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Enhancing Uptake and Use of Climate Information Services (CIS) by Smallholder Farmers in Tanzania

FINAL REPORT

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Executive Summary

This research report was commissioned by the Tanzania Meteorological Agency (TMA) in cooperation with Aalto University (official project name: PBL East Africa) to examine the possibilities of new mechanisms for enhancing uptake and utilization of weather and climate information by smallholder farmers in Tanzania. TMA has previously experimented with pilot projects to create such a mechanism. These pilots, such as the SMS-based FarmSMS service, acted as a starting point to analyze current degrees of success and areas of improvement.

This research comprises learnings from past projects as well as interviews the team performed during a two-week field trip to the Arusha and Dar es Salaam regions of Tanzania. Interviews with smallholder farmers, village leaders and local officials uncovered a lot of information regarding the current status quo about climate information, its quality, usability and areas of opportunity. Further meetings with stakeholders, TMA in particular, clarified the current technology and organizational infrastructure used to deliver and disseminate information to farmers.

We identified and defined three key areas for TMA to take into account as they move forward and improve the current system. Dissemination, Communication and Trust are the key aspects to consider so that information will be delivered on time in an easily understandable format, so that farmers know how to make use of the information and the service, and so that ultimately, the farmers know they can put their confidence in the information. This study proposes a set of short term actions for TMA to implement in order to improve in the above three areas. These actions can be implemented either as a larger entirety, or as individual improvements to the service.

Figure 1 - Solution proposals.

Mid- and long-term actions and recommendations are also proposed in this report, as well as limitations of TMA towards implementing each of them. For many of the long-term solutions, TMA would need to make commitments to allocating significant resources, for example, engaging in high-level conversations with local officials and their managing organizations; engaging in partnerships with radio stations across Tanzania; and allocating financial investments towards the improvement of technology infrastructure.

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Who we are

Niina is a first-year Master's student in Information Networks, specializing in User-Centred design. Her passion is to make technology and people work well together, but she also hopes to use this passion to create digital services that would make the world better a better place. Currently Niina is working as a UX Designer, and is also trying to improve her artsy side through various free-time projects.

Anabel has a background in International Business, completing her degree with a final dissertation in the field of sustainability and brand value. Through educational and personal experiences, Anabel is convinced that there is a necessity to change the way we do business today. This is one of the reasons why she is now enrolled as a 2nd year sustainability management student at Aalto University.

Joel is a first-year Master student in Human-Computer Interaction & Design, with several years of experience in software engineering, open source software, cybersecurity and implementation of technology in developing regions. In this new area of study, he gets to tie down best practices from both engineering and design to develop new ideas in a wide range of topics, with a focus on leveraging new technologies for the improvement of education system in developing regions around the world.

Minna is Master's student in Creative Sustainability at Aalto University with background in geography and development studies. She has been working several years in Central America with projects in economic development, corporate accountability and climate change. She believes that to achieve sustainable future, public policies should put people first, and business strategies should have impact on society at the core of their operations. Currently, she is interested in the role of business in achieving sustainable development for all.

Joanna is a final-year Master's student in Information Networks at Aalto University, focusing on user-centred design. She has experience in working as a UX designer, but she's more and more interested in service design as a larger field, and not only in a digital context. In the future, Joanna would like to work as a service design consultant on high impact projects in varying fields.

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List of Abbreviations

CAADP	Comprehensive Africa Agricultural Development Program
CDT	Communication-Dissemination-Trust
CMS	Content Management System
DIT	Dar es Salaam Institute of Technology
EO	Extension Officer
SDG	Sustainable Development Goals
TCRA	Tanzania Communications Regulatory Authority
TMA	Tanzania Meteorological Agency
UDSM	University of Dar es Salaam
UI	User Interface
USSD	Unstructured Supplementary Service Data
WMO	World Meteorological Organization

INTRODUCTION

1. Introduction

1.1 Sustainable Agriculture for Africa

Climate actions are addressed by the United Nations as part of the Sustainable Development Goals (SDG) (here: Goal 13). The aim is to strengthen the resilience to climate related hazards and natural disasters (United Nations, 2017). General initiatives involve improvement of education and raising awareness as well as impact reduction and early warning systems. This particularly influences the agricultural sectors – the livelihood of more than half of Africa's population depends on the agricultural sector (NEPAD, 2013). According to the Comprehensive Africa Agricultural Development Program (CAADP), one of the major challenges is the sustainable management of natural resources, including increasing the adaptability of farming systems towards climate change.

Another SDG addressing the agricultural sector is Goal 2 (Zero Hunger). It aims to feed 1.5 billion people in Africa by 2030 (United Nations, 2017). Africa is the only continent where the number of undernourished people has increased over the last three decades. Food insecurity is especially a rural phenomenon as many people lack adequate means of food production like land, tools, fertilizer etc. (NEPAD, 2013). Thus, climate-related changes affect particularly the poor in rural areas.

The agricultural sector plays a major role in Africa's social and economic environment. A substantial part of the working population depends on the agricultural sector, and in the future, it is estimated to even increase. The rising number of Africans entering the labor market will face limited employment opportunities in cities, and therefore depend on farming and family businesses. The rising number of people entering the labor leads to the use of land, which is not suitable for agricultural purposes. This increases the vulnerability of farmers towards climate change. Creating new mechanisms for enhancing the uptake and utilization of climate information by smallholder farmers is one of the many initiatives approaching the complex challenge to increase the resilience against climate change.

1.2 The Creative Sustainability Capstone 2018 Challenge

As part of a cooperation initiative between Aalto University and the University of Dar es Salaam (UDSM), we – a team of students from Aalto University – worked together with students from UDSM on a challenge framed by the Tanzania Meteorological Agency (TMA), related to disseminating

climate information to smallholder farmers in Tanzania. The challenge provided to us by TMA was stated as following:

> *"Create a product or service for Tanzanian farmers that provides them with reliable, accurate and timely weather information to increase resilience against the effects of changing climates."*

Together with our counterparts in Tanzania, we worked on this challenge during a research project under the Creative Sustainability Capstone course 2018 for three months. The overall project scope included preparatory work in Finland, a three weeks site visit to two locations in Tanzania and the finalization of our findings at our home institution.

As final result of this research, this project report begins with an overview of our methods used throughout the project and provides information about the Tanzanian context, including examples of reference projects and information relevant stakeholders. In the second part, the findings from our research are presented, followed by our solution proposals, which are divided into short and long-term action steps to address the challenge. In the discussion section, we assess and evaluate these proposals and give further recommendations.

1.3 Tanzania Meteorological Agency and FarmSMS

The Tanzania Meteorological Agency (TMA) is a Government Agency established in December 1999. The Agency is responsible for the provision of Meteorological services including weather forecasts, climate services and warnings, and advisories information for the country. TMA is currently operating under the Ministry of Works, Transport and Communications of the United Republic of Tanzania.

TMA has partnerships with several organizations. One of them is the World Meteorological Organization (WMO), a specialized department of the United Nations dedicated to becoming a leader in international efforts to monitor and protect the environment through its Programmes. TMA collaborates with WMO as well as several other organizations in a wide range of projects through its 4 divisions: Division of Forecasting Services, Division of Research and Applied Meteorology, Division of Infrastructure and Technical Services, and the Division of Support Services.

Through its different divisions TMA analyzes and provides weather reports for a wide range of clients, both in the public and private sectors. We worked mainly with the Research and Applied Meteorology division to understand the current activities and processes in which they engage to provide accurate

weather data in the context of farming. The departments inside this division (Dept. of Agrometeorology, Dpmt. of Hydrometeorology, Dpmt. of Climatology and Climate Change, and Dpmt. of Environment and Research) share information to develop resources such as analyses, research papers, online tools, publications, forecasting, and so on, most of them available to the public.

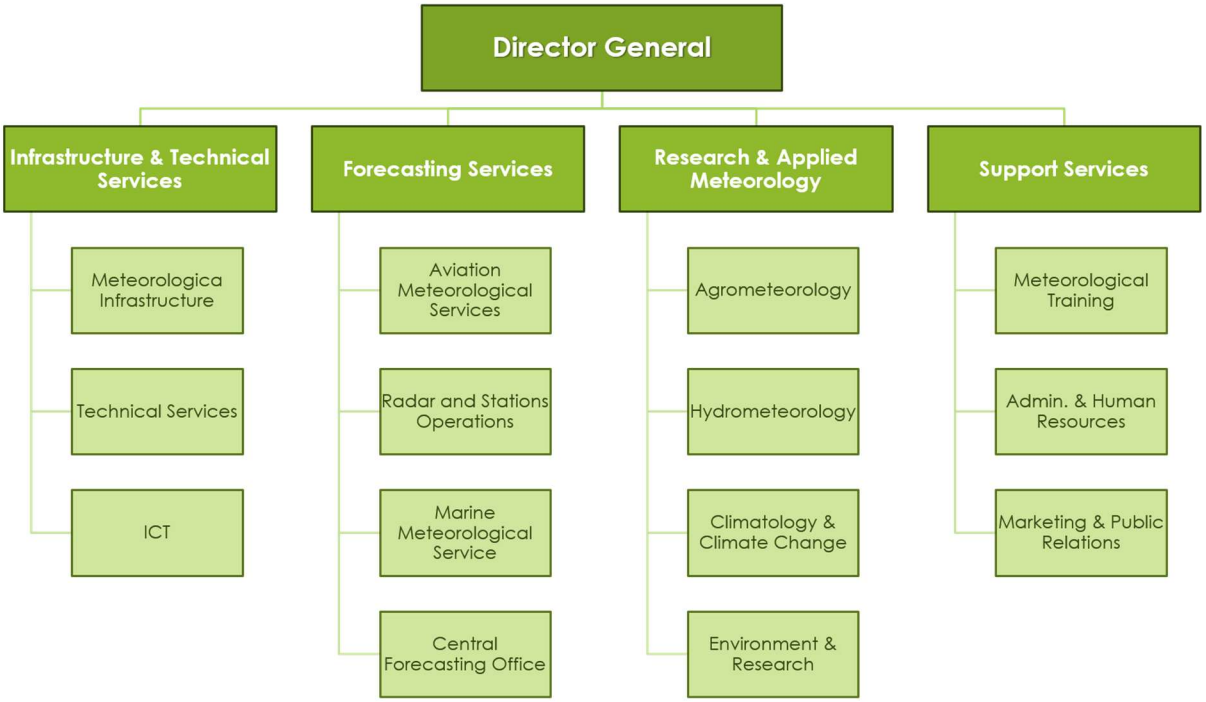

Figure 2 - TMA divisions and departments structure.

FarmSMS is a project started in 2010 under the Agrometeorology department inside the Research and Applied Meteorology division. The project was proposed in collaboration with WMO to reduce the risk of crop failure due to recurring dry spells in rural regions of Tanzania. The premise of the project was to use SMS messages to send relevant information to farmers.

TMA meteorologist Augustine Kanemba initially led the pilot project, which reported a 50-125% increase in crop yields from farmers participating in the project. The reports from this first pilot described several actions to achieve positive impact, such as providing expert forecasts and tips related to planting dates. The pilot went as far as giving guidance on how to prepare their land, choose seeds, get rid of weeds and apply chemicals like fertilisers. The information was provided via SMS accompanied by advice to listen to radio or watch television for regular weather updates.

In 2018, the FarmSMS project is still ongoing although our team found the scope, reach, and list of activities to have changed. As it stands, the FarmSMS system can be split in two areas: technical

infrastructure, and content management system (CMS). The combination of these two areas serve as the baseline to host all the features the system can handle.

The current technical infrastructure has been developed by the Dar es Salaam Institute of Technology (DIT), and it consists of a web-based user interface (UI), which allows TMA to enter the information they wish to share with farmers, select the region to which this information should be sent, as well as to produce simple quantitative graphs regarding the amount of people reached and the status of the infrastructure system. Behind the scenes, the system is hosted on a Linux server located at DIT, and it connects to the mobile network using a commodity 3G modem with a Vodacom SIM card. FarmSMS' CMS, which this research focused the most on, can be grouped into a few subcategories: emergency alerts, for warnings in case of floodings, major storms, etc; weather forecasts, spanning seasonal weather every three months as well as short term 10-day forecasts; and advice, which could be used to share specific advice for the farmers in the region.

Although the system features are programmed to work as expected, TMA pointed out at the beginning of this research that the FarmSMS project has several caveats in both areas. On the technical side, the system has reported issues delivering the messages reliably. TMA has no way to confirm whether all of the messages were successfully sent. From the content side, the advice has been focused on recommending farmers to visit their local extension officers. TMA was also concerned with the cost-effectiveness of FarmSMS, given that as the user base grows, the cost of sending the SMSs would increase accordingly on a 1:1 ratio.

1.4 How to use this report

During the project, we as students have taken over the role of consultants to assess the challenge, and after conducting this research, we are convinced of the potential of the dissemination mechanism in place. However, our initial research has opened many new questions and research opportunities. We see this report as research material for a future follow-up project, and the report can and should be updated and modified by the next student groups. We highly recommend further cooperation with TMA and other partners to address the challenge sustainably in the future.

METHODOLOGY & BACKGROUND

2. Methodology and Background Research

The main framework for approaching the challenge was Human-Centered Design. In Human-Centered Design, the actual end users and other stakeholders are involved in the design process from the beginning. They take part in brainstorming, contextualizing, developing, and implementing of the project. The aim of the approach is to make systems usable and useful for their users, so that their needs and requirements are met. This is done by combining human factors and usability knowledge and techniques into the creation process. (ISO 9241-210, 2010) We chose this framework because it involves the human perspective in all steps of the problem, which we felt would be important regarding the challenge given to us.

2.1 Methods

The data collection and analysis conducted in this project can be separated into three sections: (1) background information gathering, (2) stakeholder information gathering and (3) data processing. The purpose of the methods used in the first section was to help us gather information about Tanzania and give us understanding of the whole project, while still being located in Finland. The second section of methods was for gathering information from the actual stakeholders of the project during the field trip. The third set of methods was for analyzing and categorizing the gathered information.

