even less. Compared to the Diesel pump that pumps water in great volumes, this is not very beneficial when demonstrations are being held in dry season in a small creek.

-Lastly, an identified problem is that the pump is too expensive for individuals without the subsidies.

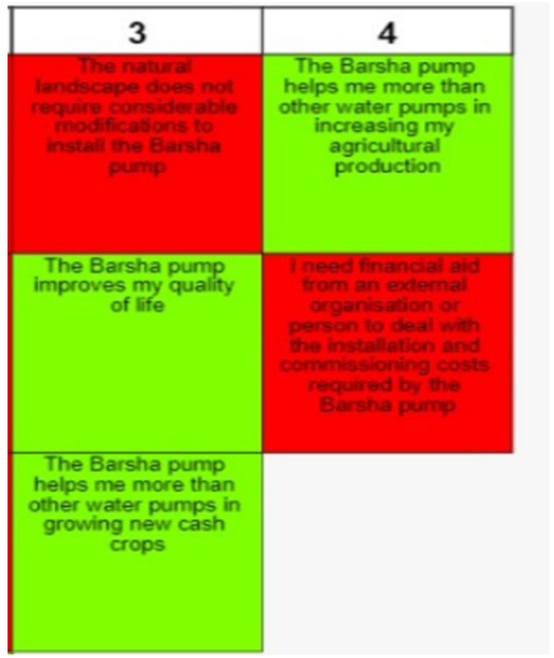


Figure 50: Agreements upon Q-statements

5. What needs can be identified from the different stakeholders?

During the research there was a focus on discovering the needs of different (possible) stakeholders. These stakeholders can either be end-users, distributors, government or other parties regarding possible partnerships. Unfortunately not many of these needs were identified during the research, just the one listed below:

- It was found that the needs of farmers regarding farming are that all help is always welcome. Especially financial aid.
- Also, as aforementioned there is a great need of a connection with the market to sell the harvest.

Other Findings
Besides the listed findings, there are also other findings that derived from this research. For example knowledge was obtained for completing the stakeholder map, system map etc. These findings are already processed in the different chapters of the analysis section.

Furthermore, the other findings that do not directly answer a question, but should be identified, are listed below:

- According to aQysta: the lifespan of pump is 10- 15 years.

- aQysta is interested in implementing EASI-pay model in Nepal. Out of this it can be concluded that aQysta

is taking steps towards a more sustainable business model by implementing a PSS.

- Famers do not want to pay for a pump if neighbour got it for free.

-It was identified that some farmers, still have an ownership mindset. This is something to keep in mind for the PSS design. Since it can be interesting to shift in ownership, if that is what they eventually want.

- There is an opportunity for a **collection centre**. Several of these initiatives already exists and farmers appreciate the services these centres offer. Currently the centres are government initiatives or led by a NGO. The centre offers all agricultural facilities and buys the crops for a fixed price from farmers, no matter the quality. In this way, the farmers always have a guaranteed income. The centre sells the harvest to a wholesaler with whom they have a partnership.

- Feeling of farmers regarding market: The farmers do not get fair prices for their crops (around 10NRs/kilo). Due to the fact that farmers have limited access to the market, they have to accept these low amounts because they have nowhere else to go.

- Water channels are popular. Farmers make use of channels leading from water streams from the hills which are constantly irrigating their farmland. However, throughout the monsoon or earthquakes it is possible that the water streams are destroyed.

- Land is often leased from the government, because plots are very expensive to buy. The lease for these plots are approximately $2500 per year (Get Involved, 2016).

Evaluation Co-creation

Evaluation Interviews

During the preparation of the interviews, several questions for different parties were prepared. However, in most cases, it was better to just let the conversation flow and to not hold on to the prepared questions. Though, sometimes when the conversation felt silent or when there was an opportunity, the prepared questions came in useful, but in most cases these were answered automatically. This spontaneous setting gave me the opportunity to dive deeper in the conversation and ask for more explanation about certain topics.
Another point was that sometimes the language and pronunciation created a barrier. It was often hard to understand what was exactly said. Due to this, some details were not captured, however the main story line was always understood.

Evaluation Surveys

The data gathered from the survey was interesting and some conclusions can be made (see picture 48: people filling in the survey), even though it was done on a small scale of 18 people (the complete data of the surveys can be found in appendix F). One of the aQysta employees had told us beforehand that people in Nepal tend to fill in surveys in a way they expect to get something. So for the question do you consider yourself poor/ wealthy for example, they will always fill in poor, hoping to get money. However, we were surprised that out of 18 participants most fill in Average and 'only' five said to be (very) poor. Furthermore, it was a shock to see how little people were able to read the survey and fill in the answers for themselves. Only few of the respondents were literate enough to read for themselves.

Evaluation Q- Methodology

The Q-methodology did not go as planned. Even though visualisations were used, people where still not able to do it in the right way. The aQysta employees were reading the statements and explaining the procedure. It was hard to tell if the farmers just did not understand the instructions or if the aQysta employees perhaps followed another procedure than they should have. However, in regards to the results, it was still valuable .It was expected to see too many neutral cards, because it could be difficult to give an opinion. However, neutral 'cards' were scarce. Again, it was not sure if this was due to wrong instructions or because people really felt that way.

Evaluation Business Origami

After the first field visit, it was realised that his model was going to be too complex to use with the farmers as they are not familiar with business models, let alone visualising them. Furthermore, it would not make much sense, as they would of course go with an option where they have to pay as little as possible. Therefore, I decided to only use the board in the interviews with NGO's and other organisations that work with interesting business models. One of the results is visualised in fig. 49. It was found that this tool was useful for visualising a system. However, I did use it differently than planned beforehand. Because initially I wanted to visualise my 'own' design and ask the NGO for feedback. However, it did not make sense during these meetings to work in that way. It was more interesting to truly understand their way of working and use those insights for further implementation.

Evaluation Preference Booklet

From all the results is learned that farmers enjoyed this tool. The tool was very easy to use because they only had to point out which one they preferred. This simple movement was very effective. In the beginning of the interview, I asked for argumentation behind these answers. Those were not always answered immediately or clear. But later it became clear why they chose one over the other. The questions are also repeated, so answers were confirmed by this means. The research shows that some services, installation and transportation make no sense to compare with each other. As I visualised it in a way installation included the transportation as well. Furthermore, even though I only had the chance to do 2 sessions, it was clear that they wouldn't even consider choosing another option over installation. It makes sense, because without installation, the pump won't work, but as soon as it works, Barsha is really easy to maintain and use. Also, the questioned participants were both experienced farmers, so help with harvest and training made not much sense to them. When I created the preference booklet I had no idea that aQysta always installs the pump, otherwise it would've made sense to let it out of the booklet.

Another service nice to put in there, is provision of spare parts with the products. That would have been interesting.
Furthermore, a last session what would have been nice to do, is to compare it with paying additional fees. E.g. would you rather have installation and paying 1000 rupees extra, or no installation at all.





4.3 CONCLUSIONS

List of Elements

Using the gathered empirical data from the field research together with the previous insights and takeaways from the Analysis (literature research), some design 'guidelines' are given in this chapter. These design guidelines for the PSS design, form the conclusion of the fieldwork (and analysis). They are translated into the "List of Elements" and into "Building Blocks". The list of Elements serves as it were a data bank for the PSS design, listing different elements that can be used within the business model. The Building blocks serve more as a list of requirements for the PSS design. The blocks form the minimal basis to build/ design upon in order to deliver a value based PSS concept for aQysta.

4.3.1 List of Elements

The list of elements lists all possibilities for the different elements that can be used within the model, such as payment options, partnerships etc. Since most of these possibilities were discovered during the field research, this list functions as the conclusion of this chapter. However, some options also came from the literature - and company analysis

Design 'Rules' : Check all takeaways (repeat if necessary) + Repeat problem def, RQ & Objectives.

Payment

- Fully subsidized
  - Pay per use
  - Pay per water
  - Periodically spread cost – pay off
- Pay at once
- Pay-per-use
- Pay per water
- Pay-off / lease to own
- Pay with vegetables
- I time payment
- Loan model
- Pay for service

Ownership

- Shifts in ownership - aqysta, farmer, middlemen, etc.
- Shift over time or shift in beginning
- Collective ownership – community

Experience

- Experienced farmers : commercial farmers
- Non-experienced farmers : New farmers

Middlemen

- NGO
- Organisation
- Landlord
- Local Government

Service

- Service elements: List of possible service elements for the business model with short explanation.
- Training (non-physical resource) : training individuals for providing service
- & training of farmers. Duration, what will be thought, who will give training. Cost
- Seeds provision
- Installation
- Maintenance
- Business training / entrepreneurial
- Sprinklers/drip system
- Connection with market : Sales certainty
- Training : learn to take care of end of life cycle –
  > Increase consumer awareness and inform users about environmental solutions available in market (also solar) (vezzoli et al, 2015).

4.3.2 Building Blocks

To properly address the problem and therefore design a solid business model, some design guidelines have to be drawn. The findings from the fieldwork and from the analysis section are critical for the design, thus requirements for the design in order to be valid. These insights, findings and takeaways are concluded into "Building Blocks" The requirements that are mentioned are literally the building blocks, thus the minimal basis to start the design.

During the field work and in the analyses, different aspects and possibilities for the final PSS model were found. The list of elements above, was the basis for the design of the new PSS Business model. The major requirements for the new model are listed below, which are from now on referred to as building blocks. The building blocks are a combined findings from field- and desk research.

Building blocks for PSS Business model:

- The user (farmer) should pay to get committed to the pump. Pay for service and sprinkler/drip system in case the pump is fully subsidized. Payment should be monthly/periodically and start small and rise gradually over time, as the farmer gains more farming and business experience.
Amount depends on subsidy and if the farmer uses the drip or sprinkler system. The recommended system is the drip system, as it is more efficient and therefore better for the environment.

- The government subsidies are opportunities (both for aQysta as for the farmers, whom clearly need financial aid) that should be used in the model. Furthermore, subsidy can cover 70% up to 100%. Take in account if the remaining amount should still be paid for.
However, it should be considered that government subsidies are not always the case and most probably also not infinite.

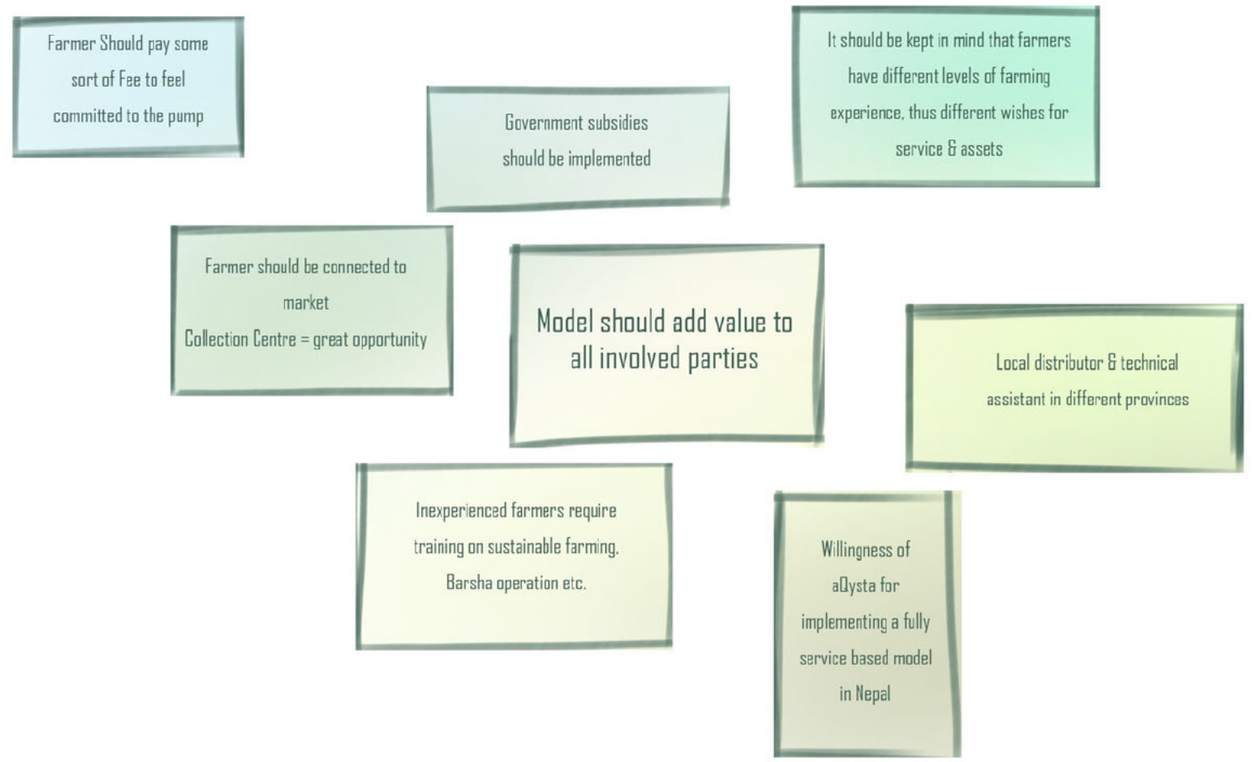
- Farmer can be yet experienced or new to farming. Amount of service provided for the farmer (like training, drip system etc) should be adapted to the situation.
- aQysta has shown interest in piloting the existing EasiPay model in Nepal. Therefore, the successful elements of this model should be considered during the design of the new PSS model for Nepal.

- Farmer should be connected to the market. It should be taken into consideration to work together with Collection Centres. These seem promising, as this means certainty for a steady cash flow for the farmers. Also there lies an opportunity for using them as distributor too.

* Lastly, the PSS should add value to ALL involved parties in the model, in order to design business model that creates more impact. It should not be forgotten that the environment in general also counts as a stakeholder. In order to call the designed PSS sustainable, it should have less negative impact on environment than the current business model.

These building blocks are the minimal requirements necessary for the PSS design in order to truly deliver a higher value-based PSS for aQysta and to solve the identified problem.







5. CONCEPT DESIGN



Description of Barsha Basecamp

In this chapter the concept design: Barsha Basecamp, will be presented and explained carefully. The model is visually explained by means of a system map and supported by a written explanation. Secondly, the validation and evaluation of the concept design by aQysta is given. This validation was then used as new requirements for an improved and final design, which is presented in the next section (6. Final Design).

5.1 Barsha Basecamp

Using the Building Blocks from the previous section as a starting point and the list of elements as a data bank, the first PSS was designed, named Barsha Basecamp. In this part this model will be presented and explained. Furthermore, the value for each stakeholder is mentioned and last but not least, the risks of the model are evaluated.

5.1.1 Description

Barsha Basecamp is the first PSS design of this project for aQysta. In this part the model is carefully explained.

As was obtained during the field work; different levels of expertise regarding farming exists amongst the target group. These different levels of experience, require different services. Hence, the model is divided into two main 'directions', aiming at the different levels of 'farming - experience' of the smallholder farmers.

The *experienced farmers* are the smallholder farmers which are **familiar with commercial farming**, meaning that they know how to generate income with their harvest. The needs of experienced farmers regarding services are mainly technical based (thus maintenance) and further training on seasonal-farming.

The *inexperienced farmers* :New farmers are smallholder farmers without a connection with the market. The harvest is currently mainly used for self-consumption, thus subsistence **purposes**. These farmers are in great need of any kind of assistance in the farming context, in order to improve their livelihoods.

Therefore the model either targets the *Experienced farmers* or Inexperienced farmers, also called the *New Farmers*.

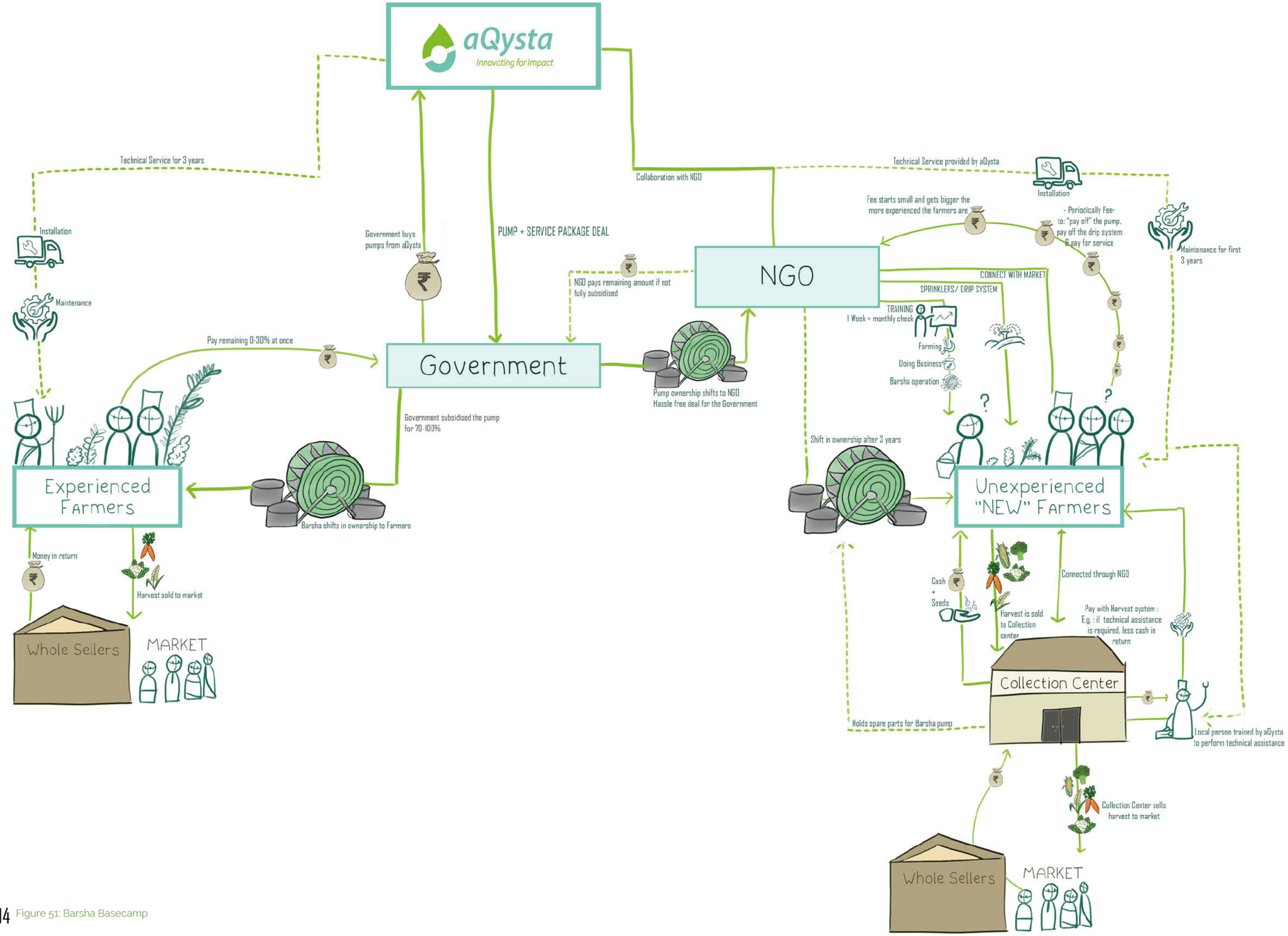
Barsha Basecamp is now explained using a system map (fig. 51). The system map helps in visualising service based business models, by showing all the different involved parties and the links between them, such as cash flows and provided services. Along with the visualisation a written explanation is now given, using the different target groups as directions.

Direction of Experienced Farmers:
This is the simple and short direction, based on the current business model of aQysta in Nepal. The current system of aQysta is valuable to maintain, as there is almost no financial risk thanks to the governmental subsidy system. Therefore it is advised that aQysta continues to do promotions in order to get the government to subsidise the Barsha pumps. In the case of the experienced farmers, the subsidised Barsha will be **installed by aQysta and basic training is given on how to operate the pump**. Furthermore, aQysta offers **maintenance as a service** for 3 years, which is based on their current warranty offering.
Often, the government subsidizes 70-100% of the initial cost. However, if the government's subsidy not covers the total amount of the Barsha for the farmer, the remaining amount (1-30%) should be paid at once by the farmer to the government. Based on the fact that the farmer is experienced and has gained and saved money over the past, he/she should be able to pay the remaining amount.
aQysta offers to **help selecting the farmers** for the subsidized Barsha, if the local governments require it. Appropriate farmers to be selected are farmers that currently use an unsustainable pumping solution, such as the Diesel pump or electric powered pump and of course those whose farm is located on land where the Barsha is able to operate.

Direction of New Farmers:
This side of the system is more complex, mainly because of the different partnerships. In this side of the system the focus is on the New farmers. aQysta offers a '**Pump + Service package deal**' (instead of only the pump) in collaboration with a NGO/organisation. The government pays aQysta for the pump and the NGO/organisation takes over the ownership of the pumps and thus the responsibility. In this way, it is a **hassle free deal for the government**, thus attractive. The government only has the responsibility in allocating their budget for the Barsha's. As soon as this deal is set, the government has no role in this side of the system anymore.

If the pumps are not fully subsidized by the government, the NGO/organisation pays the remaining amount (1-30%). As of this moment, the government is out of the picture and all responsibilities are in the hands of the partner (NGO/organisation). aQysta's role in this model is limited to: (A) selling the package deal to the government, (B) provide technical service (installation and maintenance for 3 years) and (C) training a local person to perform the technical assistance on site.

The NGO/organisation is key in this system and has three main roles: (1) **give training to the farmers**, (2) provide the farmers with **drip system** and (3) **connect the farmers with the market** (collection centre). During the training (1) an employee, most preferable a (hired and trained) experienced farmer, teaches the farmers about the basics of farming, doing business and about the use of the Barsha pump. At the initial start, the training lasts for a whole week. This is followed up by periodically checks and feedback appointments. The training will go on for a maximum period of three



104 Figure 51: Barsha Basecamp

years. The duration of three years is based on the already existing guarantee period of aQysta. The aim of the training is that the farmer is able to individually perform commercial farming. The vision is that three years should be enough in order to generating a steady income by farming. If it occurs that this is not sufficient, the duration should be extended.

The drip systems (or sprinklers) (2) are provided as a legitimate reason to ask for money. In the model the farmers will pay for the whole package, which includes the service, pump and drip system. However, it is of course unethical to ask money for the subsidised pump. Therefore the drip system (the most effective and sustainable irrigation method) is included in the package deal to let the farmers pay for something that is tangible, instead of only for the intangible service.

The **connection with the market** (3) is also of great importance, since this will be their **steady source of income**. Hence, another involved party in the model is the market. In the ideal case this is a **collection centre**. By connecting the farmers with a collection centre, the farmers have the certainty of selling their harvest and thus assurance of an income. The collection centre should always buy the crops from the farmer, no matter what the quantity or quality is. The collection centre holds an opportunity for aQysta as distributor, to hold spare parts for the Barsha.

Furthermore, it should be noted that the experienced farmers are not limited to stay at their 'side' of the system. Ideally they should also be connected to the Collection Centre for bi-directional flows, such as the possibility to easily obtain spare parts. However, based on the thought that they are experienced in generating income with farming, they probably have a consistent buyer.

Payment structure

The government pays aQysta for the pump. If necessary, the NGO or organisation pays the remaining amount. The farmers pay a periodically fee to "pay off" the pump, to pay off the drip system and for the provided service. The amount of the fee is based on the price of paying off the drip system, a small fee that covers the working hours of the employees and if necessary, the remaining amount of the initial pump costs. The fee should not be more than 600 Nepalese Rupees per week (the amount farmers pay for 1hour use of a diesel pump), so that it can be used as unique selling point of the model. Furthermore, the fee starts low and increases over time. The farmers are more experienced after a while and thus have more money to spend. The total pay off period is also three years. After that, the farmers do not have to pay anymore, they own the drip system and the pump and they are capable to generate an income with their harvest.
The collection centre pays the farmer a fair price for their crops. If the farmers 'take' new seeds from the centre or require technical assistance, they get less cash in return for their crops. So in a way, the farmers can pay with their harvest at the collection centre.
The collection centre sells the crops to whole sellers or private buyers.

