UNIVERSITY OF COPENHAGEN - FACULTY OF SCIENCE

& ROSKILDE UNIVERSITY

IRRIGATION IN KITHIRIA

– IMPACT ON LIVELIHOODS –

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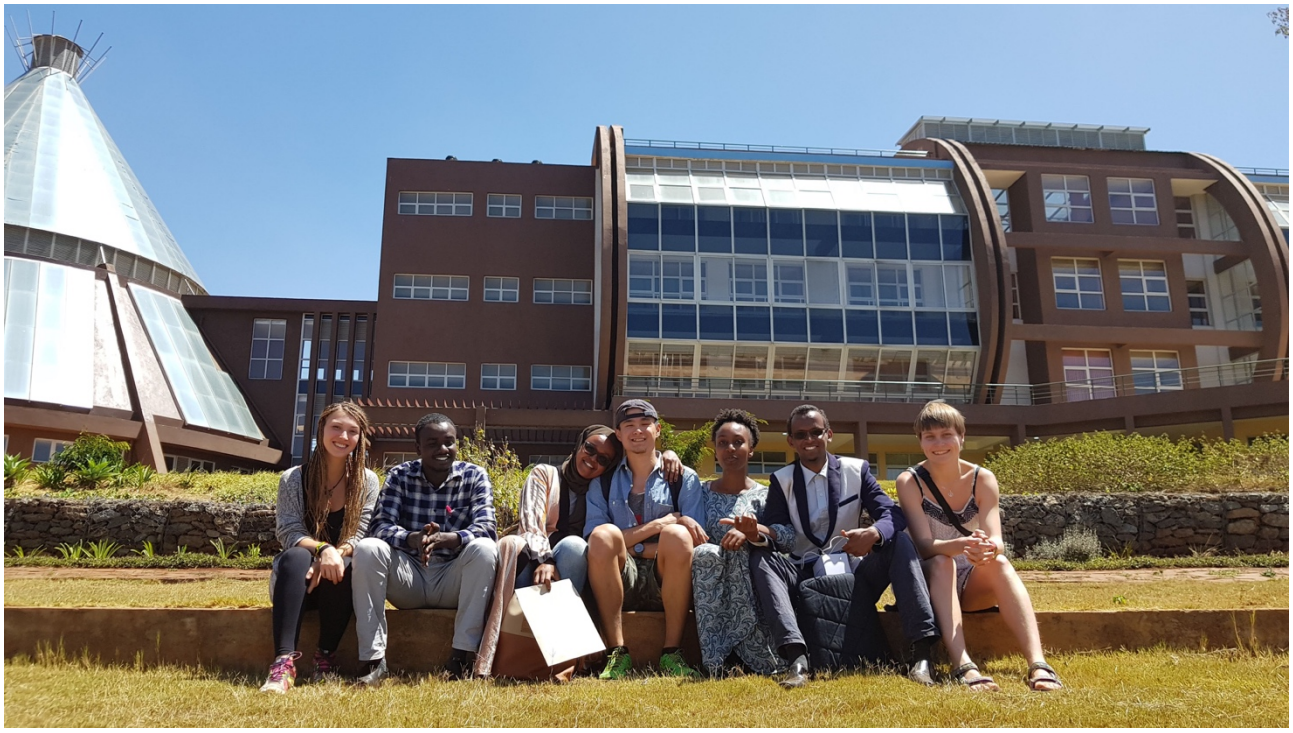

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Abstract

Applying the sustainable livelihood framework, we carried out research on the Kii-Kithiria irrigation scheme to investigate how it has influenced the livelihood outcomes of its members. We found that members benefit from the irrigation by being able to grow horticulture, and through increasing their income, water availability, free time and engagement in livestock. Soil samples have shown that the natural resource base is sustained in terms of soil fertility. Our data reflects that members of the scheme are mainly involved in agricultural activities, such as irrigated farming, non-irrigated farming and livestock. It was difficult to find correlations between their capitals and different intensities of engagement in horticultural farming. Institutions and organisations hinder the development of horticultural farming to some extent, through lack of: funds, extension services and cooperation. Market access has proven to be a significant limiting factor for intensifying horticultural production. All in all, the influence of the Kii-Kithiria irrigation scheme on its members' livelihoods is complex and multifarious.

Acknowledgement

The field-based part of the course was a collaboration between the Wangari Maathai Institute for Peace and Environmental Studies at University of Nairobi, Roskilde University and University of Copenhagen. The inputs and efforts of lecturers from the Wangari Maathai Institute, University of Copenhagen and Roskilde University are highly appreciated. This field work and design of the project was collaboratively done by students from University of Nairobi, University of Copenhagen and Roskilde University. Villagers of the Kibugu location, Embu county hosted the students and freely contributed to the information in this report through several interviews and informal communications. Their contribution is acknowledged and much appreciated. We are grateful to the chief and the community leaders in Kibugu location for logistical support in the implementation of the training. We are grateful and appreciative of our host families, Muteithia, Njue Njeru and Loise, our guides Carol and Peter, and elder Jason Kathuri, whose help and support throughout the fieldwork was invaluable.

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Abbreviation

AQD	All questionnaire data
AQN	All questionnaire notes
CDF	Constituencies Development
EC	Electrical Conductivity
FGD	Focus Group Discussion
IC	Informal conservation
KI(no.)	Key Informant - 1 committee - 2 agricultural officer - 3 irrigation officer - 4 key person in establishing the irrigation scheme - 5 Interpreter/guide - 6 chairman of the scheme /elder
KSH	Kenyan Shillings
MWI	Ministry of Water and Irrigation
NGO	Non-Governmental Organisation
O	Observation
PO	Participant Observation
PRA(no.)	Participatory Rural Appraisal - 1 Venn diagram - 2 SWOT
SLF	Sustainable Livelihood Framework
SI	Smallholder Irrigation
SSI	Semi-Structures Interview
SWOT	Strengths, Weaknesses, Opportunities and Threats Workshops
QD(no.)	Questionnaire Data (survey no.)
WASREB	Water Services Regulatory Board
WRMA	Water Resources Management Authority
WRUA	Water Resource User Associations
WSB	Water Service Boards
WSP	Water Service Providers

Introduction

Kenya, classified as a food deficit country (KIPPRA, 2018), experiences a continued increase in population. This stresses the need for an increment in food production in order to feed the current 50 million people (Mendes & Paglietti, 2015; Worldometers.info, 2019). Agriculture is a main economic driver in Kenya (Mendes & Paglietti, 2015; WFP, 2018) with 75 % of agricultural output sourced from smallholders, whose average land sizes is one hectare (Mendes & Paglietti, 2015; WFP, 2018). Nevertheless, the production of staple food crops are below optimal yields (KIPPRA, 2018) which calls for an increase in efficiency.

Kenya is among the countries that are most likely to be negatively impacted by climate change, which threatens the agricultural production and makes people vulnerable to food insecurity (FAO, 2017; Godfray & Garnett, 2014). 98% of Kenya's agricultural systems are rain-fed and highly susceptible to climate change (Kenya Climate Smart Agriculture Strategy 2017-2026, 2017). Current estimates indicate that approximately 30 percent of all greenhouse gas emissions come from food production and land conversion (Godfray & Garnett, 2014). In order to increase food production with a minimum contribution to climate change, it is argued that future increases must come from agricultural intensification rather than agricultural extensification (Godfray & Garnett, 2014; Schultz et al., 2005).

One approach to intensification is represented by irrigation practices (Mati et al., 2011). The most common irrigation system in rural Kenya is smallholder irrigation (SI), which refers to irrigation activities carried out by smallholder farmers who manage individual plots or are part of a community managed irrigation scheme (Nakawuka et al., 2018). The SI is mainly used for horticultural, floricultural and rice crops, and for the past decades, SI in Kenya has increased significantly with the initiatives from individual farmers and support from non-governmental organisation (Nakawuka et al., 2018).

Previous research on SI have been substantially carried out in Sub-Saharan Africa. These researches mainly focus on the outcomes, constraints and opportunities of SI. Findings in outcomes of SI include poverty reduction, enhanced food security, improved livelihoods, and enhanced resilience to climate change (Sikhulumile et al., 2014; Zeweld et al., 2015). Constraints and challenges of SI are analysed in detail. Findings suggest that SI is highly unsustainable in Sub-Saharan African area due to the presence of numerous constraints in finance, governance, market, land issues, infrastructure, access to inputs etc. (Franks et al., 2013; Nakawuka et al., 2018; Mati 2008; Mutambara et al., 2016). Especially for Kenya, SI is confronted with a marketing problem, water shortage and poor management (Mati 2008; Kinyuaet al.,2015).

According to Scoones (2005), in order to understand the complex and dynamic processes related to livelihoods, all the different factors that play in their formation should be investigated. In order to support the current literature, we apply the Sustainable Livelihood Framework (SLF) so as to capture the outcomes of SI, and also to explore the dynamic processes involved. We will, in addition, investigate the influence of the SI on soil fertility, as previous research have shown that irrigation can have a negative influence on soil fertility through erosion, salinisation, alkalisation and so on (Caretta et al., 2018; Sumner, 1993).

Research Objective

This project aims at understanding the impacts of the Kii-Kithiria irrigation scheme on the members' livelihood outcomes, measured in well-being and soil fertility. In order to do this, we will apply the SLF to capture the correlations between capitals and engagement in the irrigation scheme. We will also put emphasis on how this engagement is influenced by institutions and organisations.

Research Questions

What are the impacts of the Kii-Kithiria irrigation scheme on members' livelihood outcomes?

1. What kind of livelihood strategies are pursued among the members' of the irrigation scheme?
2. How do capitals shape the livelihood strategies of the members in the irrigation scheme?
3. How do institutions and organizations, involved in the irrigation scheme, shape the livelihood strategies of the members?
4. What are the outcomes of the irrigation scheme on livelihoods?
    a. How does the irrigation scheme have an impact on wellbeing?
    b. How does the irrigation scheme have an impact on soil fertility?

Background Information

Kii-Kithiria Irrigation

Our research was carried out in Kithiria, Kibugu, Embu county, and concerned the Kii-Kithiria Irrigation scheme (from now referred to as the irrigation scheme). The scheme was founded in 1993 by the community (KI1). Our sources (KI1; KI4; FGD) explain that the need for irrigation was due to a prolonged drought and food insecurity. It would in addition provide the potential to increase income and grow horticulture. For the purpose of our project we define horticultural crops as vegetables, fruits, and flowers which are characterised as highly perishable and seasonal (Mingochi, 1998). Furthermore, water is essential to the quality of horticultural crops (Janick, 2015).

The irrigations scheme used furrows in its first stage, dug by community members (KI1). With support from a politician rooted in the area, the project received KSH 1,2 million funding from the Constituencies Development Fund (CDF) in 2005 for purchasing pipes (KI1; KI4). The irrigation scheme uses water from the Kii river, deriving from Mt. Kenya. The irrigation system relies on gravity, and therefore, only households located downhills of the river can receive the water (KI1). There is one main pipe from the intake that later is divided into two pipes connected to two households. From there, water connections are achieved via pipes between these two households and their neighbouring households until all the households located downhill are connected (KI5). According to the irrigation scheme committee (from now on referred to as the committee; KI1), all of the houses that can be connected downward of the river are connected. At present, the number of households connected is 60 of which 40 are said to be active members who pay the monthly fee of KSH 100.