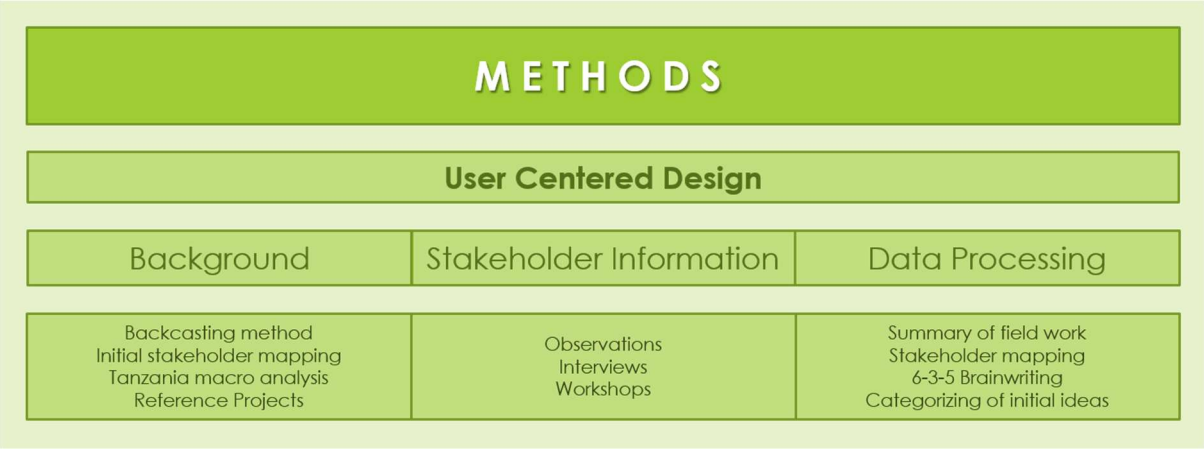

Figure 3 – Overview of methods used in the project

Background information

The methods that we used to gather background information included stakeholder mapping, backcasting, interviews, and finding research articles and similar existing projects. Stakeholder mapping was chosen to give us an understanding about the possible and relevant stakeholders of the

project. Interviews became relevant when we found stakeholders both in Finland and Tanzania that we considered valuable for our project. Gathering the background information through articles and existing projects was essential, since our team did not have much knowledge about Tanzania in general.

To study Tanzania and the project context, academic and other published articles were searched. The focus areas of the search were chosen so that they would best serve our goal of getting a wide understanding about our client organisation's needs and the environment that it is operating in. Five areas of interest were formed: (1) general information about the country, (2) climate conditions, (3) agriculture and agricultural policy, (4) ICT and (5) existing projects. The goal for studying the first four areas was to gain an understanding about their current state in Tanzania, which we believed would play an important part in our project. By studying the existing projects, we wanted to find out if there had been similar projects in other developing countries or in Tanzania, and whether they had been successful or not.

Figure 4 - Result of Backcasting exercise.
Source: Joanna Mehtälä, 2018.

We used the backcasting method to frame the challenge given to us. Backcasting is a method used in problems where there are many stakeholders from various dimensions affecting the solution. Backcasting includes three phases. In the first phase, a future vision for the problem is defined. We decided to ideate what we wanted the desired future in 2030 to look like for TMA and the Tanzanian farmers. In the second phase, a baseline for the problem is defined. The baseline is meant to depict the current situation that affects the desired future. It is meant to help with finding the factors that will affect the future view. The third phase is about actions. It is meant to help to find the salient steps that are necessary when shifting from the baseline state to the desired vision state.

Stakeholder mapping was used to identify the people and organizations that would have some impact on our challenge. Stakeholder mapping begins with writing down all of the entities that might be considered stakeholders. After this, connections are drawn between all of them in order to find

out how they affect each other. From all the connections found, the most relevant ones to the project are established.

An interview with TMA was done using Skype, since we were located in Finland and TMA in Tanzania. In addition, an interview was conducted with a Finnish company that develops services for low-income communities and is also active in Tanzania. The interview was done face-to-face in Espoo, Finland.

Collecting Stakeholder Information

Gathering of information from the stakeholders was done through observations, interviews and workshops in Tanzania between the 5th and 16th of March, 2018. Stakeholders included 70 farmers, 4 extension officers, 1 network operator, 1 representative of TMA and the head of the climate change department in the University of Dar es Salaam.

Observations and semi-structured interviews were used when talking with the farmers, extension officers and the representative of TMA. The interviews were conducted in Swahili and interpreters were used to translate the interviews to English. Most interviews were recorded and notes were also taken. Interviews with a network operator and the head of climate change department were more discussion-based.

The purpose of the interviews was to get a rich picture about the concerns, needs and problems that farmers have regarding farming and weather information dissemination. The network operator and TMA were interviewed in order to get a proper understanding about the technological restrictions and possibilities in weather forecasting. The interview with the head of climate change department was conducted to get a better understanding of how climate change affects farming practices.

Workshops were done with farmers, extension officers and local leaders to get a better understanding about their routines and needs in farming practices. These farming practices included planting, cultivation and harvesting, and how weather affects them. In total, 65 farmers took part in the workshop activities. In the workshops, we used, besides an open interview style, visual materials to support common understanding. Participants actively contributed to the creation of the bigger picture of their agricultural routines. Even though the workshops involved many villagers, which hindered deep conversations, the visualization and interactive nature of the workshop facilitated

capturing a large number of viewpoints. Additionally, the workshops contributed to an active discussion among the participants.

Categorizing and analyzing

For organizing all the collected data, we used four categories that were (1) problems, (2) observations, (3) needs and (4) quotes. Every interviewer went through their notes from the interviews and from observations and sorted the findings into the categories above. At the end, all the sorted information was combined.

After categorization, a method called 6-3-5 Brainwriting was used for ideation. We chose four problems that we wanted to use in the ideation. This ideation process is done in groups, and each group member has five minutes to come up with three ideas that would tackle the problem. These ideas are written down on paper, and after five minutes, each group member gives the paper to the person sitting on their right. Another five minutes are then used to come up with another three ideas. This procedure is repeated until a full circle is completed and each group member has their own paper in front of them. After this, every team member gives a star for three of the ideas on each paper, and in this way, the best ideas of each paper are discovered. 6-3-5 Brainwriting was chosen because it was suitable for our team's need to come up with multiple, out-of-the-box ideas fast.

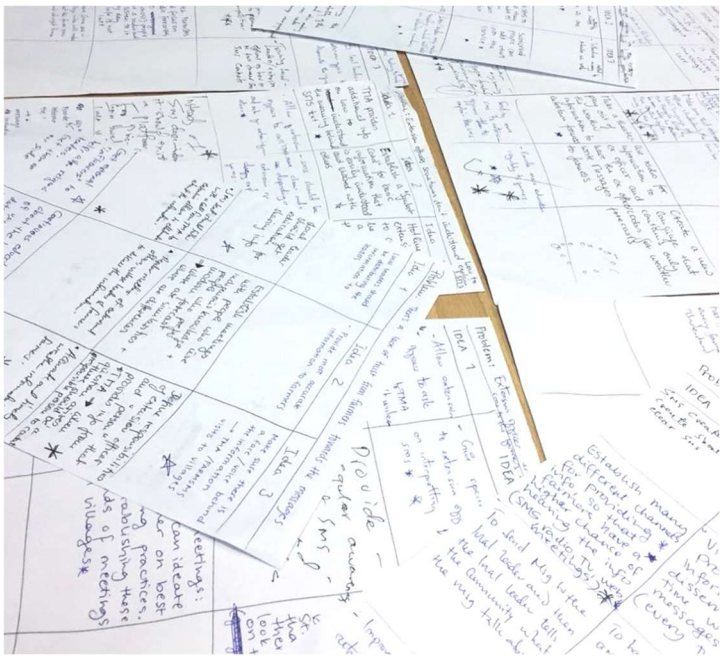

Figure 5 - Brainwriting 6-3-5.
Source: Joanna Mehtälä, 2018.

The best ideas from 6-3-5 Brainwriting were categorized into (1) System requirements and boundaries, (2) Practices for communication, (3) Education and Training and (4) External requirements. The goal was to come up with solutions that were not dependent on other stakeholders and that we could implement by ourselves. Based on these categories, each team member was given a topic to ideate on. These ideas were then combined and worked as a basis for our final solution.

2.2 Background Study

In order to better understand our challenge – the topic of this study – we conducted background research in the general context of the topic. This chapter includes information on Tanzania, its climate, agriculture and agricultural policy as well as use of information technology in the country. Moreover, we studied existing and past projects related to climate and agricultural information services to analyse lessons learned and their potential implications to the challenge presented. The aim of this chapter is to set the context for the further work done in the project.

Tanzania – An Overview

Tanzania is situated in East Africa, just below the Equator. The country consists of mainland and the autonomous island of Zanzibar. The total land area is 885,800 km2. The capital of Tanzania is Dodoma, and the biggest city and the capital for business operations is Dar es Salaam on the coast of Indian Ocean. The country has 50,1 million inhabitants. The population is young and growing rapidly with an average fertility rate of 5,2 children/ woman. The literacy rate was estimated to be 77 % in 2012, and 87 % of men and 77 % of women have some level of education (National Bureau of Statistics, 2017).

Figure 6 - Map of Africa.
Source: CIA, The World Factbook

Figure 7 - Tanzania.
Source: CIA, The World Factbook

Tanzania is manly rural country with the rural population comprising 70 % of the habitants (National Bureau of Statistics, 2017). However, urbanisation is increasing rapidly especially among the younger generations who tend to migrate to cities after job opportunities and presumed better options in life. According to household surveys, poverty rate in Tanzania is decreasing, even if the number of people living in absolute poverty is still high. The population that do not have the capacity to meet their basic needs varied from 4,1 % in Dar es Salaam to 33,3 % in rural areas, demonstrating vast geographical differences in income level.

Economic growth is of the country is rapid, and has remained constant at around 7 % for several years. Despite prolonged rapid economic growth, the GDP per capita has remained at around USD 1,000 since 2013 (National Bureau of Statistics, 2017). Agriculture has a significant role in Tanzanian

economy. The sector contributes to 31 % to the GDP, and employs 67 % of the labor force (World Bank, 2016). However, the productivity of agriculture is low, and for example crop cultivation comprises only 15,6 % of the GDP. While Tanzanian economy in general has enjoyed high sustained annual growth, the growth rate of agriculture has been modest, at around 3 %, and the trend is decreasing (National Bureau of Statistics, 2016b) despite efforts to implement policy programmes to increase productivity in the agricultural sector.

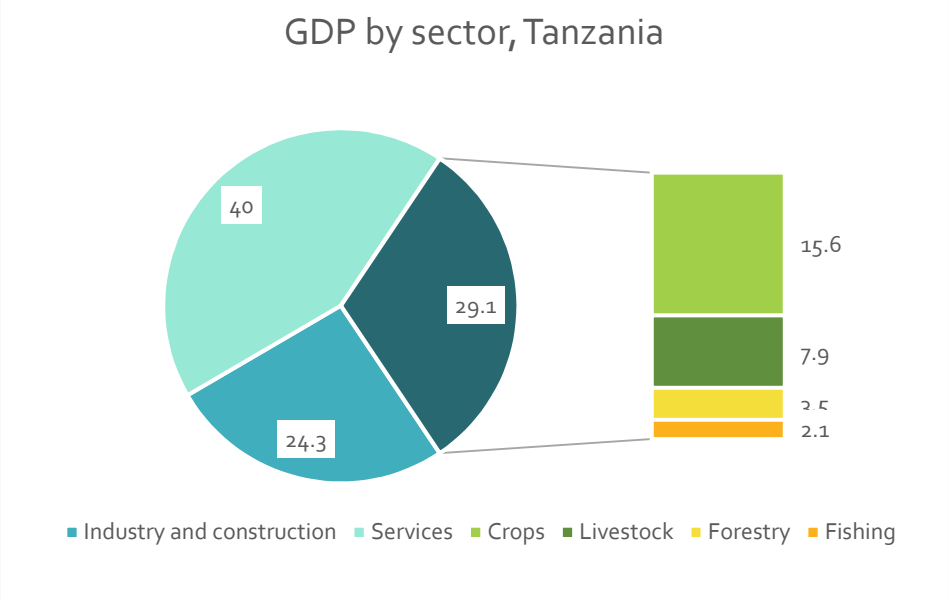

Figure 8 - GDB by sector, Tanzania, 2016.
Source: World Bank, World Development Indicators

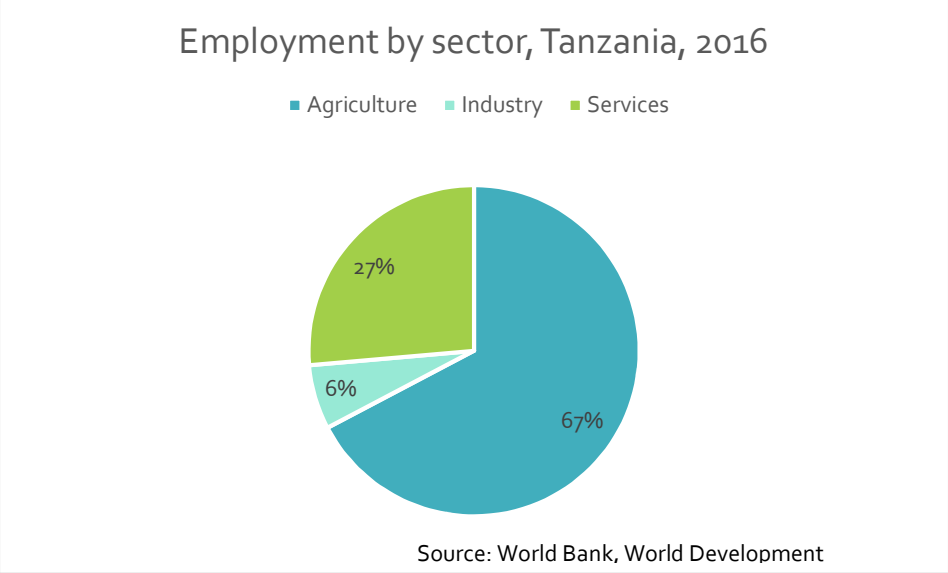

Figure 9 - Employment by sector, Tanzania, 2016
Source: World Bank, World Development Indicators

Climate and the Effects of Climate Change

Tanzania is a large country that has multiple different climates in different regions. According to the Köppen climate classification, Tanzania's regions fit into nine different climate classes. The most significant climate classes are the tropical savanna climate of the coast, the southeast, and the northwest, and the warm semi-arid climate of the country's interior.

Temperatures stay somewhat consistent throughout the year, and there is no distinguishable difference between summer and winter. The hottest period is between December and February, and the coolest period between June and September. Differences in temperature are more pronounced in the country's interior, where the annual average low temperature is about 16,4 °C and the average high 28,7 °C (figures from Dodoma); the coastal region stays hotter throughout the year, with an annual average low of about 21,9 °C and an average high of 29,6 °C (figures from Dar es Salaam; Wikipedia, BBC).