5.1.2 Role and value for stakeholders

When involving different parties in a business model, it is important to specify the value and role of each party (Sakao et al. 2009). Furthermore, one of the building blocks for the PSS design is that the model should add value to all the involved parties. Therefore, in this part for each of the involved stakeholders; aQysta, NGO/Organisation, The government and the farmer, the role in the business model is described, followed by the value that it brings for them.

aQysta

Role: - Technical service (installation & maintenance)
- Training of NGO/employees to eventually perform technical service
- Promotions (to get government subsidies)
- Site selection (help government to find right locations for pumps
- Pump provider

Value: The value this model brings for aQysta is first by the sales of more pumps. Furthermore, with this service-based business model, aQysta creates impact for local farmers by improving their livelihoods, by providing them with 'water'. Also, this model helps in developing good customer relationships. Last but not least, this partnership model leads to a mutual exchange of knowledge.

NGO/ Organisation

Role: - Provide the service to the farmer. They are responsible of all social aspects.
- Collect the periodically fee and perform the training to the farmers.
- Find a steady connection with the market or with a collection centre and make agreements with them.

Value: Helping the ones in need. Partnership with aQysta.

** The NGO/ Organisation can be non-profit organisation, profit organisations, collaborations with universities or agricultural focussed organisations.*

Government

Role: - Subsidizing the Barsha pump up to 100 %. Thereby, enabling the farmers to use a sustainable water pump for irrigation.
- Allocating their budget to aQysta.
- *In general, governments can play a crucial role regarding the adoption of PSS (Vezzoli et al, 2015). For example, they have the power to change the current subsidy system. The could adapt it and reward sustainable business models with more financial aid, to support sustainable systems.*

Value : The value for the government that this models brings is that this could result in more involved and motivated farmers. More farmers, means more agricultural production, which hopefully results in less import and eventually more export. This will lead to a better economy a better economy in general for Nepal. Furthermore, this PSS offers a hassle free deal for the government. Without too much effort, they help in improving lives of smallholder farmers.

Farmers

Role : - Simply to be the end user of the pump and to become an independent commercial farmer over a period of three years. That is all they have to do.

Value : The farming training will lead to a more diversified diet, because of the crop variety. Unlimited access to water (24 Hours of free water provision). The farmers have the ability to become commercial farmer after a period of time, which will result in a steady income, thus a financial stability in general. This is also beneficial for the rest of the household. Furthermore, the training aims to develop an entrepreneurial mindset for the farmers.

Value for environment

Another important factor is of course less negative impact on the environment. Therefore the benefits of this model for the environment are also briefly mentioned below:
- Zero food waste, because all crops all sold on the market and otherwise consumed by farmers themselves.
- Food security for all.
- Less CO^2 emissions. Barsha is Zero emission pump, especially when unsustainable pump is replaced by Barsha. Also, it will not only will it safe the employees of aQystas' team time when a local distributor is implemented, less traveling means also less CO^2 emissions caused by car travels.

5.1.3 Risk Evaluation

In this part the PSS is evaluated based on the risks that arise when this model would be implemented or the barriers that limit this design from being implemented. .

The basis of this PSS concept seems to be steady. However, the system is dependent on several factors and as soon as one factor falls short in delivering their 'part' of the system is likely to fail.

Firstly, the dependency of the system regarding the partnerships the model brings, is evaluated.
The model is highly dependent on aQysta finding the right NGO for collaboration. The basis of success of this model lies in the hands of finding the right NGO willing to do the job. But what if aQysta is not able to find such? Is aQysta willing to become service provider themselves? Another challenge lies then in the fact that aQysta is not experienced in providing these kind of services yet. How would the model look like if aQysta would be service provider? What are the necessary steps?

Secondly, thanks to the government subsidies, the financial risks is not the problem currently. However, depending on these government subsidies bring the future risk as the government subsidies may not be forever. Thought should be given on how to adjust the model when this occurs? Will the system only work if large part is subsidised or will the farmers change mindset in willingness for a lease-to-own system.

Also, there is a risk of farmers not agreeing in paying for service or are not interested in buying sprinklers/ drip system. This would mean that there is no money transfer and the pump is just received for free. As explained before, this could cause the farmers to not be connected with the pump and lack of feeling of ownership. I
n the case of the Experienced farmers, there is also most likely no money transfer. Based on the fact that these farmers know the value the Barsha brings to their lives, it can be said paying for the product is not always necessary for careful behaviours.

Last, the different partnerships in the model also cause differences in needs of the different stakeholders. It is important to keep all involved stakeholders satisfied. However, this brings the risk that the own needs of aQysta might be neglected in order to keep other parties satisfied. This is not a preferable situation, so something that should be monitored carefully. Besides this, partnership models also bring the risk of being dependent of the performance of the other party.

A less risky model would be if aQysta would search for an existing cooperative implementing these collection centres and collaborate with them. Offering to work together and use them as distribution centre for spare parts and complete pumps. This would lower all risks of this system, while in the same time aQysta is collaborating with a impactful business structure.
The cost structure of this model was explained as part of the description. However, this mainly focuses on the sales revenues and less on the costs for aQysta. Thought should be given to aQysta would invest time and money in this PSS if the current system, with only focussing in obtaining government bulk investments, works well and brings zero financial risk?

Futhermore, the more collaborations that are implemented in the model, the less profit for aQysta remains, as the profit has to be divided over different stakeholders.



5.2 Validation & Evaluation

This concept design, Barsha Basecamp, was built upon the minimal requirements of the Building Blocks. It was made using the data gathered from literature research and from the field research. Even though part of this data derived from the company analysis, the designed model should still be evaluated and validated by aQysta, in order to deliver a final PSS design that creates value for all parties. In this chapter the concept model is validated and evaluated using the 'data' that was gathered during a meeting with one of the co-founders of aQysta: Pratap Thapa.

Looking at this first concept design, it is seen that **in theory the model works well, however, it will not work in practice**. This is due to **reliability of too many different factors**. If one aspect of the model does not work (e.g. farmer hesitant to pay for service or is not interested in a drip system), the model will fail.

In addition to the previous point, there is also a **risk of partnerships**, due to a difference in needs. An example are the NGO's, who are known for giving away things for free. For aQysta, this is not preferred, as a fee for the service provision is requested. In case of the NGO involvement in this design, it would be challenging to let them ask for a service fee, because their work hours are already covered by annual funds. They like to work on a voluntary basis, which can be preferable for collaboration, but in this case, the partnership with an NGO is not preferred.

Besides all the above, the preferred situation is where work with cooperatives rather than NGOs. This is because NGOs invest in a project, but will leave as soon as the project is finished. On the other hand, cooperatives are more continuous, which is ideal for aQysta.

Now that NGOs have been taken out of consideration, another improvement needs to be found. It is important for aQysta to find a whole seller that has enough confidence to invest in the model. This whole seller could either invest in the import or export. However, before achieving this, it is required to be certain about the scale of amount of pumps in order to know when it will start to make sense to invest for the other party.

Another aspect is that aQysta is willing to go for a more service based business model, as long as it is clear that they will then create more impact. They are even willing to take over role of being the service provider as long as the returns over time are more.

Looking at the input side of the model, it can be seen that aQysta has been providing the hardware. For aQysta, this is an important aspect, but farmers can only see it from their point of view; costs. This is unfortunately hard to influence, as this is an important aspect for them. On the other hand, the output from the model will be the value of agriculture. For all parties, it would be an ideal situation for the long term if the government invests in the 'agriculture centre'. Instead of this, the government subsidies in service instead of product based (so on the use of the pump instead of the hardware).

6. FINAL DESIGN



Description of Barsha Summit

Based on the validation and evaluation of the concept design, an improved and final PSS concept was made named Barsha Summit. This section aims to carefully explain this design, by first describing it using a system map and written explanation. Secondly, the roles and values for the involved stakeholders are mentioned followed by the Business Model Canvas of the designed business model. Hereafter, the risks of this PSS are evaluated. In the second part of this section the recommendations to aQysta regarding this research and its outcomes are given.
In the end, the final conclusions on the project will be given, amongst others by answering the research question and addressing the objectives.

6.1 Barsha Summit

For this model, the previous design, Barsha Basecamp, is used as starting point. As Barsha Basecamp was build upon the Building Blocks, for this phase, these do not form the basis because they are already implemented in the system. With the List of Elements serving as a data bank for possible modifications and keeping the aforementioned feedback of aQysta in mind, the final model was designed. This chapter presents and explains the Barsha Summit PSS carefully, by means of a system map and a Business Model Canvas. Furthermore, the role of- and value for each stakeholder is mentioned. Lastly, the risks of the PSS are evaluated.

6.1.1 Description

Barsha Summit is the second and final PSS design of this project for aQysta. In this part the model is carefully explained.

To follow the comments of aQysta, an improved model was made. In this second model, **Barsha Summit**, partnerships are avoided as much as possible, thus no NGO involvement and **aQysta takes full responsibility of the Collection Centre**. This means that within this system aQysta takes care of the input and output side, so the whole value chain. Taking care of the whole value chain means; giving training (about farming, Barsha operation, doing business, etc.), providing the hardware (Barsha pump), providing technical service (installation, maintenance), irrigation system (sprinkler, drip system, reservoir, etc.), seeds, fertilizer, pesticides and sales certainty, thus a steady income. Furthermore aQysta **pays the farmers for the crops in advance**, of which the aim is to make the farmers become more loyal and moreover, they have a benefit over the competition of the local market.

Same as in the previous design, this system combines two business models and offers them as one single solution. Again, the left side of the system is the simple 'direction' and is it is based on the current business model of aQysta in Nepal. The business-as-usual scenario is implemented, with slight modifications, because it lowers the financial risks of the implementation of the new strategy. This PSS advises aQysta to keep doing business as usual and additionally start with implementing the right side of the system.

This model also uses the two directions for the target group: Experienced Farmers and New Farmers. The description of these target groups can be found in the previous section where they are properly introduced.
In Figure 52 Barsha Summit is visualised using a system map. The following text supports the description of the Design.

Direction of Experienced Farmers:
The modifications to the current business model are that the currently occasionally offered technical service in this model will always be offered. This means that aQysta takes care of the installation of the pump and providing the farmers with a short training on how the Barsha should be used. Even though the farmers are "experienced", irrigating the field with a Barsha requires a different strategy as the water output is spread over 24 hours. Furthermore, within the first three years, aQysta offers free maintenance, serving as a warranty for the Barsha. Last, aQysta is responsible for the selection of the farmers who are getting a subsidized Barsha. By this means they can create and sustain a good customer relationship.

The target group for this route is the experienced farmers. By implementing the current model in the new system, aQysta has more guaranty of sales. Furthermore, this model requires less personnel labour, meaning that aQysta has more time for the implementation of the right side of the system while the sales continue.

Same as with the current system and the previous design is that in case the government not fully subsidises the pump, the remaining amount (1-30%) has to be paid at once by the farmer to the government.

Direction of 'New' Farmers:
As can be seen in the system map, the right 'route' is also connected to the government. However, compared to the left route, at this side aQysta offers a full service-package deal to the government when applying for funds. By funding this offering, the government supports and enables sustainable business model and thereby creates impact for the farmers. The price for this package deal is explained with an amount of money bags. The price for one Barsha pump equals two money bags, thus package 1, costs two money bags. The full service package two 'costs' three money bags, of which two are still used to subsidise the pump and one money bag is to support the collection centre in offering seeds and upfront salary, by overcoming this investment gap for aQysta. The government is not subsidising aQysta with this third money bag, but the idea is that they support aQysta in offering this value-based system to the farmers.

With this provided 'service' fee from the government,

BARSHA SUMMIT

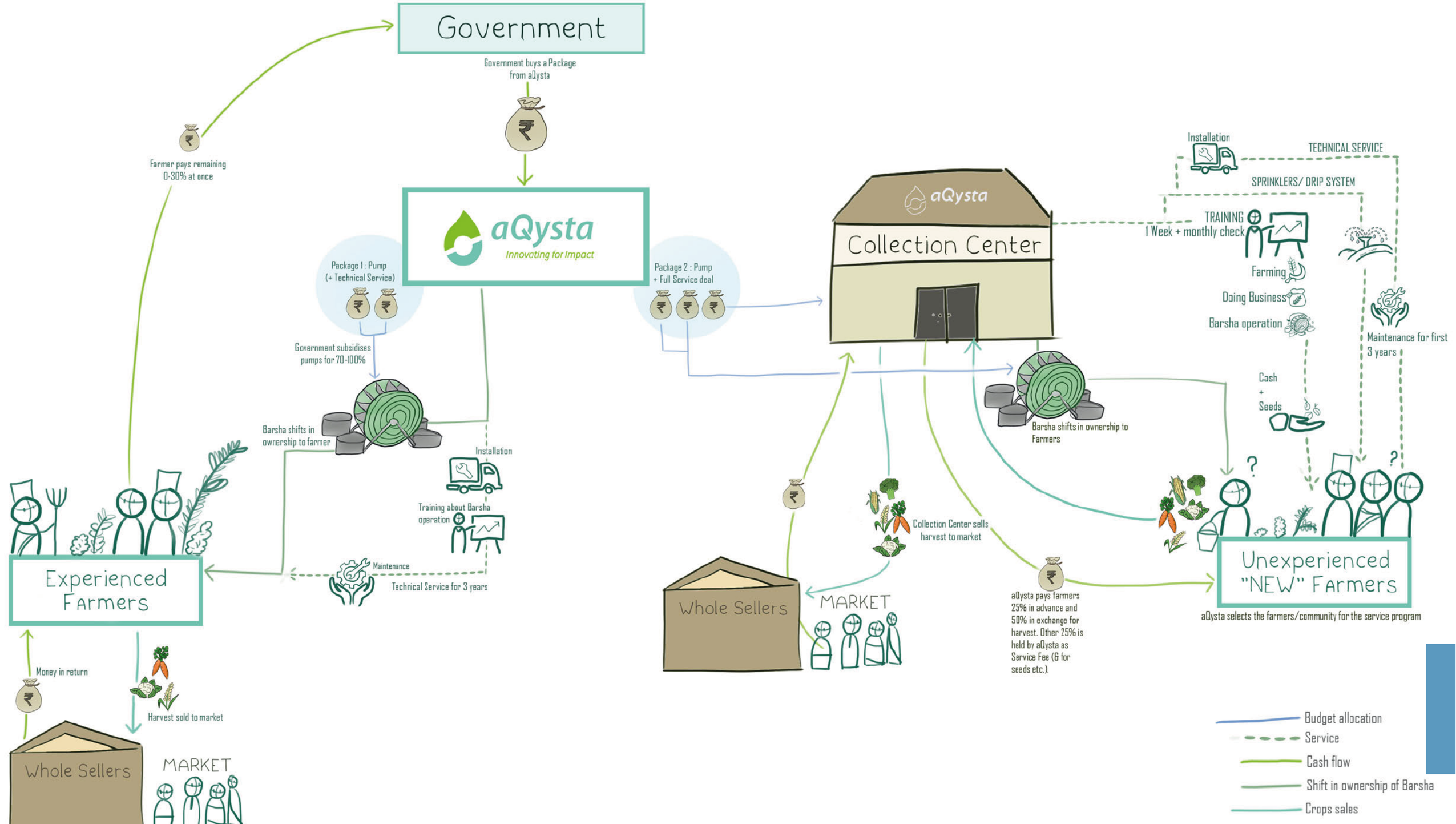


Figure 52: Barsha Summit

Role & Value for Stakeholders

aQysta can offer the farmers free seeds along with the pump. By providing the farmers with different seeds, they are assured of a varied diet and of year round harvest, thus year round income.
* *Along with the standard seeds (first harvest is subsidised by government) an option could be to give all the selected farmers 5 coffee trees (investment). By doing this, aQysta creates a coffee farm. The benefit of letting the farmers grow and harvest coffee beans, is that it is not a common crop that they can easily sell on local market. This assures aQysta that the farmers will 'sell' their crops to them and over time (4 years) the coffee farm will be profitable. The drawback of this is of course that it requires large investment, as coffee trees cost money and for a decent coffee farm, around 3000 trees are required.*

Since the government subsidies only fund the first round of seeds, aQystas' Service centre will have to provide the farmers with seeds after they finish the first round. aQysta will obtain their money by keeping 25% of harvest' sales. In the beginning of the journey, the farmers will get the seeds when training visits are made and later they can obtain seeds when they go to the collection centre.

Along with the seeds, the farmers get 25% of expected harvest price as **upfront payment**. This is to have some kind of certainty that the farmers will sell their harvest to aQysta ('s Collection centre) instead of going to the local market, where the price might be better.
aQysta sells the harvest to a whole-seller with whom they made agreements on a price per quantity and for a certain quality. It is up to aQysta to train the farmers to live up to these standards as much as possible. A failed harvest, is the risk for aQysta.

Besides offering this sales guaranty to the farmers (output), aQysta offers among others technical service, thus installation and free maintenance for the first three years. Also the centre holds sprinklers, drip systems and supplies for building a reservoir pond. Dependent on wishes of the farmers, these can be paid off over periods or a larger amount (>25%) of harvest sales is kept by aQysta. Last but not least, aQysta offers training to the new farmers. The training is given by a hired experienced farmer. It starts with one week full training, followed up by periodically checks and feedback moments. During the training, the farmers will learn about (1) sustainable farming, using different seeds for a diversified diet and year round harvest. (2) About doing business, the sales model will be explained, among others the deal with the centre, but also how to increase their income by growing more crops for example. Lastly, (3) they learn about the operation of the Barsha. This means learning when to take the pump out of the water, changing the water output to the reservoir at night and how to perform basic maintenance.

Apart from the previously mentioned services, the centre also offers fertilizers, pesticides and spare parts for the pumps as it creates a unique opportunity to act as a local distributor.

The payment structure for this system is as follows: aQysta pays the farmers 25 % upfront of the harvest and 50% when crops are returned. The remaining 25% is kept by aQysta as a fee for providing the service and to let the farmer pay-off the sprinklers. By this means, farmers "pay with their harvest".

Another addition the centre can offer is to pick up the crops at the farmers' place on a fixed day. This would really add value to the model from the farmer's perspective. It solves the problem of reaching the centre coming from a remote area, especially during monsoon, It will be the responsibility of aQysta to collect the crops in time, which solves a problem for farmers.

6.1.2 Role & Value for Stakeholders

In this part the values and roles of each stakeholder are specified. In this improved model, there is one less party involved (no NGO involvement). The roles and values are specified for aQysta, the government and the farmer. Some roles are more directly related to aQysta in this model than in the previous one.

aQysta

Role
- Providing the full service to the farmer
- Training and employment of 'experienced' farmer to become a trainer for the collection centre.
- Promotions to get the government subsidies
- Sustaining the Collection centre
- *Taking care of the whole value chain*
- Site & farmer selection for the subsidized pumps
- Find a steady connection with the market or with a collection centre and make agreements with them
- Pump provider

Value
The value of this model is clearly based on creating more impact for the farmers and having a direct customer relationship.

Government

Role
- Subsidizing the Barsha pump up to 100 %. Thereby, enabling the farmers to use a sustainable water pump for irrigation.
- Financially supporting aQysta in offering this service package to the farmer in order to improve the farmers' livelihoods.
- Allocating their budget to aQysta.

Value
The value for the government that this models brings is that this could result in more involved and motivated farmers. More farmers, means more agricultural production, which hopefully results in less import and eventually more export. This will lead to a better economy in general for Nepal. Furthermore, this PSS again offers a hassle free deal for the government. Without too much effort, they help in improving lives of smallholder farmers.

Farmers

Role
- Simply to be the end user of the pump and to become an independent commercial farmer over a period of three years. That is all they have to do.
- Opportunity to become trainer for aQysta and help other farmers in growing their business.

Value
The added value of this model is that the farmers have a guaranteed income even if acts of god destroy the harvest. The farming training will lead to a more diversified diet, because of the crop variety. Unlimited access to water (24 Hours of free water provision). The farmers have the ability to become commercial farmer after a period of time, which will result in a steady income, thus a financial stability in general. This is also beneficial for the rest of the household. Furthermore, the training aims to develop an entrepreneurial mindset for the farmers.

Business Model Canvas

6.1.3 Business Model Canvas

Along with the strategy map, the PSS is explained by means of a Business Model Canvas, using the adapted version that implements People, Planet Profit,

As can be seen in the canvas (fig. 53) :
1. Customer segments: aQysta creates value for smallholder farmers in Nepal, who are the end users of the Barsha pumps. These smallholders are mostly inexperienced regarding commercial farming. However, the more experienced farmers are also customers, but they have less needs regarding the offered services (key activity).

2. Value propositions: aQysta offers the farmers a guaranteed income, 24/7 accessibility to irrigation water by means of the sustainable irrigation pump and options for a more diversified diet.
The value for the planet is that the Barsha pump does not require energy or fuel and therefore is a emission free irrigation pump. The profit of this model is that aQysta delivers a full service package, where they take care of the input & output side of the value chain. Also, this model provides the farmers with an income.

3. Channels: The Barshas should ideally be produced more locally (India/China). From there they are shipped to Nepal. The collection centre serves as a distribution centre, so the pumps can be stalled here until they are devoted to a farmer. Assembly of the pumps can also take place in Nepal in the centre.
As for promotions, aQysta continues with doing their promotions and demonstrations. Through means of distributing flyers in surrounding villages, farmers are invited to the demonstration and they are able to apply for the package.

4. Customer Relationships: With this strategy, aQysta has direct contact with customers, through the collection centre or by means of the training. During these trainings, the customers get personal assistance. In this way, aQysta builds upon a long lasting relationship. Even when the training period is over and the package is paid off, the contact with the centre remains as the farmers continue to sell their harvest.

5. Revenue streams: In this model, the farmers pay for the full package deal, with a guaranteed income. This model is a PSS with a Functional result, where they pay for an income. They pay an usage fee for the total package which is spread over three years. This is paid through crop delivery, where the collection centre keeps a fixed percentage of the sales.
The Whole seller pays an agreed upon amount for the crops, based on quality and quantity of the crops.

The government subsidies are used to overcome the high upfront cost of the Barsha pump. In package 1, the subsidy (80-100%) is fully outsourced for the pump. However, for package 2, the funds are required to be a bit more, of which the larger part is still meant for subsidizing the pump for the farmer. The remaining part of the fund is allocated for supporting aQysta in the delivery of this model. It is used to provide the farmers with seeds and the required services.

6. Key Resources: A necessity for this business model is the connection with experienced farmers. Another key resource is the deal with the market for guaranteed sales of the crops. Without this deal, the model is too risky. Also, this model is highly dependent on the investments and subsidies (of the government). Those are needed to invest in the seeds, the building, pump manufacturing, farming attributes and for paying the employees, but also to cover the initial costs of the Barsha for the farmer.

7. Key Activities: aQysta's key activities are to sell the packages to the government and provide the total package to the farmers. Within this model aQysta takes control of the input and output side of the value chain. This means that they are responsible for providing the farmers with: pumps, seeds, farm related attributes, training and technical service. Last but not least, aQysta provides the farmers with an income.

Furthermore for this model to work, aQysta has to train their staff and workers. The hired experienced farmers need to be selected and trained to perform the training to the farmers & maintain the relationships with them.
Last but not least, aQysta has to take care of selling the crops on the market.

8. Key Partners : aQysta's local team is very important, since they have to start with building the network of players. They have to find, train and hire experienced farmers to become employees, providing the training

to the farmers.
The second partner is the government of Nepal, especially the local governments, because the model is highly dependent on them allocating their budget for the packages.
And last but not least, the employees need to connect with whole sellers to make a waterproof sales deal. Without this deal, the model is likely to fail.

9. Cost Structure :Large investments are necessary for this model to work. Amongst others, they are used for the upfront payment for the farmers and the seed provision. But also to invest in other farming materials in order to have a complete farming facility centre. When everything is more on track, the fixed costs are the rent of the building and the salary for the employees.
Other main costs for aQysta are the costs regarding to the manufacturing and transportation of the pumps. However, if the pumps are to be manufactured in Asia costs will be significantly reduced.

