Degradation or Conservation of Soils:

a Case on Soil Fertility, Perceptions, Management Practices and Livelihood Assets Among Farmers in Kibugu, Embu Region, Kenya

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Abstract

This study uses an interdisciplinary approach to investigate the case of soil fertility for maize and coffee plots in Kibugu location, Kamavindi sub-location, Kenya. Quantitative and qualitative data on farmers' management practices, their perceptions of soil fertility and soil chemical and physical properties were collected using mixed methods. The research question for this study asks about the connection between soil fertility, management practices for maize and coffee, and farmer's access to resources, and how these results fit into the bigger discussion of soil degradation in Sub-Saharan Africa. To answer this question, the data was triangulated with relevant literature which discusses different narratives on environmental degradation by resource-poor farmers. Soil chemical properties measured were pH, P, Total N, Total C and Cu. The results show soil-chemical properties to not be significantly depleted, that farmers in general perceive their soils to be fertile, and most farmers perceive an increase in soil fertility in their coffee plot, with total carbon and total nitrogen levels significantly higher compared to maize. Yields and indicator weeds were the most important indicators to farmers for soil fertility. All farmers were found to use manure and inorganic fertilizers in both coffee and maize, in varying amounts, despite perceived challenges in access to inputs. All farmers were also found to participate in various soil fertility enhancing practices such as soil erosion control, agroforestry, intercropping, application of organic fertilizers, mulching and crop rotation. The results of this study challenge conventional thinking which lies within the topic of soil degradation.

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1. Introduction

Soil fertility describes the soil's ability to facilitate plant growth, and is defined by the physical, biological and chemical properties of the soil, which all support or repress plants' nutrient uptake. Infertile soils are not able to support high yields, and high crop yields are needed to sustain and feed the world population. Low soil fertility is therefore seen as a direct major biophysical cause of low food production, contributing to food insecurity and poverty in Eastern Africa, and also on the global scale (Charles K.K. & Gachene G.K. 2003; FAO *et al.* 2018; Sanchez, 2002). At the same time however, measuring soil fertility is complex and there is little to no complete data on soil fertility on the national and global scales because of missing long-term quantitative comparative data (Vlek *et al.* 2010). Nevertheless, there is a strong scientific discussion on soil degradation as a widespread environmental crisis, its causes and how it can be defined.

Soil degradation can be defined in different ways. One definition of soil degradation from FAO and ITPS (2015) is as follows:

> *"Soil degradation is the decline in soil quality caused its improper use by humans, usually for agricultural, pastoral, industrial or urban purposes. Soil degradation may be exacerbated by climate change and encompasses physical, chemical and biological deterioration."*

According to the new Soil Atlas of Africa, soils in Sub-Saharan Africa (SSA) in general are degrading and nutrients are depleted through soil erosion and nutrient mining. They claim that this is partly due to changing management practices with growing populations, abandoning shifting cultivation and increasing intensification (FAO and ITPS, 2015; Jones *et al.* 2013). Similar to this, Vlek *et al.* (2010) argue that soil degradation is mainly a social issue of human land use such as land clearing and deforestation because of an increasing demand for

agricultural products. FAO and ITPS (2015) among others, claim that one of the drivers behind nutrient depletion in SSA are found to be the high prices of fertilizer, making replenishment of nutrients after harvesting out of reach to cash-poor farmers.

Nkonya *et al.* (2016) and Sanchez (2002) also find SSA to have experienced strong land degradation compared to the rest of the world. They see this degradation being due to a lack in government investments in natural resource protection, and similar to what the sources already mentioned, a diminishment in traditional practices and a high annual nutrient depletion in soils without sufficient replenishment.

On the other hand, Vlek *et al.* (2010) claim that soil degradation has the potential to be solved if the underlying aspects are understood and acted upon. Sanchez (2002) argues that many households in Kenya and other Sub-Saharan countries use diverse combinations of fallow periods, biomass applications and agroforestry components which support the conservation of soils.
While the highlands of Kenya are considered to be one of the most agriculturally successful areas in the world (Jones *et al.* 2013), according to Jaetzold *et al.* (2005-2012) and Muya *et al.* (2008) the issue of soil infertility is also reflected in this region, more specifically in Embu county, where the field work for this study was conducted. They argue that farm sizes are becoming smaller and land use intensification as well as nutrient depletion can be observed. This intensification can be seen in an increased use of inorganic fertilizers and pesticides and shorter fallow periods (Muya *et al.* 2008). They claim that simultaneous inadequate management practices can be linked to a decline in soil fertility and hence a decrease in the productivity of the land. Additionally, Muya *et al.* (2008) argue that apart from scientific and technological innovations in soil conservation management practices, farmers' knowledge of ecosystem interaction and perceptions on soil fertility are essential for soil conservation. It is also found that low soil fertility in certain sites in Embu county, including Kibugu, can be attributed to high acidity and aluminium toxicity.

For the purpose of this study, it will be important to keep a distinction between soil infertility and soil degradation in mind - the first having to do with the physical, chemical and biological properties of specific soils and the latter describing changes over a timespan in these properties by human induced activities. This distinction will be used throughout this investigation and used in greater detail in the discussion.

1.1 Climatic settings and agro-ecology

Because of its location on the foothills of Mt. Kenya, Embu county is very diverse agro-ecologically. It ranges from the hot and dry low zones with less than 600mm annual precipitation, to the cold and humid upper highlands with more than 2000-2500 mm precipitation. The climate is dominated by two rainy seasons, the first starting in mid-March and the second in mid-October. The volcanic soils from the mountain are generally fertile. In Kibugu, the area of interest, which lies North of the town of Embu, the soil types are nitisols and andosols, known as being well drained, dark red or brown, clay soil with an acidic humic topsoil layer, and the area is relatively steep (Jaetzold *et al.* 2005-2012, Muya *et al.* 2008).