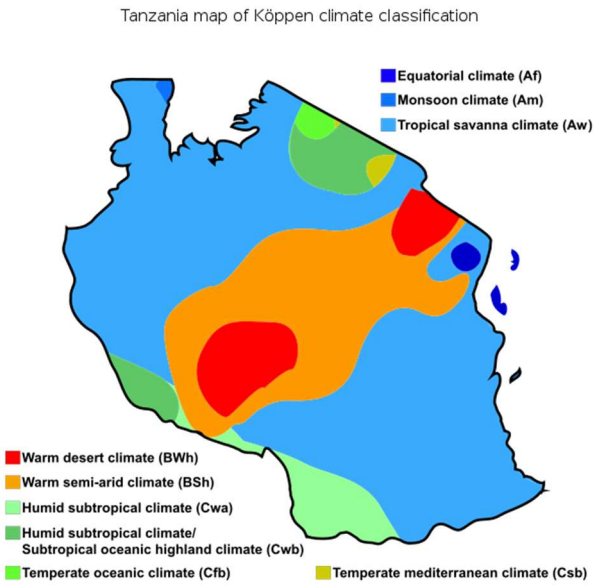

Figure 10 - Tanzania climate areas.
Source: Wikipedia, Geography of Tanzania.

Instead of pronounced winters and summers, Tanzania experiences distinct dry and wet seasons. The country is divided roughly in two when it comes to rainfall. Northern and eastern Tanzania experience bimodal rainfall, with the short Vuli rains falling between October and December, and the long Masika rains falling between mid-March and late May. Southern and western Tanzania, on the other hand, experience unimodal rainfall with the Msimu rains falling between November and April/May. (Paavola, 2008; Rowhani et al., 2010)

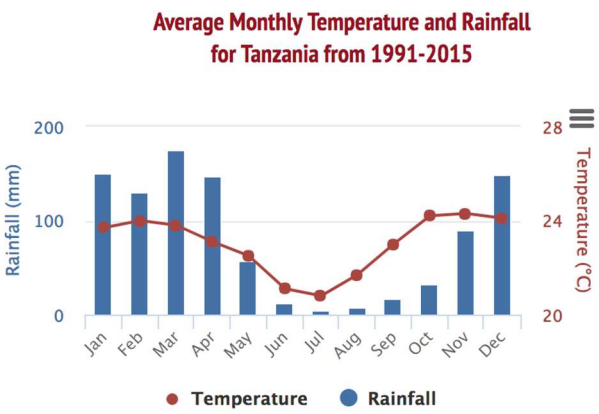

Figure 11 - Average temperature and rainfall in Tanzania.
Source: World Bank, The Climate Change Knowledge Portal

Global warming affects Tanzania just as it does the rest of the world. The country is predicted to warm by 2-4 °C by 2100, with dry seasons

warming more than wet seasons, and interior regions of the country warming more than coastal ones (Paavola, 2008). Climate change will also bring more climate variability than before, the effects of which we have already begun to see: between 1998 and 2008, both the highest and the lowest rainfall years in historical record occurred. While temperatures are expected to rise in all parts of the country, precipitation will behave somewhat differently; rainfall may decrease by 20% in Tanzania's interior regions and increase by up to 50% in coastal regions (ibid.).

The direct results of climate change vary in different parts of the country. In the interior regions, where rainfall will decrease, droughts will become more common and cause local food shortages as crop yields reduce. Coastal regions will see flooding of rivers, which will cause damage to infrastructure and increase the spread of both insect-borne diseases like malaria and diseases related to water contamination, like cholera and typhoid fever. Overall, there will be less water available for crops and more crop losses due to weeds, diseases and pests, along with a shorter growing season. (Paavola, 2008) It has been estimated that maize, sorghum and rice yields will reduce by 13%, 8.8% and 7.6% respectively by 2050; and that these numbers may even be underestimations (Rowhani et al., 2010).

Paavola (2008) suggests that the key measures for decreasing vulnerability to climate change are 1) effective governance of environmental resources (soil, forests, water), 2) increased market participation, and 3) social programs to support wellbeing. Rowhani et al. (2010) point out the importance of improving climate records to enhance understanding of cause and consequence between climate variability and crop yields; it's not always clear how climate variability will affect crops (there may even be positive effects at certain times), so increasing knowledge on the subject is key.

Role of Agriculture and Agricultural Policy

The African economy as a whole is heavily dependent on agriculture and the livelihood of more than half of Africa's population depends on the agricultural sector (NEPAD, 2013). Over the past 30 years, African agricultural production has increased steadily (value increased by +160%), yet the productivity has remained low and growth is achieved through expanding the land used rather than improving the yields. Cereal production cannot keep up with the pace of population growth. A previously self-sufficient continent – in terms of food production – now imports food that competes with local produce.

International institutions see the agricultural sector as a driver for reducing food insecurity and alleviating poverty. The UN initiative CAADP is a policy framework towards agricultural transformation. The framework provides broadly defined strategies to facilitate countries to critically review the current situation and to identify investment opportunities (UN OSSA, n.d.). Despite the efforts, the goal to increase public spending on agriculture to 10% was only achieved by 9 out of 44 countries (NEPAD, 2013).

The CAADP proposes three major sub-goals to successfully reach those targets, that are:

- Increase **production more sustainably** (including increasing resilience against climate change)
- Product **diversificatio**n and **expansion of the value chain**
- Development of **regional market integration** and protection mechanisms

Africa is the only continent where the number of undernourished people has increased over the last three decades. Food insecurity is especially a rural phenomenon, as many people lack adequate means of production like land, tools, fertilizers and so on. (NEPAD, 2013). Thus, climate related changes affect particularly the poor in rural areas.

Since the 1990s, the Tanzanian government has implemented policies on poverty reduction within the Tanzania Development Vision 2025 framework, a vision that seeks to profile Tanzania as a middle-income country through ensuring food security, increasing income and increasing export earnings. An Agricultural Sector Development Programme (ASDP) has been established, and it functions as a guiding framework for agricultural growth and poverty reduction initiatives. Key elements of the programme include increasing farm profitability through better access to agricultural knowledge, technology, and markets, and to promote private sector investment on agriculture. The agricultural sector ministries (Ministry of Agriculture, food security and cooperatives, Ministry of Livestock Development and Fisheries and Ministry of Industry, Trade and Marketing) guide the policy level work at a national level. Local Government Authorities implement the strategy based on District Agricultural Development plans through extension services such as training and the availability of agricultural extension officers. The aim of the services is to enable producers to increase productivity through access to market information, and to promote sustainable agricultural practices (Kimaro et al., 2010). While the aim is that each ward and/or village would have a designated extension officer, in practice, resources to implement the advisory services are limited and the network does not reach all of the areas.

According to World Bank (2017), agricultural sector development programmes have increased the productivity of the smallholder agricultural sector during the past ten years through improved knowledge and adaptation of better crop cultivation practices, improving animal husbandry, enhancing labour productivity and adapting practices to improve the value addition of products.

Smallholder Farming in Tanzania

Most of the farmers in Tanzania are smallholder farmers producing staple crops for self-consumption and maintaining livestock. 60 % of the farmers produce crops only, 38 % produce crops and livestock, and 2 % are dedicated solely to livestock (National Bureau of Statistics, 2016a).

The most commonly cultivated crops are staple crops (as opposed to cash-crops) for self-consumption, and the variability is limited. 90 % of the farmers grow maize, followed by beans, cassava, sweet potato, rice and groundnuts. Some of the cash-crops produced are sunflower, sesame, coffee, cotton, cashew nut and sugar cane. There is a tendency for a dependency on a single crop for consumption and/or trade, and an extremely high dependency on maize, even compared to other East African countries (Anderson et al., 2016).

Half of the smallholder families have animals of some kind. Chickens are the most common, followed by goats and cattle. Pigs and sheep are held to a lesser extent. Chickens and goats are mainly held for private consumption, while cattle and pigs are used for income generating purposes. Many of the farmers rely on livestock as a source of "insurance" if the agricultural income falls short (Anderson et al., 2016).

Land is commonly privately owned in Tanzania. In rural areas, in 2012, 89 % owned the house they lived in. However, only 14 % of the farms were officially registered. Persons living in rural areas own on average 7 acres of land (National Bureau of Statistics, 2014). Most of the agricultural production is dependent on rain-fed production systems and irrigated land represents only 3 % of the land used for agriculture.

Household Characteristics and Income

In Tanzania, youth tend not to be interested agriculture, and do not see themselves with a future in farming. Of the smallholder households, most of the heads of the household are over 40, with only 10 % being under 30. In East Africa, it is common for young and more educated generations to

migrate to cities. This tendency is even more pronounced in Tanzania, indicating strong structural changes in the agricultural sector in the near future.

The educational level of smallholder farmers tends to be low. While heads of family have typically completed at least primary school, 23 % have never attended school. Gender differences in educational levels are big: 35 % of female household heads have never attended school, while the corresponding figure for male household leads is 19 %.

Most smallholder farmers depend solely on farming activities for their sustenance. The most significant source of income is the selling of crops, fruits and vegetables, followed by rearing livestock for cash purposes. In addition, according to Anderson et al., (2016), 19 % receive income from other sources including private business and income from occasional jobs.

The productivity for farming is low. Many smallholder farmers report having difficulties in meeting their daily needs, and many live below the poverty line. In terms of income, 38 % of families report they do not have enough money for food, 45 % can cover their basic alimentary needs and clothing but not bigger purchases, and 15 % can save a bit in addition to covering their basic needs. Yet, the savings are reported to be minimal.

Climate variability leaves smallholder farmers vulnerable to poverty, as rain-fed agriculture is often their only source of income. In the past, farmers in Tanzania have attempted to cope with stress factors in four ways: agricultural extensification (farming new units of land), agricultural intensification (applying more labour on a unit of land), livelihood diversification (combining farming and non-farming activities for income) and migration. These coping strategies may be of some use when trying to reduce vulnerability to climate change, but some of the strategies also impact climate change negatively; for instance, agricultural extensification increases deforestation, which in turn, increases flooding. (Paavola, 2008).

Regarding agricultural intensification or improving productivity, the main challenges that smallholder farmers face are access to finance and financial services, inability to invest in high-quality seeds, pesticides and insecticides, and limited access to weather information. Post-harvest storage is also a commonly reported problem (Anderson et al., 2016). While these challenges have been tackled with the agricultural policy and programmes and improvements have been reported, the

ability of smallholder farmers to cope with risks or invest in required inputs to improve productivity remain low.

Use of Technology

Media used in Tanzania include print, radio, television and internet. The most popular channels are print, radio and television, since having internet access is still not a given. One barrier for the adoption of internet is that network coverage remains limited (Abdinoor and Mbamba, 2017). Many people still own a cellular phone instead of a smartphone and having an internet connection at home is rare because of the low availability of electricity. Demographic factors such as age, gender, marital status, education level, and skills have a high influence on the adoption of new technologies (Abdinoor and Mbamba, 2017).

Owning a mobile phone is common in Tanzania. Up to 95% of Tanzania's population have access to a mobile phone. (Dusabe *et al.*, 2013). Mobile phones are also becoming the most popular ICT devices to access the internet, but in Tanzania only 5.2 % of mobile phone owners use the mobile for browsing the internet and to read and write emails, and slightly less use their phones to access social networking applications (Stork, Calandro and Gillwald, 2013). However, mobile phones are still the most common way for accessing internet, since 0,8% of households in Tanzania have Internet (Stork, Calandro and Gillwald, 2013). Radio is confirmed as the medium most widely used at household level. It is present in more than 60 % of households in Tanzania (Stork, Calandro and Gillwald, 2013).

For the farmers, the most common way to access information and knowledge on farming systems is radio (Lwoga, E. et al, 2011). According Lwoga (2011) this was because large number of farmers in the rural areas preferred radio forecasts' oral nature, low cost and independence of electricity. Cell phones were also becoming important ICTs for rural farmers to seek advice regarding their farming problems, such as animal and plant diseases and technical details of farming. The study findings also indicated that television was also an important ICT used by farmers to access agricultural information and knowledge (Lwoga, 2011).

A study conducted by Anderson et al. (2016) amongst smallholder farmers in Tanzania supports the findings above and reveals that smallholder farmers obtain information about agricultural activities primordially through face-to-face contact such as from neighbours, family and community, followed by radio. All other sources of information fall short; only 19 % of smallholder farmers had used SMS services, and 5 % had used internet for obtaining information. GSMA (2015) evaluation of Tigo Kilimo

service, on the other hand, reveals that farmers seek primordially information for farming practices from government agricultural extension officers, followed by neighbours.

Mobile services accessible through a basic mobile phone are increasingly common across developing countries. The most common applications are related to mobile money and mobile banking, yet agricultural information services that combine information about finance, markets, weather and cultivation tips have become more common in recent years. The importance of some of these services becomes evident in the study of Anderson et al. (2016), which indicates that one out of ten smallholder farmers have an official bank account, yet half of them are financially included through mobile services. The relative high penetration of mobile banking services in rural Tanzania indicates an opportunity for the use of mobile phones also for the purpose of agricultural and climate information services.

2.3 Learnings from Reference Projects

Challenges faced by smallholder farmers in different parts of the developing countries are often similar and a multitude of projects and different approaches to overcome them have been implemented. Climate information services and agrometeorological services have been created to tackle the information needs of smallholder farmers across the world. Regarding adaptation to climate change, climate information services play a role in assisting individual farmers to make informed decisions about actions to be implemented. Agrometeorological services, on the other hand, are services that tackle specifically the needs of agricultural sector intending to enable producers to maximise their returns on investments and to minimise risk (World Bank, 2015).

These services can be provided by a range of different actors. Often, national meteorological agencies or similar governmental institutions provide climate information services. On some occasions International organisations or NGOs are involved in providing them. Moreover, private firms are increasingly interested in providing and promoting agricultural value-added services that that provide information relevant to smallholder farmers about issues such as market prices, access to finance, weather information and advice on crops.

A research programme on Climate Change, Agriculture and Food Security (CCAFS) conducted in 2012 an international seminar to discuss best practices on climate services. The conference document portrays a wide range of initiatives and analyses the success factors and critical points of each of the

initiatives. According to them, important features for successful service or project include (Tall, 2012, pp. 2-3):

- Delivery: timely delivery to remote rural areas with marginal infrastructure
- Salience: tailoring content, scale and format suitable for farm-level decision-making
- Legitimacy: giving farmers voice in design and delivery of services
- Equity: ensuring that women, poor and socially marginalised groups are served

Some of the projects can be highlighted here as examples of learnings that can be driven from past projects:

Project by IGAD Climate Prediction and Applications

A project led by IGAD Climate Prediction and Applications Center in Kenya between 2011-2014 was aimed at improving the downscaled information provided to farmers in rural areas as well as obtaining scientific evidence to influence government policy and improving downscaled climate information to agriculture and food security sectors. The project used, among other tools, an SMS broadcasting program. The messages included different pieces of information such as rainfall intensities and distributions, length of season, climatic hazard, among others. These messages were accompanied by capacity building workshops with the communities involved, as well as the creation of advisories based on weather forecasts and disseminated to the farmers.

The project reported pointed out the important role indigenous knowledge takes in enhancing confidence among communities in increasing the utilization of the weather information. The report also pointed out the difficulty on pinpointing weather predictions to a geographical location due to the limited number of functional weather stations, this causing significant variations between what was predicted and the actual observations. These situations caused farmers to lose confidence in the provided messages (Tall, 2012).