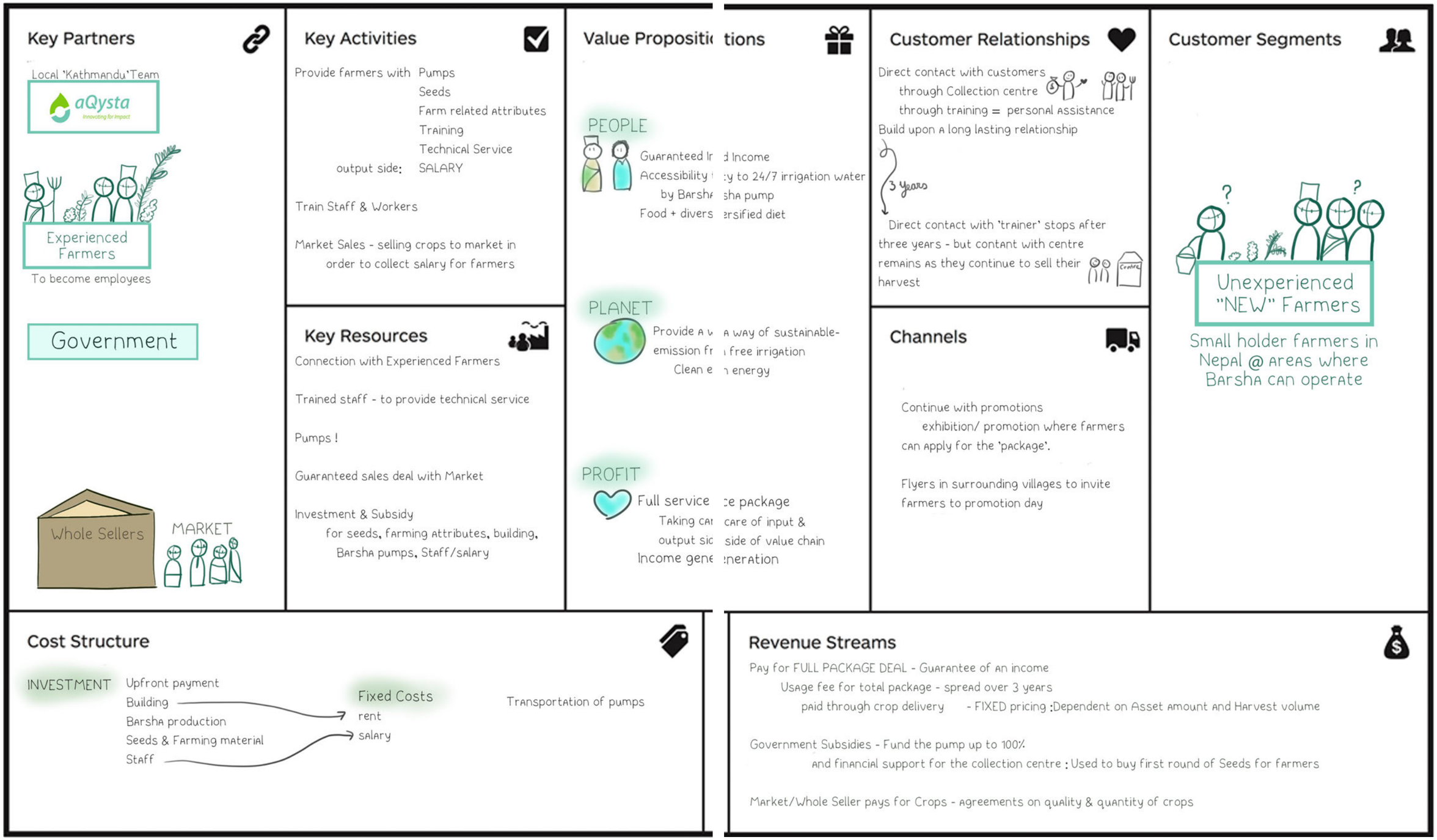


Figure 53: Barsha Summit Business Model Canvas

6.1.4 Risk Evaluation

In this part the PSS is evaluated based on the risks that arise when this model would be implemented or the barriers that limit this design from being implemented.

Even tough the risk caused by partnerships is reduced (by removing the NGO compared to the concept model, in this model aQysta is still dependent on the partnership with a whole seller or local market. If there is no guaranty of selling the crops, the model is not profitable and too much risk. aQysta highly depends on this partnership.

If unluckily, in the future the government stops subsidising, the model will change. Either aQysta could implement the lease-to-own payment system, where the fee starts small and gets bigger over time, parallel to farmers' experience. Or the farmers get even less money in return for their crops. The stop to subsidies would also create opportunities, since the farmers cannot longer use the excuse that they will get it for free otherwise. Another option would also be to search for other organisations that can help with funding.

Furthermore, there is a great risk of aQysta becoming a full service provider. However, this does not mean that the technical staff of aQysta has to become social workers helping with the farming. aQysta should open vacancies for these functions and by this means creating new jobs for the society.

The upfront payment they offer to the farmers is financially risky, because the farmers are not forced to sell their crops to the centre. It is on the basis of trust, hoping that the farmers have sense of morality and feel connected with the centre. However, if real cost estimations for this PSS are made, a default of 10 % should be taken into the calculations. If 90% of farmers feels obliged to always sell their crops through this channel and 10 % is not trustworthy, it would be acceptable. As long as aQysta takes this default into account.

As mentioned before, defaults in crop batch are also aQysta's risk. There are two possible scenario regarding crop defaults : 1) The farmer receives seeds and based on these seeds, 25% of the expected market value. However, if unfortunately by acts of god the farm is flooded and the harvest is ruined. The farmers can keep the upfront payment of 25%. In the second 2) scenario the farmers had no problems during farming, however, the crops are in bad quality of the quantity is less than expected, the collection centre still has to accept this harvest and give the remaining 50% of the value. If the crops do not fit the agreements of the whole-seller, aQysta will not receive the 25% profit marge. Bad crops are the responsibility of aQysta and if this occurs often they should consider to give the farmer better training in order to perform up to the standards.
The rejected crops are not just thrown away by aQysta, in regards of SDG zero foodwaste aQysta will always find a good purpose for these crops. In example, crops can be given back to the farmers as food for self-consumption, aQysta can try to sell it to local market whom are fine with small batches or smaller vegetables. Last option might be to give it as food for livestock.

Even though aQysta mentioned to be interested in taking over this whole service provider role, thought can be given if it is smart. Collection centre initiatives already exist and aQysta could also consider to collaborate with those existing ones. It would take away a lot of risk, whilst in the same time aQysta helps in offering a sustainable water pumping solution for irrigation. aQysta should then rather focus on targeting several of these centres, which can serve as local distribution centres, where spare parts can be obtained. For every region, there should be a trained person, hired by aQysta, who is able to perform maintenance, so that each province/ district has a nearby Barsha specialist.

Lastly, for the training it is preferred to employ experienced farmers for giving these trainings. It was learned from other experiences that current farmers do not take 'business' people serious in giving the training in farming. However, an expert of the sector would be a reliable source. Especially given the fact that Nepali people tend to be very sceptical, tips from an expert might be valuable and trustworthy. However, the risk lies in the fact that there is a large chance that these experienced farmers are not even willing to become employed by aQysta. If that is the case, aQysta should consider in finding another reliable source or invest time to make current employees experts.





6.2 RECOMMENDATIONS

Recommendations

The final design is the recommended PSS model for aQysta in order to create more impact and address the identified problems. Hence, in this chapter advice is given considering the outcomes of this project. Furthermore, a brief explanation is given on how Barsha Summit can be implemented and on what scale it starts making sense.

6.2.1 Advice

In this part an advice is given to aQysta, the company in case, regarding the outcomes of this study. What is recommended to do with these findings?

The final design, Barsha Summit was build upon the building blocks that originated from the analysis and the findings from fieldwork. The presence of these factors in the design make sure the design is truly impact-focussed. The aim of this study is to give aQysta advice on the possibilities that exist for a more impact-full and sustainable business model. The design is therefore used as a future vision towards a more service-based mindset.

The first recommendation for aQysta is to focus on **manufacturing of the pumps in Asia**. A lot can be saved (in the field of costs) regarding the manufacturing and especially the logistics of transportation. A second, closely related recommendation is to consider to have **multiple distributors in Nepal**. Not only for the complete pump, but for spare parts as well. The currently existing **collection centres** are a great opportunity for this. It is seriously recommended to aQysta to closely look into this for **possible collaborations**.. Regarding this, aQysta should make sure they start to train local people to perform maintenance for the Barsha, with the ultimate goal of having a Barsha expert in each province or maybe even district.

Also aQysta is advised to keep **providing the technical service** as it is done now. This means that aQysta takes care of the installation and provides maintenance for the first three years. However, it is advised that from now on aQysta should put effort in training the farmers on **efficient operation of the Barsha pump**. Furthermore, from now on, the **data base of installed pumps** should be complete and aQysta should do **occasionally check-ups.** A lot can be learned from (reluctant) users. Maintaining the contact with customers throughout the life-cycle, can help aQysta in attaining a better understanding of the needs and wishes of the farmers and can therefore offer better value proposition in the future, because the know what the farmers truly desire. Furthermore, a good relationship can influence the loyalty of consumers towards the brand (Beuren et al., 2013), which indirectly leads to a competitive advantage. Furthermore, good client relationships allows aQysta to co-create with their customers in order to offer improved solution.

Additionally it can be considerable to offer some spare parts with the initial delivery. A lot of time and effort can be saved for aQysta's employees if the spare parts (along with training or a manual) are provided with the pump.

Barsha summit make sure that the product is being used in its most efficient manner (by means of extensive upfront training) and with care, resulting in a more valuable Barsha. However, there is less focus on quantitative sales. It is advised for aQysta to look into this aspect if they really care to create more impact. In this way, the lifespan of the pumps can be even further improved and the farming is done more efficiently.

The last recommendation for aQysta towards a more sustainable business model, is to **search for collaboration with organisations** that are currently providing such complete packages. In this way, aQysta is creating more impact whilst having the time to focus on the supply chain of the Barsha pumps first. A possible party for such a collaboration could be Renawable world. They offer complete packages to farmers by offering training, seeds and connecting them with collections centres. In the future aQysta could maintain a greater role in this partnership by focussing on the technical training given to the farmers for example.

Because the government in Nepal is highly supporting the agricultural sector, it is believed that there is a serious chance of their (financial) cooperation for such a package offering. They already invented such cooperatives (collection centres).

6.2.2 Implementation Roadmap

In this part a plan for implementation of Barsha Summit is given. If aQysta would start now with following up on the advice and this implementation roadmap, it is possible to offer the complete package Barsha Summit brings, in a timespan of 10 years from now.

With the timespan of 10 years a lot can change. If aQysta starts with taking little steps towards this more impactful business model, a lot of impact would already be made. Furthermore, the good customer relationship and close connection with government can help in the future for implementation of the ITP.

It will now be explained how to reach Barsha Summit, so what steps have to be taken and when?
Requirements for successful implementation of the PSS are amongst others that enough Barsha's (ca. 20) should be available, enough staff to deliver the promised services and the needed logistics.

1. As mentioned in the previous advice, first thing to do is start focussing on more localised manufacturing. They should try to have a Asia based supply chain in two years from now.

2. Second step is to focus on having several distributors in Nepal instead of only one in Kathmandu

area. In one year from now the goal is to have at least distributors in each province (where the Barsha's are installed). If possible, the complete Barsha's should be stored here, but the focus is on at least more localised availability of spare parts. In the timeframe of 10 years, the aim is to have distributors of spare parts on district level.

3. Along with the local distributors, aQysta should already select local handymen for performing maintenance to the Barsha. aQysta should open a vacancy and as soon as people are selected, aQysta is adviced to organise a training week where they learn everything that is necessary. Working parallel with local distribution centres, the handyman is able to obtain the spare parts there. If the local distributor is not available yet, the parts should be transported to the handyman or he stores them at his own house.

4. Complete the data base of all installed Barsha's in Nepal. This should be done as soon as possible. It is relevant to know where the Barsha's are installed for the determination of the possible collection centre, as it does not make sense to position the centre in the middle of current users. The aim of the centre is to target new farmers, who are not using the Barsha yet.

5. Within 4 years, aQysta should start focussing on finding experienced farmers willing to be employed by aQysta for giving training to the farmers. If aQysta finds these farmers, they can add the training service to the current technical service. So from then, each time a pump is 'sold' to a farmer. The employed trainer helps with providing the technical service and stays for one week at first to train the farmer for optimal Barsha use.

6. aQysta has to start looking for possible partnerships with wholesalers and local markets. This is the main requirement before the model can be implemented, because without this insurance of sales, the PSS is financially too risky for aQysta. As the model will not be implemented within a short timeframe it does not make sense to have this deal on the table immediately. Therefore it is recommended to start with searching after 6 years from now.

7. Also, starting from now, aQysta should perform field research to discover the needs and habits of local population. The service offerings in the designed PSS are just an estimation of possible services and not validated with the needs of the farmers. As aQysta is new in providing services, a lot can and has to be learned before implementation.

8. Three years before the actual implementation, aQysta should perform a pilot. Currently, aQysta organises demonstrations to show the pump to the government for obtaining subsidies. This can perhaps also be done for the business model. If aQysta, starts with a small pilot, the demonstrations can show the success of the PSS and hopefully the government is then willing to support further development.

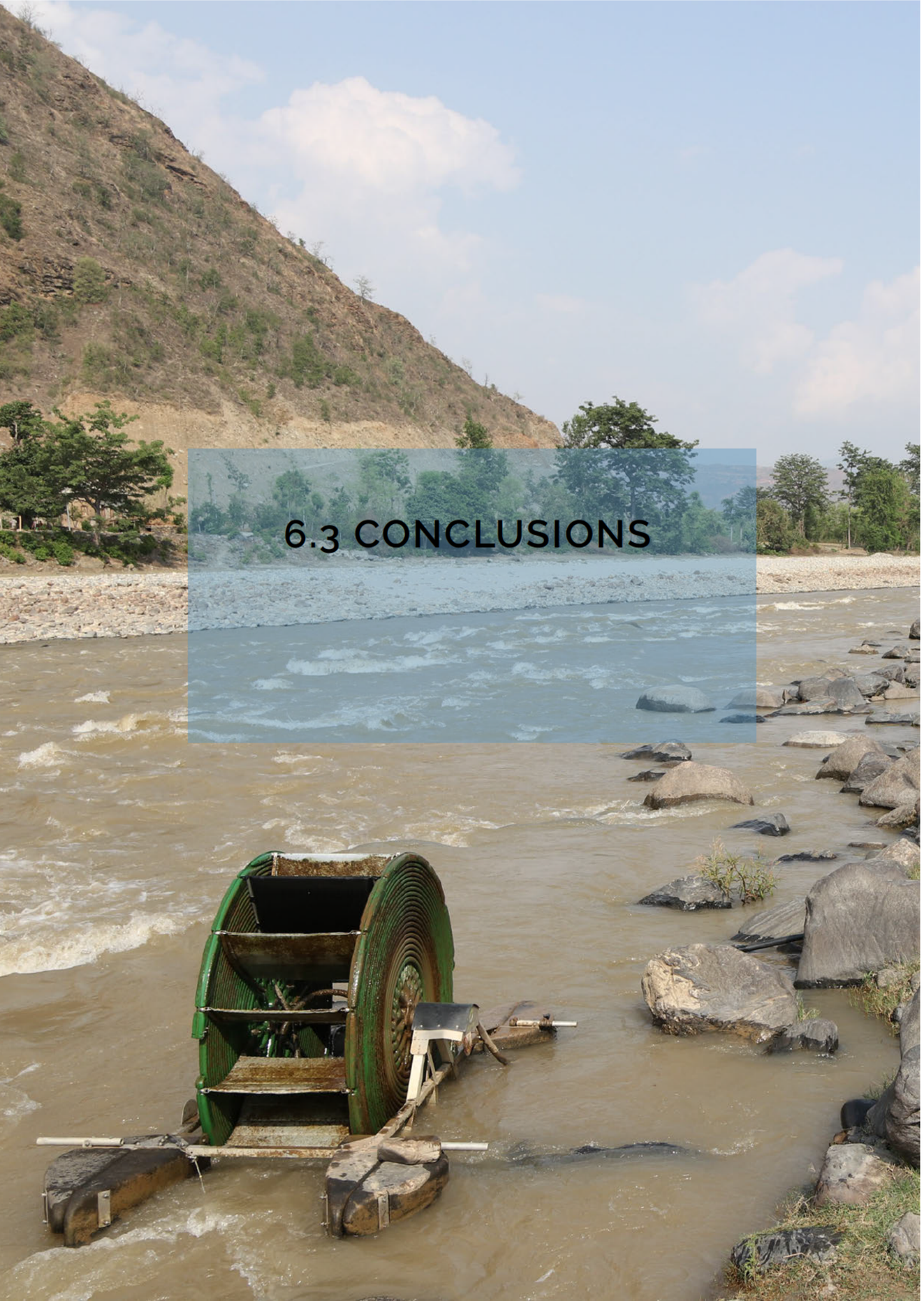
9. As soon as the pilot results in positive outcomes, actual steps towards the collection centre should be made. Therefore, aQysta has to find a suitable location to rent beforehand. As soon a place is targeted, the logistics in the surroundings should be determined and necessary personnel for the centre has to be employed.

10. aQysta could look into possible collaborations with companies providing sustainable irrigation methods, such as the drip system. Perhaps a profitable deal can be made to purchase the systems for a reduced price.

11. Lastly, aQysta has to do research in what the centre should offer, such as different kind of seeds, sprinklers, fertilizers etc., in order to deliver to complete package.

As soon as Barsha Summit is fully implemented, the co-creation should always continue to keep improving the PSS and the delivered value for the customer.





6.3 CONCLUSIONS

The project is finished, so the final conclusions should be made. In this chapter, first the research question is answered after which there will be conclusions regarding the feasibility and generalizability of the model. Lastly, the scientific contribution of this thesis is discussed.

6.3.1 Answering the Research Question

Now that the final design is presented and explained carefully, the research question is answered in this part

What additions should be made to the current Business model of aQysta in order to contribute to more benefits for the smallholder farmers, other stakeholders and aQysta?

The previous chapter explains carefully what steps have to be made from now, thus the current business model, in order to deliver a more value-based model, Barsha summit. It is already explained how the designed PSS adds value and benefits for the different stakeholders. Furthermore, in the designed PSS, the current business model is implemented as it is advised to aQysta to continue this strategy. Continuing this model and carefully making steps towards a more sustainable business model, will lead to Barsha Summit.

The main objective was to *deliver a higher Barsha-based value proposition by means of a PSS*. The designed PSS is Barsha Summit and it will now be explained how this PSS solves the identified problems.

The Problem: For the farmers it was found that without subsidies, they are not able to afford a Barsha pump. Furthermore, they are often not experienced enough in creating a profitable income with farming and find it hard to sell their crops on the market. Lastly, it was identified that the Barsha requires extra explanation on its use, as the different way of water provision requires a different way of farming.

- Barsha Summit addresses these problems in offering a package where the initial costs of the Barsha are covered and the farmers are supported in generating income with farming. The collection centre always accepts the crops, so as long as the farmers farm, there is a guarantee of income. On top of this, Barsha Summit offers an extensive training in the beginning where the farmers carefully learn how to farm with a Barsha pump.

The Problem: For Nepal and its government it was identified that the agricultural production is not enough to feed the country and moreover more products are currently imported than exported. Furthermore, the wide use of the unsustainable Diesel and electricity-powered pumps is also unfavourable.

- Barsha Summit makes sure that the produced crops are sold. Ideally this would not only be on the local market, but eventually also for export purposes. Furthermore, this model was designed with the aim to out rule the unsustainable competitors. So the more the government invests in this model, the more Barshas are being used, which results in less used Diesel - & electric pumps.

The Problem: For aQysta it was found that the unfamiliar technique of the Barsha and low flow rates cause a barrier for use. Also it was identified that it might be challenging to shift from a product-oriented mindset to a service-oriented mindset. Lastly, the government subsidies formed an opportunity as well as a threat for aQysta.

- Barsha Summit implements the government subsidy system while at the same time they make sure the Barsha is used carefully (by means of training & periodically check-ups). The long implementation plan assures that aQysta obtains a more service-oriented mindset by taking small steps at a time. Lastly, the training that is provided as a service helps the farmer in understanding how to use the low flow rates of the Barsha efficiently.

Secondly, the model is checked on the Building blocks:
The farmers should pay something in order to get committed to the pump: The collection centre holds 25% of crop sales, by which the drip system is being paid off and the service fee is covered.
Government subsidy should be implemented: The subsidies are an important factor for the implementation of the PSS.
The different experience levels of the farmers should be taken into account: The service provided is adaptable and can be changed accordingly to the needs of the farmers. From a full service package (2) to almost only a pump (1) offering, the PSS addressed both.
Farmers should be connected to the market: The farmers are connected with the collection centre, which act as the market towards the farmers. They can sell their crops here.
Local distributor: The collection centre acts as a distribution centre, where the Barshas are stored and farmers are able to obtain spare parts if necessary.
Add value to all involved parties: The model does add value to all involved parties (see description of Barsha Summit).

Last, it is reviewed on how Barsha Summit relates back to the SDG's mentioned in the introduction. Aforementioned, aQysta's current strategy aims in addressing the four SDG's : ***Climate Action, Renewable Energy, No Poverty and Zero Hunger***. It is important that the designed PSS also addresses these goals.

Climate Action: The Barsha eliminates the use of (unsustainable) energy by purely using the flow of water to pump water. Furthermore, by producing the pumps more locally, less emissions are caused by transportation of the pumps.

Renewable Energy: The Barsha Summit PSS evolves around the Barsha pump, so it definitely supports

renewable energy. Furthermore, things to support this even more, might be to solely use solar power as energy source in the Collection Centre.

No poverty: The value proposition of this model is assuring the farmer a guaranteed income. Furthermore, irrigated agriculture is twice as productive per unit of land (Worldbank, 2017). The use of the Barsha pump will therefore result in greater agricultural production. This can help the local economy in Nepal as well.

Zero hunger: With the 24/7 water supply provided by Barsha and the knowledge on farming different crops throughout the seasons, the farmers not only have enough food, but also a more varied diet. By providing training on (sustainable) farming, the aim is to significantly improve the agricultural production.

6.3.2 Feasibility & Generalizability

In this part, a conclusion regarding the feasibility and generalizability of the model is given.

Feasibility

In theory this model works well. It was build upon a thorough research, with literature and findings from real life. However, as explained in the risk evaluation, it's success depends on many different factors. The actual feasibility of the model should be determined by means of a pilot.

Generalizability

The model is specifically designed for implementation in Nepal and is fully Barsha focussed. A unique element of this model, is the subsidy system. This creates a great opportunity for aQysta in covering the initial costs for the farmers. A side effect of this model is that the farmers therefore are hesitant to pay the full amount for irrigation solution. For other countries the attitude towards paying for such a solution is likely to be very different and hence another solution should be thought of to cover the initial costs of the pump. Therefore, it can be concluded that this model is not generalizable for straightforward implementation in other companies. An identical study should be done in order to see what the best solution for a country may be.

Furthermore, the model evolves around the Barsha pump. aQysta recently implemented the HyPump and is still developing the ITP, so it can be valuable to review if this model is applicable for these pumps as well. Regarding the Hypump, the system could be applicable, but with some modifications. The Hypump is not designed for individual use of smallholders farmers. Therefore, if this pumps is suitable for collective use for a community the model should be adapted to a sharing model. Furthermore, both the HyPump as the ITP, require infrastructure. The the question would be if the government should subsidise this or aQysta. If aQysta invests in the infrastructure, the model the costs should be implemented in the payment structure, so that over time, this investment is paid back. For ITP, the model should also be reviewed and adjusted, as ITP will be used collectively as well.

6.3.3 Scientific Contribution

Finally, in this part the scientific contribution of this study is evaluated.

The scientific contribution of this graduation project is that is combines insights obtained during a thorough literature review and other analysis, with empirical data gathered in the field.

These insights were listed and combined into a list of requirements (Building Blocks) that formed the basis for the PSS Design(s).

The concept design was then validated with the companies values. Keeping these values in mind, a second model was designed.

The final design is a result-oriented Product Service System. According to literature, these are the most promising types of business model in for environmental impact.