The agroecology of Kibugu is classified as the Upper Midland zone, where coffee and tea are especially suitable crops making them the main cash crops in the area. The application of inorganic fertilizers is common on cash crops, which are often distributed by cooperatives and deducted from produce value. Produce such as kale, tomatoes, Irish potatoes, avocado and mangoes are sold in local markets and some even in Nairobi (Jaetzold *et al.* 2005-2012). Food crops for subsistence are maize, yams, beans, cassava and arrowroot. According to Jaetzold *et al.,* these are most often fertilized with manure (Jaetzold *et al.* 2005-2012).

In this area which experiences heavy rainfalls and is comprised of steep slopes, different soil fertility and soil erosion measures are taken. *Fanya juu* terraces are a widespread practice in Kenya to mitigate soil loss. It means “make it up” in Swahili and is a method where a ditch is dug along the contours and the soil spill is thrown uphill to form a ridge, which is then stabilized by napier grass (*Pennisetum purpureum*), a C4 perennial grass often used as fodder for cattle (Thomas and Biamah, 1991) and with *Calliandra calothyrsus*, a multipurpose tree which also provides fodder and soil fertilization (Jaetzold *et al.* 2005-2012). On steep slopes hedgerows can also be effective in decreasing erosion through terrace planting and their extensive root networks which improve water interception (Muya *et al.* 2008).

Traditionally, crop rotations, plant residue incorporation, occasional application of manure in planting holes and short fallows were all part of farmers maintenance of soil fertility in maize

fields. Fallows and crop rotations are seldomly seen any more in high population density areas like Kibugu, as farm sizes have decreased. Also, the incorporation of plant residues competes with the need for fuel and fodder (Crowley and Carter, 2000; Jaetzold *et al.* 2005-2012). Maize-legume intercrops are commonly used as well as leguminous trees and manure from livestock, which are often applied to home gardens and to close or mid-distance maize fields (Castellanos-Navarrete *et al.* 2015; Jaetzold *et al.* 2005-2012). Those who can afford it use inorganic fertilizer to improve soil fertility. Additionally, the practice of "niche matching", the selective use of soils for specific crops, are common in many parts of Eastern and Southern Africa (Crowley & Carter, 2000).

1.2 Economy and Political Background

The Kenyan agricultural sector contributes to 25% of the country's GDP and employs approximately 65% of the people living in rural areas. According to Kabubo-Mariara (2015), its agricultural productivity is nevertheless constrained by institutional settings, access to markets and a growing population density. Many regions in Kenya are physically remote which negatively affects investments in soil conservation. Tenure security and market access are critical aspects to be tackled for successful adoption of soil conservation technologies (Kabubo-Mariara, 2015).

Technological agricultural development in Kenya is concentrated in a few urban areas such as Nairobi, Mombasa and Naivasha. Kenya's agricultural production is not very diverse, relying on few main commodities such as coffee, tea and flowers for export, which makes it vulnerable to external factors such as fluctuations in global prices. O Ndege (2009) claims that social and economic development in Kenya continues to be shaped by colonialism and post-colonialism. Despite structural adjustment programs, Kenya's economy lacks sovereignty and as in colonial times, the market today is still used as an instrument for political control, through price regulations by the Kenyan state. Kenya's economy continues to depend technologically, financially and commercially on many Western countries, Japan and also increasingly China. O Ndege (2009) argues that colonialism in Kenya has left its traces by contributing to the country's inequality and poverty, as it supported rural-urban and class differences. The colonial state governed through authoritarianism provided a base on which the post-colonial social structures continue to exist (O Ndege, 2009).

1.3 Background on Maize

Maize (*Zea mays L.)* is a major food crop in Kenya and is grown by 58% of smallholders in Embu county (Mburu *et al.* 2016). Since 1955, 20 improved hybrid maize varieties have been sold on the Kenyan market. Many farmers in Embu district had adopted improved maize varieties by 1997, but fertilizer use remained relatively low (Ouma O.J. *et al.* 2002). A farm survey conducted in the different agro-ecological zones of Embu County shows a decline in both maize yields and in land acreage meaning that maize production per head is not enough to meet daily requirements (Jaetzold *et al.* 2005-2012; Mburu *et al.* 2016).

1.4 Background on Coffee

Coffee (*Coffea arabica*), as a perennial shrub originating from Ethiopia (Graf, A., 1978), is a dominant, high value cash crop in the field site (Mburu *et al.* 2016). In Embu county coffee covers a stable area of 28% of the agricultural lands but is concentrated in the Upper Midland zones, also called the coffee-tea zones (Jaetzold *et al.* 2005-2012). According to Jaetzold *et al.* 2005-2012, coffee has lost its importance due to coffee-cooperatives neglect of payment to farmers but is still yielding around 850 kg/ha pro annum.

2. Research Objective

This study departs from the ongoing discourse of soil infertility and land degradation in Eastern Africa. In the context of the debate between resource poor farmers being the perpetrators of soil infertility versus farmers actually being the caretakers of soil and having the knowledge and skills to maintain or even improve soil fertility through management practices, this study investigates the production of maize and coffee in Kibugu, Embu County, Kenya. These two crops will be investigated as cases, with the aim of understanding the connection between soil fertility, farmers' management practices, and farmers' access to livelihood assets. Maize and coffee are chosen because of their importance in Kibugu location as subsistence and cash crops respectively, and their different agricultural characteristics.