African Farm Radio Research Initiative (AFRRI)

African Farm Radio Research Initiative (AFRRI) by Farm Radio International in five African countries including Tanzania, Uganda, Kenya, Ghana and Mali conducted action research to study the impact of information distributed in radio to agricultural practices. The radio programmes broadcasted weather forecasts and agricultural advice combined with SMS reminders about the programme, increased number of the listeners and the uptake of new agricultural practices up to 80 %. The

research the importance to have good extension services to assist the farmers in adopting new farming practices (Tall, 2012).

Private sector projects

In addition to public and donor-funded services, an increasing interest of private sector towards agricultural information services can be observed. Many examples of such services can be obtained from such countries as India, Bangladesh, Ghana, and Kenya (GSMA, 2016). In Tanzania, two commercial network operators, Tigo and Vodacom, have had their own service with limited success, and according to our knowledge, both services were ended after some years of operation. However, the evaluation of Tigo Kilimo service (GSMA, 2015) provides important insight about the uptake and use of mobile services in Tanzania:

- Users: the service appealed to users that belong to young age groups and have higher-than-average educational levels.
- Barriers to subscription: did not know the number, the USSD menu was difficult to navigate, and the pricing structure was unclear/ people were afraid of the cost (the service was free of charge).
- Impact: repeat users were 30 % more likely than non-users to introduce new crops, and were 60 % more likely to use price information to bargain with traders when selling the crops.
- Weather information: the users felt positive about the possibility to access weather information at request, yet they reported problems with the accuracy of the data especially on certain areas of the country.

2.4 Concluding Remarks

Based on the background research, several conclusions can be drawn: smallholder farmers are dependent on rainfall and vulnerable to climate change. In theory, demand exist for weather information services, yet in practice barriers to access the services are many, mainly related to technological and socioeconomic constraints. Farmers seem to receive information for agricultural purposes from extension officers and through radio. Solutions that rely on technology seem not to be widely used even if the number of such initiatives and service providers has increased recently. The users of such services tend to be younger than average rural population and report having higher level of education. While positive results have been reported about different projects, constraints remain in designing services that provide timely, accurate and localised services that reach farmers that come from more vulnerable socioeconomic situations. The high levels of use of mobile banking services indicates that there is room for increase for agrometeorological services through mobile

phones, however, to break barriers of language and illiteracy, other channels might still remain relevant. The role of agricultural extension services and extension officers could be important on improving the skills and capacity of farmers to implement new farming practices.

2.5 Stakeholders

According to cultural dimensions of Hofstede Insights (2018), in the Tanzanian society, people accept a hierarchical order. Without further justification, everybody has a place in society and subordinates often wish to be told what to do. This becomes also visible in the interaction among the stakeholders involved in the project. The level of influence an individual has depends on his or her social status.

In this regard, local leaders can be considered as highly influential on village levels, particularly towards the farmers. Local leaders are part of various committees, e.g. village meetings or climate councils, and are generally well respected within their communities. Many villagers consult the local leader for advice in any situation, including agricultural concerns.

The extension officers (EOs) operate also on a local level in close cooperation with the community members. EOs are part of the local authorities, and thus, employed by the Tanzanian government. They are engaged in a multiplicity of tasks on village level, including supporting farmers by giving agricultural advice. For the current pilot project of the FarmSMS, EOs are promoted as advisors for smallholder farmers. However, due to a lack of resources such as time, money and knowledge, EOs face a challenge of meeting the requirements of their advisory position.

As stated above, TMA is a government agency responsible for providing weather and climate information to the public as well as private sector entities. For this project, TMA is considered the initiator and for our student group, the organization is the client who proposed the challenge. With the FarmSMS service, TMA provides climate information

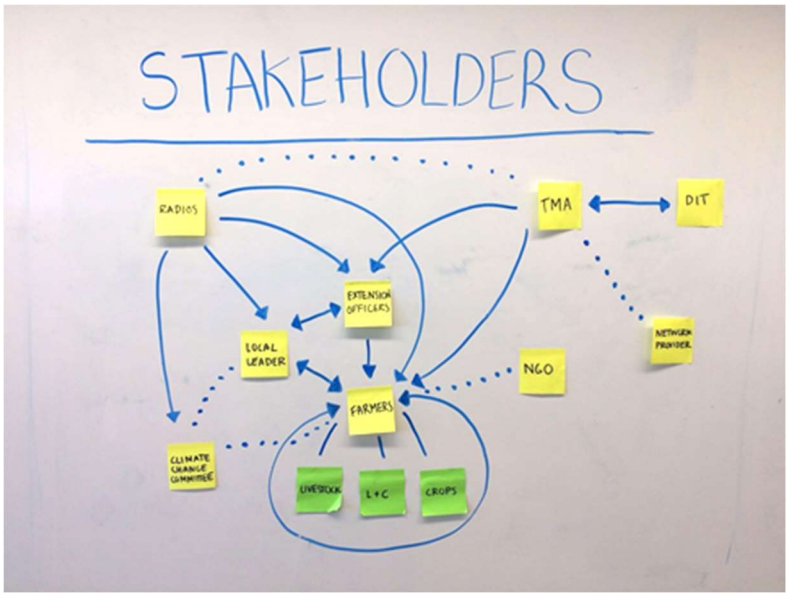

Figure 12 - Map of the stakeholders.

to the farmers in rural areas. The information is derived from different departments within TMA; an internal task force condenses the information and sends it to the farmers. As TMA is part of the government, they appear to be well respected due to their positional power. However, due to different levels of accuracy regarding weather information, we faced a certain degree of distrust towards TMA during our visit.

Smallholder farmers present the largest group of end users of the FarmSMS service and they have been the focus point of our research. Farmers' needs vary from one village to another, depending on agricultural practices (e.g. livestock or crop cultivation) and the interest in modern versus indigenous knowledge. For more details about the role of agriculture on society, please refer to the background sections.

FINDINGS & SOLUTION PROPOSALS

3. Findings and Solution Proposals

The main goal for our field trip in Tanzania was to gather a better understanding of our challenge and its larger context. We took a very user-centric approach to the challenge right from the beginning – if we were to design a service to provide smallholder farmers with weather information, we would need to know what kind of weather information the farmers actually needed, and what the activities that they needed the information for were truly like. We also wanted to understand the status quo of the FarmSMS system; who was involved, how the system worked, and what the current problems with the system itself were. Finally, we wanted to learn what kinds of limitations there were regarding the solution, and what would be feasible to implement. To acquire all of this information, we arranged as many interviews with different stakeholders as was physically possible in the span of two weeks.

Figure 13 - Day 1 morning session in Meserani.

We started off with interviewing farmers and extension officers in the Arusha region in northern Tanzania. In two days, we interviewed around 70 farmers in four villages – Meserani and Makuyuni in the Monduli district, and Mairouwi and Engikaret in the Longido district – along with four agricultural extension officers from the areas. The Monduli and Longido districts were chosen for interviews because the FarmSMS pilot had been operational there, and the specific villages were picked out by members of TMA and the University of Dar es Salaam (UDSM).

Figure 14 - Day 1 afternoon session in Makuyuni.

The villages were all located in semi-arid rural areas, and the interviewees were all part of the Maasai tribe. Most spoke the local Maa language as their mother tongue, but also spoke Swahili fluently. There was electricity available in all of the villages, but not always in each individual family's home. Cellular network coverage existed, but it was generally quite limited; not all operators covered all of the areas, and internet was not available

everywhere. Many villagers owned radios and cell phones, but televisions and smartphones were a rarity.

After the interviews at villages, we did some organizing and analyzing of the collected data to see what information was still missing and who we would still need to interview to gather that information. Finally, we conducted one interview with a representative of TMA to understand the constructs behind the FarmSMS system better, one with employees of the local network operator Vodacom to find out what kind of solutions might be feasible to implement, and one with the head of the department of climate change at the UDSM to hear more about the effects of climate change on the country in general. These additional interviews helped us formulate our final solution suggestions.

Figure 15 - Day 2 morning session in Mairouwi.

Figure 16 - Day 2 afternoon session in Engikaret.

3.1 General Observations from Villages

The forms of agriculture of the different villages we visited could be roughly divided into two: crop cultivation and livestock keeping.

Cultivators of crops grew mostly maize, beans and peas, and had a varying range of land area to cultivate: many had only 1-3 acres, but we also interviewed farmers with up to 44 acres to cultivate. Most farmers cultivated crops mainly for their own food, but in years of good yields they would sell some of their produce. Similarly, most farmers had only family businesses, but would employ extra workers for the field if they had extra money. Some used cows for ploughing, some tractors. Seeds were perceived to be quite expensive, and no fertilizers were used.

Livestock keepers raised cows, sheep, goats, and donkeys. The farmers did not own land, but used communal land for livestock grazing. The area in which livestock keepers roam can be huge, since during dry seasons, the herds can be taken tens, even hundreds of kilometres out into the country to find good pastures.

When asked about perceived changes in climate during the recent years, most reported changes in the amount of rain; droughts were becoming more common, and rain patterns were fluctuating more than before. Farmers reported that the rainy season would come later in the year than before, and it would rain less during the season. This affected crop cultivators and livestock keepers in different ways; crop cultivators had seen (sometimes significant) decrease in yields, and livestock keepers found it harder to find good grazing conditions. Livestock keepers were reluctant to sell their animals even during periods of drought, because the amount of animals one owns is closely related to social status in their culture. This would result in a part of the animals starving to death.

All of the villages had a climate change council that was responsible for spreading information about climate change to villagers. The villagers seemed, in general, very keen on understanding the phenomenon better and getting more information both on climate change and its effect on weather patterns. We interviewed both people who were receiving the FarmSMS messages and those who were not.

Figure 17 - Findings overview.

3.2 Users' Problems and Needs

Before we conducted interviews with the farmers, representatives of TMA had explained to us some of the technical problems related to the FarmSMS system. The interviews with the farmers, however, gave us a much broader perspective on the service and its challenges also from a user's point of view. After comparing interview data from different members of the group and from different villages, we were able to group our findings into three different problem areas: communication, dissemination, and trust (CDT triangle).

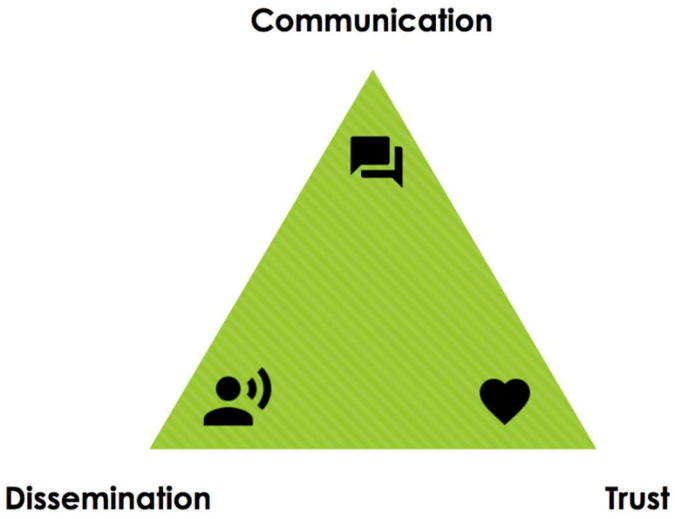

Figure 18 - Problem areas.

Communication

One of the problem areas we recognized is the lack of communication between TMA, farmers and other stakeholders. Many of our interviewees, who were receiving the messages did not fully understand the service, or why they started receiving the messages and who was sending them. Apparently, TMA has held some sessions about the FarmSMS service in the villages and collected numbers to add into their database during these visits, but it seems that information about the service and its provider has not reached all of the farmers whose numbers have been added to the service. A good example of this knowledge gap is that if a person, who has previously been receiving the messages loses his or her phone, and gets a new phone with a new number, he/she does not know that re-subscription is needed, and there is no information available on how to subscribe again.

Another problem related to communication is that farmers do not always know, what to do with the messages they receive. The messages usually contain a weather forecast for a certain period of time, and a suggestion to contact the local agricultural extension officer for farming advice based on the forecast. The farmers reported that once they contacted their extension officer for advice, the officers couldn't tell them any more than the message did. Evidently, in many cases, extension officers – who represent the local government of the area – are not much more educated than the farmers themselves, and are unable to function in the way they are expected to. The extension officers themselves also felt like they needed more education. They also mentioned that visiting all of the villages in areas allocated to them was very time-consuming, so it was hard for them to give advice to individual farmers.

The current communication flow is also very one-sided. TMA sends weather information to farmers via messages, but farmers do not know whether they could somehow ask questions or send feedback to TMA. It is currently technically possible to reply to the messages and send feedback, but users do not know about this possibility. Still, there is no helpline to call with questions.

Farmers stated that more education and information about both the FarmSMS service and about climate and weather information in general would be useful to them. Some wished that the local leaders in particular would be given education on the matters, and that the leaders could then act as contact people related to weather information and farming advice. Many thought that including agricultural advice in the FarmSMS messages themselves would be a good idea (instead of just a suggestion to contact the local extension officer for advice).

Dissemination

The second problem group we identified is related to dissemination. By this, we mean issues related to the dissemination of the weather forecasts, and the channels and format thereof. There are both technical issues and service design issues in this problem category.

Many of the technical problems related to the current FarmSMS pilot are known issues that TMA is already looking to solve. A big issue has been the fact that some messages do not reach their recipients, but are lost half-way. Also, some messages arrive too late, i.e. when the forecast has already expired. Some users reported that they had received a couple of messages after they had subscribed to the service, and then suddenly stopped receiving them; some reported that they had received quite many messages, but at varying intervals. This unpredictability is obviously a problem for the users of the service, since they do not always receive the information they need, or the information does not arrive in time. TMA, on the other end, is struggling with not having a way to find out which messages have reached their destination, and not being able to resend the messages to the right people.

The service design problems we identified were related to the format of the weather information, and the channels used to disseminate weather forecasts. While many users thought that SMS was a good channel for weather forecasts because they always had their phones with them, there were others who were not able to benefit directly from the text messages because they either could not read or did not speak Swahili (the language of the messages). These people had to rely on others to share the information with them, which did not always happen. There were also issues with

understanding the content of the message because of the way it was formulated; one local leader told us that the villagers knew the name of their own village but not the name of the larger region, so if a message said that there would be rain in the Kilimanjaro and Manyara regions, they would expect rain even though they were actually in the Arusha region.

There were different opinions as to how often the messages should be delivered. Some would have liked the messages to come once a week, some thought two weeks would be a good interval, and some were more interested in season-long forecasts. The length of the forecast needed and the information desired depended on the type of farming the user was doing. Crop cultivators wanted information on the amount and time of rains, and preferred forecasts for longer time periods so that they would have time to plan their activities and plant seeds before the coming of rains. For livestock keepers, the most important thing was getting weather information about larger areas so that they would know which places would be best for gazing, and they would have also liked to get pasture maps in addition to information about rains.