LIST OF REFERENCES

List of References

Agriculture, P. (2019). *Low-Cost Pay-Per-Use Irrigation Using Solar Trolley Systems* . Retrieved from Powering Agriculture: https://poweringag.org/innovators/low-cost-pay-use-irrigation-using-solar-trolley-systems

Aqysta. (2019). *About Aqysta.* Retrieved from aQysta: https://www.aqysta.com

aQysta. n.d. Retrieved from aQysta: https://www.aqysta.com

aQysta. n.d [1]. *Stories: Easi-pay enabling acces to sustainable irrigation with flexible pay as you go systems.* Retrieved from aQysta: https://www.aqysta.com/stories/easi-pay-enabling-access-to-sustainable-irrigation-with-flexible-pay-as-you-go-systems/ on August 2019.

ASFG. (2013). *Supporting Smallholder Farmers in Africa.* Retrieved from Food and Agriculture Organization of the United Nations: http://www.fao.org/family-farming/detail/en/c/1109849/

Aurich, J , Mannweiler, C. & Schweitzer, E. (2010). How to design and offer services succesfully. *Journal of Manufacturing Science and Technology, No. 2,* pp. 136-143.

Baillie, K. U. (2014 , November 21). *Water and food: What's next?* Retrieved from Usaid : https://www.usaid.gov/global-waters/november-2014/water-food-next

Baines, T.S , Lightfoot, H.W., Evans, S., Neely, A., Greenough, R., Peppard, J , Roy, R., Shehab, E , Braganza, A., Tiwari, A , Alcock, J.R., Angus, J.P., Bastl, M., Cousens, A., Irving, P., Johnson, M., Kingston, J., Lockett, H., Martinez, V., Michele, P., Tranfield, D., Walton, I.M , Wilson, H , (2007). State-of-the-art in product-service systems. *Proceedings of the Institution of Mechanical Engineers, Part B: Journal of Engineering Manufacture 221* (10), 1543e1552.

Baldassarre, B., Calabretta, G., Bocken, N.M.P, Jaskiewicz, T. (2016). Bridging sustainable business model innovation and user-driven innovation: A process for sustainable value proposition design. *Journal of Cleaner Production, No. 147*, pp. 175-186.

Barquet APB, de Oliveira MG, Amigo CR, Cunha VP, Rozenfeld H. Employing the business model concept to support the adoption of product–service systems (PSS). I*ndustrial Marketing Management 2013*;42:693-704.

Bayer. (n.d). *Smallholder Farming: Small Land, Large Impact.* Retrieved from Crop Science: https://www.cropscience.bayer.com/en/crop-science/smallholder-farming

Beuren, F.H., Gomes Ferreira, M.G , Cauchick Miguel, P.A., (2013). Producteservice systems: a literature review on integrated products and services. *J. Clean. Prod. 47*, 222e231.

Bezemer, L. Teeffelen, K. (2017). *TE GAST IN Nepal* (mei 2017). *The Great Himalaya Trail-project*. Nijmegen, Nederland: Informatie Verre Reizen VOF.

Bhusal, A., & LI-BIRD. (2018, April 12). *Solar based Irrigation System: A boon to farmers in enhancing their livelihood, resilience and adaptive capacities.* Retrieved from LI-Bird: http://www.libird.org/app/news/view.aspx?record_id=72

Bocken, N., Short, S , Rana, P., Evans, S. (2013). A value mapping tool for sustainable business modelling. *Corp. Gov. 13* (5), 482-497

Brent, W. (2018, June 27). *Agro-centric mini-grids and solar trolleys could transform Indian farming*. Retrieved from PV -Tech: https://www.pv-tech.org/guest-blog/agro-centric-mini-grids-and-solar-trolleys-could-transform-indian-farming

Brouwer, C. (n.d.). *Irrigation Water Management: Irrigation Methods.* Retrieved from FAO: http://www.fao.org/3/S8684E/s8684e00.htm#Contents

Brown, S.R. (1980). Political subjectivity: application of Q methodology in political science. New Haven, CT: Yale University.

Bruce Hanington, B.M. (2012). McCullin. *Businessorigami in Universele Ontwerpmethoden* (1 9789063692919 september 2012). Neder-land: BIS Publishers.

Business Dictionary. (n.d). *Lease to own*. Retrieved from Business dictionary: http://www.businessdictionary.com/definition/lease-to-own.html

Butera & Balesca, 2015

Cairns, R. C. (2012). "Understanding Science in Conservation: A Q Method Approach on the Galápagos Islands." *Conservation and Society 10*(3): 217-231.

CBS (2013). Government of Nepal National Planning *Commission Secretariat Central Bureau of Statistics, National Sample Census of Agriculture Nepal.*

CDC. (2016, October 11). *Types of Agricultural Water Use.* Retrieved from Centers for Disease Control and prevention: https://www.cdc.gov/healthywater/other/agricultural/types.html

Chaudhary, S., & Sinkemana, G. R. (2017, January 1). *Better irrigation*. Retrieved from The Kathmunda Post : https://kathmandupost.com/opinion/2017/01/01/better-irrigation

Chu, J. (2017, April 19). *Watering the world.* Retrieved from MIT News: http://news.mit.edu/2017/design-cuts-costs-energy-drip-irrigation-0420

Clara Aida Khalil, F. (2016, November 8). *Defining Smallholders (Clara Aida Khalil, FAO)*. Retrieved from Slideshare: https://www.slideshare.net/FAOoftheUN/defining-smallholders-clara-aida-khalil-fao

Claro energy. (n.d.). *Our Journey.* Retrieved from Claro energy: http://13.233.214.20/our-journey/

Climate & Development Knowledge Network . (2017, June 20). *POLICY BRIEF: Framework for effectiveness and resilience of small and medium-scale irrigation systems in Nepal.* Retrieved from Climate & Development Knowledge Network : https://cdkn.org/resource/effectiveness-resilience-small-medium-irrigation-nepal/?loclang=en_gb

Cordis. (n.d). *Enabling Sustainable Irrigation through Hydro-Powered Pump for Canals.* Retrieved from Cordis Europe : https://cordis.europa.eu/project/rcn/205127/factsheet/en

Culture of Nepal. (2006). *Nepal*. Retrieved from Countries and there Cultures: https://www.everyculture.com/Ma-Ni/Nepal.html

Danielle, F., Raimundo, N., & Luciano, M. (2019, july 20). *Pros and cons of furrow irrigation on smallholdings in northeast Brazil*. Retrieved from Science direct : https://www.sciencedirect.com/science/article/abs/pii/S0378377418306681

Desikan, A. (2016, September 3). *Pay-per-use model helps small farmers quell labour issues* . Retrieved from The times of India : https://timesofindia.indiatimes.com/business/india-business/Pay-per-use-model-helps-small-farmers-quell-labour-issues/articleshow/53989542.cms

Difference Between. (2019). *Difference between Agriculture and Irrigation.* Retrieved from Difference Between: http://www.differencebetween.info/difference-between-agriculture-and-irrigation

Dixit, A. (n.d.). *Climate Change in Nepal: Impacts and Adaptive Strategies*. Retrieved from World Resources Institute: https://www.wri.org/our-work/project/world-resources-report/climate-change-nepal-impacts-and-adaptive-strategies

Dolakha, S. D. (2018, June 15). *Lifting livelihoods by lifting water.* Retrieved from Nepali Times: https://www.nepalitimes.com/banner/lifting-livelihoods-by-lifting-water/

Donaldson & Preston, 1995; Donaldson, T., Preston, L.E , 1995. The stakeholder theory of the corporation: concepts, evidence, and implications. *Acad. Manag. Rev. 20* (1), 65-91.

Dornveld, D.A. & Linke, B.S. (2012) *Leveraging Technology for a Sustainable World*. Proceedings of the 19th CIRP Conference on Life Cycly Engineering, University of California at Berkeley, Berkeley, USA, May 23-25, 2012. Springer.

Duan, N. (2018). *Irrigation Innovation.* Retrieved from Stanfords Social Innovation review: https://ssir.org/articles/entry/irrigation_innovation

Ebix Smartclass. (2017, June 29). *Methods of Irrigation*. Retrieved from Youtube: https://www.youtube.com/watch?v=RTR-2RgMbJ-g

Electric water pump Guide. (n.d). *Best Water Pump Reviews – The Ultimate Water Pump Buyers Guide*. Retrieved from Electric water pump guide: https://electricwaterpumpguide.com

Endev. (2018, July 5). *Nepal*. Retrieved from Energising Development: https://endev.info/content/Nepal

Ertsen, M., & Intriago, J. C. (2018, February). *The self-reliant irrigation pump: a fine mess*. Retrieved from Tu Delft : https://www.tudelft.nl/en/ceg/research/stories-of-science/the-self-reliant-irrigation-pump-a-fine-mess/

Fao. (2012). *Smallholders and Family Farmers* . Retrieved from Fao: http://www.fao.org/fileadmin/templates/nr/sustainability_pathways/docs/Factsheet_SMALLHOLDERS.pdf

Fao. (2013). *The State of Food Insecurity in the World*. Retrieved from Fao: http://www.fao.org/3/a-i3434e.pdf

Fontana, M., and C. Paciello (2009). Gender dimensions of rural and agricultural employment: differentiated pathways out of poverty. Paper presented at the FAO-IFAD-ILO Workshop on Gaps, *Trends and Current Research on Gender Dimensions for Agricultural and Rural Employment*, Rome 31 March 2009.

Food & Business knowledge platform. (2019, June 30). *Enabling Access to Sustainable Irrigation with EASI-Pay for Barsha pumps in Indonesia*. Retrieved from Food & Business knowledge platform: https://knowledge4food.net/research-project/arf3-indonesia-easi-pay/

Geng, X., Chu, X., Xue, D , Zhang, Z. (2010). An integrated approach for rating engineering characteristic's final importance in product-service system development. *Journal Computers and Industrial Engineering 59* (4), 585- 594

Get Involved Group : Aben, M., Genuchten, van E., Hulst R., Lukkers B. & Vette, J. (2016). *Barsha - Joint Master Project Final Report*, Delft University of Technology. Faculty of Industrial Design Engineering, The Netherlands.

Gham Power. (2019). *Solar pumps*. Retrieved from Gham Power: https://ghampower.com/product/solar-pumps/

Global Impact Investing Network. (n.d.). *What you need to know about impact investing.* Retrieved from GIIN: https://thegiin.org/impact-investing/need-to-know/#what-is-impact-investing

Global Innovation Exchange. (n.d.). *Stage 4: Transition to Scale.* Retrieved from Global Innovation Exchange.

Globalgiving. (2019). *Sustainable Agriculture in Nepal.* Retrieved from Global Giving Foundation inc.: https://www.globalgiving.org/projects/sustainable-agriculture-in-nepal/

Goedkoop, M., van Halen, C , te Riele, H , Rommes, P. (1999). Product Services Systems, Ecological and Economic Basics, *PWC (Report 1999/36). VROM, The Hague*.

Goedkoop, M., Heijungs, R., Huijbregts, M., Schryver, A.D , Struijs, J., Van Zelm, R. (2009). ReCiPe 2008: *a Life Cycle Impact Assessment Method Which Comprises Harmonised Category Indicators at the Midpoint and the Endpoint Level*: first edition. Report l: characterisation. Ministry of Housing. Spatial Planning and the Environment (VROM), The Hague.

Gragt, van der T. (2018). *Exploring Conceptual Variation by Design for the aQysta pump placement process*. Thesis, Delft University of Technology, The Netherlands.

Green-serve Ventures Limited. (2017). *Solar powered water pump.* Retrieved from Youtube: https://www.youtube.com/watch?v=gJtb2B9sF90

Hedge, S. (2015, May 15). *What is the difference between the agriculture, irrigation and farming?* Retrieved from Quora: https://www.quora.com/What-is-the-difference-between-the-agriculture-irrigation-and-farming

Hibbet, K. (2018, May 27). *The importance of agriculture in Nepal.* Retrieved from Borgen Project: https://borgenproject.org/importance-agriculture-in-nepal/

List of References

Holland . (2014, December 23). *aQysta builds six new river-powered low-cost Barsha pumps for farmers in Nepal*. Retrieved from Holland Dutch water Sector : https://www.dutchwatersector.com/news/aqysta-builds-six-new-river-powered-low-cost-barsha-pumps-for-farmers-in-nepal

Housingnepal. (2013). *The Right Time to Build* . Retrieved from Housing Nepal: https://www.housingnepal.com/articles/display/the-right-time-to-built

Hussain, I. and M.A. Hanjra (2004). Irrigation and poverty alleviation: review of the empirical evidence. *Irrigation and Drainage, 53*.

ICIMOD. (2018, July 26). *Fifty-three Solar-powered Irrigation Pumps Operational in Four Districts of Nepal.* Retrieved from Icimod: http://www.icimod.org/?q=31895

Improvement. (n.d). *How Much Does a Drip Irrigation System Cost?* Retrieved from Improvement: https://www.improvenet.com/r/costs-and-prices/drip-irrigation-system

Indiamart. (2019). *Petrol Water Pump Set, Voltage: 240 V*. Retrieved from Indiamart: https://www.indiamart.com/proddetail/petrol-water-pump-set-20291463148.html

Interactions. (n.d.). *Social, economic and political context in Nepal.* Retrieved from Interactions: http://interactions.eldis.org/unpaid-care-work/country-profiles/nepal/social-economic-and-political-context-nepal

Intriago Zambrano, J.C , Michavila, J., Arenas Pinilla, E., Diehl, J.C., Ertsen, M. W. (2019) Water Lifting Water: A Comprehensive Spatiotemporal Review on the Hydro-Powered Water Pumping Technologies. *Water 2019, 11,* 1677.

Karki, S. (2018, February 8). *What is the present federal structure of Nepal and what are the significances?* Retrieved from Quora: https://www.quora.com/What-is-the-present-federal-structure-of-Nepal-and-what-are-the-significances

Kharel, P , Dhakal, S., & Poudyal, S. (2014). *Seismic Demand Behaviour of Low-rise Reinforced Concrete*. Retrieved from Shocksafe Nepal Team One Final report, Delft University of Technology, The Netherlands.

Kimmons. (2018). *Ondernemersverhalen* . Retrieved from Oiko Credit: https://www.oikocredit.nl/ondernemersverhalen

King, B. (2019, October 11). *What is the difference between the agriculture, irrigation and farming?* Retrieved from Quora: https://www.quora.com/What-is-the-difference-between-the-agriculture-irrigation-and-farming

Knowledge4food. (2019, January 1). *Enabling Access to Sustainable Irrigation with EASI-Pay for Barsha pumps in Indonesia* . Retrieved from Food & Business knowledge platform: https://knowledge4food.net/research-project/arf3-indonesia-easi-pay/

Kowalkowski, C. (2010). What does a service-dominant logic really mean for manufacturing firms? *CIRP Journal of Manufacturing Science and Technology, 3* (4), 285-292.

KTM 2 Day. (2019). *Oil-Gas Price in Nepali Market 2019*. Retrieved from Katchmanda today: https://www.ktm2day.com/petrol-diesel-lpg-gas-aviation-fuel-price-in-nepal/

Kujala, S. Artto, K., Aaltonen, P., Tukalainen V. (2010). Business models in project based firms – Towards a typology of solution-specific business models. *International Journal of Project Management, No. 28,* pp. 96-106.

Kumar Karki, Y. (2015). *Nepal Portfolio Performance Review*. Retrieved from http://www.mof.gov.np/uploads/document/file/Agriculture_NPPR-2015_20150913011507.Pdf

(Lawrence et al., 2018)

Ledesma, D. (2017, December 22). *Infrastructure in Nepal: Gaps Between Mountains and Plains.*

Linden, van der, G J.P., Mastbergen, van L A., Liende, van der, J. A. H. & Plink, L.V. (2012) *Team Across. Joint Master Project*, Delft University of Technology. Faculty of Industrial Design Engineering.

Lüdeke-Freund, F., Massa, L, Bocken, N., Brent, A. & Musango, J. (2016). *Business Models for Shared Value - Main Report*. Luiten, H., Knot, M., van der Horst, T., 2001. Sustainable product-service-systems: the Kathalys method. *In: Proceedings Second International Symposium on Environmentally Conscious Design and Inverse Manufacturing. IEEE Comput. Soc.,* pp. 190e197.

Makin, I. W. (2016, September). *Irrigation Infrastructure for Sustainable and Improved Agricultural Productivity*. Retrieved from Topic Guide: https://assets.publishing service.gov.uk/media/581b2b8940f0b661fe000008/EoD_TGYr4-05_Irrigation_and_Infrastructure_FINAL_VERSION.pdf

Manzano-Agugliaro, F , Taher, M , Zapata-Sierra, A., Juaidi, A , & Montoya, F. G. (2017). An overview of research and energy evolution for small hydropower in Europe. Renewable and Sustainable Energy Reviews, (75), 476–489. doi:10.1016/j.rser 2016.11.013

Manzini, E., Vezzoli, C., & Clark, G. (2001). Product-service systems: Using an existing concept as a new approach to sustainability. *Journal of Design Research, 1*(2).

Manzini, E., Vezzoli C. (2003). A strategic design approach to develop sustainable product service systems: examples taken from the 'environmentally friendly innovation' Italian price. *Journal of Cleaner production No. 11.* Pp. 851-857.

Marilungo E, Coscia E , Quaglia A., Peruzzini M , Germani M. Open innovation for ideating and designing new product service systems. *Procedia CIRP. 2016; 47:* 30-35.

Marques, P., Cunha, P.F., Valente, F., Leitão, A. (2013). A Methodology for product-service systems development. *Forty sixth CIRP conference on manufacturing systems 2013.Procedia CIRP 7(2013)* 371-376.

Marvasti, R. (2014, November 8). *aQysta: Winner of Climate-KIC's Most Innovative Clean-Tech Start-up Award*. Retrieved from Reset: https://en.reset.org/blog/aqysta-winner-climate-kic's-most-innovative-clean-tech-start-award-11082014

Meier, H , Völker, O., Funke, B , (2010). Industrial product-service systems (IPS2). *The International Journal of Advanced Manufacturing Technology 52* (9e12), 1175e1191.

MoAD. (2015). *Nepal Portfolio Performance Review 2015*. Retrieved from http://www.mof.gov.np/uploads/document/file/Agriculture_NPPR-2015_20150913011507.pdf

Mont, O. (2000). Product-Service Systems, AFR-Report 288, Swedish Environmental Protection Agency: Stockholm, Sweden.

Mont, O. (2001). Reaching Sustainable Consumption through the Concept of a Product-Service system (PSS). *Nordic Council of ministers, TermaNord, Copenhagen*.

Mont, O. (2004a). Producteservice Systems: Panacea or Myth? (PhD dissertation) Lund University.

Mont, O. (2004b). Institutionalisation of sustainable consumption patterns based on shared use. *Ecol. Econ. 50,* 135e153.

Mont, O., Plepys, A. (2003). Customer Satisfaction: Review of Literature and Application to the Product service Systems *(Final report to the Society for Non-Traditional Technology, Japan)*. International Institute for Industrial Environmental Economics, Lund, Sweden.

Mont, O., & Plepys, A. (2008). Sustainable consumption progress: Should we be proud or alarmed? *Journal of Cleaner Production, 16*(4). 531–537.

Moors, W., VP, Pumps, & Energy, A. C. (2017, 10 11). *Powering the pumps: electric or diesel?* Retrieved from WWT: https://wwtonline.co.uk/features/powering-the-pumps-electric-or-diesel

Morelli, N. Designing product/service systems: a methodolical exploration. *Design Issues. 2002;18*(3):3-17

Morelli, N. (2006). Developing new product service systems (PSS): methodologies and operational tools. *Journal of Cleaner Production 14* (17), 1495e1501.

Morelli N. Service as value co-production: reframing the service design process. *Journal of Manufacturing Technology Management. 2009; 20*(5): 568-590

Muto K., Kimita, K., Shimomura, Y. (2015). A Guideline for Product-Service-Systems Design Process. *Procedia CIRP 30* (2015). 60-65.

Nambisan, S. Designing virtual customer environments for new product development: Toward a Theroy. *Academy of Management Review. 2002;27(*3):392-413

Nedersticht J., Bom G. J , Dijk R , (2013). Renewable energy for smallholder irrigation. SNV.

Nellemann, C., Verma, R. & Hislop, L. (eds). (2011). *Women at the frontline of climate change: Gender risks and hopes. A Rapid Response Assessment.* United Nations Environment Programme, GRID-Arendal.

Nepkart. (2019). *WATER PUMPS.* Retrieved from Nepkart: https://www.nepkart.com/water_pumps_Nepal

Osterwalder, A. & Pigneur, Y. 2010. Business Model Generation. New Jersey, John Wiley & Sons. 281 p.

Our World in Data. (n.d.). *Nepal*. Retrieved from Our World in Data: https://ourworldindata.org/country/nepal

Pandit, V., & Tamhane, T. (2018, February). *A closer look at impact investing* . Retrieved from Mckinsey & Company: https://www.mckinsey.com/industries/private-equity-and-principal-investors/our-insights/a-closer-look-at-impact-investing

Papa Pump. (n.d). Retrieved from PapaPump: https://papapump.com

Paul-Bossuet, A. (2017, March 21). *Can solar pumps give Nepal's women farmers a brighter future?* Retrieved from Reliefweb: https://reliefweb.int/report/nepal/can-solar-pumps-give-nepals-women-farmers-brighter-future Water, Land and Ecosystems, CGIAR.

Poldaw. (n.d.). *Why use the paldow wind?* Retrieved from Poldaw: http://www.poldaw.co za

Prem Engineering. (2019). *Diesel Engine Pump Set*. Retrieved from Prem Engineering Private Limited: https://www.premengineering.net/diesel-engine-pump-set.html

Ramprasad, A. (2016, February 28). *What is the difference between the agriculture, irrigation and farming?* . Retrieved from Quora: https://www.quora.com/What-is-the-difference-between-the-agriculture-irrigation-and-farming Rapsomanikis, G. (2015). *The economic lives of smallholder farmers.* Retrieved from FAO: http://www.fao.org/3/a-i5251e.pdf

Reim, W., Parida, V., Örtqvist, D. (2015). Producteservice systems (PSS) business models and tactics e a systematic literature review. *J. Clean. Prod. 97*, 61e75.

Rexfelt, O., Ornäs, V.H. (2009). Consumer acceptance of product-service systems: designing for relative advantages and uncertainty reductions. *Journal of Manufacturing Technology Management 20* (5), 674 -699.

Richardson, J. (2008). The business model: an integrative framework for strategy execution. *Strateg. Change 17* (5-7), 133-144.

Sarah, K., Jakob, S., & Terri, R. (2016, November). *The Number, Size, and Distribution of Farms, Smallholder Farms, and Family Farms Worldwide.* Retrieved from Science Direct: https://www.sciencedirect.com/science/article/pii/S0305750X15002703

Savada, Andrea Matles (1991). "Nepal: A Country Study:Agriculture". Washington GPO for the Library of Congress. Retrieved September 4, 2008.

Securing Water for Food, Archives. Roa, D. V. (n.d.).*Getting water up the mountainside: how the barsha pump utilizes nepal's 6,000 rivers to power irrigation. Aqysta pump impacts smallholder farmers. Hydro-powered pump offers eco-friendly irrigation solution.* Innovator News. Retrieved from https://securingwaterforfood.org/tag/nepal & https://securingwaterforfood.org/tag/aqysta

List of References

SELF (2008). *A cst and reliability comparison between solar and diesel powered pumps*. Retrieved from http://www self.org/SELF_White_Paper_-_Solar_vs_Die¬sel.pdf

Shah, T.; Singh, O.P.; Mukherji, A. Some aspects of South Asia's groundwater irrigation economy: Analysesfrom a survey in India, Pakistan, Nepal Terai and Bangladesh. *Hydrogeol. J. 2006,14*, 286–309.

Sharma, K. (2018, January 19). *Agrarian crisis: Small farmers at receiving end*. Retrieved from The Himalayan Times: https://thehimalayantimes.com/opinion/agrarian-crisis-small-farmers-receiving-end/

Sinkemana, G. R. (2017, January 2). *The Kathmunda Post.* Retrieved from Nepal's own zero emission pump: https://yetaautaa.blogspot.com/2017/01/nepals-own-zero-emission-pump.html

Sinkemana, G. R , & Chaudhary, S. (2017, January 1). *Better irrigation.* Retrieved from The Kathmandu Post: https://kathmandupost.com/opinion/2017/01/01/better-irrigation

Subedi, A. (2017, September 24). *Focus on farming.* Retrieved from The Kathmandu Post: https://kathmandupost.com/opinion/2017/09/24/focus-on-farming

Sundin, E., Sandström, G.O., Lindahl, M., Rönnbäck, A.O. (2009). Using companyacademia networks for improving product/service systems at large companies. In: Sakao, T., Lindahl, M. (Eds), *Introduction to Product/Service-system Design. Springer, London*, pp. 185e196

Sunfarmer Nepal (n.d.). *Powering Agriculture: Affordable & Reliable Solar Water Pumping for Irrigation.* Retrieved from https://tech4farmerschallenge.files.wordpress.com/2016/06/sunfarmer.pdf on September 15th, 2016.