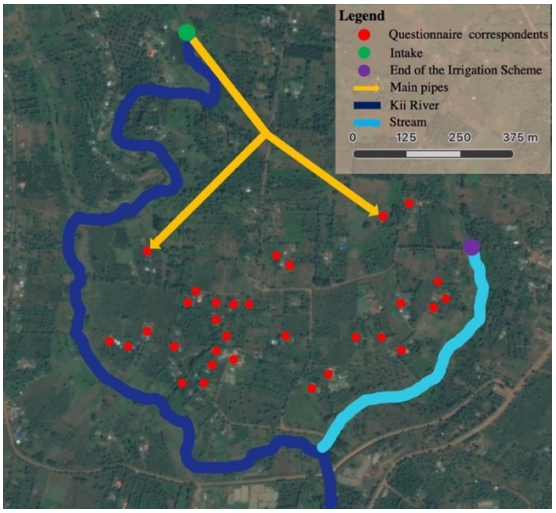


Figure 1 Map of the Kii-Kithiria Irrigation Scheme, showing the Kii river, its stream, main pipes, intake, the end of the irrigation and our questionnaire respondents. Source: field notes, GPS data and KI5

Analytical Framework

We have applied the Sustainable Livelihood Framework (SLF) to guide us in our research and to structure our findings in order to obtain an insight into people's livelihoods (Figure 2) (Scoones, 2015). The term "Livelihood" is used in accordance with the definition by Chamber and Conway: "*A livelihood comprises the capabilities, assets and activities required for a means of living*" (Chambers & Conway, 1991, p. 6).

In order to make a living, a household follows a livelihood strategy which consist of activities, and the outcomes of the strategy depend on how successful it is. The activities can be divided into three categories: agricultural activities, livelihood diversification or migration (Scoones, 2015). Agricultural activities can furthermore be dived into strategies of intensification and/or extensification (Ellis, 2000). A households' livelihood strategy is continuously altered according to its changing asset position. The assets are divided into five capitals: human, social, natural, financial and physical. The assets are utilized to generate the means of survival or maintain material well-being at levels above survival (Ellis, 2000). Access to assets is influenced by the institutions and organisations that operate in a given livelihood setting. Institutions and organisations can mediate support to a livelihood strategy or cause constraints and barriers. Both access to assets and how this is influenced by institutions and organisations are continuously changing according to the context, which consists of history, politics, climate, terms of trade, and demography among others (Scoones, 2015). The complexity and diversity of livelihood strategies are not captured in the SLF diagram but the intention is that it is to be investigated and understood by the researchers during a lengthier and thoroughly done fieldwork.

The framework has guided our collection of data in the field, where we have focused on obtaining data of the households' capitals, their strategies and current well-being. Furthermore, we have put a lot of emphasis on understanding how the institutions and organisations influence households' ability to pursue different strategies. The framework has helped us structure our analysis: we have first looked at the strategies, then tried to find correlations between different strategies and stocks of capitals and lastly looks at how these have been influenced by institutions and organisations which have resulted in different outcomes. The main focus throughout the research has been on how access to the irrigation scheme influences livelihoods.

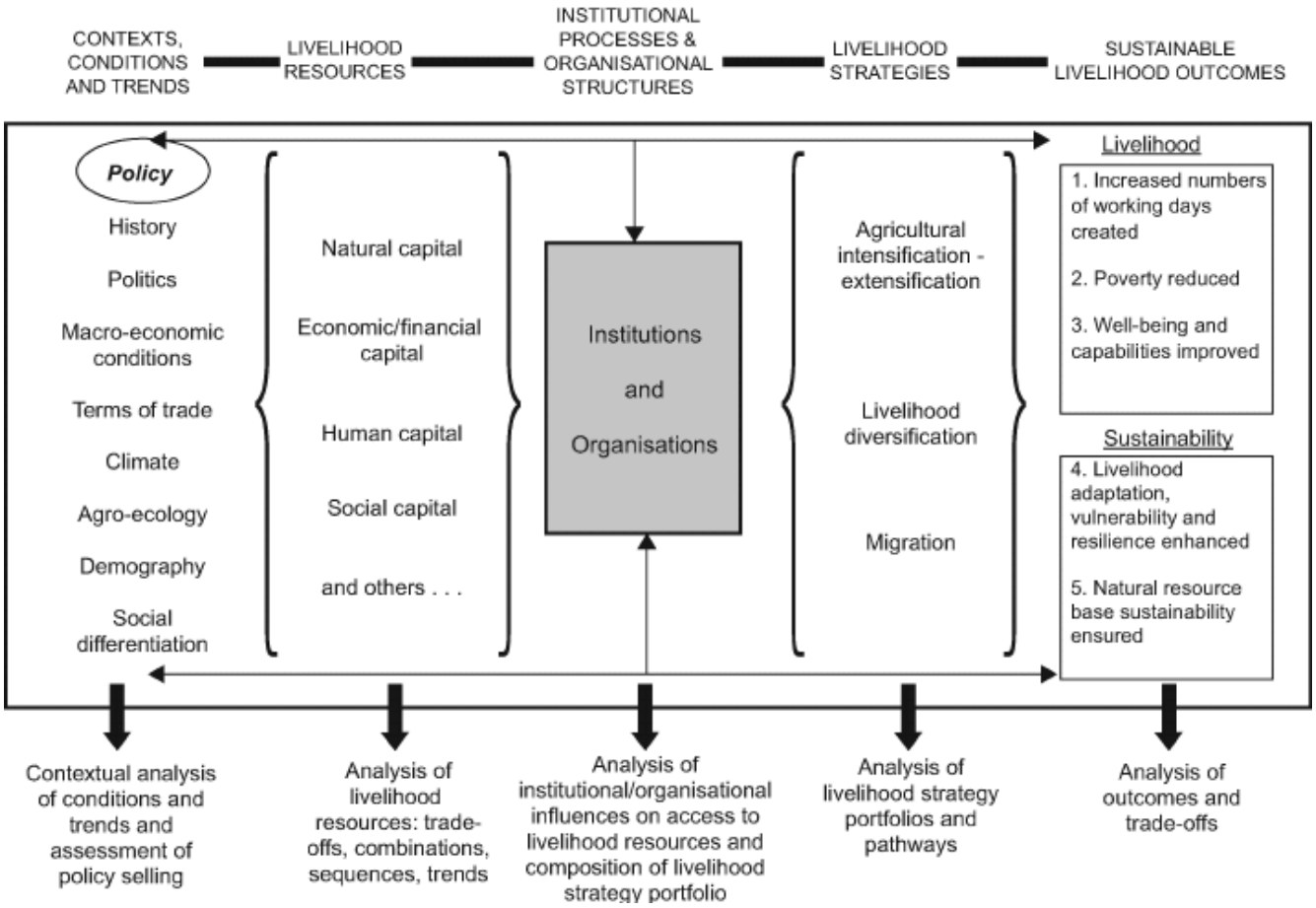


Figure 2 The Sustainable Livelihood Framework. Source: Scoones, 2015

Methodology

The field research was carried out in a group of seven students, studying in either Denmark or Kenya. We were hosted in local households during our stay. The two student bodies came together in carrying out the data collection that should cover both student bodies' research objectives. The group acted as coherent unit in which decisions were taken collectively.

Transect Walk

The transect walk was carried out on the day after we settled down in Kithiria (Image 1). The method is used to observe, discuss and register the endowments and problems of the area (Mikkelsen, 2005). It took us around two hours to finish the walk which was divided into two phases. Starting from the middle of the irrigation scheme, we finished our first phase by walking along the Kii river to the end of the irrigation. The second phase started from the end of the irrigation to the intake. During the walk, we got insights into the natural and living environment in Kithiria, initiated contact with local people and wrote down useful notes in order to get an overview of our researching area. We also tracked GPS waypoints in important sites such as the intake so we could create a map of the irrigation scheme (Figure 1).

Image 1 Transect Walk in Kithiria

Questionnaire

The knowledge about how to conduct a questionnaire is based on Rea and Parker (2005). Our questionnaire is based on a draft produced by the Kenyan students, which was discussed, dissected and modified within the complete group. We performed three pre-tests, one at each of our host's location. We have done systematic random sampling to select our respondents, consisting of choosing to interview every other household on a road. If no one was home, the next household available was taken as a starting point and the sampling proceeded. We carried out 31 questionnaires in total in two days, 29 of which are valid. We divided into two groups for efficiency. Each group consisted of an interviewer, a note-taker, an observer and an interpreter (provided by the course). The interviewer and note-taker were the Kenyan students due to the language barrier. The students from Denmark were the observers who also took charge of tracking waypoints in the GPS and taking pictures. The purpose of carrying out a questionnaire was to gather quantitative data about our sample group in terms of capitals owned, their use of the irrigation scheme, outcomes resulted from the irrigation scheme, and the influence of institutions and organisations.

Semi-Structured Interview

Compared to a rigorous structured interview, a Semi-Structured Interview (SSI) consists of open-ended questions that are not predetermined in sequence; the interviewer is allowed to ask additional questions (Mikkelsen, 2005). In our field work, we conducted SSIs with officers from organisations (Agricultural officer, Irrigation Officer and the committee) and key informants. Furthermore, famers were chosen from our questionnaire respondents, representing 3 different age ranges and both genders, and interviewed. For officers from organisations, we focused on their role in facilitating development in the area. As for the farmers, we have prepared interview guides with questions concerning their use of irrigation technologies, their farming strategies, their farming knowledge, challenges and well-being. We also carried out observations and soil samplings during our SSI with farmers.

Image 2 SSI carried out in the field.

Focus Group Discussion

A Focus Group Discussion (FGD) described by Mikkelsen (2005) was carried out. The desired pieces of information from this method concerned a nuanced picture about irrigation practices, water conservation practices, market accessibility, training and how the irrigation systems influence wellbeing. 15 respondents picked randomly. The invitation was carried out by visiting the respondents' houses. The FGD was held at one of our host's houses, outside. By the end of the FGD, which was combined with PRA exercises, 6 respondents had shown up in total, 5 females and one male. The FGD was overlapping with a different meeting which several of the respondents needed to go to, so the FGD was done quickly. Kenyan students were responsible for guiding the discussion in Kiswahili, while the rest were notetakers and observes. The guides worked as translators for the Danish students.

Participatory Rural Appraisal

Two Participatory Rural Appraisal (PRA) methods were applied: a Venn diagram and a Strengths, Weaknesses, Opportunities and Threats Workshop (SWOT), described by Mikkelsen (2005). The Venn diagram was applied to reveal the farmers' relation to organisations. The participants had to stand, one at a time, and draw a circle based on a common assessment. The method was moderated by a Kenyan student who had previous experience, and the rest of the students were notetakers and observers. The SWOT analysis reveals weaknesses related to the irrigation scheme, the opportunities the system provides such as improvements in well-being, the strengths of the scheme and its threats.

Observations

Observation provides important information for posing central questions (Mikkelsen, 2005). We have made observations during the questionnaire, SSI and transact walk. The data gleaned from the observer was used to enrich the picture of people's capitals, strategies and social standing, as well as to be critical of our quantitative data and become aware of complex, dynamic processes. In the questionnaire and SSI, our observations were about well-being markers (type of house, type of phone), respondents' body language and behaviour, number and height of sprinklers and the way they are practically used in a demonstration by our informants.

Participant Observation and Informal Conversation

Participant observation is a method in which researchers participate in the daily activities as a means of learning both the explicit and tacit aspects of their life and culture (Musante DeWalt, 2014). Participant observation and informal conversation have been an implicit qualitative data collection tool that we carried out throughout our field research. By living in houses connected to the irrigation scheme together with the local families, we have both participated and altered the daily activities, habits, rituals and interactions within the household. Informal conversation occurred throughout our stay. The three authors of this report were separated into three different households, which they also shared with Kenyan students. Depending on the household assigned and the gender of the author, some of us engaged into the daily activities and chores of the family, while others were engaged in a guest-host relationship. The data collected was related to people's livelihood strategies, the context of life in Kibugu and the influence of institutions and culture. The data was not collected consistently by the three authors, but it was captured in the form of journal entries, photographs, embodied experiences and memories.