Trust

The final problem area we identified is trust. We heard mixed experiences about the FarmSMS service from farmers, but the negative experiences were nearly always somehow related to the reliability of the service. The trust issues that we found can be divided into two areas: problems arising from technical unreliability, and problems related to perceived unreliability.

By technical unreliability, we mean the dissemination-related issues described above (such as messages arriving too late or messages not reaching their recipients), but also issues related to accuracy of the weather data. TMA has only 24 weather stations around the country, and the rest of the weather data is derived from satellite imaging. This means that while weather forecasts are accurate for places near the weather stations, villages far away from the stations might experience significantly different conditions. In other words, TMA is able to provide weather forecasts that are accurate on a regional or even a district level, but it is hard to predict weather conditions for each individual village. The farmers that we interviewed had had some negative experiences concerning the accuracy of the data; sometimes it hadn't rained even though the forecast had said it would. In these kind of situations, trust towards the service is affected even if the forecast had been accurate for the rest of the district area. An example of weak trust towards the service came from a lady in Makuyuni, who said that she feels it is too risky to sow expensive seeds before she sees rain with her own eyes – even if a message said that it would rain soon.

Also some of the extension officers we interviewed had noted that the weather forecasts in the messages were not always accurate. An extension officer in the Longido area had been sharing the information from the messages on the village notice board, but when the forecasts had turned out to be faulty, the villagers had blamed the extension officer and called him a liar. After that, the officer had stopped sharing the information on the notice board (which, in turn, weakened dissemination of the information in the village).

In addition to experiences of technical unreliability, the perceived level of reliability of the service affects how much it is trusted. In many villages, indigenous methods (such as looking for signs of rain in the blossoming of plants and in the behaviour of animals and insects) are still the preferred way of predicting weather. People trust their local leaders and elders greatly, and follow them in their own practices and actions; if the elders trust indigenous methods over the text messages, so will many other people, too. The importance of indigenous knowledge in weather forecasting differed a lot between the villages, though: some interviewees reported that they had not been relying on indigenous knowledge for generations, but some said they would always trust indigenous knowledge over FarmSMS if they differed in their predictions.

Some farmers stated that radio was, in general, a more trusted source of information than the messages. They said this was because they knew where the information on the radio came from, which was not the case with the messages. In the Longido area, close to the Kenyan border, people would listen to Kenyan radio stations over Tanzanian ones, because they were more easily available. People seemed keen on listening to radio forecasts in their own language, Maa, over Swahili-speaking stations. From this information, one could infer that radio is more trusted because it feels more familiar and human-like than text messages; when people hear an actual human being report weather forecasts in their own language, they are more likely to listen. Here, we also come back to the fact that not many of the farmers knew who was sending the FarmSMS messages.

A local leader in Mairouwi stated that if people heard more success stories and positive experiences about the service from their peers, people would be more likely to use and trust the service. These positive experiences do exist – especially when the correct kind of advice has been combined with the weather information. For example, a farmer from the Longido area had received a message about upcoming short rains, and advice about planting maize seeds that survive with little rain. He had planted the seeds, the short rains had come, and he had got a good harvest.

In conclusion, good communication about the service, education about modern weather information and reliable dissemination of the forecasts all affect the level to which the FarmSMS service is trusted. Trust, on the other hand, is paramount for getting more people to use the service.

3.3 Expert Interviews and Other Activities

As mentioned before, we conducted some expert interviews with other stakeholders in addition to the interviews with farmers and extension officers. We interviewed a TMA representative, employees from Vodacom Tanzania, and the head of the department of climate change at the UDSM. The interview with the TMA representative was conducted mainly to understand the whole set-up of the FarmSMS system better (see chapter 7 for more detailed information).

The interview with Vodacom was conducted so that we would understand better what kind of technical solutions would be feasible to implement, and what would not. Team members visited Vodacom headquarters in Dar es Salaam to get advice on some of the ideas and findings within the project so far. Vodacom representatives showed positive interest in the project goals, which was key in entering an open dialog, and raising enthusiasm on their side. They expressed the value not only for farmers but for the country as a whole.

Several representatives from Vodacom joined this interview including one infrastructure engineer, one system engineer, and two people from business sales department. The team presented the project as a whole and shared preliminary findings from the field research in the Arusha region (need of audio messages, possibility of a different text-based menu). The team also described the current technical setup used to send the messages, as well as its current shortcomings (delivery success confirmation). Lastly, the team brought up TMA's concern of scaling costs (price per sms). The biggest takeaways involved confirming what was technologically possible; the amount of technical effort required to implement our ideas; and advice on how to manage the current CMS system. Vodacom experts suggested analyzing the possibility of using an existing service in contrast to developing and maintaining the one created by DIT.

The interview with the head of the department of climate change at UDSM gave us some fresh perspective into the context we were exploring. He told us that according to studies about climate change in Tanzania, the total rainfall amounts haven't fallen much, but the real problem is that mid-season dry spells during rainy seasons are becoming more common. These dry spells are hard to predict, and they can be very detrimental to crops; seeds are planted when the rains start, but if there

suddenly is no rain, the crops perish. This increased unpredictability, according to him, means that it would be even more important than before for the farmers to listen to weather forecasts and use them, but people are still set in their old ways and expect the rains to come at the same time as before. He also said that the government is investing in more weather stations, so the weather information is slowly becoming more and more accurate. We discussed about the possibility of creating micro weather stations with small sensors operated and maintained by university students, and about somehow combining indigenous knowledge with modern weather forecasts to increase trust towards the service.

3.4 Solution Proposals

The original challenge requested to come up with innovation mechanisms, service or product to increase resilience of smallholder farmers to climate change. However, after analysing all the information collected, we found it more feasible to provide suggestions for a series of small improvements that could be implemented or studied further instead of concentrating on a single product or service.

Our research demonstrated that considering existing resources within TMA and in the communities and use and availability of technology, a SMS based system is an adequate tool for disseminating agrometeorological information to smallholder farmers, since SMS, even with its limitations, is efficient in reaching wide numbers of people. Therefore, most of our solutions are closely related to improving some of the features in the existing SMS system. However, our conclusion is that a SMS-based system should always be complemented with other mechanisms to make sure that people who cannot benefit from a SMS service are not excluded, and to tackle the limitations related to the shortness of a SMS message and the amount of information possible to enter into it. To come up with solutions and recommendations we used results from the ideation process in Tanzania as a starting

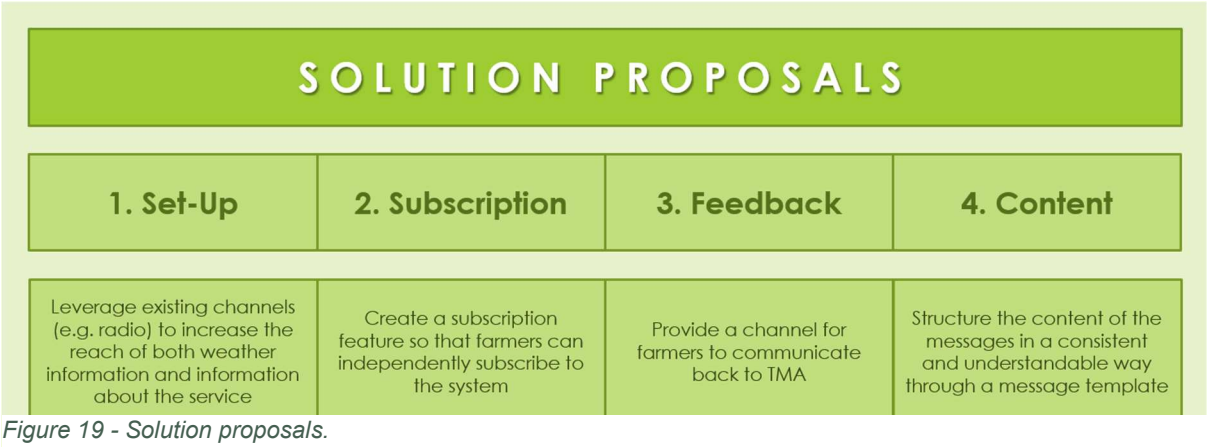

Figure 19 - Solution proposals.

point and narrowed down the ideas into concrete proposals that would be possible to implement with limited resources.

The three problem areas identified – communication, dissemination and trust - functioned as a guiding principle in defining the proposals presented in this chapter. Suggestions that are easy to implement in a short time frame are named solutions. In addition, several recommendations were gathered. Recommendations are issues which would increase the spread and impact of agrometeorological services, yet they would take more time and resources to install or implement, or would require strategic-level decision making within TMA regarding their implementation and collaboration with other stakeholders over which TMA would not have direct influence. Solutions and recommendations are partially overlapping, but they are structured in a way that each of them could be implemented either separately or as a combination with others.

3.4.1 Overall Set-Up of the Service

Currently, the FarmSMS system sends out weather information to farmers and extension officers in the form of SMS messages. On a national level, the usage of the service is very low, since the service is only in its pilot phase. As we described above in our field research findings, trust towards the service among its current users could be higher, and not everyone benefits from the service since some people cannot read or do not speak Swahili. The extension officers are often unable to elaborate on the information in the messages, even though the messages contain a line that encourages users to consult with their local extension officers.

Based on all of our findings, we suggest that TMA continues the development of the FarmSMS system – with certain improvements that will be described below –, but also adds radio stations into the mix. There have been previous projects in other African countries that have combined SMS messaging with radio with good results, and we see no reason why this would not work in Tanzania, too. Radio stations are currently using TMA's weather information for radio forecasts, but there is no other cooperation between TMA and radio stations. The radio could, however, act as a very important player in improving all three of our problem areas: communication, dissemination, and trust.

The reason for picking radio as a supplementary information dissemination channel is that, as we mentioned before, radio is a rather trusted channel among farmers, and a very common technological apparatus even in rural areas. Communication about the FarmSMS service could be improved via radio by advertising the service on radio channels, preferably right before and after

forecasts. There could even be dedicated radio shows for informing people about the service, its benefits, some positive experiences users have had, and about how to subscribe to the service. People who trust information from radio channels would feel more compelled to start using the service if it was recommended on the radio. Moreover, radio shows could be used to disseminate agrometeorological information and agricultural advice to farmers, to overcome the difficulties related to reduced content of SMS message and farmers or even extension officers not knowing what action to take based on weather information they receive.

As TMA cannot possibly send messages in all of the over hundred tribal languages in Tanzania, partnering up with radio channels and providing them with accurate, district- or perhaps village-level weather information would solve issues related to language and illiteracy. People who cannot benefit from the text messages could certainly benefit from the radio forecasts, and they could even be reminded of radio forecasts with short alert messages – either in their own language, or including some visual sign symbolizing the start of a radio forecast.

While radio would provide regional forecasts and agricultural advice to farmers, the FarmSMS messages would still play an important part in individuals' lives. With the subscription features that we suggest in the following chapter, more personalized weather information and agricultural advice could be sent to users. The FarmSMS service could also allow users to send over feedback and questions to TMA, so that farmers would feel like their concerns and opinions were taken into account.

In the long term, as infrastructure in rural areas develops, TMA could explore building a web-based smartphone application for providing farmers with real-time weather information and even more personalized profiles. This is not an option today, since internet coverage is not good in most rural areas, and very few

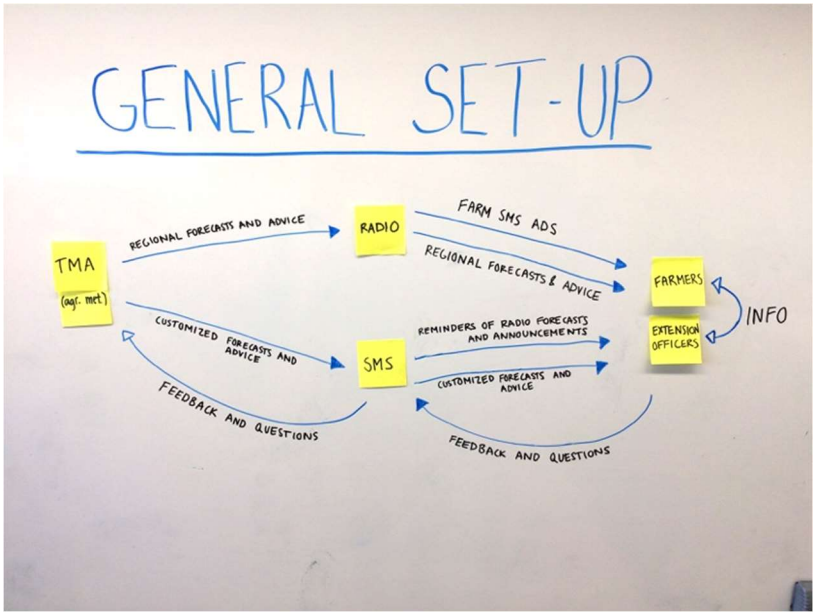

Figure 20 - The overall set-up for the short-term solution.

farmers have smartphones. However, as years go by, these technologies will become more accessible to everyone and at some point, it will make more sense to provide the information mainly via the internet.

3.4.2 Service Subscription

The current FarmSMS pilot does not have a subscription feature. The phone numbers of the people who are currently receiving the messages have been manually added into the database by TMA employees visiting the villages and collecting people's phone numbers on their way. A stated before, it seems that the purpose of this collecting of numbers has not always been clear to all of the farmers; some of the farmers we interviewed reported that they did not really know where the messages were coming from, and that they did not remember signing up to the service in the first place. There is also currently no way to unsubscribe from the service (unless you managed to get someone from TMA to manually delete your number from the database). The advantage of the current approach is that TMA employees know the area to which each collected number belongs – as the numbers come from area-specific lists – so they have been able to send users information about their own regions (albeit not very downscaled, village-specific information).

The earlier version of the FarmSMS system, which was created by a PhD student as study-related project work, had a subscription feature through which people could register by sending a certain code by SMS to a certain number. The trouble with the subscription feature was that the code that needed to be sent was somewhat cryptic – not easy to remember – and it was not visibly advertised anywhere. The codes and numbers were given to the extension officers and local leaders for dissemination, but individual people had no other means of finding out about how to subscribe to the service.

<u>Short-term solution</u>

A short-term solution to the subscription issue would be to set up a feature similar to the one in the earlier version of FarmSMS, but with an easier subscription code, and to advertise the subscription mechanism better. The subscription message should be something that is simple and easy to remember, like "subscribe". The information about how to subscribe – the message content and the number to which it should be sent – should be advertised, for example, on the radio along with FarmSMS-related announcements and weather forecasts. People could also get the information through the Wakalas partnering up with TMA for FarmSMS branding or extension officers.