Sunfarmer Nepal (2016). *Agriculture*. Retrieved from Get Involved, Joint Master Project Report (2016) from http://www.sunfarmernepal.org/agriculture/

Sunfarmer Nepal. (2019). *Our models*. Retrieved from Sunfarmer Nepal: http://www sunfarmer.org/models-1
SURE-Farm (n.d). *Co-Creation Platform*. Retrieved from https://surefarmproject.eu/co-creation-platform/

Susan Jedeloo, A. V. (2016, mei 18). *Q-methodologie, een werkelijke mix van kwalitatief en kwantitatief onderzoek?* Retrieved from Kwalon : https://www.tijdschriftkwalon.nl/inhoud/tijdschrift_artikel/KW-14-2-2/Q-methodologie-een-werkelijke-mix-van-kwalitatief-en-kwantitatief-onderzoek

Technology Exchange Lab. (n.d.). *Barsha Pump.* Retrieved from Technology exchange lab : https://www.techxlab.org/solutions/aqysta-barsha-pump

Thapa. (2015, Augustus 31). *Aqysta*. Retrieved from Youtube : https://www.youtube.com/watch?v=m4cFlOK4Ri8

The longest way home . (2012). *Guide to Nepal.* Retrieved from The longest way home : https://www.thelongestwayhome.com/Countries/nepal.html

Tisdell, C. (2011). Structural economic changes in China and Viet Nam: policy: issues and consequences for agriculture. *Paper presented to the 9th Biennial Pacific Rim Conference, Western Economic Association, April, 2011*.

Toolsvilla. (2019). *Kisankraft Petrol Start Water Pump Set,KK-WPK-30,4 Stroke*. Retrieved from Toolsvilla: https://www.toolsvilla.com/petrol-start-kerosene-run-3-inlet-x-3-outlet-kisankraft.html

Trading Economics . (2016). *Worldbank database Nepal GDP per capita*. Retrieved from Trading Economics: https://tradingeconomics.com/nepal/indicators-imf

Trading Economics. (2019). *Nepal GDP Annual Growth Rate.* Retrieved from Trading Economics: https://tradingeconomics.com/nepal/gdp-growth-annual

Trading economics. (n.d). *Indonesia Roads Pavedpercent Of Total Roads*. Retrieved from Trading economics: https://tradingeconomics.com/indonesia/roads-pavedpercent-of-total-roads-wb-data.html

Tran T, Park J. Y. (2014). Development of a strategic prototyping framework for various types of product-service systems. *Journal of Computational Design and Engineering. 2014;* 1: 37-47.

Tribology. (n.d.). *The Poldaw Windpump*. Retrieved from Neale Consulting Engineers: http://www.tribology.co.uk/poldaw-windpump/

Tukker, A. (2004). Eight types of producteservice system: eight ways to sustainability? *Experiences from SusProNet. Business Strategy and the Environment 13* (4), 246e260.

Tukker, A., Tischner, U. (2006). A practical guide for PSS development. In: Tukker, A., Tischner, U. (Eds), New Business for Old Europe. *Product-service Development, Competitiveness and Sustainability. Greenleaf, Sheffield,* pp. 375e393.
Tyl, B., Vallet, F., Bocken, N.M., Real, M. (2015). The integration of a stakeholder perspective into the front end of eco-innovation: a practical approach. *J.Clean. Prod. 108*, 543-557.

UN. (n.d). *About the Sustainable Development Goals.* Retrieved from United Nations: https://www.un.org/sustainabledevelopment/sustainable-development-goals/

UNEP e United Nations Environment Programme, 2002. Product-service Systems and Sustainability: Opportunities for Sustainable Solutions. INDACO Department, Politecnico di Milano, Milan.

Usaid. (2015, January). *Nepal's farmers pedal bikes to pump water and irrigate land*. Retrieved from Usaid: https://2012-2017.usaid.gov/results-data/success-stories/pumping-water-pedaling-bikes

Ventures, S. (2018, June 26). *WATER — The bane of the Indian farmer*. Retrieved from A Medium Corperation : https://medium.com/@sangamvc/water-the-bane-of-the-indian-farmer-84407f0b7397

Venugopal, S. (2015, May 15). *What is the difference between the agriculture, irrigation and farming?* Retrieved from Quora: https://www.quora.com/What-is-the-difference-between-the-agriculture-irrigation-and-farming

Vezzoli, C., Kohtala, C , Srinivasan, A., Diehl, J.C , Fusakul, S.M., Xin, L , Sateesh, D. (2014). Producteservice System Design for Sustainability. *Greenleaf Publishing*, Sheffield, UK.

Vezzoli, C., Ceschin, F., Diehl, J.C., Kohtala, C. (2015). New design challenges to widely implement 'Sustainable Product-Service Systems'. *Journal of Cleaner production 97*. 1-12.

Von Hippel, E, Katz, R. Shifting innovation to users via toolkits. *Management Science. 2002;48*(7):821-833

Water Enviroment Partnership in Asia. (2018). *Country overview.* Retrieved from Wepa: http://www.wepa-db.net/policies/state/nepal/overview.htm

Welcome Nepal. (2019). *CLIMATE OF NEPAL* . Retrieved from Welcome Nepal: https://www.welcomenepal.com/plan-your-trip/climate.html

White, D. B. (n.d.). *METHODS VIGNETTES: Q METHOD.* Retrieved from Steps centre: https://steps-centre.org/pathways-methods-vignettes/methods-vignettes-q-method/

Wikiwater. (n.d.). *E40 - MOTOR PUMPS.* Retrieved from Wiki Water: https://wikiwater.fr/E40-Motor-pumps

Wong, M. (2004). Product service systems in consumer goods industry. Thesis, Cambridge University, UK.

World Atlas. (2017, April 25). *Major Rivers Of Nepal*. Retrieved from World Atlas: https://www.worldatlas.com/articles/the-major-rivers-of-nepal.html

World Bank. (2016, February 17). *Strengthening Connectivity in Nepal.* Retrieved from The World Bank : https://www.worldbank.org/en/news/feature/2016/02/17/strengthening-rural-connectivity-in-nepal

World Bank. (2017[1]). *GNI per capita, Atlas method (current US$)* -. Retrieved from The World Bank: https://data.worldbank.org/indicator/NY.GNP.PCAP.CD?locations=NP%5B2

World Bank. (2017[2] April). *Water in Agriculture*. Retrieved from The World Bank: https://www.worldbank.org/en/topic/water-in-agriculture

World Bank. (2017[3], July). *Nepal*. Retrieved from The World bank: https://data.worldbank.org/country/nepal

World Bank. (2019). *The World Bank in Nepal.* Retrieved from The World Bank : https://www.worldbank.org/en/country/nepal/overview

World Bank (2019) Government (World Bank, 2019) "Nepal: Priorities for Agriculture and Rural Development".

World Bank. (n.d). *Nepal*. Retrieved from The World Bank: https://data.worldbank.org/country/nepal

World Population Review. (2019). *Nepal Population 2019.* Retrieved from World Population Review: http://worldpopulationreview.com/countries/nepal-population/

Young, T. A *Course of Lectures on Natural Philosophy and the Mechanical Arts*; Joseph Johnson: London, UK, 1807; Volume 1.

(CBS [29], n.d)

(Government of Nepal, 2014).

APPENDICES

Appendix A : Project Brief



Appendix B : Survey

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यस सर्तको बारेमा

यो छोटो सर्वेक्षणमा 23 प्रश्नहरू छन्। यसलाई भर्नाले लगभग 15 मिनेट लिन्छ। पहिलो एक (तपाईंको पूरा नाम) अपवादको साथ, सबै अन्य एकल चयन प्रश्नहरू छन्; यसको अर्थ तपाईंले प्रति प्रश्न मात्र एक छनौट रोज्नु पर्छ।

यस सर्वेक्षणमा सहभागी गरेर, तपाईले मलाई मेरो अनुसन्धान परियोजनाको साथ सहयोग पुर्याउनु भएको छ। यसबाहेक, यो सर्वेक्षणको जानकारी गोप्य रूपमा उपचार गरिनेछ। अन्तिमसम्म अझै कम्तीमा, कुनै सही वा गलत परिणाम छैन; सबैभन्दा महान् ईमानदारीसँग जवाफ दिन नि: शुल्क महसुस गर्नुहोस्।

यदि तपाईंसँग कुनै शंका छ भने कृपया मलाई सोध्न संकोच नगर्नुहोस्। दुर्भाग्यवश म नेपाली बोल्न सक्षम हुंदैन, यसैले मलाई एक भाषाको दयालु र बहुमूल्य सहयोगमा भरोसा गर्नु पर्छ। म ईमानदारीसाथ तपाईंको बुझाइको प्रशंसा गर्छु।

ABOUT THIS SURVEY

This short survey consists of 23 questions. Filling it takes approximately 15 minutes. With exception of the first one (your full name), all the other ones are single-selection questions; it means that ***you must pick only one choice per question.***

By participating in this survey, you are considerably helping me with my research project. Furthermore, ***the information of this survey will be treated confidentially.*** *Last yet not least, there is no right or wrong result; feel free and comfortable to answer with the greatest sincerity.*

If you have any doubt, please do not hesitate to ask me. Unfortunately I am not able to speak Nepali, thus I will have to rely on the kind and valuable help of an interpreter. I sincerely appreciate your understanding.

1. **पुरा नाम** *Full name*

2. **लिङ्ग** *Gender*

❑ महिला *Female* ❑ पुरुष *Male*

3. **उमेर समूह** *Age group*

❑ 18-29 ❑ 30-39 ❑ 40-49 ❑ 50-59 ❑ ≥60

4. **मुख्य जीवन व्यवस्था** *Main living arrangement*

❑ एक्लै *Alone* ❑ परिवार संग *With family* ❑ गैर-नातेदार संग *With non-relatives*

5. **शिक्षा स्तर** *Education level*

❑ अनपढ *Illiterate* ❑ प्राथमिक विद्यालय *Primary school* ❑ उच्च विद्यालय *High School*
❑ विश्वविद्यालय *University* ❑ स्नातक *Graduate*

6. **वर्तमान नागरिक स्थिति** *Current marital status*

❑ एकल *Single* ❑ विवाह *Married* ❑ राँडो *Widowed* ❑ सम्बन्ध खुला *Open relationship*

7. **औसत मासिक आय** *Average monthly income*

❑ <1 मूल ज्याला *<1 Basic wage* ❑ ~ 1-2 मूल ज्याला *~1-2 Basic wages* ❑ 2 मूल ज्याला *>2 Basic wages*

8. **फारम आकार** *Farm size*

❑ <1 बिघा *<1 Bigha* ❑ 1-2 बिघा *1-2 Bigha* ❑ 2-3 बिघा *2-3 Bigha* ❑ 2 बिघा *>3 Bigha*
❑ <1 हा *<1 ha* ❑ 1-2 हा *1-2 ha* ❑ >2 हा *>2 ha*

9. **खेती को भूमि कार्यकाल** *Land tenure of farm*

❑ Raikar *Private land* ❑ ??? *Government land* ❑ Guthi *Trust land* ❑ मिश्रित *Mixed*

http://www.fao.org/gender-landrights-database/country-profiles/countries-list/land-tenure-and-related-institutions/prevailing-systems-of-land-tenure/en/?country_iso3=NPL

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10. खेतमा वर्षौंको उत्पादन *Year-round production in the farm*

❑ हो *Yes* ❑ कुनै *No*

11. खेती उत्पादनको मुख्य उद्देश्य *Main purpose of the farm production*

❑ स्व खपत *Self-consumption* ❑ वाणिज्य *Commercial*

12. खेती गर्न समर्पित समय *Time dedicated to farming*

❑ पुरै समय *Full time* ❑ आंशिक समय *Part time*

13. अन्य काम (हरू) खेती छेउमा *Other job(s) beside farming*

❑ हो *Yes* ❑ कुनै *No*

14. खेतीले मेरो परिवारको कुल आवश्यकताहरु लाई आवरण गर्दछ *Farming covers total needs of my household*

❑ हो *Yes* ❑ कुनै *No*

15. खेती भन्दा फरक आयको अन्य स्रोत *Other sources of income different than farming*

❑ हो *Yes* ❑ कुनै *No*

16. स्थिति को आत्म-धारणा *Self-perception of economic status*

❑ धेरै गरिब *Very Poor* ❑ गरिब *Poor* ❑ औसत *Average* ❑ धनी *Rich* ❑ धेरै धनी *Very Rich*

17. खेती अनुभव ***Experience in farming***

❑ <1 वर्ष *<1 year* ❑ 1-5 वर्ष *1-5 years* ❑ 5-10 वर्ष *5-10 years* ❑ >10 वर्ष *>10 years*

18. फारमको मुख्य प्रकारको फसल *Farm's main type of crop*

❑ अनाज *Cereals* ❑ फल *Fruits* ❑ तरकारी *Vegetables*

19. फारमको शीर्षोग्राफी *Farm's topography*

❑ सादा *Plain* ❑ पहाडी *Hilly*

20. खेतीको उत्पादनको लागि मुख्य जल स्रोत *Main water source for farm's production*

❑ नदी *River* ❑ नहर *Canal* ❑ वर्षा *Rainfall*

21. फारमको पहुँच *Farm's accessibility*

❑ सजिलै पहुँचयोग्य वर्ष दौर *Easily accessible year round* ❑ वर्षको सजिलै पहुँचयोग्य भाग *Easily accessible part of the year*
❑ शायद पहुँच *Hardly accessible*

22. को Barsha पम्प प्रयोग *Use of the Barsha Pump*

❑ म लगातार यसको प्रयोग *I use it continuously*
❑ मैले यसलाई समय-समयमा प्रयोग गर्दछु *I use it from time to time*
❑ मैले अतीतमा प्रयोग गरेको छु तर तर अब *I have used it in the past but not anymore*
❑ म यसको बारेमा धाहा तर म यसलाई प्रयोग कहिल्यै *I know about it but I have never used it*
❑ म पाठका बारेमा कहिल्यै सुनेका *I have never heard about it whatsoever*

23. को Barsha पम्प स्वामित्व *Ownership of the Barsha Pump*

❑ म एक (वा बढी) स्वामित्व *I own one (or more)* ❑ म एक (वा बढी) भाडामा *I rent one (or more)*
❑ म एक (वा बढी) उधारो *I borrow one (or more)* ❑ म स्वामित्व वा कुनै पनि भाडामा गर्छन् *I do not own or rent any*

यस सर्वेक्षणमा भाग लिनको लागि धेरै धेरै धन्यवाद!

Thank you very much for participating in this survey!

TU Delft

यस कार्यशालाको बारे – क्रमबद्ध

यो कार्यशालाले क्रमबद्ध चार्ट अनुसार अनुसार कार्डहरू क्रमबद्ध गर्नेछ, दिईएका व्याख्याहरूको सेट अनुसार, तल उल्लेखित रूपमा। यसले लगभग 60 मिनेट लिनेछ।

यस कार्यशालामा सहभागी गरेर, तपाईं हाम्रो अनुसन्धान परियोजनाहरुमा योगदान गर्दै हुनुहुन्छ। यसबाहेक, **यस कार्यक्रमबाट प्राप्त जानकारी गोप्य रूपमा उपचार गरिनेछ**। अन्तिम तर कम से कम, कुनै सही वा गलत परिणाम छैन; सबैभन्दा महान् ईमानदारीसँग जवाफ दिन नि: शुल्क महसुस गर्नुहोस्।

यदि तपाईंसँग कुनै शंका छ भने, कृपया हामीलाई सोध्न संकोच नगर्नुहोस्। दुर्भाग्यवश हामी नेपाली बोल्न सक्षम छैनौं, यसैले क्षणहरूमा हामी एक प्रजाटरको दया र बहुमूल्य सहयोगमा निर्भर रहनुपर्छ। हामी ईमानदारीसाथ तपाईंको समझको मूल्यांकन गर्छौं।

ABOUT THIS WORKSHOP – THE SORTING

This workshop will consist of sorting a number of cards in accordance with a sorting chart, under a set of given instructions, as explained below. It will take approximately 60 minutes.

By participating in this workshop, you are considerably contributing to our research projects. Furthermore, ***the information obtained from this event will be treated confidentially****. Last yet not least, there is no right or wrong result; feel free and comfortable to answer with the greatest sincerity.*

If you have any doubt, please do not hesitate to ask us. Unfortunately we are not able to speak Nepali, thus at moments we will have to rely on the kind and valuable help of an interpreter. We sincerely appreciate your understanding.

निर्देशनहरू

INSTRUCTIONS

1. **तपाईंले प्रदान गर्नुभएको प्याकेज खोल्नुहोस्**। यसमा धेरै कार्डहरू र एउटा पानाको प्रश्न र रङ चार्ट हुनु पर्दछ।
   Open the package you were provided*. It must have several cards and a sheet with a question and a coloured chart.*
2. **सबै कार्डहरू गणना गर्नुहोस्**। कृपया निश्चित गर्नुहोस् कि तपाईसँग 38 विभिन्न कार्डहरू छन्।
   Count all the cards*. Please make sure you have 38 different numbered cards.*
3. **रङ चार्ट माथिको प्रश्न जाँच गर्नुहोस्**। प्रत्येक कार्डले एक तत्वको प्रतिनिधित्व गर्दछ जुन तपाईंको व्यक्तिगत विचारमा, "थप" वा "कम" त्यस प्रश्नको सम्झौतामा, रंगको चार्टको रूपमा चिन्ह लगाइएको छ।
   Check the question above the coloured chart*. Each card represents one element that can be, in your personal opinion, "more" or "less" in agreement with that question, as pointed in the scale of the coloured chart.*
4. **क्रमबद्ध चार्ट गाइड हेर्नुहोस्**: यसमा 9 स्तम्भहरू, प्रत्येक वर्गहरूको साथ प्रत्येक।
   Check the coloured chart*. It comprises 9 columns, each with a number of squares.*
5. **कार्डहरू क्रमबद्ध गर्नुहोस्।** दिमागमा प्रश्नको साथ, रङ चार्टको आकारमा नक्कली कार्डहरू राख्नुहोस्। तिनीहरूलाई विचार गर्नुहोस् तपाईंले प्रत्येकलाई सम्झौतामा वा प्रश्नको सन्दर्भमा असहमति गरेको हदसम्म। प्रत्येक स्तम्भ भित्र ठाडो स्थान फरक गर्दैन; कुन कुरामा स्तम्भहरू बीचको स्थान हो।
   - क्रमबद्ध गर्न सजिलो सुझावहरू:
     1. पहिलो समूह लगभग तीन ढिलाइहरूमा कार्डहरू: सम्झौता, तटस्थ, र असहमति। मन नबिर्सनुहोस् यी तीन वटा ढोकाहरूमध्ये कति धेरै जान्छन्।
     2. ती तीन ढेरबाट, रंग चार्टद्वारा आवश्यक वितरणसँग मेल खाने कार्डहरू प्राथमिकता दिन सुरु गर्नुहोस्।
     3. तपाईलाई मनपर्ने कार्डहरू पुन: व्यवस्थित गर्न र समायोजन गर्न नि: शुल्क महसुस गर्नुहोस्।

Sort the cards*. With the question in mind, place the cards emulating the shape of the coloured chart. Place them according to the extent you think each one is in agreement or disagreement in regard to the question. The vertical position within each column does not matter; what matters is the location between columns.*

- *Tips to make the sorting easier:*
    1. *First group roughly the cards in three piles: agreement, neutral, and disagreement. Do not mind how many go into each of these three piles.*
    2. *From those three piles, start prioritizing the cards to match the distribution required by the coloured chart.*
    3. *Feel free to rearrange and adjust cards as many times as you like.*

6. **क्रम समीक्षा गर्नुहोस्**। एकपटक सबै कार्डहरू क्रमबद्ध भएपछि, फिर्ता आएर जाँच गर्नुहोस् कि तिनीहरूको प्लेसमेन्ट प्रश्नको बारेमा तपाईंको राय प्रतिबिम्बित गर्दछ। नयाँ समायोजन गर्न नि: शुल्क महसुस गर्नुहोस्। यो चरण धेरै पटक तपाईंलाई आवश्यक भए दोहोर्याउनुहोस्, जब सम्म तपाईं परिणाम बाट सन्तुष्ट हुनुहुन्न।
   ***Review the sort**. Once all the cards are sorted, step back and check if their placement reflect your opinion about the question. Feel free to make new adjustments. Repeat this step as many times as you need, until you are satisfied with the result.*
7. **मध्यस्थहरूसँग जाँच गर्नुहोस्**। जब कार्डहरूको क्रमबद्ध रूपमा प्रश्नको बारेमा तपाईंको राय प्रतिबिम्बित गर्दछ, मध्यस्थ मध्ये एक कल गर्नुहोस्।
   ***Check with the moderators**. When the sorting of cards faithfully reflects your opinion about the question, call one of the moderators.*
8. **नम्बरहरू लेख्नुहोस्**। मध्यस्थतासँग प्रमाणीकरण पछि, पानामा रङ गरिएको चार्टको सम्बन्धित खाली वर्गहरूमा प्रत्येक कार्डको नम्बर लेख्नुहोस्।
   ***Write down the numbers**. After the validation with a moderator, write down each card's number in the corresponding blank squares of the coloured chart in the sheet.*

यदि तपाईंसँग कुनै प्रश्न छ भने, कुनै पनि क्षणमा मध्यस्थकर्ताहरूलाई कल गर्न निःशुल्क महसुस गर्नुहोस्
If you have any question, feel free to call the moderators at any moment

यो कार्यशालामा भाग लिनको लागि धेरै धेरै धन्यवाद!
Thank you very much for participating in this workshop!

यदि तपाईं यस परियोजनाको बारे थप जान्न चाहनुहुन्छ वा / वा यो कार्यशालाको नतीजाहरू, तपाईं हामीलाई हामीलाई सम्पर्क गर्न सक्नुहुनेछ
E.M.Maas@student.tudelft.nl र J.C.IntriagoZambrano@tudelft.nl।

If you want to know more about this project and/or the results of this workshop, you can contact us to E.M.Maas@student.tudelft.nl and J.C.IntriagoZambrano@tudelft.nl.

पुरा नाम *Full name*

मेरो समुदाय भित्र बाराशा पंप स्थापना र संचालन बारे मेरो स्थान के हो?

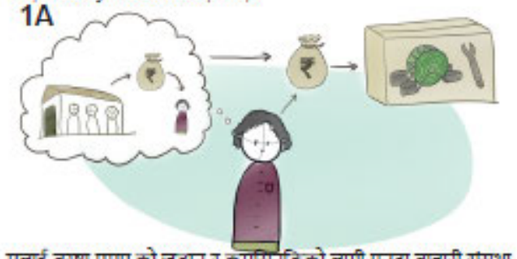
What is my position about the installation and operation of the Barsha pump within my community?