Soil Sampling and Analysis

To understand how the irrigation scheme influences soil fertility, we carried out soil sampling in Kithira and had lab analysis at University of Copenhagen. The soil sampling sites were at our SSI respondents' fields. It was hard for us to rule out all the variables that could influence the soil fertility such as the crop types, farming strategies, etc. Therefore, we decided only to take regularly irrigated and non-irrigated soil samples separately in each member's farmland. We used composite sampling which combines different individual sub-samples into one homogeneous sample. We also asked farmers the basic information about sampled soils. We air-dried most of the soil samples in Kenya and the remaining was dried in the lab. In the lab, we measured the four parameters: soil pH, soil electrical conductivity, total N% and C%. We first sieved the soil through a 2 mm sieve and measured the pH and Electrical Conductivity in a 1:5 soil: water solution. For total N% and C%, the analysis was conducted by Isotope-Elemental Analysis.

Results

In the following section, we outline and analyse our results concerning livelihood strategies, capitals, institutions and organisations, and outcomes.

Livelihood Strategies

Our respondents mainly rely on agricultural activities such as irrigated farming, non-irrigated farming, forestry, and livestock to build their livelihood strategies. They have also, to some extent, managed to pursue business activities and other activities than agriculture (AQD) (Figure 3). Migration patterns could have been an important factor in understanding household dynamics and livelihood strategies, but they have not been investigated. In the following sections we will present the different activities that are used in the area to build up a livelihood strategy. First we will present agricultural activities continued by other activities. Irrigation will be covered more thoroughly after this.

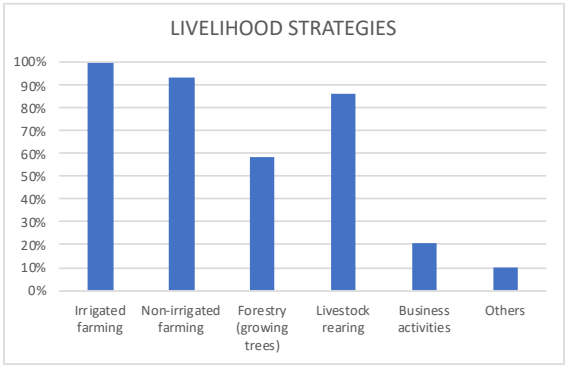


Figure 3 Livelihood strategies practiced by the respondents. Source: AQD.

Agricultural Activities

First of all, most of the respondents (93 %) are engaged in non-irrigated farming (AQD) (Figure 3). Among the crops grown, generally without irrigation, are three important cash crops: coffee, tea and macadamia (AQN and O). From our questionnaire notes we know that at least 13 of our respondents grow coffee, 2 grow tea and 8 grow macadamia, but potentially more of the respondents rely on cash crops as part of their livelihood strategy. According to our AQD 72 % of the farmers do not irrigate more than 25 % of their land indicating that a lot of land is used for non-irrigated farming activities. This, together with observations, AQD, AQN, and interviews indicates that cash crops are an important activity in the respondents' livelihood strategies. Secondly, we tried to capture data about how the respondents engage in forestry as a part of their livelihood strategy. From the questionnaire data we know that 59 % do forestry defined simply as growing trees (Figure

3). The way we posed the question causes uncertainties in how respondents interpreted it. Therefore, the number of respondents who grow trees may vary from the number displayed here. Thirdly, livestock is a part of many respondents' livelihood strategy (Figure 3). Based on our observations during the questionnaire survey, the most common animals are cattle, goats and poultry. The number of cattle varies between 1-7, the number of goats varies between 1-3 and when rearing poultry they usually have numerous (O). Lastly, the respondents engage in irrigation farming. Due to the centrality of this issue to our research, we will analyse irrigation farming in further details below.

As already mentioned, only a few pursue other activities than agriculture. Though, the approach used to gain knowledge about these activities have been shown to provide inadequate data. Though, an important piece of information we obtained is, that out of all the nine specific cases, only one, an electrician, ranked 'other activities' as having the highest financial value. The remaining 8 respondents ranked 'business activity' or 'other activity' as their third of fourth activity, sorted after financial value. This indicates that only one respondent receives his/her main income based on an activity other than agriculture.

Irrigation Farming

All the respondents are engaged in irrigated farming activities (Figure 3) and according to our data all but one are engaged in cultivation of irrigated horticultural crops (AQD). More than 30 % of the respondents grow tomato, cabbage and kale (Table 1). This shows that most people have a few types of horticultural crops in common, while many of the crops grown are grown by less than 10% of the respondents.

Table 1 Horticultural crops categorized according to the percentage of the respondents that cultivate each of them. Source: AQD.

	Horticultural crops
1-10 %	Tree tomato, pumpkin, onion, potato, yam, cassava, strawberry, carrots, corriander
11-20 %	Arrowroot, sweet potato
21-30 %	Banana, beans, spinach
>30 %	Tomato, cabbage, kale

The rainfall pattern in Embu county is bi-modal with two distinct rainy seasons. The long rains occur between March and June while the short rains fall between October and December. The irrigation is mainly used from January to March, after the short rains end (FGD) (Figure 4). After the long rains end in June, most people do not start to irrigate before September, just before the short rains fall. This might be related to their cropping calendar, and harvest and sowing time, but it can also imply that the soil holds the water for some time after the long rains end, or that the precipitation pattern in Kibugu is slightly different from the climate data we

have used. The irrigation is mainly carried out in the dry seasons and is therefore mainly used to prolong of the season rather than increasing the yield per land the whole year.

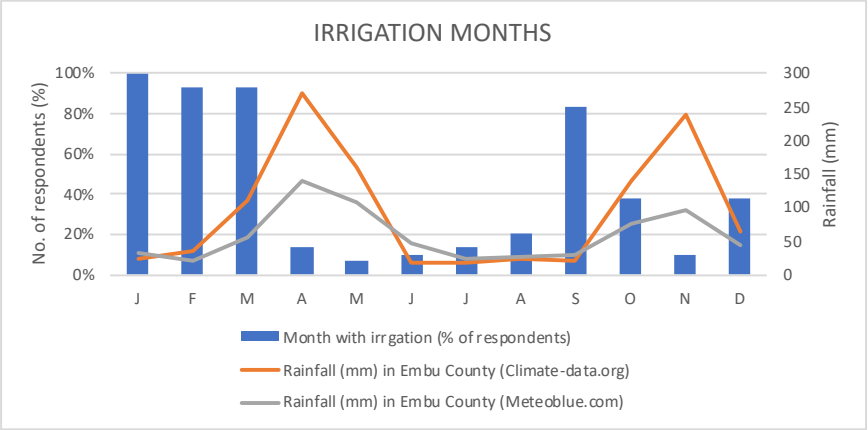


Figure 4 Month where irrigation is practices compared to the month with rain. The two different lines represent precipitation in Embu from two different sources. The grey line is more likely to represent data from an area at lower altitude (average annual precipitation 699 mm) compared to the orange line (average annual precipitation 1.120 mm) that is more representable for Kibugu, located approximately 1.600 m above sea level. Source: Climate-data.org (n.d.), meteoblue.com (n.d.), AQD.

March is the warmest month of the year in Embu, with an average temperature of 20.9°C and max temperature reaching 30.6°C (climate-data.org, n.d.). The data was collected in March, before the long rains have arrived, and showed that irrigation is practiced throughout the whole day (Figure 5). Due to evaporation of the water in the warmest hours of the day, it is likely that there is a high waste of water when irrigation is carried out given the pattern we have observed.

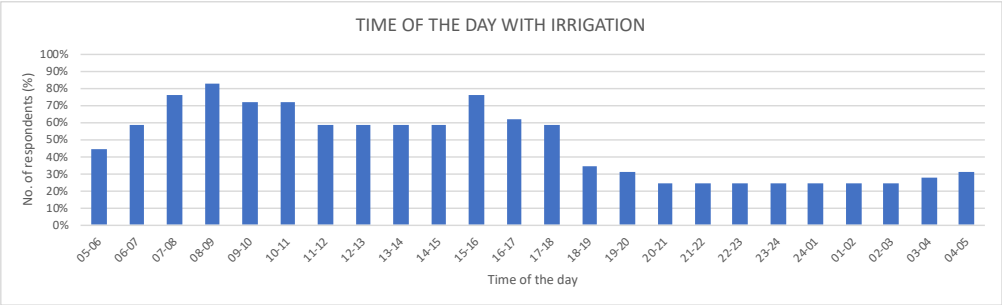


Figure 5 Time of the way where irrigation is carried out. Source: AQD

86 % percent of the total respondent group used sprinklers to irrigate, while the rest used buckets, the pipe system or drip (AQD; AQN). Generally, the sprinklers were set high in order to cover a larger area, but this also lead to evaporation of a large amount of the water. The respondents usually had between one to five

sprinklers, which they moved around after need (SSI). One of the respondents stated that the water pressure was too low to add more than two sprinklers to the system (SSI).

The irrigation system is also used on crops other than horticulture. 62 % of the respondents irrigate maize (AQD). We do not know the exact reason for this but the practice was observed in the dry season where there might be insufficient water, and therefore it is a way of prolonging the growing season of maize. Another explanation might be that, because the water is always flowing, they irrigate maize after the horticultural crops have been saturated. Furthermore, a few irrigate coffee, tea, Napier grass and plant seedlings (AQD).

Categorisation of Farmers who Irrigate Horticulture

In the previous section we presented the irrigation practices carried out in Kithiria. This section will show how people engage in irrigation farming at different levels.

The respondents are categorised into 4 groups according to yield, in order to determine if there is a correlation in how they as a group engage in the activity and their capital stocks. Measured in total yield, the production differs in a gradient from 10 kg to 17,500 kg. We have separated the respondents when a yield doubled from one respondent to the next (Table 2). This serves as a rough categorization of the farmers.

Table 2 Division of respondents into four groups according to their total yield of irrigated horticultural crops in kg for the last cropping season. The groups have been separated where the yield of the respondents went from 90 to 180 kg, from 450 to 950 kg, and from 3270 kg to 8010 kg. Group 1 represent the respondents with highest yields, where group 2, -3 and -4 have lower yields corresponding to the named number of the group. Source: AQD

Group No.	Survey No.	Spinach	Tomato	Kale	Cabbage	Beans	Coriander	Arrowroot	Banana	Sweet potato	Potato	Carrots	Others		Total yield (kg)
Group 1	8								17.500 kg						17.500 kg
	15		6000 kg	4000 kg				1500 kg	600 kg	3000 kg					15.100 kg
	3		250 kg		10.000 kg										10.250 kg
	17		2000 kg	1000 kg	5000 kg	10 kg									8010 kg
Group 2	10		250 kg	20 kg	3000 kg										3270 kg
	2			30 kg	500 kg				2650 kg				20 kg		3200 kg
	18	500 kg	1000 kg	500 kg	500 kg										2500 kg
	19	720 kg		720 kg	720 kg				120 kg	100 kg					2380 kg
	29		1000 kg		700 kg										1700 kg
	6			400 kg									1000 kg		1400 kg
	1	10 kg		20 kg	1000 kg										1030 kg
	16			300 kg	200 kg	50 kg						400 kg			950 kg
Group 3	31	50 kg	250 kg	150 kg											450 kg
	28	200 kg		200 kg						ND.					400 kg
	24		50 kg	100 kg	100 kg	50 kg	100 bunches	50 kg			13 kg				363 kg
	23		87 kg	75 kg	35 kg	60 kg					100 kg				357 kg
	21	30 kg		25 kg		270 kg	ND.	15 kg							340 kg
	25			10 kg	150 kg								ND.	140 kg	300 kg
	22				ND.	40 kg				ND.			ND.	200 kg	240 kg
	12							150 kg	48 kg						198 kg
	9			50 kg	ND.	30 kg		100 kg							180 kg
Group 4	4			90 kg			ND.								90 kg
	27	30 kg		30 kg											60 kg
	5									20 kg		20 kg			40 kg
	13			30 kg											30 kg
	20			10 kg											10 kg
	11			ND.		ND.									ND
	7								ND.						ND
	14														ND

Table 2 shows the four groups, the horticultural crops they grow with use of irrigation and their total yield in kilograms. As can be seen, group 4 (the producers with lowest levels) grows one to two different crops, with only one respondent (survey 4) yielding more than 30 kg from one crop type. In contrast to this, most of the respondents in group 1, -2 and -3 have invested in several crops. A few respondents from group 1 and 2 stand out in that they only grow one or two crops but produce high yields (survey no. 8, 3, 29, 6).