2.1 Research Question

What is the connection between soil fertility, management practices for maize and coffee, and farmer's access to resources, and how do these results fit into the bigger picture of soil degradation in Sub-Saharan Africa?

a. What are farmers' perceptions of soil fertility, and how do these compare to our measurements of soil fertility?
b. Which soil fertility management practices do farmers choose for maize and coffee production and why?
c. What kind of access do farmers have to livelihood assets?

2.2 Description of Study Site

The location had a main paved road running through it, with homesteads situated either on the road, or down smaller dirt roads which run off of the main road. Types of houses ranged from small traditional like houses, to much larger villa like estates, and tended to correlate to the size of land owned, which ranges on average from 1 to 3 acres, according to a report of the Embu below ground biodiversity (BGBD) project (Muya et al. 2008).

3. Methodology

Our research topic is inherently interdisciplinary: the sampling of soils and the analysis of them in terms of fertility utilizes the natural sciences, while comparing these samples to questions of farmer's access to and wealth of livelihood assets along with their perceptions of soil fertility relies mostly on the social sciences. For this reason, we have employed a variety of mixed research methods to be able to gain knowledge from both disciplines. Because we as researchers come from different academic backgrounds, our mixed methods approach compliments and integrates our different skill sets and academic knowledge. No specific methodology necessarily outweighs the other in terms of importance; all methods are equally significant for us to be able to produce adequate data for analysis and respond to our research question.

3.1 Questionnaires

31 questionnaires were carried out in the Kamavindi sublocation, Kibugu location to collect quantitative data on information such as area of land owned, education levels, household contributors and dependents, types and numbers of livestock owned, types of crops grown, management practices for maize and coffee, perceptions of soil fertility, and sources of farmer's agricultural knowledge. We started in the southern end of the area, and worked our way north, visiting every household, and collecting data from all households who had a member home who made decisions having to do with maize or coffee and was willing to speak with us. As many households did not fulfil these criteria, every household was visited in the area until we had sufficient respondents.

3.2 Semi-structured interviews

After collecting the questionnaires, we identified ten households to return to, and carry out semi-structured interviews. These were chosen by considering a good geographical distribution within the Kamavindi area, as well as an even distribution within gender, age and our preliminary impressions of households' wealth. Another factor which was considered was whether or not we had the impression that the person of concern would contribute to a fruitful interview. All questionnaire respondents grew both coffee and maize, so this was not an issue in choosing our interviewees. In the end we carried out nine semi-structured interviews with six male and three female farmers, because two female farmers could not be found at their homes, so one other male interviewee was chosen instead. Interviewees were asked to describe their experiences with growing coffee and maize, their management practices, their yields, and their main challenges. As the interviews were in the semi-structured format, this left room for questions which were not necessarily prepared beforehand and allowed for greater investigation into topics brought up by the interviewees themselves. The colour coded interviews can be found in Appendix 9.3.

We also selected five key-informants to interview: one shopkeeper from an Agrovet, one vice-chairman from the local coffee cooperative, one Kenyan Agricultural Research Institute informant, one local agricultural officer and one private coffee producer and processor, who was also treated as a part of the group of interviewees from the semi-structured interviews. The key informants were chosen based on who we thought would be most relevant and informed about soil fertility especially having to do with coffee and maize in the Kamavindi area.

3.3 Farm Mapping Exercise

Before beginning the interviews, farmers were asked to map out their farm on paper and note the things which they deemed to be especially important. This was used both as an "ice-breaker", and to gain a preliminary understanding of the interviewees' land, which made for good background information that we were able to refer to later on in the interview. It also gave farmers the opportunity to "show" us the important aspects of their farms, which might otherwise be forgotten during the semi-structured interview.

3.4 Soil Sampling

Samples were taken from each of the semi-structured interviewees' coffee and maize plots. A composite sample from four average looking spots in zigzag pattern across the plot were pooled. Samples were collected using a soil auger to a depth of 20 cm. For coffee, the augering was done underneath the coffee trees. A small portion of each composite sample was kept in a closed plastic bag to retain moisture and the rest was air dried and packed in plastic bags.

The physical properties of the soil were evaluated by field texture determination and bulk density sampling. The texture of the soil was analyzed on one farm using the feel method adapted from Schlichting, Blume & Stahr (1995). A 100cm^3 sample was taken on one farm in 20 cm depth with a soil ring to measure bulk density.

The chemical characteristics of the soil were evaluated using five parameters which together gives an indication of the soil fertility. pH measurements were done on dry soil in 0.01 M $CaCl_2$, using a glass electrode pH-meter after end to end shaking for an hour. Water-extractable phosphorus (1:60 dry soil:water) was measured on moist samples. Extracts were analyzed with flow injection analysis. Modified after Van der Paauw (1971). Water content was calculated with weighing samples before and after oven drying for calculation of P concentration. Total carbon and total nitrogen were analyzed by elemental analysis on dry soil.

Copper content was analyzed by ICP-OES after microwave digestion with HNO_3 and H_2O_2. Copper is a metal which we observed to be used as a fungicide in coffee production. It is not directly related to soil fertility.

Nitrate was measured for all soils, but results are not reported due to inconsistency in the execution of the sampling and analysis.

3.5 PRA Transect Walk

After completing the interview, we conducted transect walks with the farmers, so that we could give the opportunity for him/her to explain to us their methods and practices in a more visual manner. This was complementary to the interviews as the visual aid of walking through the plots gave farmers the opportunity to remember certain aspects about their practices which they may have forgotten while sitting in place during the interview and mapping process. This also helped us to decide where the best place to take the soil sample would be.