The problem with this solution is that there would be no way for TMA to know which region the user belongs to, unless users could add their location into the subscription message. This would be somewhat challenging to implement – the system would probably understand only locations included in a specified list, and it would take some effort to effectively communicate to users what these pre-specified locations were. Possible ways to do this would be to disseminate location lists at the partner Wakalas or extension officers, or to establish a helpline that people could call to inquire about their specific area.

If enabling users to provide their location at the time of subscription would prove too hard to implement, there is still one thing that could easily be done with the SMS-based subscription feature: enabling users to specify the type of their farming activities in the subscription message. Our interviews revealed that farmers cultivating crops and farmers keeping livestock have very different kinds of needs for weather information; for example, crop cultivators need information specific to their location, whereas livestock keepers need information of grazing conditions in larger areas. So, livestock keepers could register for information tailored for livestock keeping by sending a message that said, for example, "subscribe livestock". Since there are not that many different farming types (in general), a feature like this would be quite easy to implement. It would also be very straight-forward to inform people of this feature on the radio (vs. instructing people about adding their specific location); radio announcements could simply state to send a message saying "subscribe crops" or "subscribe livestock" to a certain number.

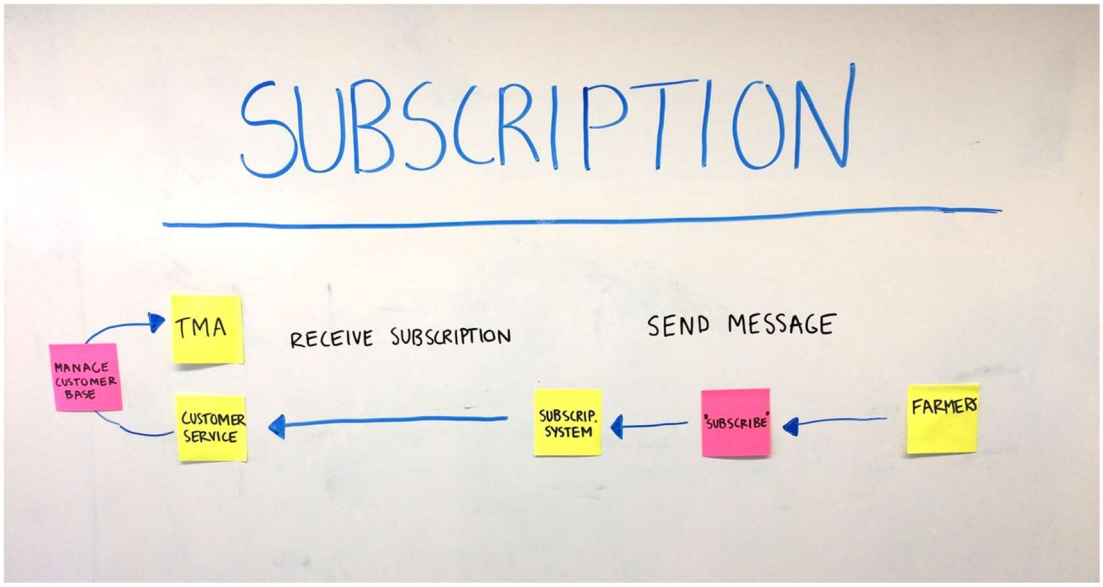

Figure 21 - Structure of the short-term subscription service.

Medium-term solution

A medium to long-term solution that we strongly recommend exploring would be establishing a Unstructured Supplementary Service Data (USSD) quick code system for subscription. The USSD system would make it easy for users to provide information about themselves and their practices, and a personalized profile could be automatically created for each individual user. From a user's point of view, this would mean dialing a certain number to access a text menu with different subscription options. The user would be shown options for selecting their location, the type of farming they do, and any other demographics that would be useful for personalizing the service for each individual. Unlike with the SMS-based option, giving a specific location all the way down to village level would be easy this way; the users could choose from a menu starting with large regions, getting more and more specific with each pick. For example, for the village of Meserani, users could choose "Arusha Region – Monduli – Meserani".

The USSD subscription feature, as appealing as it sounds, is not a short-term option for two main reasons. First, implementing the USSD feature is expensive and takes a lot of time. You need a shortcode number from TCRA – the Tanzania Communications Regulatory Authority – and getting it might take around a year, not to mention that holding a shortcode costs about 2000 US dollars annually. You would also need to either set up a partnership with an aggregator that works with network operators, or set up partnerships directly with all of the major network operators to make the system to work for all users regardless of their operator. Second, you would need a backend system that would be able to generate customized content automatically according to a user's profile, because it would be impossible to write customized messages manually for all of the different geographical areas and farming types. Implementing a system like this would, again, take some time and money. However, the goal of TMA is to increase the subscriber base radically and to that end investing in the automatization of the content generation would be a necessary step to have a fully functional system with decent operational costs.

TMA's goal is to reach as many users as possible, and implementing an easy-to-use subscription feature is key to reaching this goal. The short-term solution is already a good start, and will enable people to take the service into use more easily. Despite the challenges related to the USSD menu, we still recommend looking into implementing it after a more basic subscription feature is in place, because it would significantly enhance the user-friendliness of the service and the applicability of the weather data sent to farmers. This, in turn, would mean a further increase in user numbers. In general, the subscription feature along with personalization options is key to improving the quality of weather

data sent to farmers, and thus, trust towards the service. A subscription feature would also mean that no farmer would wonder where the information is coming from, because they would have signed up for the service completely knowingly. So, communication about the service would also be improved.

Long-term solution

In the long term, as infrastructure around the country improves, we would recommend building a web-based smartphone application for the whole service. This app would, of course, include also a web-based subscription feature with full personalization options. Creating such an application does not make sense yet, though, as internet coverage in rural areas is still low and smartphones are rare.

3.4.3 Feedback Mechanism

The FarmSMS messages are distributed through a system that uses existing phone numbers and the users are theoretically able to reply to the messages. While the system does not have a purpose-built feedback mechanism, there are cases, where a user has replied to the FarmSMS, even if they have been more accidentally or without any follow up on the feedback.

Currently, the system uses one-way communication to provide weather information from TMA to the farmers, but the farmers do not know about the possibility to respond to the information provided. Setting up a feedback mechanism would allow farmers to communicate their concerns relating to FarmSMS to TMA and this two-way communication would increase communication and trust amongst the users. For the farmers, a feedback system could be the first step to bringing a "face" to the service and moving from passively receiving information to a more active role.

In the immediate context, a feedback mechanism could provide valuable information on the service that TMA provides, providing information on accuracy of information, delivery notification and customer satisfaction that could be used to improve the quality of the service. On a long term, a customer service system could be set up, allowing users to engage in direct communication with the service provider.

Short-term solution

The feedback mechanism is crucial to provide basic information about the service in general. Since the system already allows receiving information, the first set-up would be simply to communicate this option to the users. Requirements on TMA side would be to set-up a "customer service" section designated to receive, categorize and summarize the feedback that is received and communicate it

further depending on the type of feedback or to implement changes in the system based on customer feedback. Farmers would need education and information about the existence of the feedback service.

In short-term, the implementation of the feedback mechanism should contain two phases:

Phase 1: The first phase involves little changes to the existing system itself, as the farmers already have the possibility to respond to the messages. We are turning theory into practice. As a first step, the users could be instructed to simply respond to the accuracy of the information by replying with "yes" or "no" to a message sent from FarmSMS. The "customer service" at TMA receives and categorizes this information. Asking for a simple feedback does not only reflect the accuracy of TMA's data but also shows which users are active in the service and where more education regarding the use of the service is necessary.

Phase 2: The first part can be seen as pilot phase to monitor user activity in very simple terms. Once the farmers have been familiarized with the feedback system, the responses could be expanded from a "yes" and "no" to more detailed information. This can include accuracy of information, timeliness, delivery notification, technical problems etc. Taking the illiteracy rates into account, it is possible to create a simple code for the feedback mechanism that is shared with the extension officer or local leader.

Implementing this phase requires that adequate resources are available in TMA to evaluate and interpret the data, as well as to implement the findings obtained through the feedback mechanism. Moreover, farmers might need comprehensive training to make use of the more complex response function.

Example of Feedback Structure – Feedback Message could contain: 1A;2A;3B		
1.	Accurate Weather Forecast	A. Yes B. No
2.	Timeliness of message	A. On time B. Not on time
3.	Advice from FarmSMS	A. Helpful B. Not helpful
4.	Technical Issues	A. Parts of the message is missing B. Last message did not arrive C. Other issues

Figure 22 - Structure of the Feedback Mechanism.

Medium and long-term solutions

In the medium-run, several benefits exist on two-sided communication between TMA and the farmers. While currently only the farmers receive information from TMA, in the future, the farmers could actively produce valuable information for TMA. Two-way communication aims to satisfy both needs, TMAs and the famers'. In addition to providing feedback on the system performance, farmers could be engaged in many ways, for example to providing weather data themselves or comparing modern forecast with indigenous knowledge and communicating the information to TMA.

In the long term, we suggest to steadily improve and increase the responsibilities of the TMA "customer service" to introduce a customer hotline. A phone hotline available for concerns and requests of the farmers, would allow TMA to actively reach out to its customers. Not only farmers would benefit from the phone line, but also extension officers could contact TMA in case they would face difficulties with the service or problems in interpreting the weather information sent to them.

3.4.4 Message Content Template

Currently, the FarmSMS delivers messages that are created manually by employees of TMA's agrometeorological department. In practice, one or several person(s) uses the information from TMA's general forecasting, "downscales" the forecasts into region or district-level information and reduces the content to a size of a text message (e.g. 160 or 305 characters). The information is then typed into messaging system following a structure that includes forecast, advice and impact to the farmers. A separate message needs to be formulated for each district. Needless to say, the manual generation of the message is not only time consuming and requires human resources, but for the responsible employees it is requires also a lot of information management. Clear guidelines on how to construct a message and what the contents should include would increase the consistency of the information sent to the end user and make the information easier to interpret.

One of our findings was that many farmers and also some extension officers found the information in the messages difficult to interpret. Paying attention to the message content and consistency of the messages would improve the trust in the service, since little-by-little, the farmers would learn to interpret the information that comes always in the same format. Moreover, improved content management would lead to better understanding of information needs on the farmers' end, improving communication. Increased trust and accuracy may lead to increased word of mouth publicity and ultimately, wider dissemination of the information.

Short-term solutions

In the short-run, we suggest to establish basic rules for the manual creation of the messages. A message template will help TMA employees to create messages fast and easy. The length of the message is based on SMS size and should not exceed a maximum of 305 characters (equivalent of 2 sms). Creating a template requires no changes in the system itself on a short-term, however it is still advised to incorporate an educational program to the dissemination of the messages. Some farmers still face difficulty to act upon the information due to lack of knowledge and experience with modern weather information.

A message template could look like the following:

Message Information	Description:
1. **Intro & Length of the Forecast**	# of characters: 50-60 The length of the forecast refers to the time the content of the message is estimated to be accurate. The longer the forecast, the higher the degree of uncertainty. In general, the content of the FarmSMS should not be provided for more than seven days.
2. **Date**	# of characters: 8-10 For the template, the date is crucial as it serves as point of reference for the user. E.g. when the message is dated 01/01/18 but only arrives on 28/01/18 the user can personally estimate the accuracy of the text message. Adding the date to the message functions as control mechanism for the users as for TMA alike.
3. **Regional Forecast**	# of characters: 30-70 Adding information about the region/district to the message works as another control mechanism. By integrating more information about the region in the message, the farmers have more ability to estimate the accuracy of the information. E.g. when information about Kilimanjaro region is stated in the message but the farmer is currently positioned in Arusha, he or she can better assess the information.
4. **Rainfall** a) **Amount of Rain*** b) **Probability**	# of characters: 50-60 Through our field research, we learnt that information about rainfall is probably the most important information farmers require for their agricultural purposes. By providing two different information regarding amount and probability of rainfall, farmers can make better decisions for their respective crops or livestock. From TMAs perspective, they help farmers make better decisions without promising rainfall that is not guaranteed to come. *Rain is measured in units of depth per unit time, typically in millimeters per hour. The "depth" being measured is the depth of rainwater that would accumulate on a flat, horizontal surface during a given amount of time, typically an hour. One millimeter of rainfall is the equivalent of one liter of water per square meter.
5. **Temperatures** a) **Highest** b) **Lowest** c) **Avergage**	# of characters: 23-25 Farmers also stated in the interviews that temperatures mattered depending on the stage of the cultivation process. If an average temperature plus max. and minimum is provided, it allows again for better decision making.
6. **Advice/additional Infomartion**	# of characters: max 150 (incl. Thank you note) So far, the "advice" section in the FarmSMS states to contact the extension officer for advice. At the moment, we suggest to remove this advice and either leave it blank or replace it with more concrete information - an option would be to include information about wind or indigenous knowledge. Currently, the role of the extension officer is not entirely clear and helpful for the users (EO often lacks information him/herself). The advice can be picked up at a later point in time.

Figure 23 - Message content template.

A message could thus look like the following:

Figure 24 - An example message with approximately 257 characters.

The content of the message should combine farmer's needs of information and the information available at TMA. Preferred message format and content should be consulted with the end-users even in the short-term solution to provide information that the users find easy to interpret and use. User validation in the simplest form would require few focus group sessions with farmers and extension officers about preferred message format and content, and could be realised with relatively low resources.

Long-term solution

Based on the interviews and workshops we held with end users, we learnt about the diversity of needs the end users have, and how the needs differ from one village to another, or even within the village depending on the type of activity the user dedicates on, educational level, language spoken, technology used and so forth. In the long run, we envision a customized content management system that helps to automatize the content creation and tailor information based on the needs of the individual user. Implementing a USSD menu for subscription would be a step towards segmenting the customers and moving towards more customised content creation. In addition, a back end system discussed in the chapter about subscription feature would be required to fulfil the differing requirements for information.

In the long-haul, a web-based smartphone application for the whole service would facilitate the customer segmentation and content creation. The customized content management is in line with the future subscription function to the service and could also integrate the feedback system. While currently, the messages are generated manually, in the future it is desirable to automate the message creation.

3.5 Recommendations

RECOMMENDATIONS			
1. Wakalas	**2. Extension Officers**	**3. Data Quality**	**4. Partner Up**
Give a "face" to the service; brand the FarmSMS service; increase reputation	Provide sufficient resources to adequately present the service, reinforce existing partnerships to support EOs	Investment in infrastructure e.g. weather stations; downscale info to local levels	Make use of existing networks; evaluate the potential of outsourcing services; allow students to test their skills

Figure 25 - Overview of Recommendations.

3.5.1 Get Inspired from Wakalas

Currently the FarmSMS is faceless. Our research demonstrate that farmers do not often know who is providing the information for FarmSMS. The service provider is not visible for the farmers and is hard to be contacted. Some of the farmers using FarmSMS demonstrate only a little trust to the service, since they do not know from where the messages they receive come from and who sends them. In addition, they do not know whom to ask for help if there is a problem with the service or they would need additional advice regarding the use of the service. TMA is the only entity capable of answering to questions and helping with the problems, but at the moment, no direct channel for communication between farmers and TMA exist.