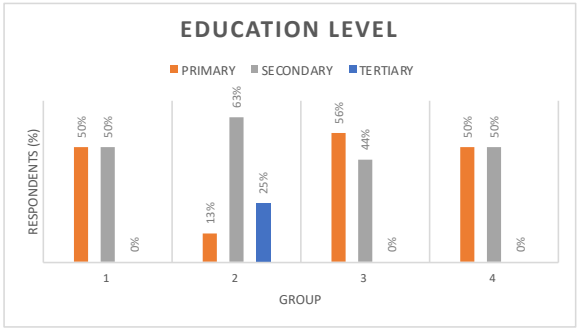
Capitals

The point of dividing the farmers into the four production groups was to investigate whether the differences in their production numbers could be due to access to different capitals. We will first present data about the human-, social-, and natural capital. Thereafter we will go into an analysis of the correlations between the groups and the different capitals. We discover that there is no correlation between the groups and their capital stocks. Qualitative data is presented to highlight the different uses of the irrigation scheme and the various ways of building up a livelihood strategy.

Human Capital

To estimate stocks of human capital, data about education and age of the respondents were collected together with data about the type of labour used in the field (Figure 6). Primary and secondary school are the most common education levels. Only two of the respondents are younger than 35 years while 15 are between 35-50, and 12 are over 50 years old. Family labour is, for 45 % of the respondents, accompanied by hired labour, while the remaining 55 % is equally divided between either using family labour or hired labour.

6a



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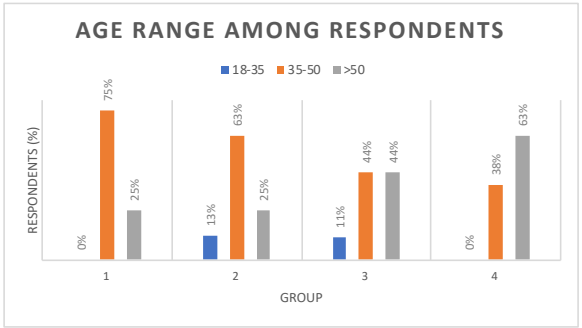

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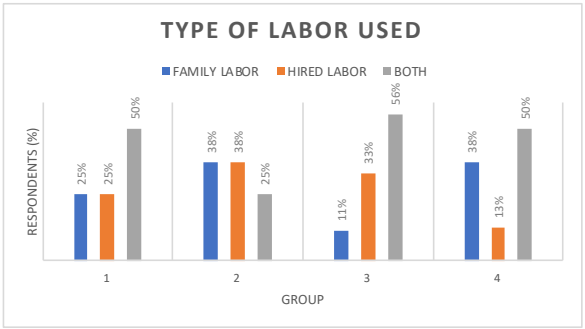
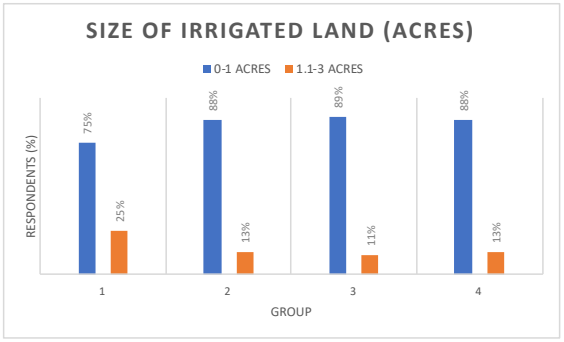


Figure 6 Human capital stocks estimated based on data on education level, age and type of labour. The variables are compared between the groups in order to see any correlation between the human capital stock and irrigation practices.

Natural Capital

Natural capital stocks were measured based on land size. Some respondents had land outside Kithiria, so in order to capture this, we obtained data for size of land in total and land located in Kithiria. Further, the size of the land irrigated in Kithiria was obtained. Among the four groups, most people irrigate less than an acre of land (Figure 7a). The size of the irrigated land makes up different proportions of the respondents' total land in Kithiria (Figure 7b). For group 1, all the respondents irrigate between 26-50 % of their land whereas the proportion of land irrigated for the remaining groups varies.

7a



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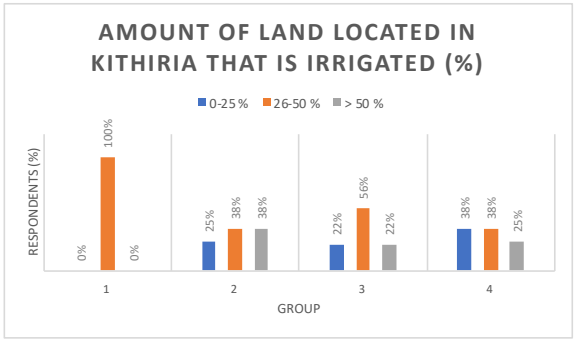


Figure 7 Natural Capital. Distribution of the size of land irrigated among the groups, counted as a natural capital stock (7A) and the proportion (%) it represents of the total amount of land, that the respondents have a mean of access to within Kithiria (7b).

Social Capital

Social capital stocks were measured based on the period of residence in Kithiria and the period of membership in the irrigation scheme. The membership period was recorded according to whether the respondent became a member before or after the installation of the pipes in 2005. Just like most people have resided in Kithiria for more than 10 years, most people also became members of the scheme before the pipes were installed. This is the trend among all the four groups. We also collected data that showed whether people were engaged in other groups and counted the number of groups they were members of (Figure 8c). Among the respondents in group 1, 2 and 4, there are people who are members of either no group, 1 group or 2-3 groups whereas group 3 only consists of people who are members of 0 or 1 group. Lastly, data was collected about how many of the respondent receive county government support (Figure 8d).

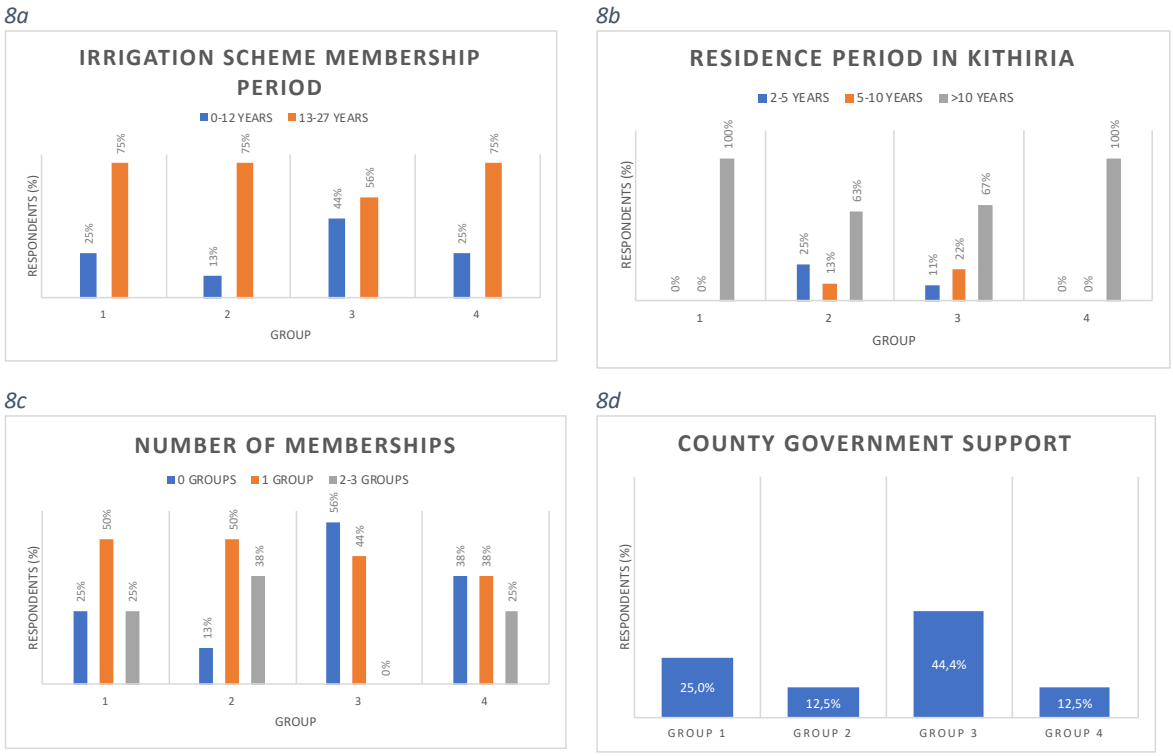


Figure 8 Social Capital. The amount of years the respondents had been members of the irrigation scheme was measured as a social capital and it was compared whether people from the different groups had been members from before or after the installation of pipes (8a). The number of years that people have lived in Kithiria was compared between the groups (8b). The number of groups where the respondents had memberships was also included as an indicator social capital stock (8c), and whether they receive county government support (8d).

Analysis of Correlations

We have analysed all the tests presented in the previous section to see whether there is a correlation between the different capitals the respondents have access to, and the grouping of the respondents. The analysis showed no significant difference between the four groups when comparing any of the capitals measured (Table 3).

Table 3 P-values of the analyses of any correlation between assets and the four groups. Most of the chi-tests that we have completed have been based on too few samples which make the test-results uncertain. Source: AQD

HUMAN CAPITAL	PARAMETERS	P-VALUE
Education	1) none 2) primary 3) seconday 4) tertiary	0,.254
Age	1) <18 2) 18-35 3) 35-50 4) >50	0.665
Labor	1) family 2) hired 3) both	0.740
SOCIAL CAPITAL		
Residence period in Kithiria (years)	1) <2 2) 2-5 3) 5-10 4) >10	0.367
Member of other groups	1) yes 2) no	0.721
Number of groups with a membership	1) 0 2) 1 3) 2-3	0.465
Extension service provided	1) yes 2) no	0.360
Membership of the irrigation scheme (years)	1) 0-12 2) 13-27	0.596
NATURAL CAPITAL		
Total land size (acre)	1) 0-1 2) 1.1-3 3) 3.1-5 4) >5	0.151
Total land size in Kithiria (acre)	1) 0-1 2) 1.1-3 3) >3	0.457
Size of land that is irrigated (acre)	1) 0-1 2) 1.1-3 3) >3	0.919
Percentage of land in Kithiria that is irrigated (%)	1) 1-25 2) 26-50 3) >50	0.469

For further analysis, we crossed checked the quantitative data with the qualitative data and neither of them reveal any obvious correlation between capital stock and the four groups (AQN; SSI). However, the qualitative data does reveal an important piece of information about different uses of the irrigation system. We have detected 3 different cases of irrigation uses across three of the groups. While one respondent from group 1 produces a high yield of several horticulture crops (QD15), a respondent from group 2 uses the irrigation water to support her livestock rearing (QD1; SSI). In her case, the horticulture production allowed the farmer to invest in several cows (SSI). This respondent ranks livestock rearing as her most valuable financial activity (QD1; Figure 9). The cows are now fed with irrigated Napier grass and the irrigation system supports their water requirements (QD1; SSI). For a respondent belonging to group 3, the irrigation system is used to irrigate coffee seedlings and the respondent aims at opening a seedling nursery (QD31; SSI). These examples show the diverse uses of irrigation that exist between the groups and the complexity and diversity of livelihood strategies.