3.6 Pooling of Livelihood Assets

As a means to group questionnaire respondents in terms of their livelihood assets, a point system was made which took human, financial, natural, social and physical livelihood assets into account. These assets and their corresponding points given can be seen in table 1. Amount of land owned was weighted as having by far the most value, because of the observed proportionate differences between the farmers in the same community and because of the importance of access to land when describing livelihood assets in relation to agriculture and soil fertility.

Table 1. Point system for wealth assessment.

Category	**Asset**	**No. Points Given**
Education Level of Respondent	Primary education	1
	Secondary education	2
	Tertiary education	3
	Number of other household members with tertiary education	1 point per each extra household member
Household	No. of household contributors	No. of household contributors

Contributors		divided by household size
Land owned or leased	Total land in acreage	1 point/acre
Livestock owned	Cows	0.5/cow
	Goats and pigs	0.25/goat or pig
	Chicken, ducks and rabbits	0.125/chicken, duck or rabbit
Access to Knowledge	Access to multiple sources where agricultural knowledge is obtained	1 point for 3-5 indicated sources, 2 points for 6 or more
Diversification of livelihood activities	Multiple sources of income	0.5/livelihood activity
Crop Diversification	Multiple crop production which farmers can depend on	1 point for 3-5 different crops, 2 points for 6 or more
Other agricultural assets	Ownership of machine(s) for agricultural purposes, access to irrigation, and/or use of hired labour in agriculture	0.5

After each asset was accounted for in terms of the point system, a range from 0 to the highest point achieved (39.83) was divided into thirds. The lower third was defined as those farmers having 0 to 13.275 points, the middle third with 13.275 to 26.55, and the upper third with 26.55 to 39.83 points. Although it may be controversial as to whether or not diversification of livelihood strategies and crop diversification can directly correlate to improved wealth, in this case they are counted as assets because we consider them to count towards farmers' food and income security. While this simplified system does not account for everything, it has been used to find a rough estimate of farmers' assets.

3.7 Statistics

Most results are reported as averages. Results in table 2 and 4 are tested for significant differences by a simple t-test using STASA and evaluated on a P-value < 0.1 significance level. Results reported in table 5 and 6 are not tested for significance because of the small sample size.

4. Results

The interviewees subject to this study are nine households, all of them were respondents to our questionnaire and have been interviewed as described in section 3.2. Six of the interviewees are male and three females. Age wise they are well spread out between <30 to >60 years with different educational backgrounds and varying experience in farming. The farms vary in sizes from 0.5 to 20 acres and number of household members varies, but all have farming as their main source of income.

Soil samples from two more households have been included. Those two were both respondents of the questionnaire and one was a key informant. In total 11 farms had two soil samples taken and analyzed each; 12 samples from coffee plots and 10 samples from maize plots.

Furthermore, 13 out of 31 questionnaire respondents (QR) all had completed primary education, 17 had completed secondary, and one QR had completed tertiary. All except three QR listed either farming, crop farming, livestock farming, coffee farming or macadamia farming as their main income source. The three exceptions listed “casual labour and business”, “pension and farming”, and “business” instead. When it comes to diversification, 29 of the 31 QRs participate in three or more livelihood activities, and nine out of 31 grow three to five different crops, while 20 grow six or more. There were two QR’s which grow less than three different crops. 29 QR’s grow coffee, while 27 grow maize; all QR’s grow at least one of the two crops, and all QR’s grow coffee as a cash crop, while maize was grown primarily for subsistence. Men tended to almost always be the ones in charge of the coffee production, while women were those mostly responsible for subsistence crops such as maize. We also found that in total, 24 out of the 31 respondents own at least one cow.

4.1 Physical and chemical soil fertility parameters

The texture analysis of the soil in the study area showed it to be a clay rich silt loam (SiL) with around 10-27% clay. The bulk density was measured and calculated to be 0.792 g/cm^3. Most soils have a bulk density between ~1.20 and 1.60 g/cm^3 (Canarche *et al.* 2006) and lower bulk

densities are mainly found in soils with a high organic matter content. According to Hazelton et al. (2016), bulk densities for all soil types below 1 are satisfactory for plant growth and root development. The sample was taken in a plot waiting to be prepared for maize after being left fallow on the lower part of a farm, close to a small river.

The results of the soil analysis done on five parameters - pH, phosphorous, total nitrogen and total carbon and copper content - are shown in table 2, and raw data can be found in Appendix 9.2. The results are shown for maize and coffee plots and on average. The soil is strongly acidic, with a low pH averaging around 4.41 measured in $CaCl_2$, which is below the range most suitable for plant growth (Hazelton *et al.* 2016). The differences in pH between the plots are not significant, but the coffee does show to have lower pH on average. Even though differences in phosphorus levels seem large between the maize and coffee plots, and it would be tempting to state that here a difference in prioritization of fertilization can be seen, the results are not significant.