कडा असहमत *Strongly disagree*				तटस्थ *Neutral*				कडा सहमत हुनुहोस् *Strongly agree*
-4	-3	-2	-1	0	+1	+2	+3	+4

Appendix C : Q - Methodology

I need financial aid from an external organisation or person to deal with the installation and commissioning costs required by the Barsha pump

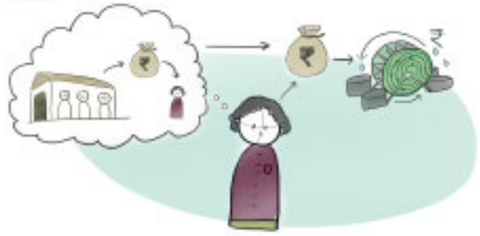
1A



मलाई बर्षा पम्प को जडान र कमिसनिङ को लागी एउटा बाहारी संस्था को आर्थीक सहयोगको आवश्यकता छ

I need financial aid from an external organisation or person to deal with the operation costs required by the Barsha pump

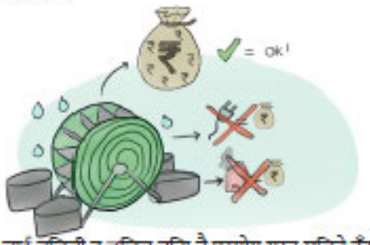
2A



मलाई बर्षा पम्प को सन्चालन लागतको लागी कुनै बाहारी संस्था वा व्यक्ती को आर्थीक सहयोगको आवश्यकता छ

The savings on the operation of the Barsha pump—because it does not need electricity or diesel—is worth the (relatively) high upfront cost

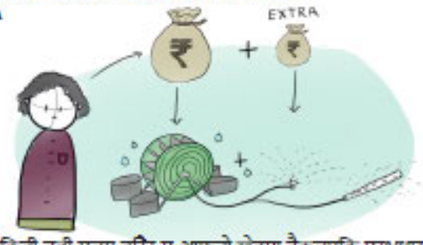
3A



बर्षा पम्प लाई बिजुली वा डिजल बिना नै प्रयोग गर्न मिल्ने हुँदा यसको प्रयोग ले उर्जा खपत हुनेछ । तसर्थ, बर्षा पम्पको मुल्य न्यायपुर्ण हुन जान्छ

I prefer to pay more to have extra optional infrastructure in my farm (e.g. sprinklers, drippers), so I can make better use of the water provided by the Barsha pump

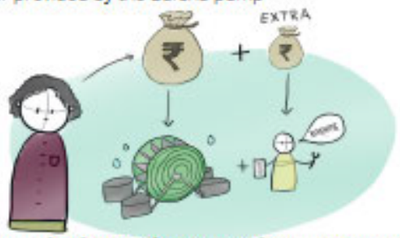
4A



अतिरिक्त बढी मुल्य तिरेर म आफ्नो खेतमा वैकल्पिक पुर्वाधार जोड्न सही सम्झन्छु ताकी बर्षा पम्प को पानी को सही उपायोग होस

I prefer to pay more to have additional technical assistance (e.g. irrigation advices, growing advices) beyond just irrigation water provided by the Barsha pump

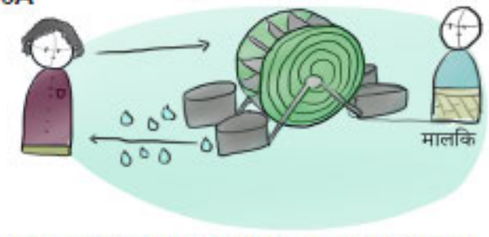
5A



बर्षा पम्प ले दिने सचिाइको लागी पानी बहेक प्रावधिक सहयोग को लागी थप मुल्य तरिन रुचाउछु (जस्तै सचिाइ र खेती को लागी सुझाव)

It is more convenient for me to make use of the Barsha pump without being the owner

6A



बर्षा पम्प कन्नि भन्दा प्रयोग मात्र गर्नुमा मलाई सहजता हुनछ

The natural landscape does not considerable modifications to install the Barsha pump

7A



बर्षा पम्प जडान गर्दा प्रकृतिक सम्रचनालाई धेरै संशोधति गर्न आवश्यकता छैन

The water bodies do not require considerable modifications to install the Barsha pump

8A



बर्षा पम्प जडान गर्दा नदी नाला उच्च मात्रमा संशोधति गर्न आवश्यकता छैन

Q-Statements

I need financial aid from an external organisation or person to deal with the installation and commissioning costs required by the Barsha pump

I need financial aid from an external organisation or person to deal with the operation costs required by the Barsha pump

The savings on the operation of the Barsha pump—because it does not need electricity or diesel—is worth the (relatively) high upfront cost

I prefer to pay more to have extra optional infrastructure in my farm (e.g. sprinklers, drippers), so I can make better use of the water provided by the Barsha pump

I prefer to pay more to have additional technical assistance (e.g. irrigation advices, growing advices) beyond just irrigation water provided by the Barsha pump

It is more convenient for me to make use of the Barsha pump without being the owner

The natural landscape does not require considerable modifications to install the Barsha pump

The water bodies do not require considerable modifications to install the Barsha pump

The existing irrigation infrastructure (e.g. canals, gates) does not require considerable modifications and adaptations to install the Barsha pump

An external organisation or person must be in charge of installing and commissioning the Barsha pump

An external organisation or person must be in charge of installing and commissioning the Barsha pump

Some members of the community could have job positions by being involved in the installation and commissioning of the Barsha pump

An external organisation or person must be in charge of operating the Barsha pump

Some members of the community could have job positions by being involved in the operation of the Barsha pump

I prefer to use the Barsha pump over electricity- or diesel-based water pumps because it operates on clean energy

An external organisation or person must assist me in how to irrigate with the water provided by the Barsha pump

An external organisation or person must assist me in how to grow more efficiently with the water provided by the Barsha pump

An external organisation or person must be in charge of maintaining the Barsha pump

Some members of the community could have job positions by being involved in the maintenance of the Barsha pump

I think my farm facilitates the installation and commissioning of the Barsha pump

I think the Barsha pump can be installed straightforward in my farm without much expertise

I think my farm facilitates operating the Barsha pump

I think the Barsha pump can be operated straightforward in my farm without much expertise

I think that a person without much expertise can provide maintenance to the Barsha pump

I think the Barsha pump can provide enough volumen of water to my farm for producing year round

I think the Barsha pump can provide enough water pressure to my farm for producing year round

The Barsha pump helps me more than other water pumps in increasing my agricultural production

The Barsha pump helps me more than other water pumps in growing new cash crops

The Barsha pump improves my quality of life

The use of the Barsha pump in my farm saves me labour

I would recommend other farmers to use the Barsha pump as well

I would prefer a person from my own country to provide me with the Barsha pump

I prefer to see another person using the Barsha pump before using it myself

I think the Barsha pump would be more valuable if seeds are provided along with it

I would like to have entrepreneurial training on the Barsha pump, so I can start my own business

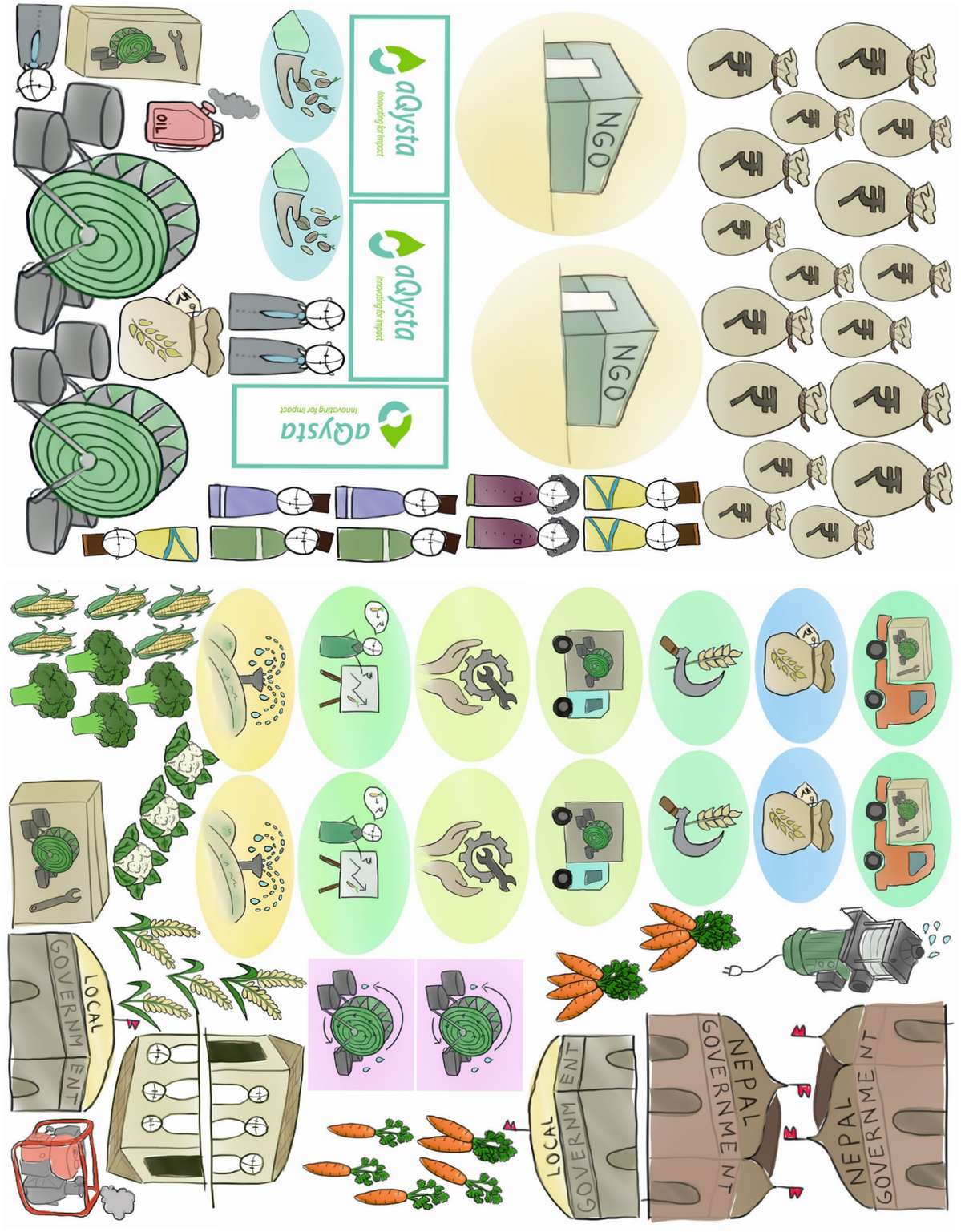
The laws of my country facilitates me to have access to the Barsha pump

The national government facilitates me to have access to the Barsha pump

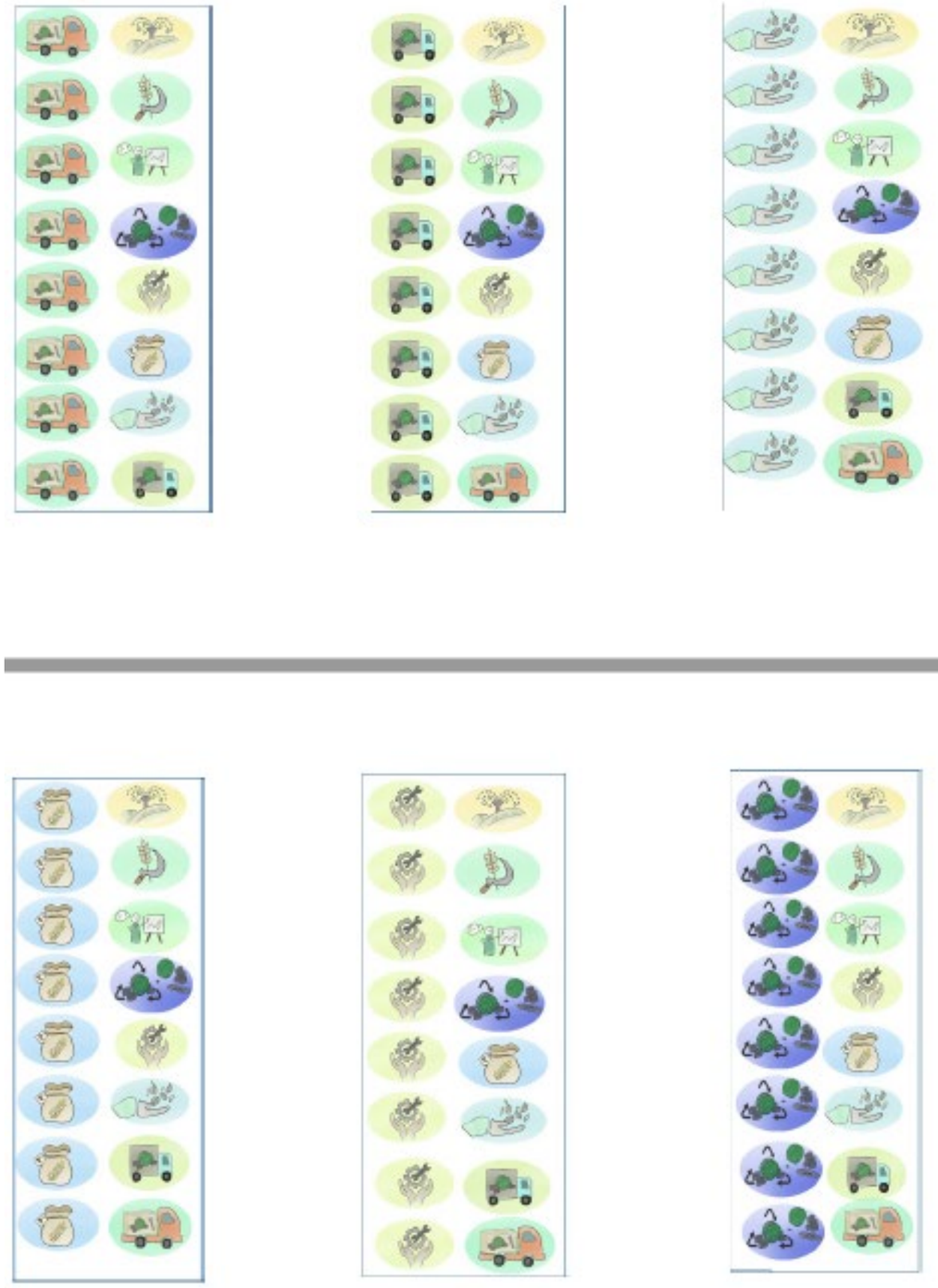
The local government facilitates me to have access to the Barsha pump

NGOs operating in the area of my community facilitate me to have access to the Barsha pump

Appendix D : Business Origami

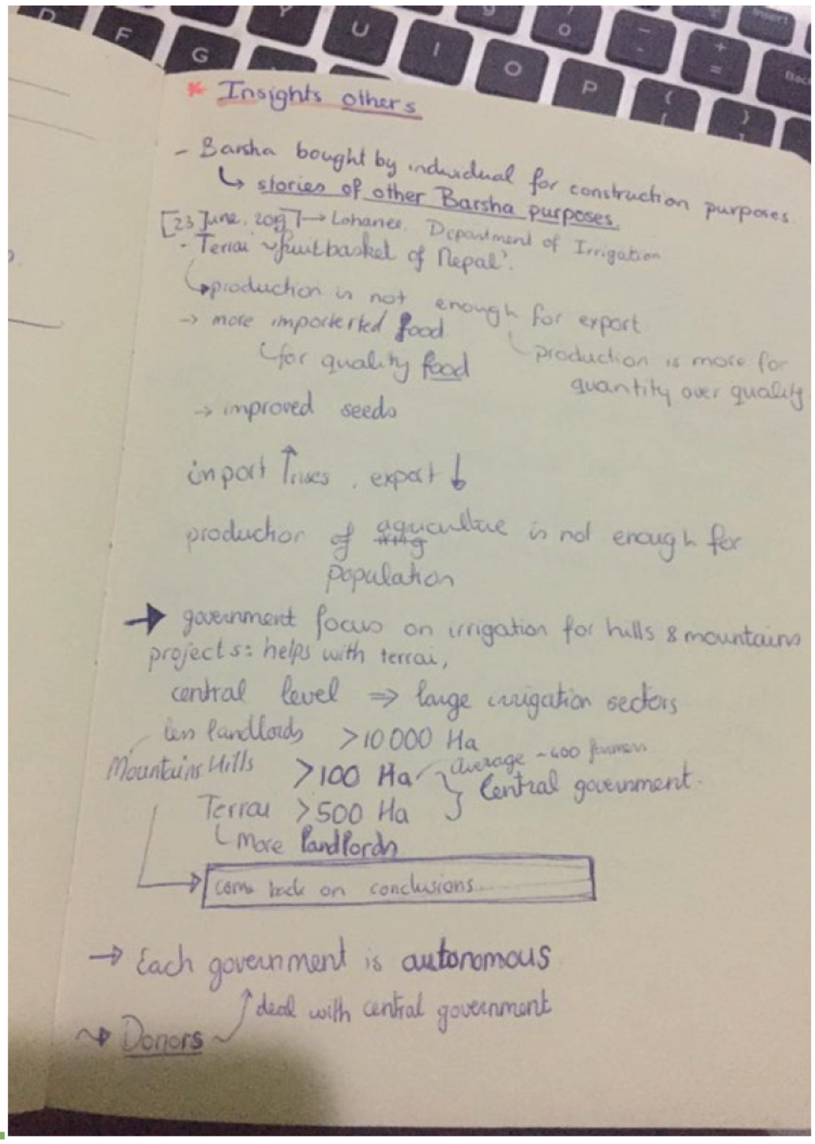


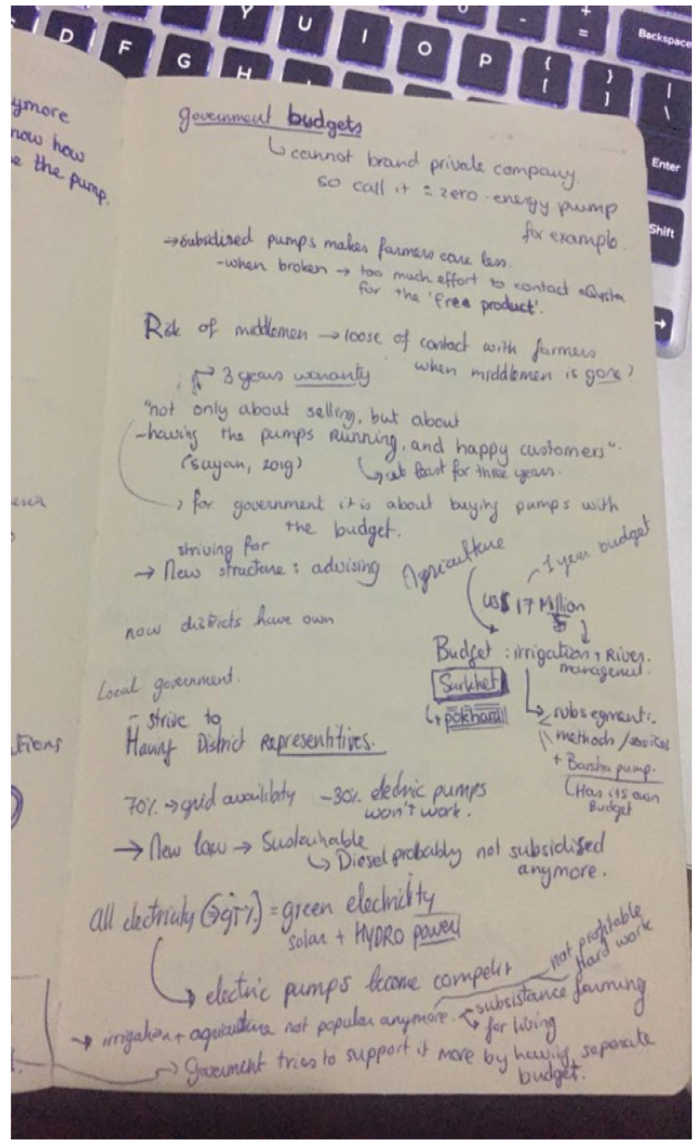
Appendix E : Preference Booklet

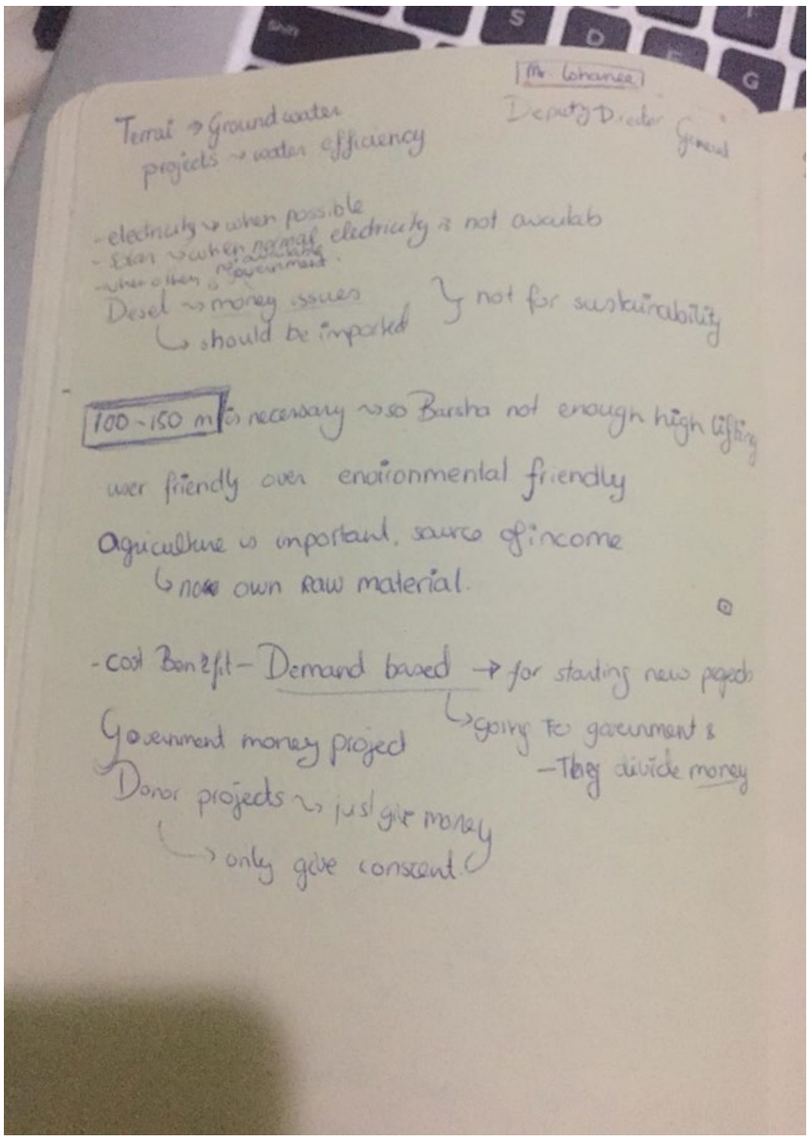


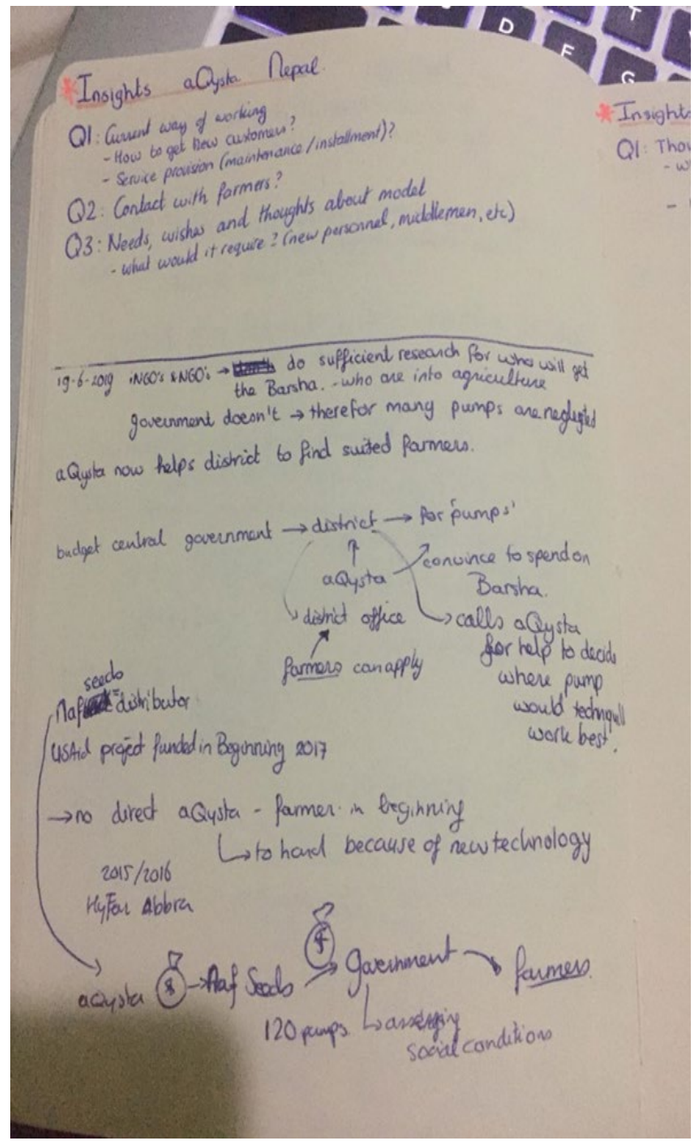
	2	3	4					5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
ID	Gender	Age group	Women	Men	Children	Size total	Size adult	Education	Marital st	Average n	Farm size	Land tenu	Year-roun	Main dest	Time dedi	Main type	Farming c	Other inc	Economic	Experienc	Farm's to	Main wat	Accessibl	Use of the	Ownershi
1	2	4	1	2	0	3	3	3	2	2	2	1	1	3	1	4	1	1	3	3	1	1	3	1	1
2	2	5	4	8	2	14	12	3	2	2	3	1	1	1	2	1	1	1	3	3	1	5	3	4	4
3	2	5	6	6	0	12	12	2	2	1	2	1	1	1	1	4	1	2	2	4	2	1	3	4	4
4	2	4	2	3	0	5	5	2	2	1	2	1	1	1	1	4	1	1	3	4	2	1	3	4	4
5	2	3	9	2	0	11	11	2	2	3	2	1	1	3	1	3	1	2	3	4	1	2	1	4	4
6	1	3	4	3	0	7	7	1	2	1	1	1	1	1	1	4	2	2	2	4	1	5	1	4	4
7	2	3	3	2	0	5	5	2	2	1	2	1	1	1	1	1	3	2	1	3	1	2	3	4	4
8	1	3	5	5	0	10	10	1	2	2	1	1	1	3	1	3	1	2	6	3	1	6	1	5	4
9	2	2	3	4	0	7	7	3	2	2	3	1	1	2	1	4	1	1	3	4	1	2	1	4	2
10	2	3	2	2	0	4	4	2	2	1	1	1	1	1	1	4	3	2	6	4	1	1	1	4	4
11	2	3	3	3	0	6	6	2	2	1	2	1	1	1	1	4	1	2	2	4	1	5	1	4	4
12	2	3	3	4	0	7	7	2	2	1	1	1	1	1	1	4	1	2	3	4	1	2	1	4	4
13	2	4	4	3	0	7	7	2	2	2	2	1	1	3	3	3	1	2	3	4	2	1	3	4	4
14	2	2	1	3	0	4	4	2	2	1	2	1	1	3	1	3	1	2	3	4	2	1	3	4	3
15	2	3	3	3	0	6	6	2	2	2	2	1	1	3	1	3	1	2	3	4	2	1	3	4	4
2nd vil	2	2	9	2	0	11	11	3	2	3	4	2	1	2	1	3	1	2	3	4	1	4	1	2	1
Lele 1 W	1	2	1	1	2	4	2	1	2	1	2	2	1	3	1	3	2	2	2	4	2	3	1	4	4
Lele 2 M	2	1						2	1	1	2	2	1	3	1	4	1	2	3	4	2	2	1	4	4