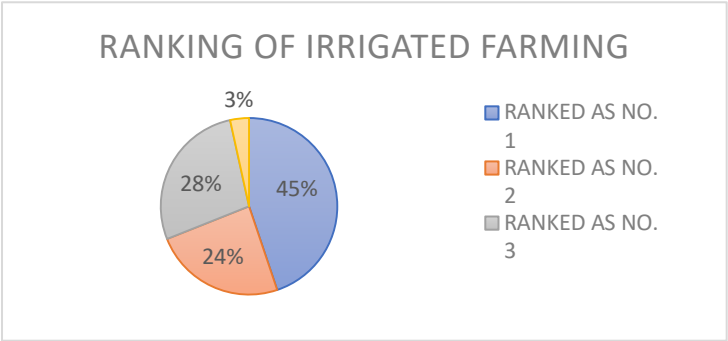


Figure 9 Percentage of the respondents who ranked irrigation farming as their first, second or third priority.

Furthermore, to see if the division of the groups was correlated to differences in other activities, we searched our data for information about non-irrigated crops (AQN). We had data concerning coffee production and macadamia production for 11 and 8 respondents, respectively. The yield of these cash crops was compared between the groups, but in order to increase the sampling size of the groups, it was necessary to pool together group 1 and 2 and likewise group 3 and 4. The result of the chi-test shows no significant difference when studying the ranges of coffee yield between the two groups. However, there is a significant difference (0.05 level) in the yield of macadamia (Table 4). This indicates that the respondents who have a high yield of macadamia nuts engage less intensively in horticultural production.

Table 4 P-values of analyses of any correlation between production of cash crops and the two distinct groups.

COFFEE			MACADAMIA		
Yield (kg)	Group 1 + 2	Group 3 + 4	Yield (kg)	Group 1 + 2	Group 3 + 4
0-1500	3	5	0-500	4	1
1501-3000	1	2	501-900	0	3
P-value	**0.8982**		**P-value**	**0.0285**	

This result suggests that the respondents in the groups engage in different livelihood strategies. Based on our results, for group 1 and 2 irrigation of horticulture makes up a bigger part of their livelihood strategies, whereas macadamia production appears to be a more important part of the livelihood strategies of group 3 and 4.

Institutions and Organisations

In this section we will look at how institutions and organisations affect the activities that local people engage in. We begin by showing the irrigation farmers' relationship to different organisations (Figure 10), followed by three sections describing barriers and limitations connected to the irrigation scheme, the extension officers and the institutions involved. We finish this section with focus on market access.

Figure 10 Venn-diagram. Source: PRA

The Venn diagram exercise reveals the perceived relational proximity between the irrigation community and different organisations and institutions (Figure 10). It illustrates that there are no NGOs present in the area. The extension officer (agricultural officer) and the irrigation officer are rarely involved with the community. The coffee officers (officers from coffee cooperatives and Saccos) are perceived to be more involved (Figure 8c). CDF is placed relatively close to the community due to the initial funding, but is currently not involved. The Kibugu village chief has an ambivalent relationship to the community, and the committee is the most-involved and closest organisation related to the irrigation scheme.

Kii-Kithiria Irrigation Scheme

In this section we address local barriers to the development of the irrigation scheme and possible explanations of how organisations and institutions might affect the processes of horticulture production. We address leadership and tradition.

Lack of leadership and initiative have been recurring themes in some of key informants' assessments of the community members (KI2; KI3; KI4). The agricultural officer and the irrigation officer blamed both the farmers and the committee for not being proactive (KI2; KI3). The irrigation officer stated that he once advised the committee to write a proposal that would grant them funding for the project, but that they never did, even though they are struggling under the current budget (KI3). Lack of leadership can be another explanation for why the scheme as a unit does not develop further and why only some of the more determined farmers manage to intensify horticulture production.

The fact that not more people pursue strategies that involve horticulture at a high yield level (Table 2) could also be attributed to the pursuit of traditional farming practices. Both extension officers have mentioned the reluctance of farmers to invest in different crops than the ones they are used to (coffee) (KI2; KI3). This is supported by the fact that people from all four groups are engaged in coffee production (Table 4). The transition from coffee to horticultural cultivation has been slowed down by the fact that farmers seem to rely on knowledge passed down to them from their parents as a basis for their strategies (AQN; FGD; SSI).

County Government

The agriculture- and irrigation officers are placed in two different departments in the county government. Their actions or lack thereof also affect the development of the irrigation scheme and the farmers' ability to engage in horticultural production. Here, we address their lack of budget and their miscommunication with the scheme members.

Both the agricultural- and the irrigation officers have complained about county budget limitations. The allocated budget is not even enough to fulfil basic job-related needs, such as stationary and car fuel for going into the field (KI2; KI3). The farmers are required to pay for transportation if they want the extension officers to come (KI2; KI3). The agricultural officer said that "*they (the county government) have not realised that agriculture is the backbone of the country*" (KI2). Actions and decisions taken at the county level are always prioritised according to political interests (KI2). Furthermore, the community is in no way benefiting from the KSH 52 million budget for irrigation for 2018/2019 (KI3). The county government chooses to invest its limited resources (both man-power and money) on larger irrigation schemes that have a significant potential for producing returns (KI3). The lack of money allocated for extension services to SI farmers explains why we do not see a significant difference in the groups' access to county government support (Figure 8), because they so rarely get help. 76 % of our respondents said the officers came zero times a year, 14 % did not answer the question and only 10 % said they received extension services (AQD) (Figure 8d).

Public extension services are demand based (KI2; KI3). Within this framework, farmers should decide themselves if they need help, and reach out. Both the agricultural officer and the irrigation officer complained about the farmers not reaching out. "*If farmers do not ask anything it means they are content*" (KI3). However, it seems that many of our respondents are not aware of this rule (AQN; FGD; SSI), and they claim that "*they (agricultural officers) should come to our homes because it is their job*" (FGD). This shows that

there is an obvious communication gap between the government officials and the community members. Their mutual blaming and general disinformation could also explain the lack of extension services in the area, and is a barrier for intensification of horticultural crops. When community members do manage to reach out and demand extension services, they ask for field days and demonstrations about how to deal with their coffee crops rather than how to set up horticultural cultivation (KI2; KI3). This is correlated to the fact that most farmers across all the four groups engage in coffee production (Table 4).

Market Access

The two previous sections have shown how different factors within institutions and organisations mediate the processes of building up a livelihood strategy. In addition to the factors already mentioned, market access stood out as another important issue that directly affects the engagement with horticulture crops (SSI, FGD; KI1; KI4; KI5). Our data limits us from knowing whether at any given point our informants refer to the local, regional, national or international market.

The irrigation committee, participants in the focus group discussion, and a founding member of the scheme, think that market access is problematic. In the very beginning of the scheme, competition for horticultural crops was low and the market opening was conductive to profit (KI4). Now, however, the community consensus is that the market is oversaturated with horticultural produce due to irrigation (KI1; KI4; FGD). The agricultural officer mentioned that the farmers base their decisions of what crops to grow solely on word of mouth (KI2). This goes together with the fact, that many of our respondents grow the same kind of crops (Table 1), and is illustrated in a quote from one of the FGD participants, who explains how she decides what to grow: *"I look around at what the neighbours are doing, go back home and do the same"* (FGD). Moreover, people are at the mercy of the market, since lack of storage facilities means that horticultural crops cannot be stored and must be sold straight away, whether the price is low or high (KI1).

Extension officers disagree with the community's assessment of the situation and state that the market is there, in Kibugu and Embu, and also in the export of French beans (KI2; KI3). They believe that members could significantly increase the outcomes provided by the irrigation scheme if they took action, formed a production group, and coordinated what crops to grow (KI2; KI3). The officers complained that farmers are not willing to do a market survey before they start growing the specific crops (KI2). However, there are no trainings or seminars from the county government on how to proceed (FGD; IC; AQN).

We see a contradiction among the officers and the irrigation farmers in their perception of market access, and an accompanying lack of communication in this regard. We speculate that when they complain, the farmers might only have local markets in mind, whereas the officers see more possibilities from a broader perspective. Further, we speculate that some farmers avoid growing horticulture crops due to lack of market, and one even wanted to stop irrigating for this very reason (SSI).

Institutions and organisations enable dynamic and interrelated processes that affect the farmers' access to assets and the formation of different livelihood strategies. Limiting factors appear at local level, in relation to governmental agencies and in relation to market access, and could potentially explain the difference in farmers' level of engagement with irrigated horticultural production.

Outcomes

Well-being

Regardless of all the barriers presented in 'Institutions and Organisation', the irrigation scheme has contributed to the members' livelihoods in several ways, including increased income, food security, access to water, more time and livestock rearing. Respondents in the four groups generally agree to the same extent that irrigation has improved their lives. 97% of our respondents say they have benefited from the irrigation scheme, with 87 % affirmed "*greatly benefitted*" (AQD). One of our SSI respondents said the following sentence to describe how he benefited from the irrigation scheme *"Life was not well for me until I started irrigation farming" (SSI).*

Increased Income

100 % of our respondents agreed that the irrigation scheme had contributed to the increase in their income (AQD). The increased income is mainly due to horticultural production. With the irrigation scheme, now members are able to produce and sell horticulture all year round. One of our attendants from the FGD said that *"once you sell kales you can built a house or buy a cow"* (PRA2). This is in agreement with a statement from the irrigation committee saying the irrigation members now have a higher income than before.

Some of the respondents used this money to pay for their kids' school fees (SSI; Q24), while others used the money to buy livestock (SSI; AQN), to hire more labour (SSI), lease more land (Q29) or to improve their material well-being by getting connected to electricity or buying a TV (SSI), and building brick houses rather than mud houses (PRA2).

Food security

Apart from increased income, the irrigation scheme also helps improve local livelihoods by increasing food security. The irrigation scheme makes it possible for farmers to grow crops all year round, and they thereby produce more food. An FGD attendant affirmed that members can also save money because *"now people do not need to go to the market to buy cabbage as there was more food security"* (FGD).

Access to Water

The irrigation scheme has also improved the local livelihoods through increasing the water availability for other purposes than farming. 93% of our respondents use the irrigation water for domestic purposes such as washing cloth and taking showers. 90% of the respondents use the irrigation water for drinking due to its cheaper price compared to the local supply of treated drinking water. The fact that this many people drink the water is of concern. Even though most boil the water (SSI, IC), we noticed that local people were washing clothes in the river and that fields were located right next to the river, with the risk of chemicals running into the water.

Time

Access to irrigation water has changed the way people use their time. Members save time, because they do not need to travel to fetch the water, and this time can now be used for other activities. Members declared that they can spend more time working in the field because now people have prolonged growing seasons (PRA2). Another SSI respondent even compared the efficiency between two irrigation stages. He said *"it (the sprinkler) also saves on time unlike furrow where you can't leave it unattended and the water usage is much".* An attendant from FGD expressed that now people can work through the year but in the past, people used to be idle during the dry seasons.