For total carbon and total nitrogen, the story is different. Here we observe significantly higher levels for coffee plots than for maize plots. Higher total carbon can be partly due to coffee being a perennial crop, nevertheless total carbon and total nitrogen can be indicators of higher fertility and maybe also a higher prioritization in management practices, considering for example fertilizer and manure application as well as soil erosion control. The importance of coffee is explained by a farmer: "*I have used coffee to educate my children. We were given checks at the factory where the school fees would be deducted after the payout.*" (QR 28). The same farmer explains why maize is also important to her, but for a different reason: *"I have never been employed and I rely on maize for subsistence and for selling, so I cannot complain, because I have been sustaining me and my family since I started."*

Table 2. Chemical soil properties for coffee and maize plots and pooled. Source: own data

Chemical parameters of soil fertility	**Coffee plots**	**Maize plots**	**Total**	**Significant (P-value <0.1)**
pH	4.32	4.53	4.41	No
P [mg/kg]	7.915	5.744	6.928	No
Total N [%]	0.36	0.32	0.34	Yes

Total C [%]	3.00	2.65	2.84	Yes
Cu [mg/kg]	52 (excl. outlier) (incl. Outlier: 92)	n/a	n/a	n/a

The levels of total nitrogen are on average high (Hazelton *et al.* 2016), but it is important to note that the total nitrogen in the soil is not a measure for the nitrogen which is available for plant growth - it might be held in organic matter or in its unavailable forms. The strongly acidic soil also inhibits the plant uptake of nitrogen as well as other nutrients, further inhibiting the availability of nitrogen, even though the soils' content of N is high.
The copper content in the soil was 52 mg/kg on average, excluding one outlier of 450 mg/kg. This level of copper in the soil is higher than other nitisols usually show (Elias, 2017), but overall not high enough to cause concern. The only exception is the outlier of 450 mg Cu/kg soil which exceeds the effective concentrations of 355 mg Cu/kg reported elsewhere to be mildly damaging to establishment of new crops (Mondaca *et al.* 2017).

4.2 Farmer Perceptions

Questionnaire respondents were asked about their general perception of the fertility of their soils and a majority perceives their soils as fertile (Table 3). Respondents were also asked about whether or not they observed an improvement in their soil fertility under maize and coffee since they started farming. Many more respondents indicated improvements in their soil fertility under coffee rather than that under maize, as seen in table 3. Farmers indicated most frequently that they experienced similar yields in maize over time, to explain the fact that they didn't see any changes in the fertility of these soils.

Table 3: The perceptions of soil fertility and changes in soil fertility of farmers. Source: own

	All farm	
Perceives soils fertile	58.1 %	
Perceives soils infertile	38.7 %	
Unknown	3.2 %	
	Coffee	**Maize**
Observes increase in soil fertility	61 %	45 %
Observes decrease in soil fertility	32 %	23 %
Observes no change in soil fertility	6 %	32 %

If respondents answered that their soils under coffee and maize had either improved or declined, they were asked to distinguish from a list of indicators which ones they valued to be indicative of this change (figure 1). Overall, yields were the most determining factor in farmers' evaluation of changes, but weeds were also considered an indicator by most farmers. Many farmers seem to know indicator weeds for soil fertility quite well. *"Some sections show weeds indicating fertility, some show weeds indicating lack of it. This is similar for the maize plots though the latter shows more weeds indicating poor fertility."* (QR 30)

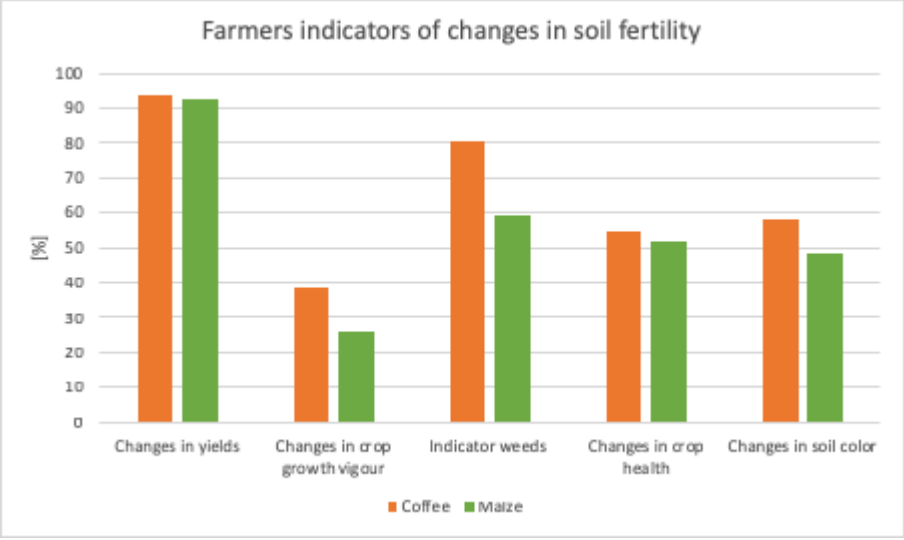

Figure 1: The percentage of farmers perceiving different observations as indicators for soil fertility changes.

Yields from last season's coffee (2018) were collected from nine respondents and maize yields from seven respondents which were interviewed and were subjects for soil analysis. The numbers given were calculated into kg per ha for comparison. The yields are shown in figure 2, where it can be seen that the variance in the reported yields for both coffee and maize is large. The reported average yields for green coffee in Kenya for 2017 are 355.7 kg/ha and for maize 1522.6 kg/ha (FAOSTAT data, 2017). Some possible explanations for these large differences could be that 2018 was a bad year for maize (per say of interviewees), the numbers are based on farmers' memory and estimates of acreage and that the agro-ecological zone is better suited for coffee than for maize. Coffee yields are monitored more precisely since farmers are told the kilograms they sell to the coffee cooperative, while for maize the amounts were mostly told in buckets. Also, as FAOstat bases their reported yields on national publications and in FAO-questionnaires the maize yields might not cover farmers growing maize for subsistence and not for markets.