In Tanzania, people using mobile services are familiar with service agents, called Wakalas, to ask for help and advice with problems related to the services they are using. For example, Tanzanian mobile banking service M-Pesa and all network operators in Tanzania have these service agents, who function with the customer service of the company. These service agents can be found from physical company stores or they can be owners of grocery stores or kiosks, who are just providing services of other companies and are not actually employed by the mobile service providers.

Figure 26 - Wakala shop. Source: https://www.ippmedia.com/en/news/vodacom-pesa-ni-m-pesa

All the agents have a sign "Wakala" on their facade and also a specific sign that shows which service agents they are. An example of the sign could be "Wakala - M-Pesa".

Short-term solution

A short-term recommendation for improving trust and visibility of the FarmSMS service provider would be rebranding extension officers as "FarmSMS Wakalas" of their region. This would mean that the role of extension officers would be communicated to the farmers so that they are representatives of the FarmSMS service, who help with questions related to the service, messages farmers receive and questions about farming practices. This way, trust between FarmSMS and farmers could be created and farmers would have an actual person to turn to, in case there would be need for that. Having FarmSMS Wakalas would also solve the issue that farmers do not understand where the weather information comes from and who is sending it.

In practice, first steps for rebranding would be hanging up "Wakala FarmSMS" signs outside the extension officers' offices. Even though it would be a small change, it would still provide a quick solution to the problem that farmers do not know from where, who or how to ask help with FarmSMS. The sign would also solve the problem of farmers not knowing who sends the information, since there would be an actual person representing the service. Extension officers are already the ones who communicate with TMA about the weather and FarmSMS practicalities, so no new connection between TMA and extension officers would need to be established, but the existing communication should be improved. This would require that more information would be given to extension officers about how FarmSMS works and how to answer to most common questions that farmers usually have about FarmSMS. In a short-term, this could be solved providing extension officers with "FarmSMS Handbook" that would contain the basic information about the service. The handbook could also contain information on the most common weather-related agricultural tips.

The short-term solution is cost-effective, since painting the walls of extension officers' offices or hanging up sings would not be a big investment. Also, writing a handbook about the basic information would be worth the effort, since it would benefit not only the extension officers but also employees of TMA, since it could work as a introduction of the service for employees working with FarmSMS. Distributing the handbook could be done via email for employees and as a print out for extension officers.

Long-term solution

In the long-run, TMA could follow the example of M-Pesa and network operators and partner with kiosks, shops and other actors that already provide their services in the field to have more FarmSMS agents that could help farmers with the service. These new FarmSMS agents could provide the service for subscribing and unsubscribing, and also have the latest information about the weather. Increased number of FarmSMS Wakalas would increase the visibility of the service and dissemination of the information. The main representative of FarmSMS would still be the extension officer, who would possess more knowledge about the actual system and who would advice both the farmers and FarmSMS agents with their questions. Another considerable long term solution would be partnering up with network operators and providing the FarmSMS customer service through them. A long-term recommendation might require a relatively big investment, since FarmSMS agents would need to be given a premium about their services.

3.5.2 Increase Skills of Extension Officers

Extension officers are part of the agricultural extension services based on Tanzania's agricultural policy and coordinated by Local Government Authorities. Extension officers are either government employed or private service providers who work with smallholder farmers and local communities to provide information and advice on agricultural practices. While our previous recommendation explored the possibilities to brand the extension officers as Wakalas for FarmSMS, we understand that TMA does not have a direct control over their work, and such branding could be difficult to implement. However, we do see that the extension officers can have an important role in disseminating information and advice in communities, also related to weather and climate change. Extension officers can both promote the FarmSMS service, and with their additional knowledge and information increase understandability of the messages and how to act upon them, increasing trust.

Based on our field research and interviews, TMA cooperates with extension officers in terms of providing weather information and providing occasional training, but our research indicates that the extension officers would benefit from further training on how to access and interpret meteorological information, and how to advice farmers on utilizing the information for decision-making related to farming and adapting to changing climate. TMA should reinforce existing partnerships with the Agricultural Sector Ministries and Local Government Authorities to ensure that extension officers receive adequate training on agrometeorology and that they have necessary skills to interpret weather information and to provide related advice to smallholder farmers.

Since the government has existing projects that provide further training to extension officers, a possible first step would be to incorporate agrometeorological training and information on FarmSMS to existing and ongoing training processes.

On a long-term a system of cascading trainings could be established in which TMA and agricultural authorities provide training to a determined number of extension officers per region, who could then act as trainers within their respective regions. This would be a medium to long-term activity, which would require financial investment for the trainings, and require applying donor funding for it. However, if the trained extension officers would be then able to replicate the trainings in their own districts using existing meetings or trainings to do so, costs could be reduced.

In addition to providing further tools for existing officers on how advice farmers, awareness should be raised within the farmers about the extension services and the FarmSMS, as well as climate change so that farmers could better benefit from the existing agrometeorological services. It will be especially important to train the local leaders, since, based on the interviews we conducted in the communities, their opinion tends to be significant in adapting new practices amongst the rest of the population.

3.5.3 Tackling Data Quality to Increase Trust

Based on the interviews with the users of the FarmSMS service, inaccuracy of the forecasts was a problem in some areas and observed and perceived lack of trust to the service is a common problem. The inaccuracy of the information may depend on several factors: The weather stations of TMA are few and sparsely located, and gap areas in which the accuracy of the forecasts is relatively low may exist. In the northern Arusha region the presence of mountains generates a series of micro-climates making the forecasting more difficult, and in the plains exact forecasting is also deemed difficult. Capability and existing resources within TMA might not be sufficient to provide good quality long-term downscaled forecasts to all of the districts of the country, especially since 10-day and seasonal forecasts are prone to uncertainties to begin with.

It is out of the scope of this study to assess the data collection and processing practices of TMA, or to evaluate whether and how they could be improved. Ongoing projects to improve the quality of weather information seems to exist, for example a joint project with Global Environmental Facility, UNDP and Tanzanian Government to improve the quality of weather information and early warning systems, including installation of new weather stations. Thus, it can be thought that the accuracy of

forecasts will improve in the future at the same rate than TMA is able to invest in its current information collection and processing systems. Having noted that this area is basically out of the scope of this study, a few recommendations are to improve the data quality and understandability are introduced for further consideration.

Short-term solutions

On a short term, TMA could analyse the quality of the district-level forecasts: does the existing weather station network allow to provide better quality downscaled forecasts in some areas compared to others? Explore the possibility to start expanding the FarmSMS pilot in the districts where the quality of forecasts is estimated to be better.

To take a step further, inspiration could be sought from crowdsourcing applications that use weather information collected by people to generate or fine-tune weather information. Communities could collect weather information with basic rain gauges and thermometers and send it to TMA. This information could be then compared with the information provided by TMA to increase both the accuracy of the data and trust. TMA can revise internal data processing practices if noted that problems with accuracy over certain areas are constant.

The weather information collection system can be set up in different ways, but may include, for example: the use of basic rain gauges and thermometers to collect information manually, bookkeeping by hand or cellular phone. The results can be sent to TMA through FarmSMS feedback system, or through a separate data collection system, which may still be SMS-based. This crowdsourcing system can be combined with local indigenous knowledge comparing the results: what did the indigenous signs suggest? What was the weather like? The solution in its simplest form would be relatively low cost, but would require investment in basic meteorological equipment, require human resources at TMA to process the information, and training for farmers at local level to collect, interpret and send the information.

Long-term solutions

On long-term, the information from the communities or villages could be collected with the use of more automated sensors that use basic technology and solar energy to collect and restore information, that may be automatically or manually sent to TMA. Even more so, when smart phones and internet start to penetrate rural areas, web-based smart phone applications could be used to collect and send the information. While introducing this kind of ways to collect weather information

would require more investigation and investment to necessary technology, many start-up companies use crowdsourcing methods to generate weather information and their experiences could be studied to develop the idea further. Crowdsourcing of weather information could be turned into a a student project or a cooperation project with the university to either create completely new monitoring devices or to experiment with existing solutions. Introducing a system like this would require investment in equipment, training for the maintenance of the stations, and personnel at the central level to process the information.

3.5.4 Partner with Existing Initiatives

So far, our solutions and recommendations have mainly tackled improving the existing FarmSMS service. On way to lessen the administrative and operational burden of an in-house service with aim is to reach a massive user base in the future would be partnering with an existing agricultural information service to provide weather information to smallholder farmers. Our background research indicates that such services exist in many developing countries, and trials and pilot projects have been implemented in Tanzania by different actors.

The basic idea behind such collaboration would be to improve communication and dissemination of information to farmers. A service provider (that can be an independent company or a network operator) would provide information relevant to smallholder farmers such as information about the markets, finance, and advice on agricultural practices while TMA would be responsible of providing weather information. The user would sign up or access the service through a single USSD menu and would not need to access many different services or remember several numbers.

While we are aware that initiatives in which TMA has been responsible of the weather information have been implemented in the past, the research does not provide indication on the prevailing roles between TMA and the service provider in such settings. TMA could either sell the weather information for the service provider or start developing the service in partnership with such an actor to jointly improve the service and engaging in joint action to promote the service. Agricultural information services are still a new concept, and a business case for them has proven difficult to establish (see chapter 5). Thus, there might not exist a real business case for selling the weather information for such purposes, yet, partnering for such a service might help to reduce costs for both TMA and the agricultural information provider.

Benefits from a joint service would be the presumed interest to farmer to receive all relevant information through a single channel or service, and subsequent increase in the user base. Joint efforts to promote the service could help to disseminate information about the service and facilitate the subscription of farmers. If the partner would be a network operator, existing channels, such as Wakalas, could be used to promote the service.

Setting up a partnership would require, of course, clear agreements on how to divide costs and benefits of the service, whether the service would have a cost to the end user, and if not, how should it be maintained. While this kind of a partnership could help to reduce some of the technological and financial burden to TMA, investment would be required to establishing the partnership and suitable technology, marketing the service, and covering costs of the service (human resources, price of the message) in case the business model would not generate profit as yet. Finally, a careful analysis should be made on why such initiatives have failed in the past to avoid repeating past mistakes or falling into past problems.

A step in between establishing a joint service with an agricultural service provider and having an in-house solution would be to find ways in which to partner with existing network operators to disseminate information with lower cost and to improve the coverage of FarmSMS.

3.5.5 Partner with Universities

Through our brief and based on the interviews with TMA, we understood that a limited budget is a constraint that affects the choice of technology for FarmSMS and for other initiatives conducted by TMA. Basically, development of new technology or the operation should not incur any significant costs. Many of our solutions and recommendations require at least some level of investment in technology, training, or human resources and they all have either direct or indirect costs.

One way to reduce these costs, or costs related to research and training, would be to establish partnerships with institutions sharing interest in similar themes. A natural step would be to continue working with universities and university students to develop existing technologies and services further, related to both technology itself and to the adaptation and use of such technologies.

FarmSMS itself is an outcome of a series of student projects. Examples of future projects could include students experimenting with suitable technology or models for crowdsourcing of weather

information, or university students providing training or training manuals on the effects of climate change and how to interpret weather information or act upon it. Just to name a few.

A long-term approach to cooperation with a University would be to move from single student projects into programmes that last for longer periods and in which new groups of students continue to work with a challenge initiated by previous student groups. This would help to overcome the challenge that student projects tend to be limited in time and scope. Future student groups could, for example, take further some of the ideas presented in this document.

The solution or recommendations should be supported by the information provided in above chapters. Crossing the information from what the users wish and what is possible from the client perspective. The solution needs a solid sustainability argumentation.

DISCUSSION

4. Discussion

The proposed solutions and recommendations have been derived in accordance with our framework the Communication-Dissemination-Trust (CDT) triangle. In the initial ideation process, we intended to assess, besides the free-of-charge approach, also means to commercially disseminate climate information. This includes partnering up with existing service providers. After consulting with a private service provider operating in Tanzania, whose service range includes weather information, we learnt that the cooperation with governmental institutions in Tanzania has been challenging in the past. For the scope of the project, we decided to focus only on a free-of-charge approach.

4.1 Assessment of our Solution Proposals and Recommendations

Through our initial research and the interview process, it became clear that the existing system used by TMA, the FarmSMS, has the potential for providing weather information to smallholder farmers on a larger scale. For that reason, our solution proposals focus on how to improve the current system in place. One issue, which was particularly emphasized by TMA, was the cost factor of the project. Ideally, the solution proposals should not result in any additional expenses for the client. Besides enhancing one or more of our defined problem areas (of the CDT triangle), our proposals stress the financial feasibility. That said, it should be pointed that the above mentioned proposals are based on low-cost implementation, however, labor and maintenance make an entirely "no-cost" solution unrealistic.

The solutions are divided into short-term actions and long-term views. The short-term actions are easily implementable and focus more on technical improvements of the current FarmSMS system (e.g. adding a subscription or feedback mechanism). While those little enhancements can make a vast impact on the overall CDT triangle, the solutions do not involve large financial investments for TMA. The short-term actions pave the way towards addressing the challenge holistically.

The implementation of our solution proposals can be seen as an ongoing learning process, where little improvements accumulate the potential for a positive impact. Therefore, our long-term proposals cannot be viewed separately from the short-term actions. While the short-term actions focus on technical improvements, the aim of the long-term proposal is to address the CDT triangle from a wider perspective. By partnering up with existing service providers, consulting expert in the field of agriculture or further investing in university cooperation, the number of expansion opportunities are limitless. The long-term proposals as well as our recommendations call for an open-

minded way to deal with the complex challenge that affects a majority of Tanzanian farmers. While creating synergies with potential stakeholder, we face the problem of coordinating a growing network with partners that possibly pursue different interests.

At this point, the question of responsibility for the project coordination should be raised. While some of the long-term proposal can be implemented within a division of TMA (e.g. tracking and evaluating feedback), some recommendations may exceed TMA's area of responsibility (e.g. training the extension officers). We suggest a more detailed analysis about the role division for the implementation of our long-term proposals.

Our research report exhibits the complexity of the challenge at hand. Lastly, we would like to remind that the dissemination of weather and climate information is only one method to increase the resilience of smallholder farmers. In order to address the challenge sustainably, we encourage to further investigate into other methods and seek for possible synergies to keep the learning process flowing.

4.2 Limitations

When providing solution proposals, it is important to analyze the feasibility of completing them. In this section, limitations and challenges are discussed in order to determine how best to overcome them. Also for a follow-up project, we recommend to conduct further research based on the subsequent limitations. Significant factors, which we perceived as obstacles during the project, are related to culture and language barrier, scope and timeframe of the project and communication with the client.