Livestock

Promoting livestock rearing is another benefit from the irrigation scheme. Irrigation members can now afford more livestock with the increased income from growing horticulture. One of the SSI respondents mentioned that she bought 7 cows with the money gained from the irrigation. 77% respondents use the irrigation scheme for livestock rearing.

Soil Fertility

To see the outcomes and effects of the irrigation scheme on the natural resource base sustainability, we carried out soil sampling (Table 5). We measured four parameters: soil pH, soil electrical conductivity (EC), total N% and total C%. We will first present the results from the test on soil pH which are indicators of acidification/alkalization, and EC which shows salinization. Then we present the result from the test on the nitrogen- and carbon content in the soil, which are overall parameters to see if there is a change in the soil fertility level.

Table 5 Information of soil samples (Source: soil sampling and analysis)

Information of Soil Samples								
Sample No.	Date	Types	Vegetables	Slope/Degree	Sample Depth/cm	Color	Comment	History
No.1	11.03.2019	Irrigated	Kales	0	20	Reddish		
	11.03.2019	Non-irrigated	Banana	0	20	Reddish	No fertilizer	Used to be maize and potato
No.15	08.03.2019	Irrigated	Kales/Pineapple	0	20	Reddish	Intercropping	Been irrigated for 15 years
	08.03.2019	Non-irrigated	Coffee	9	20	Reddish	Using Manure fertilizer	
No.22	08.03.2019	Irrigated	Cabbage, carrots, and spinach	0	20	Reddish	No chemical fertilizer	
	08.03.2019	Non-irrigated	Maize	0	20	Reddish	No chemical fertilizer, and land ready for planting	
No,27	08.03.2019	Irrigated	Kales	16	20	Reddish		3 years of horticulure
	08.03.2019	Non-irrigated		0	20	Reddish		
No.31	08.03.2019	Irrigated	Cabbage	0	20	Reddish		
	08.03.2019	Non-irrigated	Coffee	0	20	Reddish		

The range of pH scale in irrigated soil is from 5.5 to 7.3 with an average pH of 6.3, while the average pH of non-irrigated soil sample is from 4.9 to 6.3 with an average pH of 5.3 (Figure 11). In each sampled household, it is clear to see that the pH value in the irrigated soil is consistently higher than the corresponding non-irrigated soil (Figure 11). The pH scale shows the level of acidity or alkalinity, and can be influenced by many factors (e.g. fertilizer and lime inputs). It is therefore hard to conclude that the increase of pH in the irrigated soil is caused solely by irrigation. This is because we have only limited information about the sampled soil and the chemical characteristics of the irrigation water. Though the soil in the region is overall acidic, as long as the pH does not increase much more in the future than the current state, irrigation is still beneficial to the agricultural production.

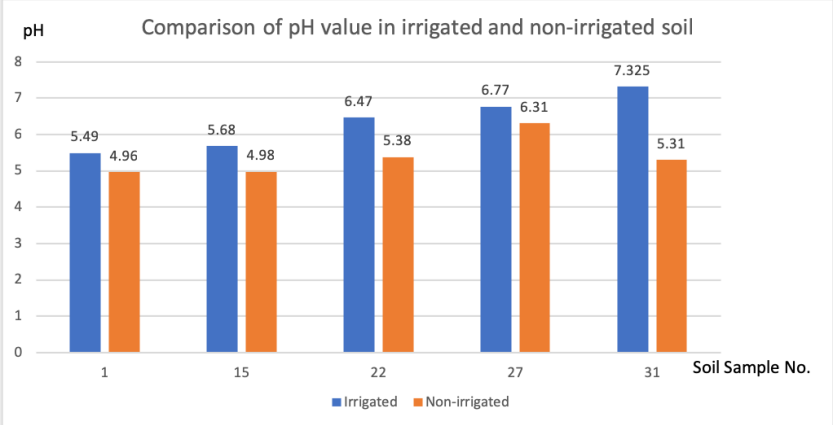


Figure 11 The comparison of pH value in irrigated and non-irrigated soil. Source: soil sampling and analysis

The salt concentration in the soil determines the EC value, which is an important index about the soil salinity. The average EC value for irrigated soil is 0.098, while the average EC value for non-irrigated soil is slightly higher, which is 0.105. We can see that the EC values in irrigated soil are neither consistently lower nor higher than the corresponding EC values in the non-irrigated soil (Figure 12). If there is a soil salinization, there should be a consistent increase of EC value in irrigated soil samples compared to the paired non-irrigated soil samples. However, based on our data, it is hard to see such a correlation and we conclude that so far, there is no increase in soil salinity due to the irrigation water.

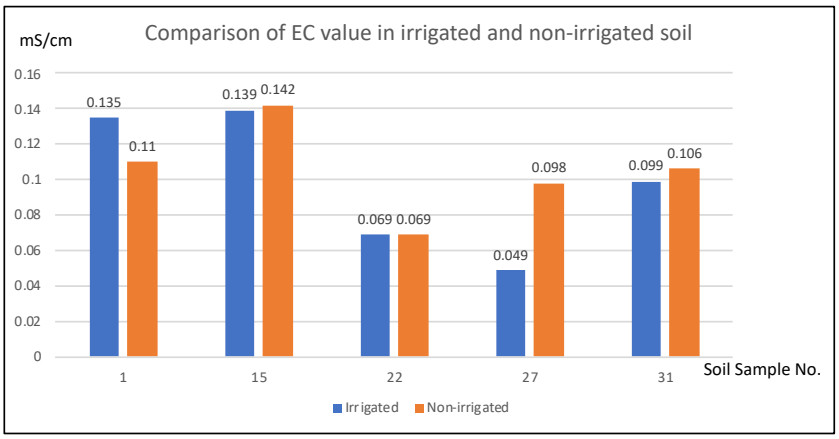


Figure 12 The comparison of EC value in irrigated and non-irrigated soil. Source: soil sampling and analysis

To determine the influence of intensified production on the level of soil fertility, we measured the total N% and total C%. We can see that the total N% values in the irrigated soil are neither consistently lower nor higher than the total N% values in the non-irrigated soil (Figure 13). The same counts for the total C% (Figure 14). However, the total N% and C% in irrigated soil are slightly higher than non-irrigated soil. The average of

total N% in irrigated soil and non-irrigated soil are 0.366% and 0.352%, respectively and the average of total C% in irrigated soil and non-irrigated soil are 3.204% and 3.037%, respectively. This result may indicate a slight overall increase in the soil fertility in the irrigated soil than the non-irrigated soil, though this increase is not consistent among all our sampled soils. This could be explained by the increased input of the organic manure in the irrigated soil compared to non-irrigated soil. For the irrigated farmland, farmers can grow crops all year around and the soil requires more input of nutrients to support the production.

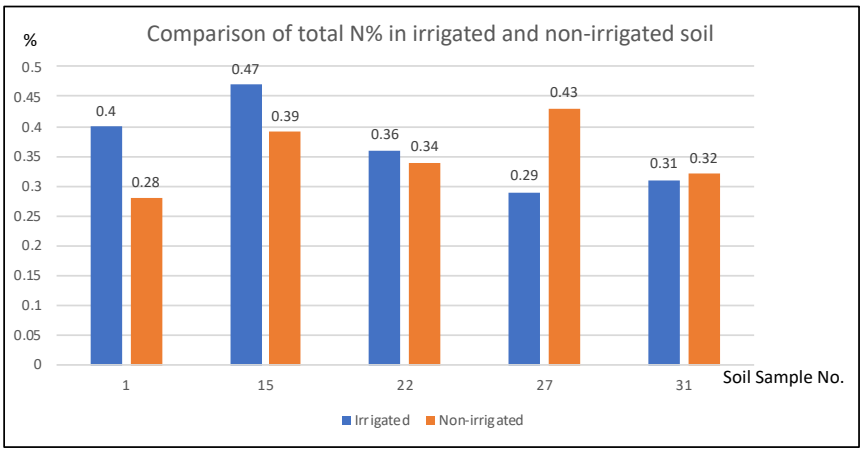


Figure 13 The comparison of total N% in irrigated and non-irrigated soil. Source: soil sampling and analysis

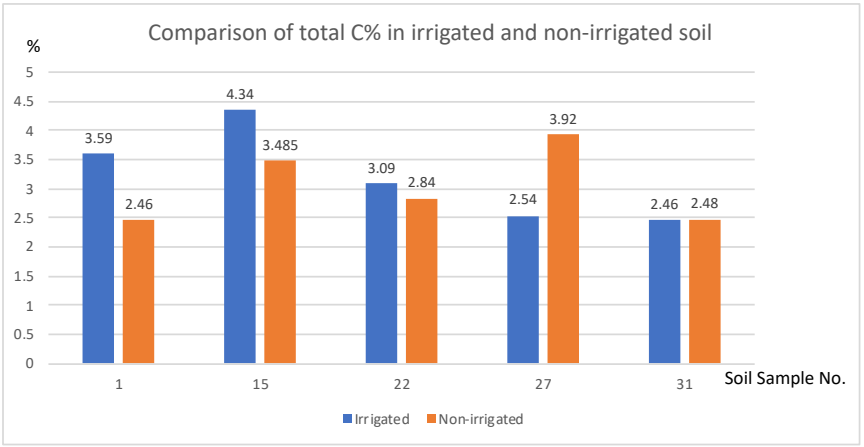


Figure 14 The comparison of total C% in irrigated and non-irrigated soil. Source: soil sampling and analysis

Discussion

We have, throughout our study, looked at how our respondents produce different yields of horticulture. We tried to find a correlation to their capitals and to see how the process of engaging in irrigation farming was influenced by institutions and organisation. When looking at our findings we see that other activities might make up more important alternatives to irrigation farming. We have observed that many grow the same crops and that the market is oversaturated with horticulture. We have seen a lack of capacity building within the scheme and a lack of extension service. Furthermore, inefficient use of the water was observed, and one respondent complained about water pressure. Many of these challenges are not unique for the Kii-Kithiria Irrigation Scheme.

72 % of our respondents irrigate less than 25 % of their land in Kithiria, which is often less than 1 acre. We have, in our report, indicated that this might be due to the importance of other activities like growing cash crops and that farmers lack knowledge and are reluctant to invest in new crops. However, when comparing to a case from South Africa, we see that larger plots are too labour intensive and expensive to handle, and that the highest crop intensities was found at small plot of less than an acre (Fanadzo & Ncube, 2018). Therefore, the fact that people irrigate less than 1 acre might be more productive. And the fact that the respondents do not irrigate more land might be correlated to labour issues that we did not capture.

We have also speculated that some people do not intensify their horticulture production because the market is oversaturated, since the farmers grow the same crop (like 72 % grow kale). These findings are also shared by Nakawuka et al. (2018) and (Fanadzo & Ncube, 2018). In their work it is likewise mentioned how smallholders saturate the local market by producing the same crop at the same time of the year which result in a decline in the market price. This is also linked to a lack of access to more markets afar and storage facilities for the perishable crops (Fanadzo & Ncube, 2018; Nakawuka et al. 2018), which also came up in our study.

The committee of the irrigation scheme seems to lack budget and leadership capabilities in order to lead development of the scheme. Lack of budget can be related to funding, which is hard for irrigation schemes to obtain due to limited access to financial and credit services (Nakawuka et al., 2018). The inability of the scheme to provide capacity building to the members or form a production group causes the farmers to lack bargaining power and market strategy, both needed in order to effectively reach markets. This might cause some to find growing horticulture less beneficial, and make it difficult to enter the production of high-value horticultural crops. Lack of bargaining power, market strategies and production groups are also mentioned

elsewhere (Fanadzo & Ncube, 2018; Nakawuka et al. 2018), and seem like a common problem in value chains, where farmers end up without a fair price for their produce. Though, the solution of forming production groups has also produced new challenges, where farmers end up not being paid (Nakawuka et al. 2018).