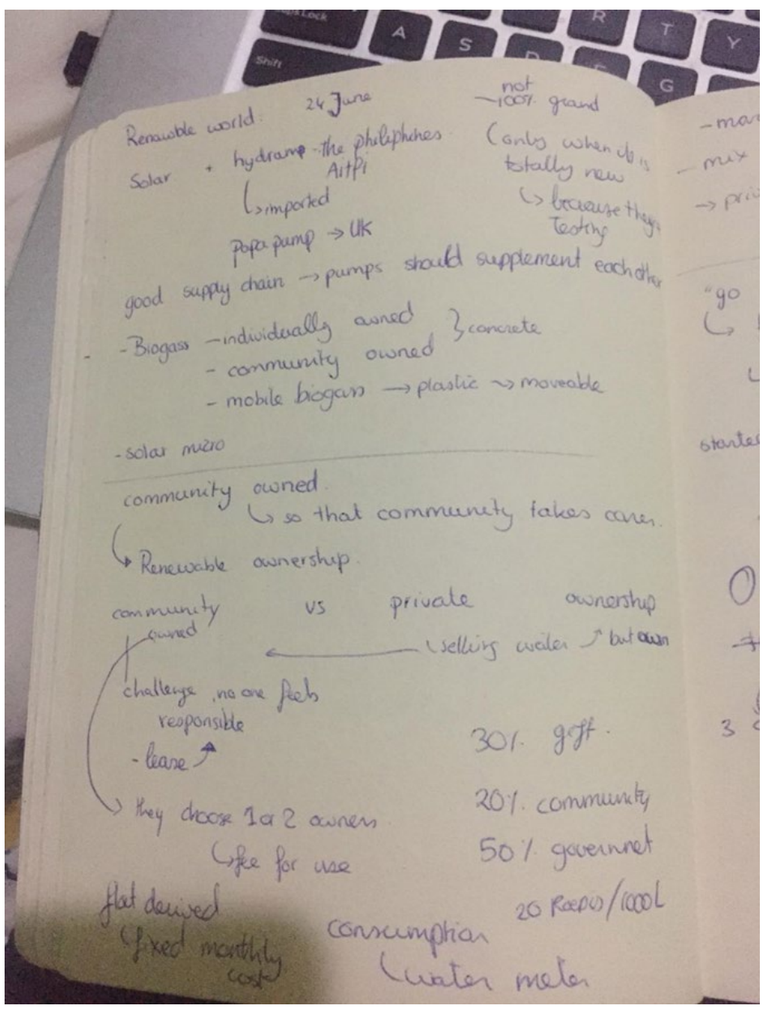
	Code	Code						Code	Code	Code	Code	Code	Code	Code	Code	Code	Code	Code	Code	Code	Code	Code	Code	Code	Code
	1=Female	1=28-29						1=Illiterati	1=Single	1=<10,00(	1=<5	1=Private	1=Yes	1=Self-cor	1=Full tim	1=Cereals	1=Yes	1=Yes	1=Very pc	1=<1year	1=Plain	1=River	1=Easily y	1=Use cor	1=I own
	2=Male	2=30-39						2=Primary	2=Marriec	2=10,000-	2=5-10	2=Private	2=No	2=Comme	2=Part tin	2=Fruits	2=No	2=No	2=Poor	2=1-5 yea	2=Hilly	2=Creek	2=Hardly	2=From ti	2=I rent
		3=40-49						3=High sc	3=Widow	3=>20,00(	3=10-15	3=Government land		3=Both	3=N/A	3=Vegetal	3=N/A		3=Average	3=5-10 years		3=Canal	3=Easily p	3=In the p	3=I borrov
		4=50-59						4=Univers	4=Open re	lationship	4=15-20	4=Trust land				4=Mixed cereals and vegetable			4=Rich	4=>10 years		4=Groundwater		4=I know	4=Nothing
		5=>60						5=Graduate			5=>20	5=Mixed							5=Very rich			5=Rainfall		5=Never heard	
																			6=N/A			6=Other (tap water)			

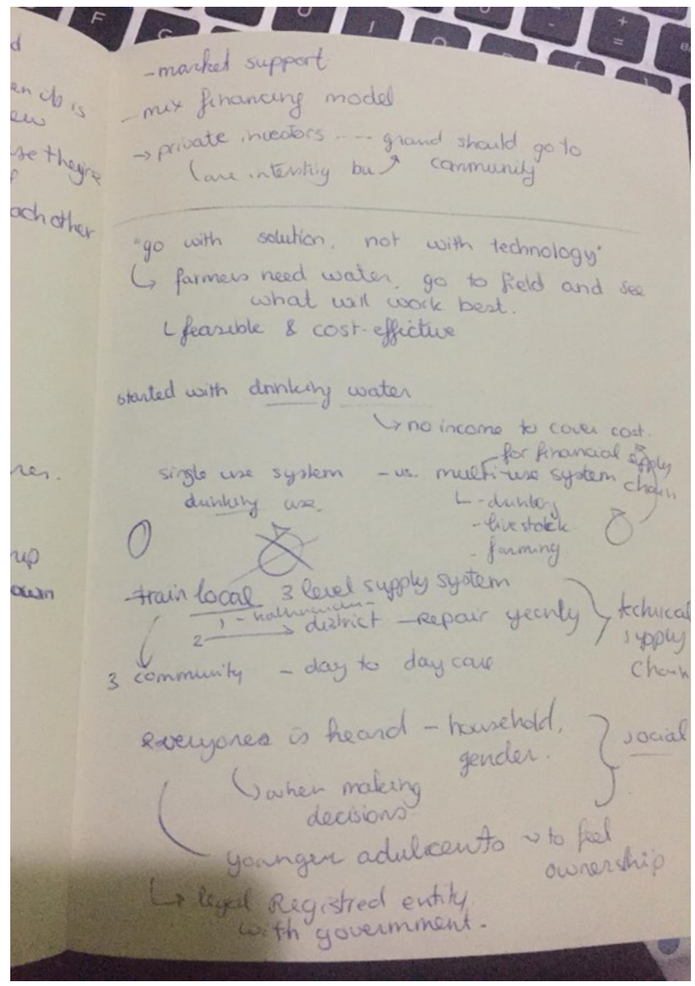


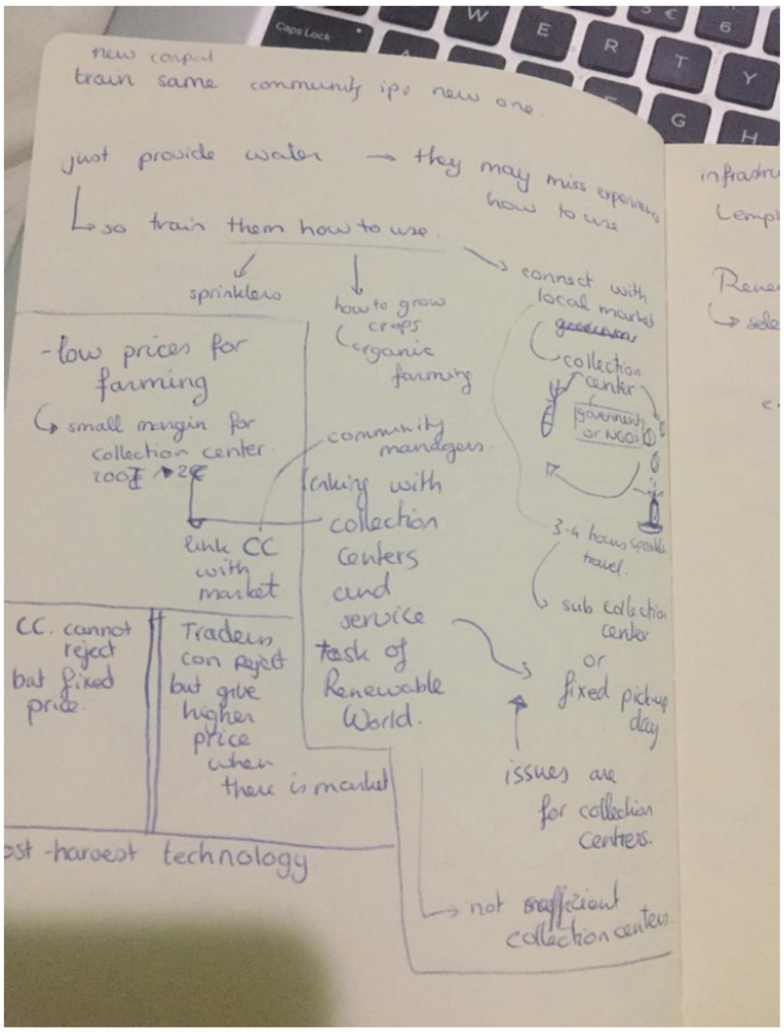


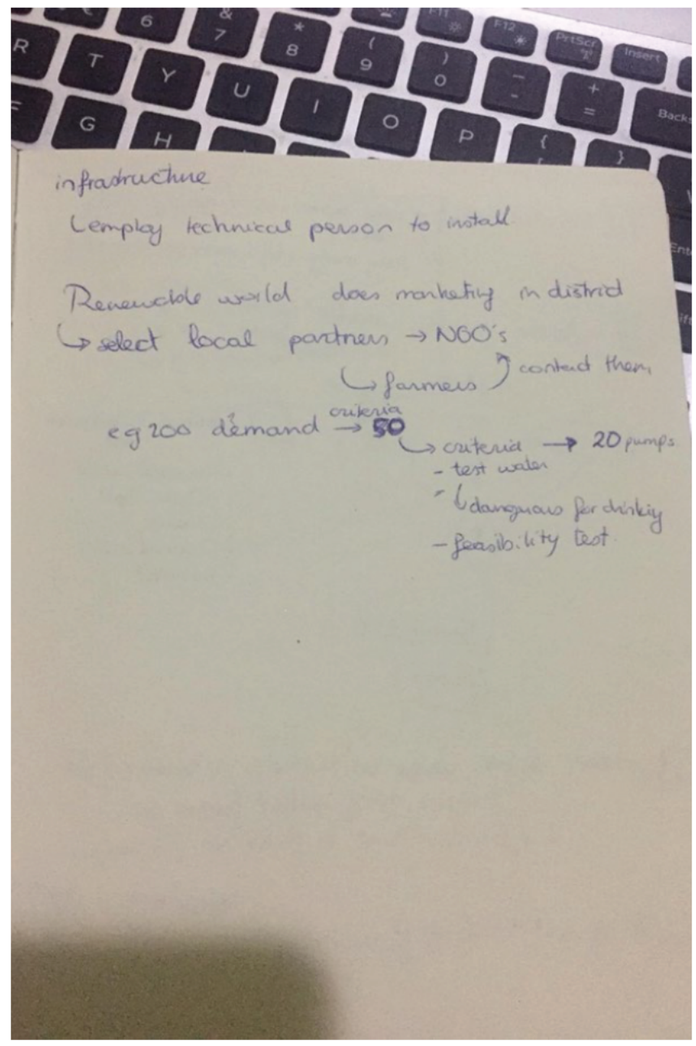

Mr. Lohaniga
Deputy Director General
Terai → Groundwater
projects → water efficiency
- electricity → when possible
- Eday → when normal electricity is not available
- when other → government
Desel → money issues
↳ should be imported
} not for sustainability
100 - 150 m is necessary → so Barsha not enough high lifting
user friendly over environmental friendly
Agriculture is important, source of income
↳ now own raw material
- cost Ben2/ft - Demand based → for starting new projects
↳ going to government
- They divide money
Government money project
Donor projects → just give money
↳ only give consent

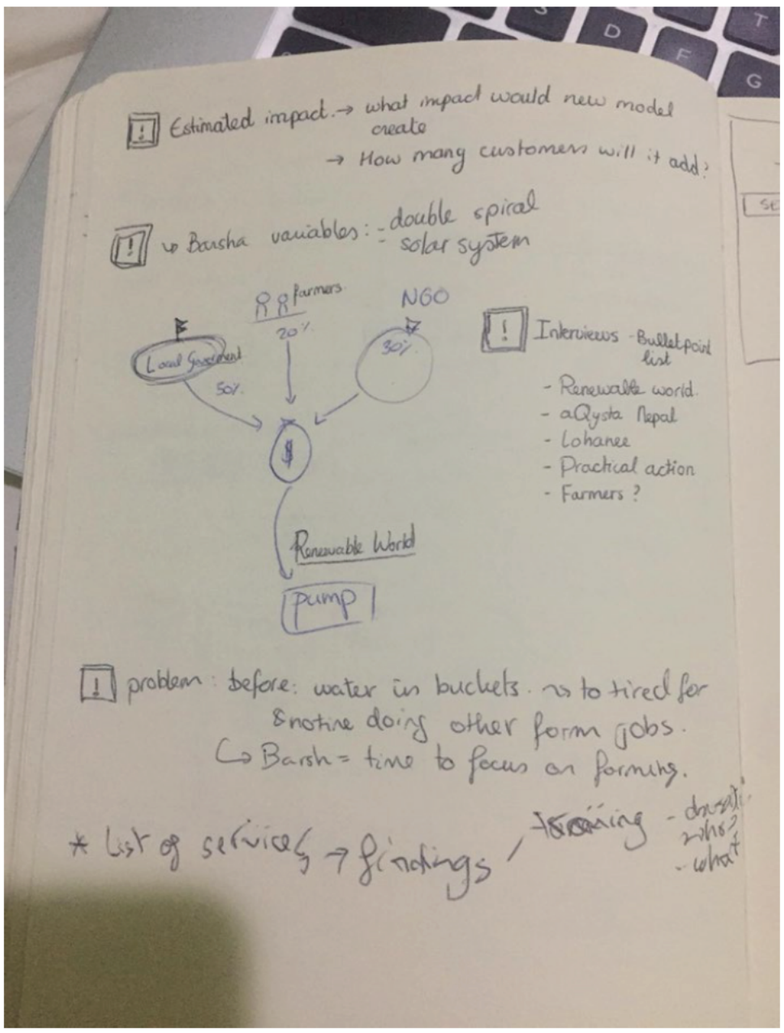

Insights aQysta Nepal
Q1: Current way of working
- How to get new customers?
- Service provision (maintenance / installment)?
Q2: Contact with farmers?
Q3: Needs, wishes and thoughts about model
- what would it require? (new personnel, middlemen, etc)
19.6.2019 INGO's & NGO's → [redacted] do sufficient research for who will get the Barsha. - who are into agriculture
government doesn't → therefor many pumps are neglyted
aQysta now helps district to find suited farmers.
budget central government → district → for 'pumps'
aQysta → convince to spend on Barsha.
district office → calls aQysta for help to decide where pump would technoll work best!
farmers can apply
seeds
[redacted] distributor
USAid project funded in Beginning 2017
→ no direct aQysta - farmer in beginning
↳ to hard because of new technology
2015/2016
Hyfar Abbra
aQysta → Haf Seeds → Government → farmers
120 pumps ↳ assessing social conditions

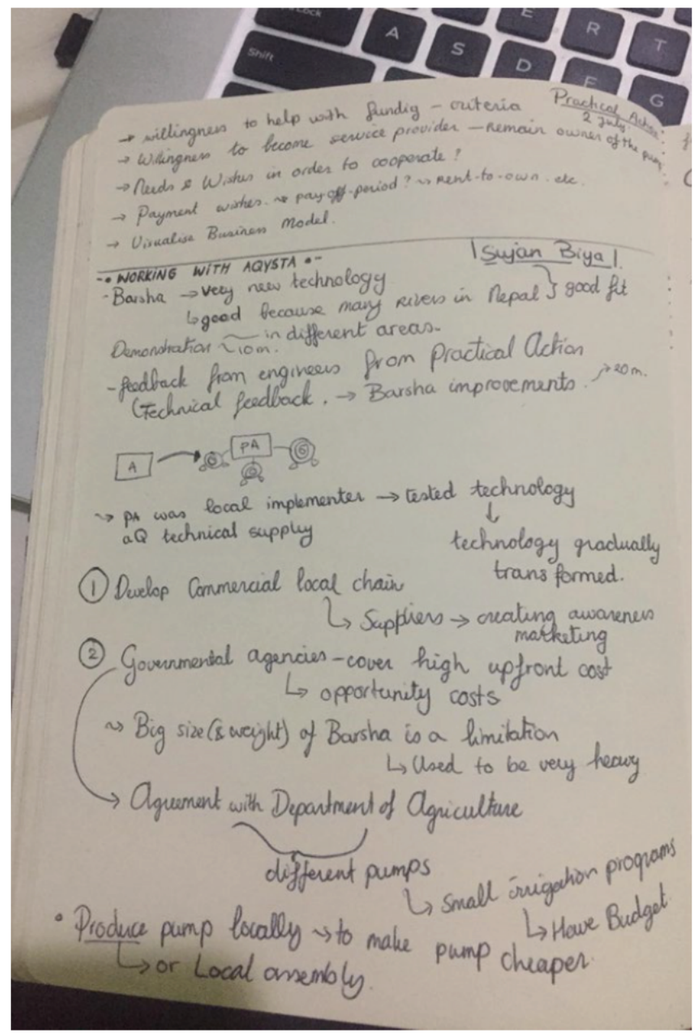

Renewable world: 24 June
not 100% grand
Solar + hydramp - the philiphines AitPi
↳ imported
(only when it is totally new
↳ because they Testing
Popa pump → UK
good supply chain → pumps should supplement each other
- Biogass - individually owned } concrete
- community owned
- mobile biogass → plastic → moveable
- solar micro
community owned
↳ so that community takes care.
↳ Renewable ownership
community owned vs private ownership
↳ selling water → but own
challenge, no one feels responsible
- lease
They choose 1 or 2 owners
↳ fee for use
flat derived
(fixed monthly cost
consumption
(water meter
30% govt.
20% community
50% government
20 Rupees/1000L

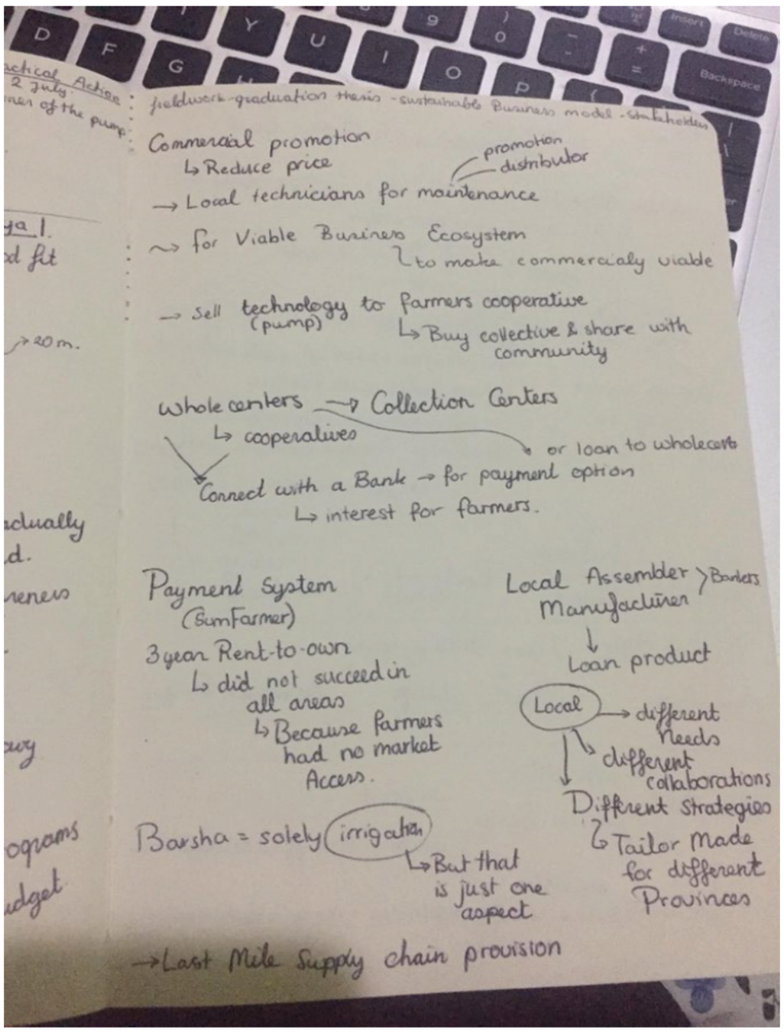

- market support
- mix financing model
→ private investors --- grand should go to community
(are intentig bu
"go with solution, not with technology"
↳ farmers need water, go to field and see what will work best.
↳ feasible & cost-effective
started with drinking water
↳ no income to cover cost.
single use system - drinking use
vs multi-use system for financial supply chain
↳ - drinking
- livestock
- farming
train local 3 level supply system
1 - kathmandu
2 → district - repair yearly } technical supply chain
3 community - day to day care
everyones is heard - household, gender } social
(when making decisions
younger adulscents → to feel ownership
↳ legal Registred entity with government.