In regard to cultural and language barrier, the most dominant challenge is the communication in English, which is for all involved parties not the native language. During the interview process, the Tanzanian students functioned as translator between interviewees and Aalto students. Translating a conversation always involves a risk of missing some part of the information. To maximize the validity of the information, each team summarized and presented their findings to our student group, which allowed us to clarify potential misunderstandings and contradictions.

Another limitation to the project is its scope and timeframe. Through staggered visits (Minna's preparatory week before the arrival of the full team), we were able maximized our short time in

Tanzania. However, as described above, the challenge provided by the client is extremely complex. It is not possible to fix the issue with a linear solution approach nor is three months sufficient time to meet the needs of this challenge. Our work can be seen as initial field research, but the current results have their limits. One example is improvement of the FarmSMS content. In order to positively affect the problem areas of the CDT triangle, potential content templates require testing with the end users, which is applicable for all other solution proposals (e.g. subscription, feedback etc.).

Lastly, in our research we focused particularly on understanding the needs of the end users (the farmers). While this process took up an extensive part of our field research, we were not able to interview the management of TMA. As we promote a two-way communication, it is crucial to gain more thorough insights into the driving motivation of TMA in pursuing the FarmSMS project. Except for the request for a "no-cost" solutions, we currently know little to nothing about the financial capabilities and internal structures, long-term strategies to follow-up with the current project.

4.2 Future Research

After evaluating the limitation to this research, we suggest that the subsequent fields should be addressed in follow-up projects.

1. Identification of motivation and interests of TMT towards the FarmSMS project
2. Analysis of roles and responsibilities of TMA in the future of the project
3. Piloting and testing the solution proposals and alteration based on users' needs
4. Alternative dissemination models (potentially commercial use)

CONCLUSION

5. Conclusion

TMA's ongoing challenge is to improve farms uptake by leveraging the use of their weather data and technology infrastructure. This research project took a user-centered design approach to analyzing farmers' needs as well as the FarmSMS pilot in its latest form.

Initial meetings with TMA pointed at the importance on financial cost of the current system and suggested to find a technological solution that would both sustain the growth of users of the system as well as requiring a near-zero financial cost. The team used design thinking activities before, during, and after the field research trip to better understand the farmers as well as their context. Through those activities many issues were uncovered which pointed at different aspects that need to be addressed before any user growth can happen. Most notably, this report suggest to think of the challenge in 3 main areas: Dissemination, referring to the ability to reach a high amount of people; Communication, the content value of the message as well as its presentation; and Trust, building confidence amongst the users towards the information being provided.

Another key finding during the research was the importance of key stakeholders involved in the process. As a point of comparison, the information found regarding the first pilot of FarmSMS in 2010 differs in some ways from the practices observed at the time of this research in 2018. Currently, most of the work is performed by TMA remotely, extensions officers expressed low support from TMA regarding training to interpret messages or providing supporting resources; this contrast the description of the 2010 pilot where constant feedback and follow up was given to several stakeholders.

This research suggests it is necessary to look at this challenge from a different perspective. The system as-is, even with a zero-cost infrastructure, may not be able to reach the user growth TMA is seeking. User growth can be obtained as long as the 3 points above are addressed through careful implementation of the suggested actions such as opening a channel for users to subscribe, allowing users of the system to provide feedback, using guidelines when phrasing the messages, and more. This report details these actions in the short, mid and long term, as well as general recommendations to move forward.

The need for this information from the farmers was confirmed, and interviews showed positive opinion from farmers about the intention behind the project. This research report outlined the

positive effects of working towards a comprehensive solution outside just technology infrastructure. By considering the areas defined above and making strategic decisions based on them, the team is confident that the challenge proposed by TMA can be achieved.

References

Aalto Global Impact. (2018) *PBL East Africa.* [online] Available at: http://aaltoglobalimpact.org/pbl-east-africa/ [Accessed 9 Apr. 2018]

Anderson, J., Collins, M., and Musiime, D. (2016). *National Survey and Segmentation of Smallholder Households in Tanzania*. CGAP. [online]. Available at: http://www.cgap.org/publications/national-survey-and-segmentation-smallholder-households-tanzania, [Accessed 30 Jan. 2018]

Andersson, M., Hjalmarsson, A. and Avital, M. (2013). *Peer-to-peer service sharing platforms: Driving share and share alike on a mass-scale,* International Conference on Information Systems, 4(Gawer 2009), pp. 2964–2978. [online]. doi: f8081dfb-afd8-4021-9940-e89f8e9c3939. [Accessed 30 Jan. 2018]

BBC. 2018. *Dar es Salaam Weather*. [online]. Available at: https://www.bbc.com/weather/160263. [Accessed 10 April 2018].

CIA, (n.d.). *The World Factbook - Tanzania*. [map, online]. Available at: https://www.cia.gov/library/publications/the-world-factbook/geos/tz.html, [accessed 10 Apr. 2018]

Dusabe, J. *et al.* (2013). *Design of a community-based mobile phone text message referral intervention in Tanzania*, Journal of Telemedicine and Telecare, 19(5), pp. 295–297. [online]. doi: 10.1177/1357633X13492291, [Accessed 30 Jan. 2018]

GSMA. (2015). *Tigo Kilimo – Impact Evaluation*. [online]. Available at: https://www.gsma.com/mobilefordevelopment/programme/magri/assessing-the-impact-of-tigo-kilimo/, [Accessed 30 Jan. 2018]

GSMA. (2016). *Weather Forecasting and Monitoring: Mobile Solutions for Climate Resilience.* [online]. Available at: https://www.gsma.com/mobilefordevelopment/wp-content/uploads/2016/02/GSMA_mAgri_Weather_forecasting_and_monitoring_mobile_solutions_for_climate_resilience.pdf, [Accessed 30 Jan. 2018]

ISO 9241-210. 2010 Ergonomics of human-system interaction. Part 210: Human-centred design for interactive systems. Switzerland: International Organization for Standardization. 32 s.

Hofstede Insights, 2018. *What about Tanzania?.* [online]. Available at: https://www.hofstede-insights.com/country/tanzania/, [Accessed 09 Apr. 2018].

Kimaro, H., Mukandiwa, L., and Mario, E. Z. J. (2010). Towards Improving Agricultural Extension Service Delivery in the SADC Region. In *Workshop on Information Sharing among Extension Players in the SADC Region*. Tanzania: Dar Es Salaam

Lwoga, E. T., Ngulube, P., Stilwell, C. (2011). *Access and use of agricultural information and knowledge in Tanzania.* Library Review, Vol. 60 Issue: 5, pp. 383-395. [online]. Available at: https://doi.org/10.1108/00242531111135263, [Accessed 30 Jan. 2018]

Makoye, K. (2013). *SMS weather advice cushions Tanzanian farmers from drought*. [online] Thomson Reuter Foundation News. Available at: http://news.trust.org//item/20131104120841-2fm9a [Accessed 1 Apr. 2018].

National Bureau of Statistics. (2014). *Tanzania National Household and Budget Survey 2011/2012.* [online]. Available at: http://www.nbs.go.tz/nbstz/index.php/english/statistics-by-subject/household-budget-survey-hbs [Accessed 06 Apr. 2018]

National Bureau of Statistics. (2016a). *Annual Agricultural Sample Survey Report 2014/2015.* [online]. Available at: http://www.nbs.go.tz/nbs/takwimu/Agriculture/Annual_Agricultural_Sample_Survey_Report2014_15.pdf, [Accessed 29 Jan. 2018]

National Bureau of Statistics. (2016b). *National Accounts of Tanzania Mainland 2007-2015.* [online]. Available at: http://www.nbs.go.tz/nbs/takwimu/na/National_Accounts_of_Tanzania_Mainland_Publication_2015.pdf, [Accessed 29 Jan. 2018]

National Bureau of Statistics. (2017). *Tanzania in figures 2016.* [online]. Available at: http://www.nbs.go.tz/, [Accessed 27 Mar. 2018]

NEPAD. (2013). *African agriculture, transformation and outlook.* [online] Available at: http://www.un.org/en/africa/osaa/pdf/pubs/2013africanagricultures.pdf [Accessed 27 Jan. 2018].

Stork, C., Calandro, E. and Gillwald, A. (2013) *'Internet going mobile: internet access and use in 11 African countries'*, Info, 15(5), pp. 34–51. [online]. doi: 10.1108/info-05-2013-0026, [Accessed 1 Apr. 2018]

Sullivan, B. (2011). *The new age of radio: How ICTs are changing rural radio in Africa*. [ebook] African Farm Radio Research Initiative. Available at: http://farmradio.wpengine.netdna-cdn.com/wp-content/uploads/farmradio-ictreport2011.pdf [Accessed 1 Apr. 2018]

Paavola, J. (2008). Livelihoods, adaptation and vulnerability to Climate Change. *Environmental Science and Policy*, 11, pp. 642-654

Rowhani, P., Lobell, B.D., Linderman, M. and Ramankytty, N. (2010). Climate Variability and Crop Cultivation in Tanzania. *Agricultural and forest meteorology,* 151, pp. 449-460

Tall, A. (2012). Identifying Good Practice in the Provision of Climate Services for Farmers in Africa and South Asia. *Background paper for the workshop: Scaling Up Climate Services for Farmers in Africa and South Asia*, [pdf] Dakar: CCAFS/ICRISAT. Available at: http://scalingup.iri.columbia.edu/uploads/1/5/8/6/15865360/white_paper_good_practices_in_scaling_up_climate_services_for_farmers.pdf [Accessed 1 Apr. 2018].

UN OSSA. (n.d.) *Comprehensive Africa Agriculture Development Programme (CAADP).* [Online] Available at: http://www.un.org/en/africa/osaa/peace/caadp.shtml, [Accessed 27 Jan. 2018].

United Nations. (2017). *Goal 13: Climate Action.* [Online] Available at: http://www.un.org/sustainabledevelopment/climate-change-2/ , [Accessed 29 Jan. 2018].

United Nations. (2017). *Goal 2: Zero Hunger.* [Online] Available at: http://www.un.org/sustainabledevelopment/hunger/, [Accessed 29 Jan. 2018].

Wikipedia. (2018). *Geography of Tanzania.* [online]. Available at: https://en.wikipedia.org/wiki/Geography_of_Tanzania, [Accessed 10 Apr. 2018]

World Bank. (n.d.). *The Climate Change Knowledge Portal – Tanzania.* Available at: http://sdwebx.worldbank.org/climateportal/index.cfm?page=country_historical_climate&ThisCCode=TZA, [Accessed 10 Apr. 2018]

World Bank. (2015). *Increasing agricultural production and resilience through improved agrometeorological services.* World Bank Group report number 94486-GLB, Washington DC: World Bank Group

World Bank. (2016). *World development Indicators.* [Database]. Available at: http://databank.worldbank.org/data/reports.aspx?source=world-development-indicators, [Accessed 26 Mar. 2018]

World Bank. (2017). *Implementation, Completion and Results Report for an Agricultural Sector Project in Tanzania*. Report No: ICR00004131. [online]. Available at: http://documents.worldbank.org/curated/en/629091493843984944/pdf/ICR00004131-04052017.pdf, [Accessed 10 Apr. 2018]

Appendix

A. Learnings and challenges

The learning outcomes from the project are wide. We have learned about what is it like to work as a part of an international team and how to coordinate projects across countries. International teamwork has also taught us how cultural differences affect teamwork and how to overcome the challenges related to them. We have also learned about communication, best practices for it and also the worst practices. Through the actual project work, we have learned how to utilize our problem-solving skills even better, and also how to exploit knowledge from User-Centered design methods in sustainable development thinking. We have also learned how to include different stakeholders into design thinking process and how to advantage their knowledge most efficiently. Interviewing, ideation and analyzing methods have also become extremely familiar, which will definitely be useful in the future.

There were also some challenge during the project, from which most of them somehow related to communication. Already while being in Finland, we had some communication problems with the client, the Tanzanian team and also among our group. This was mostly because of the different ways of working and because of cultural differences. We also encountered some challenges with hierarchy structures present in Tanzania, which was affecting the practical arrangements of the overall course and the field trip too. In addition, there were some challenges with assignment of responsibilities, which were mostly because of the communication problems.

B. Problem Based Learning East Africa

PBL East Africa is a joint initiative between University of Dar es Salaam, University of Nairobi, Makerere University and Aalto University. Taking place in 2017–2020, the project engages faculty, students and external partners in the four countries to work on sustainable innovation challenges in East Africa. As a whole, the project operates as a piloting platform for the universities to test, share and refine best practices in problem-based education – while also building regional and global networks in an effort to share knowledge and deepen innovation capabilities in East Africa and beyond. (Aalto Global Impact, 2018)

C. Interview questions for farmers and extension officers

Background information

- To what farming activities you dedicate to?
- What crops do you plant? How much land are you using?
- Do you produce for your own consumption or for selling? How big proportion are you selling?
- Are you working on the farm field yourself or do you have paid workers?
- Have you had good yields during the recent seasons? Yes/no, why?
- What do you think are the biggest risks or factors that difficult the farming activities?
- How do you get information that are needed for the farming activities? Through which channels? (eg. discuss with neighbours, extension officers, radio, internet, etc.)
- How do you define when to plant and what crops?

Weather & Farming

- How does the weather affect your farming practices?
- How do you predict the best timing for planting or harvesting?
- Have you observed changes in the seasonal variations of weather in recent years? if yes, what kind of changes?
- Can you think ways in which weather information would be useful to you? What kind of weather information would be useful to you?
- Have you received weather information or forecasts? From where? Has this information been accurate? Have you used it to make decisions on agricultural practices?
- What would be the best way to receive the weather forecasts?
- Do you communicate with other farmers about the weather? How do you communicate with them?

FarmSMS

- Have you subscribed to FarmSMS and have you received messages from it?
- When was the last time you received a message from FarmSMS?
- What was the content of the message?
- Why did you decided to start using FarmSMS?
- How did you subscribe to the FarmSMS service?
- Is the information that FarmSMS provides useful? How?
- Do you trust the information that FarmSMS provides? Yes/no? Why not?
- Would you recommend FarmSMS to other farmers?
- Has FarmSMS changed your farming practices somehow? How? Mention examples.
- What would you change in FarmSMS?
- Is there something that you would like to change in the message content?
- Is the message format easy to understand? (note: are the messages too long, divided for 1,2,3 messages)
- What would be barriers for using FarmSMS? (for example: are the messages too long, wrong language, died battery)
- Would you be willing to pay for the FarmSMS text messages? No: Why?
- Would you rather have a system that sends you periodical weather information automatically or would you wish to order the information when you need it?

Use of technology

- Do you have a mobile phone? To what activities you use it (calls, sending sms, sms services - which services?)
- Do you have a smartphone? To what activities you use it?
- Do you have access to internet? How often can you access internet? How do you access internet? (phone, computer, etc)?