As to the extension services, a study carried out in nine SI schemes in Kenya concludes that Kenya has always suffered from lack of targeted extension and suggests that actions and operations from different sectors are needed (Mati 2008). Nakawuka (2018) also points out that lack of extension services is a major problem in SI in Eastern Africa. These results coincide with our findings that there is a lack of extension services which leads to blaming and disinformation between extension officers and community members. This constrains the development of the scheme.

Inefficient water use came up during our study, when gaining insight into the use of sprinklers and the time of irrigation. Furthermore, we saw old and broken equipment that was leaking several places. An insufficient maintenance fee is collected by the committee, and high maintenance fees have always been a problem in Kenyan SI schemes (Franks et al., 2013; Kulecho & Weatherhead, 2005). Since some of the respondents said that water was not enough during the dry season and the water was rationed, with access every other day, the scheme would greatly benefit from less water wastage and a more efficient use. Lack of maintenance of irrigation system is not only observed in our study (Nakawuka et al. 2018) and the need for knowledge in water management is connected to the need for a more innovative leading committee and extension service. Nakawuka et al (2018) also highlighted how inefficient water management can result in unequal distribution of the water in gravitational irrigation systems. However, this only came up once in our study and the committee claims that the pressure is strong enough for any number of sprinklers. Nevertheless, the number of sprinklers we did see consistently during our research was never higher than five pieces, and we are unsure of the reason.

Main outcomes from our investigation in the irrigation scheme, such as increased income, food security, access to water, more time are also to be found in the majority of SI schemes. (Nakawuka et al., 2018; Sikhulumile et al., 2014; Zeweld et al., 2015).

It is obvious from our study, that not all the farmers manage to exploit the potential yields correlated to irrigation farming nor apply water efficiently. According to Fanadzo & Ncube (2018), there is an ample opportunity to raise crop yields among the SI in order to meet the growing demand for food in the future. In

order to do this in Kithiria, we see a need for improved extension services, development initiatives within the scheme, cooperation among the farmers and more focus on market in their farming strategies.

Methodology

Generally, for all the methods applied, having more respondents or samples would have led to a more solid and comprehensive data analysis. Furthermore, comparison with livelihood strategies of people lacking access to irrigation could have been beneficial for highlighting the influence of irrigation.

One of the important reflections on the questionnaire is that we could have collected more comprehensive data on farmers' livelihood strategies and capitals. We ignored the data about non-irrigated farming, financial capital and physical capital. We could perhaps have captured this better, if we have had our own questionnaire prepared before entering the field, rather than adopting to our Kenyan counterparts' survey. Other factors that could have made our data of higher quality, would be if we had prepared more based on the pre-tests. We could also have agreed upon more specific definitions of things such as forestry and in general went through how we interpreted the questions.

When we carried out SSI, we should have chosen some interesting cases from our questionnaire instead of selecting them randomly according to age and gender. In addition, although we were in a rush due to farmers being busy, we could have posed more open-ended questions and follow up questions. We should also have focused more on their activities. This could have been obtained if we had spent more time on revising the objectives relevant for SSI.

Our results are also influenced by the data we collected from FGD & PRA. Because the method was rushed due to few and busy participants, we were not able to obtain all the data we planned to. We could have booked our FGD in advance so we might have had more attendants. Further, our moderators either suggested too much or did not manage to facilitate the discussion well, which influences the data. Another issue was the seating arrangement. We all sat on the opposite side of our attendants, which proved to be a mistake. As a last statement, the methods could have been carried out during the first days, to give us more focused data collection later.

We could have analysed our sampled soils in a better way if we had managed to obtain more detailed information on other variables involved in the soil fertility.

Group Work

It is natural that, as a multi-disciplinary, multi-cultured group, we have faced challenges related to group work. One of the things that we would have liked to do differently would be to allow more space for data processing and analysis during our field research. This would have resulted in overall better, more relevant and complete data related to our subject. Additionally, the division of the roles and responsibilities, while seeming like a good and efficient idea at the time, proved to be less than ideal during the analysis. During the SSI, FGD and questionnaire, the Kenyan students were

the only ones posing all the questions because of the language barrier. In retrospect, we believe that the result obtained could have been better if all the students were involved in the formal interactions with the locals, even if the process would have been slowed down by the use of an interpreter. Furthermore, the differences in specialisation, personalities and work habits have posed a significant challenge in the report-writing part of the course. We hope that we have managed to change these weaknesses into strengths, and that the final result is better for it.

Conclusion

The Kii-Kithiria irrigation scheme have generally benefitted the members by increasing their income, water access, free time and engagement in livestock rearing. It was not possible for us to detect if they benefitted differently according to how well they manage to intensify horticultural production. According to our soil sample results, natural resource base sustainability is ensured concerning soil fertility.

The members are mainly engaged in agricultural activities, such as growing horticulture, staple crops, cash crops, and livestock rearing. We did not manage to capture the full picture of the members' livelihood strategies. This might explain why we did not see any correlation between capitals and the level of intensification in their production of horticulture.

We have looked at institutions and organisations from two perspectives. At a local level, we conclude that the irrigation committee do not facilitate development of the scheme, and a county level, the extension officers cause limitations for farmers in improving their livelihood strategies. This is further related to their own budget constrictions and lack of communication. A central barrier within institutions is the issue of market access. The local market is saturated with horticulture crops and it is difficult for the farmers to access a different markets.

This study has revealed the difficulty in capturing livelihood strategy outcomes from only the perspective of capitals or organisations and institutions. All of these act together to paint a picture of the complex livelihood strategies in which irrigating Kithirian farmers are involved.

Reference List

Chambers, R., & Conway, G. (1991). Sustainable Rural Livelihoods: Practical Concepts for the 21st Century. [online] Available at: http://publications.iwmi.org/pdf/H_32821.pdf [Accessed the 02th of April 2019].

Chepyegon, C. & Kamiya, D. (2018). Challenges Faced by the Kenya Water Sector Management in Improving Water Supply Coverage. *Journal of Water Resource and Protection*, 10, pp. 85-105.

Climate-data.org. (n.d.). Embu climate: Average Temperature, weather by month, Embu weather averages - Climate-Data.org. [online] Available at:

https://en.climate-data.org/africa/kenya/embu/embu-927025/ [Accessed 29 Mar. 2019].

Dell'Angelo J., McCord P. F., Baldwin E., Cox M. E., Gower D., Caylor K., and Evans T. P. (2014). Multilevel Governance of Irrigation Systems and Adaptation to Climate Change in Kenya. In: A. Bhaduri, J. Bogardi, J. Leentvaar, and S. Marx, ed., *The Global Water System in the Anthropocene*, 1st ed. Basel: Springer International Publishing Switzerland, pp. 323-341.

Ellis, F., (2000). A Framework for Livelihood Analysis. In: F. Ellis, ed., *Rural livelihoods and diversity in developing countries*, 1st ed. Oxford: Oxford University Press, 28-51.

Fanadzo, M. & Ncube, B. (2018). *Challenges and opportunities for revitalising smallholder irrigation schemes in South Africa.* Water SA, 44, pp. 436-448.

FAO (2017). *The future of food and agriculture - Trends and challenges*. [online] Rome: Food and Agriculture Organization of the United Nations, 11-13; 39-47. Available at: http://www.fao.org/3/a-i6583e.pdf [Accessed 10 February 2019].

Franks, T., Cleaver, F., Maganga, F., and Hall, K. (2013). *Water governance and livelihoods: Outcomes for smallholders on the Usangu plains, Tanzania*. Water Resources and Rural Development, 1, pp. 1-16

Freeman, H. A. & Silim, S. N. (2002). Chapter 4. Commercialization of smallholder irrigation: Economic and social implications in semiarid areas of eastern Kenya. In: H. G. Blank, C. M. Mutero and H. Murray-Rust, eds. 2002. *The changing face of irrigation in Kenya: Opportunities for anticipating change in eastern and southern Africa*. Colombo, Sri Lanka: International Water Management Institute, pp. 265-275.

Godfray H. C. J. & Garnett T. (2014). Food security and sustainable intensification. *Philosophical Transactions of the Royal Society B*, [online] 369 (1639), article ID: 20120273, 1-10. Available at: http://dx.doi.org/10.1098/rstb.2012.0273 [Accessed 13 February 2019].

Kinyua, M. M., Mwangi, A. W., Riro, G. K., and Muchiri, P. N. (2015). *Financial Management Aspect on Sustainability of Community Managed Water Projects In Kieni West District, Nyeri County, Kenya*. European Journal of Business and Social Sciences, 4(4), pp. 123–141

KIPPRA (2018), *Realizing the "Big Four" Agenda through Energy as an Enabler Issue 9-3 January - March 2018* (Issue 9 No. 3). Nairobi: Kenya Institute for Public Policy Research and Analysis, 9-11. Available at: http://kippra.or.ke/wp-content/uploads/2017/05/Realizing-the-"Big-Four"-Agenda-through-Energy-as-an-Enabler-Issue-9-3-January-March-2018.pdf [Accessed 10 February 2019].

Kulecho, I. K. & Weatherhead, E. K. (2005). Reasons for smallholder farmers discontinuing with low-cost micro-irrigation: a case study from Kenya. *Irrigation and Drainage System*, 19, pp. 179–188.

Mati, B. M. (2008). *Capacity development for smallholder irrigation in Kenya*. Irrigation and Drainage, 57, pp. 332-340.

McCord P., Wadlman K., Baldwin E., Dell'Angelo J., and Evans T. (2018). Assessing multi-level drivers of adaptation to climate variability and water insecurity in smallholder irrigation systems. World Development, 108, pp. 296-308

Mendes, D. M. & Paglietti, L. (2015). *Kenya: irrigation market brief*. Rome, Food and Agriculture Organization of the United Nations, 1-5. Available at: http://www.fao.org/3/a-i5074e.pdf [Accessed 15 February 2019].

Mingochi, D. S. (1998). Introduction to horticulture. In: *FAO Special Programme for food security in Zambia. Small-holder irrigation and water use programme – irrigation component.* [online]. Available at: http://www.fao.org/3/X5642E/x5642e05.htm#introduction%20to%20horticulture [Accessed 29 Mar. 2019].

Mutambara, S., Darkoh M.B.K., and Atlhopheng J.R. (2016). A comparative review of water management sustainability challenges in smallholder irrigation schemes in Africa and Asia. Agricultural Water Management, 171, pp. 63-72.

Nakawuka, P., Langan, S., Schmitter p., & Barron, J. (2018). A review of trends, constraints and opportunities of smallholder irrigation in East Africa. *Global Food Security*, 17, pp. 196–212.

Janick, J. (2015). Horticultural Crops. [online] Access Science. Available at:

https://www.accessscience.com/content/323900 [Accessed the 26th of March 2019].

Mikkelsen, B. (2005). Participatory Methods in Use. In B. Mikkelsen, ed., *Methods for Development Work and Research: A New Guide for Practitioners,* 1st ed. New Delhi: SAGE Publications India Pvt Ltd., 87–123

Ministry of Agriculture, Livestock and Fisheries, (2017). *Kenya Climate Smart Agriculture Strategy 2017-2026*. Nairobi: Government Printer, pp. 2-3

Meteoblue.com. (n.d.). *Climate Embu.* [online] Available at:

https://en.climate-data.org/africa/kenya/embu/embu-927025/ [Accessed 29 Mar. 2019].