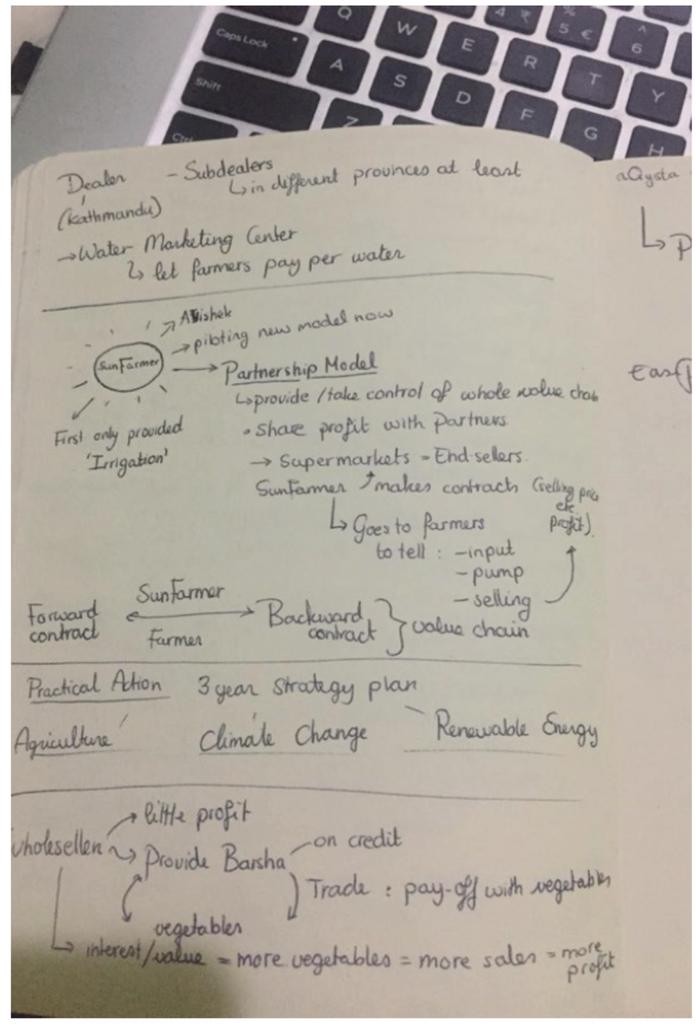

new carpet
train same community ipv new one.
just provide water → they may miss experience how to use
↳ so train them how to use.
sprinklers
how to grow crops (organic farming)
connect with local market
collection center
government or NGO's
- low prices for farming
↳ small margin for collection center
community managers
linking with collection centers and service
task of Renewable World.
link CC with market
3-4 hours possible travel.
sub collection center
or
fixed pick-up day
CC. cannot reject but fixed price
Traders can reject but give higher price when there is market
issues are for collection centers.
ost-harvest technology
↳ not sufficient collection centers.

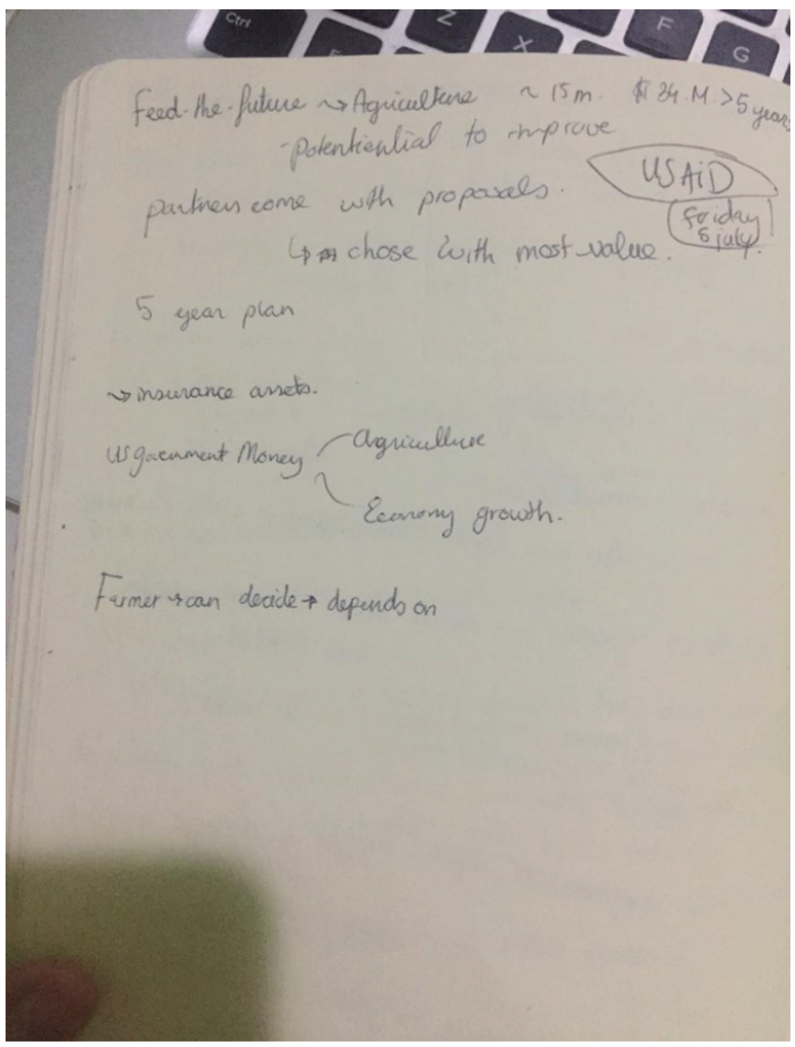

infrastructure
Lemploy technical person to install
Renewable world does marketing in district
↳ select local partners → NGO's
↳ farmers ↳ contact them
eg 200 demand → criteria 50
↳ criteria → 20 pumps
- test water
- bacteriological for drinking
- feasibility test

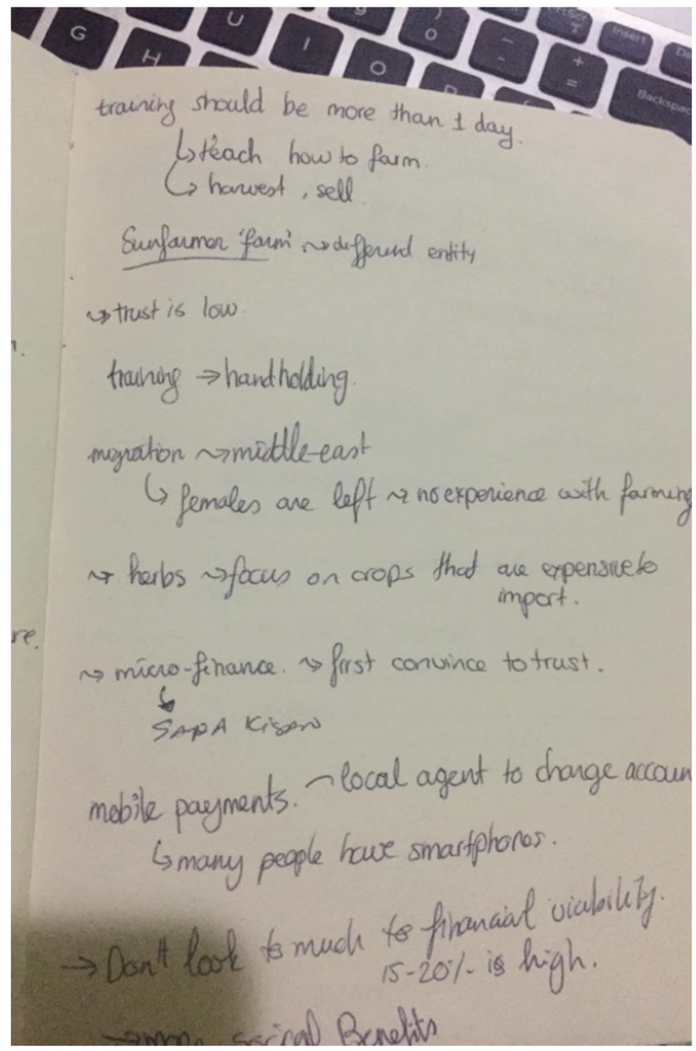

Estimated impact → what impact would new model create
→ How many customers will it add?
Barsha variables: - double spiral
- solar system
RR farmers
NGO
20%
30%
Local Supplier
50%
$
Renewable World
pump
Interviews - Bullet point list
- Renewable world
- aQysta Nepal
- Lohanee
- Practical action
- Farmers ?
problem: before: water in buckets. → to tired for & noone doing other form jobs.
↳ Barsh = time to focus on farming.
* List of services → findings / training - drought 2016? - what


→ willingness to help with funding - criteria
→ Willingness to become service provider - remain owner of the pump
→ Needs & Wishes in order to cooperate!
→ Payment wishes → pay off-period? → rent-to-own etc.
→ Visualise Business Model.
Practical Action 2 July
Sujan Bijal
-• WORKING WITH AQYSTA •-
- Barsha → very new technology
↳ good because many rivers in Nepal } good fit
Demonstration ~ 10 m. in different areas.
- feedback from engineers from Practical Action (Technical feedback. → Barsha improvements. → 20 m.
A
PA
→ PA was local implementer → tested technology
aQ technical supply
technology gradually transformed.
① Develop Commercial local chain
↳ Suppliers → creating awareness marketing
② Governmental agencies - cover high upfront cost
↳ opportunity costs
→ Big size (& weight) of Barsha is a limitation
↳ Used to be very heavy
→ Agreement with Department of Agriculture
different pumps
↳ small irrigation programs
↳ Have Budget
• Produce pump locally → to make pump cheaper
↳ or Local assembly

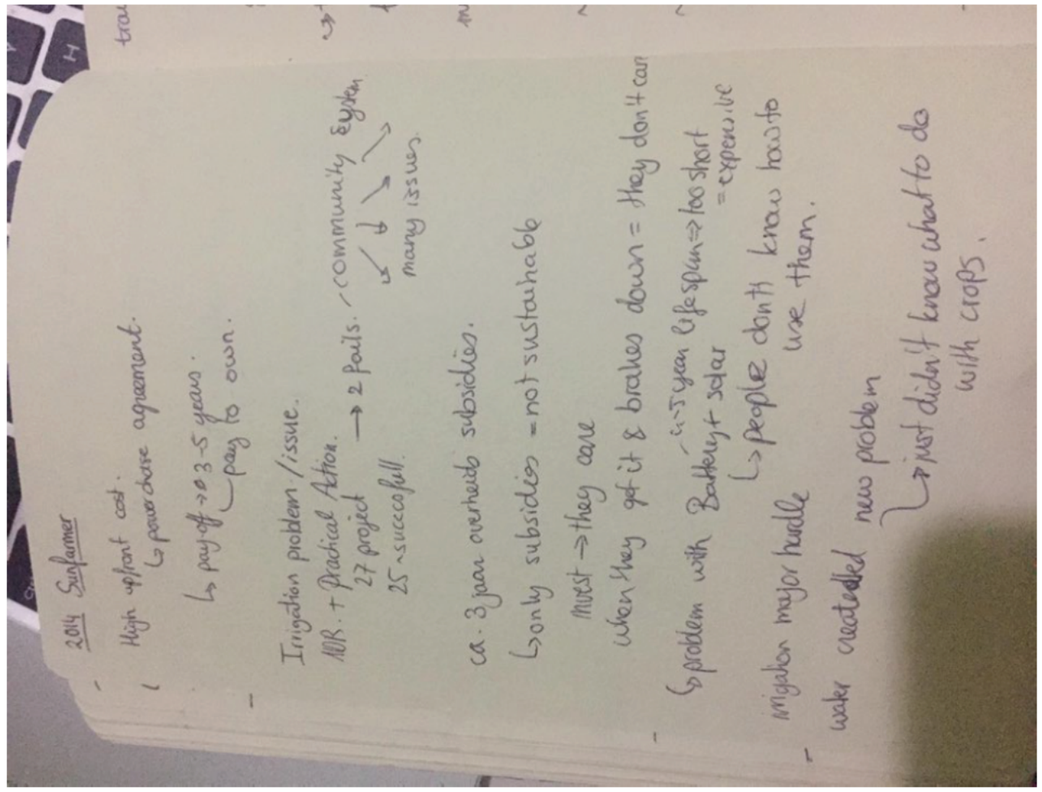

Practical Action
2 July
fieldwork-graduation thesis - sustainable Business model - stakeholders
Commercial promotion
↳ Reduce price
promotion
distributor
→ Local technicians for maintenance
~> for Viable Business Ecosystem
↳ to make commercialy viable
→ Sell technology (pump) to farmers cooperative
↳ Buy collective & share with community
Whole centers → Collection Centers
↳ cooperatives
or loan to wholecents
Connect with a Bank → for payment option
↳ interest for farmers.
Payment System
(SunFarmer)
3 year Rent-to-own
↳ did not succeed in all areas
↳ Because farmers had no market Access.
Local Assembler / Manufacturer
Borders
↓
Loan product
Local → different needs
different collaborations
Different strategies
↳ Tailor made for different Provinces
Barsha = solely irrigation
↳ But that is just one aspect
→ Last Mile Supply chain provision


Dealer (Kathmandu) - Subdealers
↳ in different provinces at least
→ Water Marketing Center
↳ let farmers pay per water
Ajyata
SunFarmer
Ajyata
→ pilotting new model now
Partnership Model
↳ provide / take control of whole value chain
• Share profit with partners
→ Supermarkets = End-sellers
First only provided 'Irrigation'
SunFarmer → makes contracts (Selling price etc profit)
↳ Goes to farmers to tell : - input
- pump
- selling
Forward contract
SunFarmer
Farmer
Backward contract
value chain
Practical Action
3 year Strategy plan
Agriculture
Climate Change
Renewable Energy
wholeseller → little profit
Provide Barsha — on credit
Trade : pay-off with vegetables
vegetables
↳ interest/value = more vegetables = more sales = more profit


Feed the future ~> Agriculture ~ 15m. $ 34 M >5 years
- potential to improve
partners come with proposals.
USAID
Friday 5 July
↳ chose with most value.
5 year plan
~> insurance assets.
US government Money
Agriculture
Economy growth.
Farmer ~> can decide ~> depends on


training should be more than 1 day.
↳ teach how to farm.
↳ harvest, sell.
Sunfarmer 'farm' ~> different entity
~> trust is low
training ~> hand holding.
migration ~> middle-east
↳ females are left ~> no experience with farming
~> herbs ~> focus on crops that are expensive to import.
~> micro-finance. ~> first convince to trust.
↳ SAPA Kisan
mobile payments. ~ local agent to change accoun
↳ many people have smartphones.
~> Don't look to much to financial viability.
15-20% is high.

Appendix G: Interviews



Appendix H : Outcomes Q-study

Composite Q sort for Factor 1

-4	-3	-2	-1	0	1	2	3	4
Some members of the community could have job positions by being involved in the operation of the Barsha pump	Some members of the community could have job positions by being involved in the maintenance of the Barsha pump	The use of the Barsha pump in my farm saves me labour	I prefer to pay more to have extra optional infrastructure in my farm (e.g. sprinklers, drippers), so I can make better use of the water provided	The laws of my country facilitates me to have access to the Barsha pump	It is more convenient for me to make use of the Barsha pump without being the owner	I think the Barsha pump can be installed straightforward in my farm without much expertise	The natural landscape does not require considerable modifications to install the Barsha pump	The Barsha pump helps me more than other water pumps in increasing my agricultural production
I think that a person without much expertise can provide maintenance to the Barsha pump	I prefer to pay more to have additional technical assistance (e.g. irrigation advices, growing advices) beyond just irrigation water provided by the Barsha pump	Some members of the community could have job positions by being involved in the installation and commissioning of the Barsha pump	I think the Barsha pump can be operated straightforward in my farm without much expertise	I think my farm facilitates operating the Barsha pump	I would like to have entrepreneurial training on the Barsha pump, so I can start my own business	An external organisation or person must be in charge of maintaining the Barsha pump	The Barsha pump improves my quality of life	I need financial aid from an external organisation or person to deal with the installation and commissioning costs required by the Barsha pump
	The savings on the operation of the Barsha pump because it does not need electricity or diesel is worth the (relatively) high upfront cost	The existing irrigation infrastructure (e.g. canals, gates) does not require considerable modifications and adaptations to install the Barsha	The national government facilitates me to have access to the Barsha pump	I think the Barsha pump can provide enough volume of water to my farm for producing year round	The local government facilitates me to have access to the Barsha pump	I think the Barsha pump would be more valuable if needs are provided along with it	The Barsha pump helps me more than other water pumps in growing new cash crops	
		An external organisation or person must be in charge of installing and commissioning the Barsha pump	An external organisation or person must be in charge of operating the Barsha pump	The water bodies do not require considerable modfications to install the Barsha pump	An external organisation or person must assist me in how to irrigate with the water provided by the Barsha pump	I think my farm facilitates the installation and commissioning of the Barsha pump		
			NGOs operating in the area of my community facilitate me to have access to the Barsha pump	I would recommend other farmers to use the Barsha pump as well	An external organisation or person must assist me in how to grow more efficiently with the water provided by the Barsha pump			
			I prefer to see another person using the Barsha pump before using it myself	I think the Barsha pump can provide enough water pressure to my farm for producing year round	I would prefer a person from my own country to provide me with the Barsha pump			
				I need financial aid from an external organisation or person to deal with the operation costs required by the Barsha pump				
				I prefer to use the Barsha pump over electricity- or diesel-based water pumps because it operates on clean energy				

Legend

- Distinguishing statement at P< 0.05
- Distinguishing statement at P< 0.01
- ► z-Score for the statement is higher than in all other factors
- ◄ z-Score for the statement is lower than in all other factors
- Consensus statement

Appendix H : Outcomes Q-study

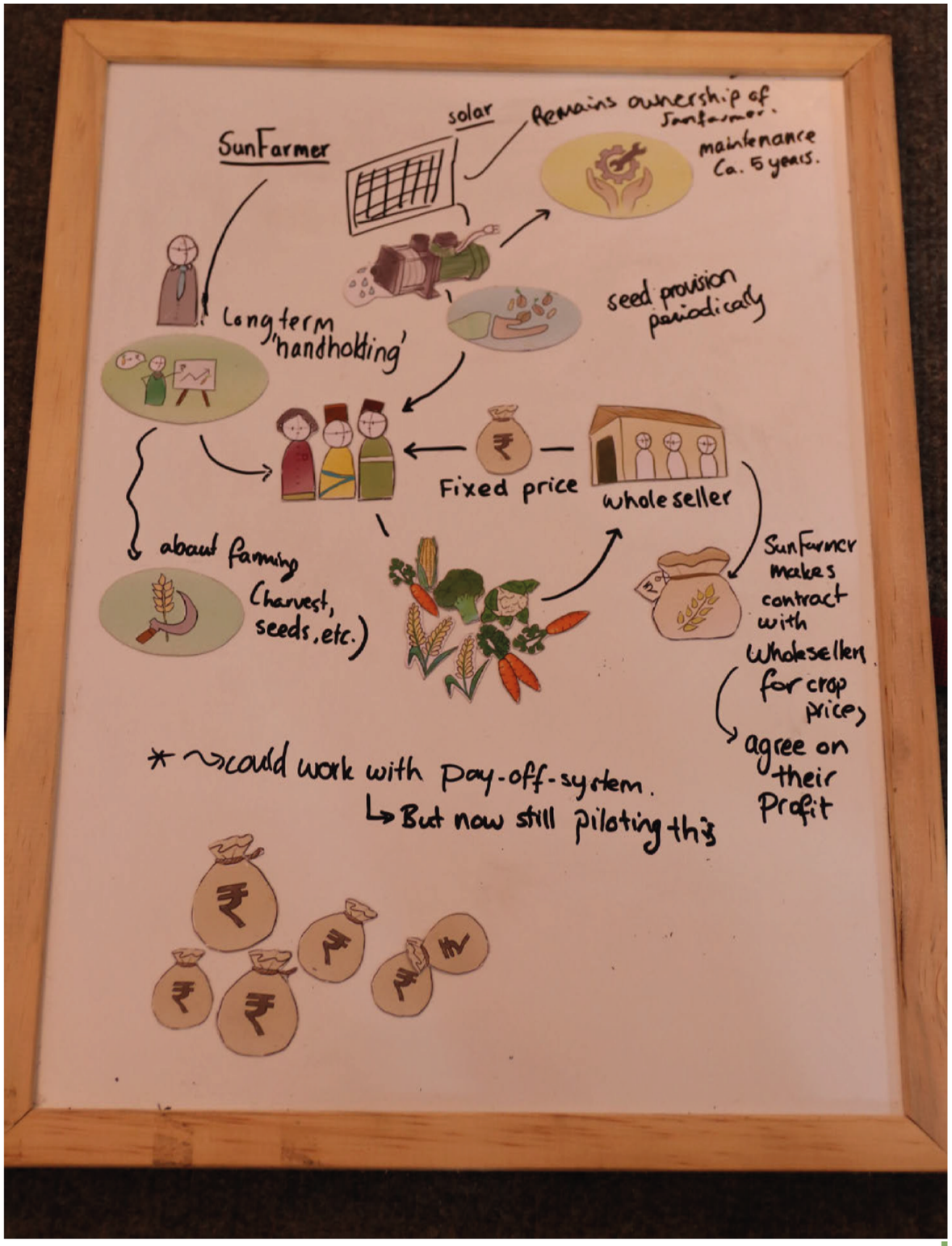
Composite Q sort for Factor 2

-4	-3	-2	-1	0	1	2	3	4
I think the Barsha pump can be operated straightforward in my farm without much expertise	I would like to have entrepreneurial training on the Barsha pump, so I can start my own business	I think the Barsha pump would be more valuable if seeds are provided along with it	An external organisation or person must assist me in how to irrigate with the water provided by the Barsha pump	An external organisation or person must assist me in how to grow more efficiently with the water provided by the Barsha pump	The Barsha pump improves my quality of life	An external organisation or person must be in charge of installing and commissioning the Barsha pump	I prefer to pay more to have additional technical assistance (e.g. irrigation advices, growing advices) beyond just irrigation water provided by the Barsha pump	The laws of my country facilitates me to have access to the Barsha pump
It is more convenient for me to make use of the Barsha pump without being the owner	I prefer to see another person using the Barsha pump before using it myself	Some members of the community could have job positions by being involved in the maintenance of the Barsha pump	I would prefer a person from my own country to provide me with the Barsha pump	The existing irrigation infrastructure (e.g canals, gates) does not require considerable modifications and adaptations to install the Barsha	I would recommend other farmers to use the Barsha pump as well	The Barsha pump helps me more than other water pumps in increasing my agricultural production	The local government facilitates me to have access to the Barsha pump	The savings on the operation of the Barsha pump because it does not need electricity or diesel is worth the (relatively) high upfront cost
	An external organisation or person must be in charge of maintaining the Barsha pump	The water bodies do not require considerable modifications to install the Barsha pump	The use of the Barsha pump in my farm saves me labour	I need financial aid from an external organisation or person to deal with the installation and commissioning costs required by the Barsha pump	I need financial aid from an external organisation or person to deal with the operation costs required by the Barsha pump	Some members of the community could have job positions by being involved in the installation and commissioning of the Barsha pump	The national government facilitates me to have access to the Barsha pump	
		The natural landscape does not require considerable modifications to install the Barsha pump	I think the Barsha pump can be installed straightforward in my farm without much expertise	I think my farm facilitates operating the Barsha pump	I think my farm facilitates the installation and commissioning of the Barsha pump	I prefer to use the Barsha pump over electricity- or diesel-based water pumps because it operates on clean energy		
			I think the Barsha pump can provide enough water pressure to my farm for producing year round	I think the Barsha pump can provide enough volume of water to my farm for producing year round	NGOs operating in the area of my community facilitate me to have access to the Barsha pump			
			I prefer to pay more to have extra optional infrastructure in my farm (e.g. sprinklers, drippers), so I can make better use of the water provided	An external organisation or person must be in charge of operating the Barsha pump	The Barsha pump helps me more than other water pumps in growing new cash crops			
				Some members of the community could have job positions by being involved in the operation of the Barsha pump				
				I think that a person without much expertise can provide maintenance to the Barsha pump				

Legend

- Distinguishing statement at P< 0.05
- Distinguishing statement at P< 0.01
- ► z-Score for the statement is higher than in all other factors
- ◄ z-Score for the statement is lower than in all other factors
- Consensus statement

Appendix I : Outcome Business origami



Master Thesis of Elsbeth Maas | Design of a Product Service System for aQysta

TU Delft Delft University of Technology