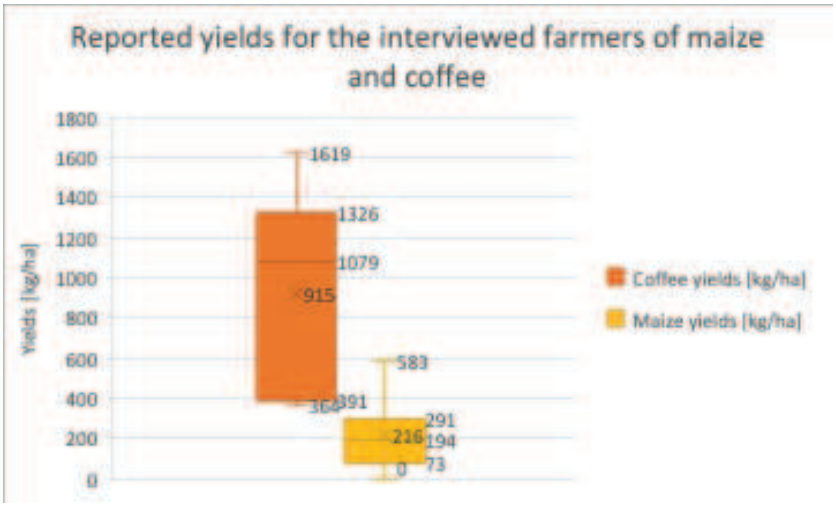

Figure 2: The yields reported by nine of the interviewees for maize and coffee. Only seven responses for maize were given. The boxplots show the minimum and maximum reported yields, the average (x), the median and the quartiles.

In general, respondents strongly associate manure application with soil fertility and improved yields. *"In areas without manure, soil is light brown in colour and crops don't do well, are mainly weak"* (QR 02). Some interviewees explained that after adding manure the soil darkens and crops do better. Light brown and reddish soils are associated with poor fertility and are often caused by "over-cultivation" of the lands. Some people experience soil degradation which

they relate to farming and explained that they try to increase soil fertility by adding manure, which they claim to be partly successful.

Table 4: Perceptions and chemical parameters of soil fertility

Chemical parameters of soil fertility	Perceives soil fertile	Perceives soil infertile	Significant (P-value <0.1)
pH	4.47	4.33	No
P [mg/kg]	7.724	5.778	No
Total N [%]	0.35	0.34	No
Total C [%]	2.78	2.93	No

In Table 4, it is possible to see farmers' perceptions of soil fertility compared to the chemical parameters measured. From the table it seems that farmers with higher phosphorus (P) levels and higher pH in their soil were more likely to tell that their soils were fertile. None of these differences in soil parameters compared with farmers perceptions of soil fertility are found to be significant. This might be explained by the low sample size or because soil fertility for farmers is not necessarily categorized with these parameters only. It may also have to do with the fact that farmers were asked about their soil fertility in general, and not specifically about coffee and maize.

4.3 Management Practices

A list of different management methods for maize and coffee which influence soil fertility were assessed, as well as the sources of inputs used. This can be seen in Figure 3. The management practices of fallowing, crop rotation and legume intercropping were only registered for maize plots.

Figure 3: The percentage of farmers using different management practices for maize and coffee plots. Source: own data

Mulching is done to maintain soil moisture, prevent soil erosion and add organic matter to the soil. Farmers usually use plant materials from their own farm such as banana leaves, coffee husks or pulp, the hard parts of the napier grass and moringa leaves to cover their soils.

As seen in Figure 3, most respondents practice legume intercropping in their maize plot, which is mainly done with beans. Sweet potatoes were also found to be a common intercrop, although not leguminous. Respondents seem to give importance to the practice of crop rotation, as one interviewee states: *"Crop rotation is beneficial because what beans eat is not the same as what maize eat, so when I plant beans here they will eat up their nutrients but they will retain the maize nutrient, so when I plant maize again, their food is still there."* (QR 28). In addition to this interviewee's observation, beans are nitrogen-fixing, and therefore serve multi-purposefully in soil fertility management. One respondent leaves their maize plot fallow for a season of six months and continuously rotates maize with coriander and beans.

Most interviewees claim manure application to be the best practice for improving soil fertility and that using it has brought benefits to their farms. More than three-quarters of respondents use manure from their own animals and a few respondents purchase additional manure. Some statements are made on manure reducing soil acidity and making plants less susceptible to diseases and pests. The use of lime and ash is done by one respondent in order to reduce the acidity on their farm. Four other respondents have either done it once or are thinking about

applying ash or lime in the future. Data on amounts of manure and inorganic fertilizer applied was not systematically collected and are therefore not shown.

Coffee management

Mulching, spraying against berry fall as well as pruning and agroforestry are common practices done by most interviewees in their coffee plots. Most interviewees have macadamia (*Macadamia tetraphylla*) and grevillea (*Grevillea robusta*) trees in their coffee plots as well as bananas which are rarely mentioned. Grevillea mostly grows by itself and is seen as beneficial for soil fertility while macadamia is planted for income purposes. Moringa trees are stated by one interviewee as *"good for soil fertility because of its leaves. So, when the leaves fall, they decay very fast and they make manure. they improve the humus in the soil."* (QR 17).The most commonly used inorganic fertilizers are NPK (nitrogen-phosphorus-potassium) 17-17-17 and CAN (calcium-ammonium- nitrate). They are usually applied according to the time of the year and availability in the cooperative. One interviewee claims to use CAN in April and NPK 17-17-17 in October. All respondents say they get fertilizers from the cooperative unless they don't have enough credit because of low yields, and they instead buy it from the agrovet shops. A few respondents also use NPK 23-23-0 on their coffee plots. Especially for coffee, most interviewees attribute improved harvest to the application of manure. Manure is generally applied before the rainy seasons.