Musante DeWalt, K (2014). Participant observation. In: H. R. Bernard and C. C. Gravlee, ed., *Handbook of Methods in Cultural Anthropology, 2nd ed*. Lanham: Rowman & Littlefield, pp. 251-293.

Republic of Kenya (2002). *Water Act 2002*. Nairobi: Government Printer, pp. 7-18.

Rea, L. M. & Parker, R. A. (2005). Designing Effective Questionnaires. In: L. M. Rea & R. A. Parker, 3rd ed., *Designing and Conducting Survey Research*. San Francisco: Josey-Bass, 30-47.

Scoones, I. (2015). Livelihood Frameworks and Beyond. In I. Scoones, ed., *Sustainable Livelihood and Rural Development,* 1st ed. Canada: Fernwood Publishing, 34-45.

Schultz, B., Thatte, C.D., & Labhsetwar, V.K. (2005). Irrigation and drainage. main contributors to global food production. *Irrigation and drainage.* 54, pp. 263–278.

Sikhulumile, S., Maxwell M., and Edilegnaw W. (2014). The impact of smallholder irrigation on household welfare: The case of Tugela Ferry irrigation scheme in KwaZulu-Natal, South Africa. Water SA, 40, pp. 145-156.

Spaling, H., Brouwer, G., & Njoka., J. (2014). Factors affecting the sustainability of a community water supply project in Kenya. Development in practice, 24(7), pp. 797-811.

Thompson, Paul B (2008). The Ethics of Sustainable Agricultural Intensification: FAO Ethics Series. In *The Ethics of Intensification: Agricultural Development and Cultural Change*. The International Library of Environmental, Agricultural and Food Ethics. Dordrecht: Springer Netherlands, pp. 19–41.

WFP (2018). *Kenya country strategic plan (2018–2023)*. Rome: World Food Programme, 3-4. Available at: https://docs.wfp.org/api/documents/WFP-0000070522/download/ [Accessed 13 February 2019].

Zeweld, W., Huylenbroeck, G. V., Hidgot, A., Chandrakanth, M. G., & Speelman, S. (2015). *Adoption of Small-Scale Irrigation and Its Livelihood Impacts in Northern Ethiopia*. Irrigation and Drainage, 64, pp. 655–668.

Appendices I – Table of Applied Methods

Method	Numbers
Transect Walk	1
Questionnaire	31 respondents
Semi-Structured Interviews	6 with farmers and 6 with key informants
Focus Group Discussion	1 with 6 attendants
Participatory Rural Appraisal	2: Venn-diagram and SWOT with 6 attendants
Observation	37: goes along with questionnaires and SSI
Participant Observation	Numerous
Soil Sampling and Analysis	15

Appendices II – The Multilevel Governance in Kenya

The Kenyan government started to improve its national water supply just after its independence in 1967 (Chepyegon & Kamiya, 2018). A new water policy was introduced in 2002, enacted in 2003 and the implementation began in 2004, to overcome both obstacles in expanding water infrastructure and sustainability issues from existing systems (Chepyegon & Kamiya, 2018; Spaling et al., 2014; Republic of Kenya, 2002). Under this water act, management of the water resources was separated from the provision of water services and institutions was established for each in a multilevel institutional regime (Dell'Angelo et al., 2014; Spaling et al., 2014) headed by the Ministry of Water and Irrigation (MWI) who is in charge of policy formulation (Chepyegon & Kamiya, 2018). The Water Resources Management Authority (WRMA) at the national and the regional level manage the water resources and are responsible for distributing water permits to the users, for legally withdraw of the water. A consumption tariff must also be paid based on the actual (metered) or permitted (no meter) withdrawal. In order to participate in water resource management, users can become members of Water Resource User Associations (WRUA) who report to WRMA and advise it on regulations and control of the local water source. The association may access expertise and funding to enhance capacities of its members. The national Water Services Regulatory Board (WASREB) authorises the regional Water Service Boards (WSB) to provide efficient and economic provision of water. The Water Service Providers (WSP) are agents of the WSB licensed to deliver water.

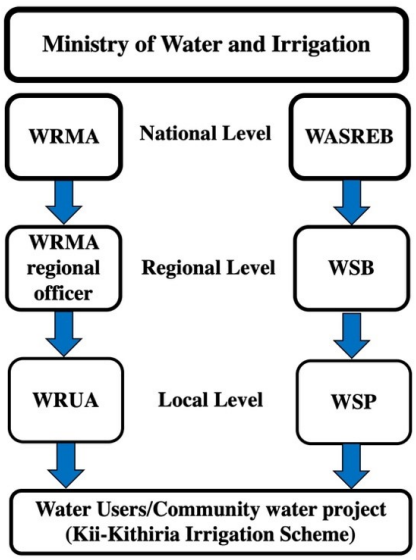


Figure 15 Chart shows the structure of Kenya's water sector management

Appendices III - SWOT

Strengths	**Weaknesses**
- They have land - They have access to the river Kii - They have organic manure (cows, chickens, etc.) - They have some farming knowledge - How to you get farming knowledge? Madlyn: we walk around and see what neighbours are doing, ask about it and they go back and do the same	- Insufficient amount of water in the dry seasons - Issues of market access - Poor extension services - Poor road infrastructure - Lack of farming inputs (e.g. seedlings and pesticides) - Pauline: "we don't get pesticides, the pests are many, and they destroy our crops" - Issue of them not having water harvest at the intake
Opportunities	**Threats**
- Food security, now they do not need to go to the market to buy cabbages (Catherine Ruguru) - Employment – during the dry season people used to rest but now they can work through the whole year (Emilyo) - The standards of living have improved, the houses used to be built from mud, but now there are more stone houses. Emilyo: "once you sell kales you can built a house or buy a cow". Tabitha agreed. Emilyo explained how he had used the income from tomato farming to build his house and pay school fees. - Water availability for domestic use all the time - Catherine Ruguru: they get feed for cows because they can now irrigate napier grass - The cow production of milk increased due to availability of feed and water - The opportunities are just one, they see that the youth can farm using irrigation water - Emilyo: Implied that he sees (expect) that the roads will improve in the future (since they are producing so much)	- Talked about climate changes. - Louise: when the rain is too heavy, the coffee produce falls off the trees. - Prolonged drought - Emilyo: Market flooding (overproduction) - Pest and diseases

Appendices IV – Questionnaire

RESEARCH QUESTIONAIRE

Interview No.		Interviewer	
Date		Note taker	
GPS waypoint		Observer	
		Interpreter	

INTRODUCTION

"We would like to ask some questions about irrigation. Are there any in this house involved in irrigation who would volunteer to answer our questions?"

- Our names
- The institutions we come from
    - (Denmark, Copenhagen) University of Copenhagen
    - (Kenya, Nairobi) Wangari Maathai Institute for Peace and Environmental Studies
- Purpose
    - We are here as students as a part of our education.
    - The theme of our project is irrigation and how it influences local people's lives.
    - We are interested in all information about the irrigation scheme, even if it is just used at a small scale or any other use of the irrigation water.
    - Next Monday there will be a feedback session.
- Time
    - The questionnaire will take about 30-40 minutes
- Confidentiality
    - We will not share your private information such as name and where you live with anyone and we will only use the information you provide us for our research.

PART A: BIO-DATA

Name (optional): _____

	Male	Female
Gender		

	<18	18-35	35-50	>50	(years)
Age					

	None	Primary	Secondary	Tertiary
Level of education				

	<2	2-5	5-10	>10	(Years)
Residence period in Kithiria					

PART B: SOCIO-ECONOMIC & ACCESS TO RESOURCES

1. What type of activities are you involved in? **Fill out table below.**

2. Please can you rank the activities according to financial value (referring to question 1)? **Fill out table below.**

   (1 is your main economy, 2 is your second economy and so on)

	Question 1	**Question 2**
Activities:	Activities involved in (X)	Ranking according to financial value: *From highest (1) to lowest (higher number)*
Irrigated farming		
Non-irrigated farming		
Forestry (growing trees)		
Livestock raring		
Business activities		
Others (specify)		

3. What is your type of ownership to the land?

Private	Public	Lease	Other (specify)

4. How many acres of land do you have in total, including settlement and farmland elsewhere? ☐

5. How many acres of farm land do you have within Kithiria approximately? ☐

6. How many acres of farm land in Kithiria do you irrigate approximately? ☐

7. Which of the following farming strategies are you applying?

Chemical fertilizer	Organic manure	Intercropping	Mulching	Crop rotation	Other:

8. Please can you answer the following questions about the irrigated crops you have harvested in the last cropping season?
    - **a.** What kind of crops?
    - **b.** Can you rank the crops after their financial value? (From the best (1) to worst)
    - **c.** Is the crop irrigated?
    - **d.** What is the yield of each crop?
    - **e.** Do you mainly sell or consume the produce?

a	**b**	**c**	**D**	**e**
Crop	**Crop ranking (financial value)**	**Is the crop irrigated? (yes/no)**	**Yield (specify units)**	**Sell or consume?**

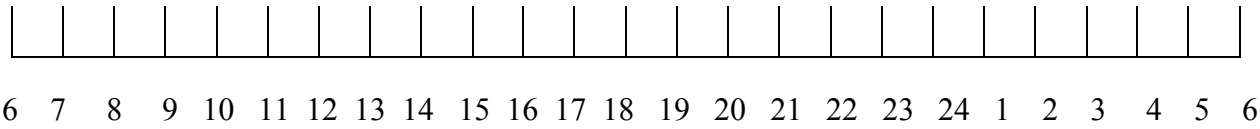
9. What kind of irrigation methods do you use?

Sprinkler	Drip	Furrow	Other (specify)

10. In which month do you irrigate?

All	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

11. What time of the day do you irrigate?



12. Please, can you tell us if you use the water from the irrigation system for any of the following purposes, other than farming?

Domestic	Drinking	Livestock	Others (specify):

13. What kind of labor do you use on your farm?

Family labor	Hired labor	Both

14. Do you think that the irrigation has contributed to the increase in your income?

Yes	No	Other

PART C: GOVERNANCE

15. How many times a year does the agricultural officer (extension staff) visit to advise you? ☐

16. Does the county government support you with any of the following services?

None	Provision of Seedlings	Fertilizer subsidy	Mechanical assistance	Financial assistance	Training	Other (specify)

17. In what year did you became a member of the irrigation scheme? ☐

18. Do you benefit from being a member of the irrigation scheme?

Do not benefit	Somehow benefit	Greatly benefit	Explain reason:

19. Do you participate in the decision making in the irrigation group?

Do not know	Strongly disagree	Disagree	Agree	Strongly agree

20. Are you member of any other farmer group, Sacco, cooperative, or other organisation?

Specify:

PART D: CLIMATE CHANGE

21. To what extent do you support this statement:

"The temperatures have increased during the last 10 years"

Do not know	Strongly disagree	Disagree	Agree	Strongly agree

22. To what extent do you support this statement:

"The rainfall patterns have changed compared to 10 years ago"

Do not know	Strongly disagree	Disagree	Agree	Strongly agree

23. To what extent do you support this statement:

"The amount of water in the river has reduced compared to 10 years ago"

Do not know	Strongly disagree	Disagree	Agree	Strongly agree

24. To what extent do you support this statement:

"The issues mentioned in the 3 previous statements have changed your irrigation practices"

Do not know	Strongly disagree	Disagree	Agree	Strongly agree

25. To what extent do you support this statement:

"Climate change is a concern for me"

Do not know	Strongly disagree	Disagree	Agree	Strongly agree

Ending statement:

1) Thank you for your time
2) Please, can we get your phone No. if we need to get back to you for a more detailed interview?

   _____
3) Remember, this is anonymous and your information will only be used for educational purposes.

Appendices V – Synopsis