Compost is used by two interviewed households, but more than half of the questionnaire respondents. It has not been specified what kind of composts these households used.

The interviewee with the largest coffee acreage purchases mostly farmyard manure and gets only 10% from his own dairy cows. This individual claim to concentrate on manure for soil fertility and to use inorganic fertilizers only as supplements. There was no data on manure and inorganic fertilizer amounts collected from all respondents, therefore no general correlation can be made on amounts of inputs in relation to nutrient contents and livelihood assets. At least four interviewees stated to use copper against coffee leaf rust, but we observed that it was a widespread input for disease management, and one could argue that many more use it than only these four. As expected, soil erosion control resulted to be of great importance in Kibugu location. 90% of people have soil erosion control practises on their coffee. Almost all interviewees build terraces or small benches for their coffee and give importance to soil erosion control. It is common to plant napier grass along the terraces. According to one interviewee terraces are *"the best management practice because they prevent soil erosion, so after making the land fertile by applying manure the soil will still be retained"* (QR 28).

Maize management

Almost all respondents use manure on their maize plots in different ways. Some state to mix manure with inorganic fertilizers, some continuously add the manure during crop growth, and some put it into the holes before planting every season. 94% of respondents state to use inorganic fertilizers such as NPK 23-23-0 and DAP which are most commonly used and often mixed together before usage because “it makes the maize grow fast” (NO. 25). Also, CAN fertilizer is used by three respondents on the maize and one interviewee additionally uses a fertilizer called NPK 20-20-0. Another interviewee top dresses with NPK 17-17-17. Few said that they use inorganic fertilizer leftovers from coffee. One interviewee uses only inorganic fertilizers during planting and later on foliar feeds. Few respondents say that they irrigate their maize plot. Soil erosion control on maize is done rarely, because it is often planted on the flat parts of the farms.

In general manure application as a management practice stands out as its importance in soil fertility and crop performance has been talked about continuously by many interviewees. Respondents typically use a combination of animal manure and inorganic fertilizer, although most people say they would like to add more manure if it was available. Mostly NPK 17-17-17 and CAN is used on the coffee plot while NPK 23-23-0 and DAP is applied for the maize.

4.4 Livelihoods

The 31 questionnaire respondents were given points based on their livelihood assets, and then pooled into three thirds based on these points (methodology described in section 3.6). The minimum amount of points which were given was 5.92, and the maximum 39.83, which we believe reflects the differences in wealth that we both observed and were given accounts of through the qualitative interviews. The average number of points given was 13.2, and the median was equal to 11.84. The respondents were distributed in three groups as seen in Figure 4.

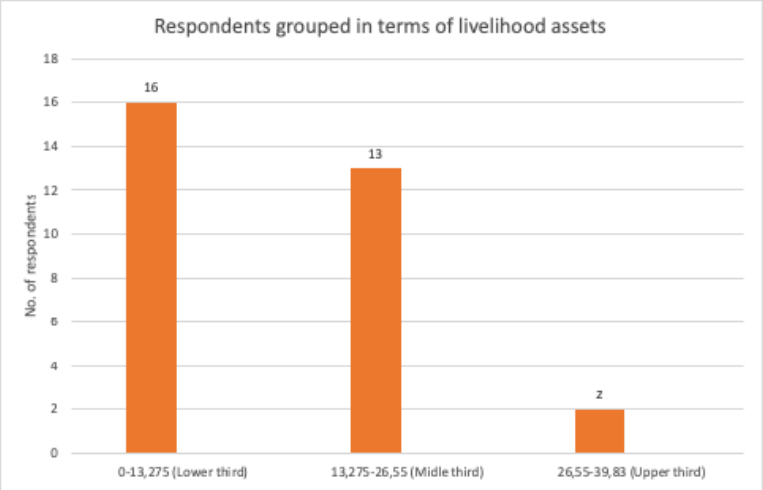

Figure 4. Number of respondents grouped into thirds according to the point system for livelihood assets.

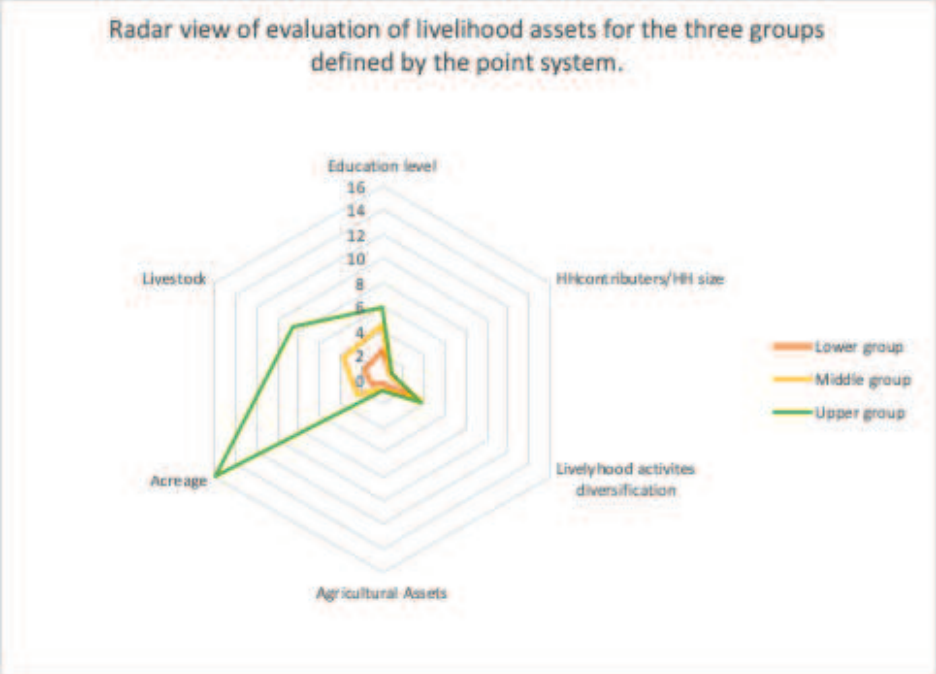

Figure 5. Livelihood assets of the wealth groups created for this study are shown in a radar view.

The distribution of livelihood assets among these three different groups (as seen in Figure 5), closely relates to what was observed in the field. From the radar view it can be seen that the lower group scores lower or equal to the other groups on all parameters. The middle group ranked middle or equal to and the upper group highest on all parameters. The importance of acreage, livestock and education level as the differentiating factor stands out.

Farmers' perceptions of soil fertility can also be observed in terms of the wealth groups which is shown in Figure 6 below:

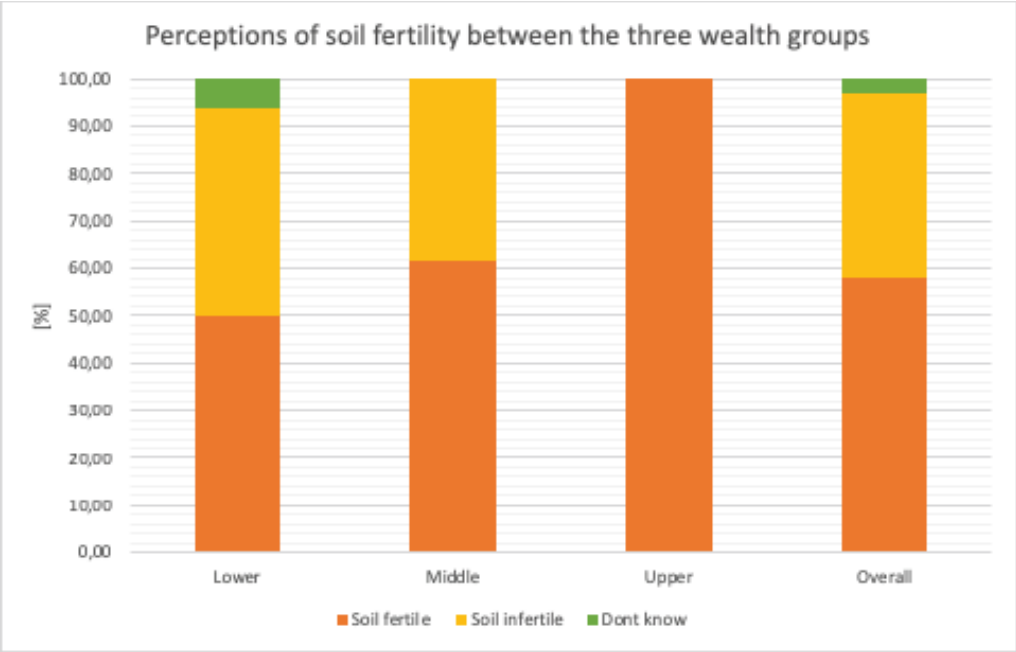

Figure 6. Perceptions of soil fertility among the three wealth groups and overall. Note that the upper third only consists of two people and that statistical test on differences among these groups are therefore not conducted.

When each wealth group is compared with perceptions of soil fertility, it is only those in the lowest group who have indicated that they do not know if their soils are fertile or not. A slightly higher percentage of those in the middle group perceive their soils to be fertile compared to the lower group. One might hypothesize that there is a possible connection between being in a lower wealth group and perceiving your soil as less fertile, and that this might correlate with the chemical properties of the soils. As seen in table 5 and 6 it seems like this correlation is true at least for coffee, because a trend can be observed for all tested parameters increasing from lower to higher wealth groups, indicating that there may also be a difference in how the soils are managed. In the maize plot on the other hand, the correlation is not as clear, even though phosphorus still seems to correlate. None of these possible connections have been tested statistically because of the small sample size in the upper third.

Table 5. pH, P, total N and total C measured in coffee plots are presented as averages for the three wealth groups and in total.

Coffee	Lower third	Middle third	Upper third	Total
pH	3.28	4.40	4.52	4.34
P [mg/kg]	3.855	6.948	17.007	7.507
N [%]	0.28	0.34	0.44	0.35
C [%]	2.43	2.73	3.74	2.89

Table 6. pH, P, total N and total C measured in maize plots are presented as averages for the three wealth groups and in total.

Maize	Lower third	Middle third	Upper third	Total
pH	4.35	4.66	4.47	4.49
P [mg/kg]	4.630	5.152	8.895	5.146
N [%]	0.31	0.32	0.36	0.33
C [%]	2.65	2.58	2.81	2.72

Questionnaire respondents were also asked about changes they experienced in soil fertility under both coffee and maize. As seen in Figure 7, the majority of respondents agreed that their soil under coffee had improved since the time they had started farming, whereas for maize, less than half agreed that this soil had improved, and 32.3% agreed that they saw no changes in the fertility of their soil under maize since the time they started cultivating it. This differed to farmer's perceptions of soil fertility under coffee, where only 6.5% experienced no change in soil fertility.

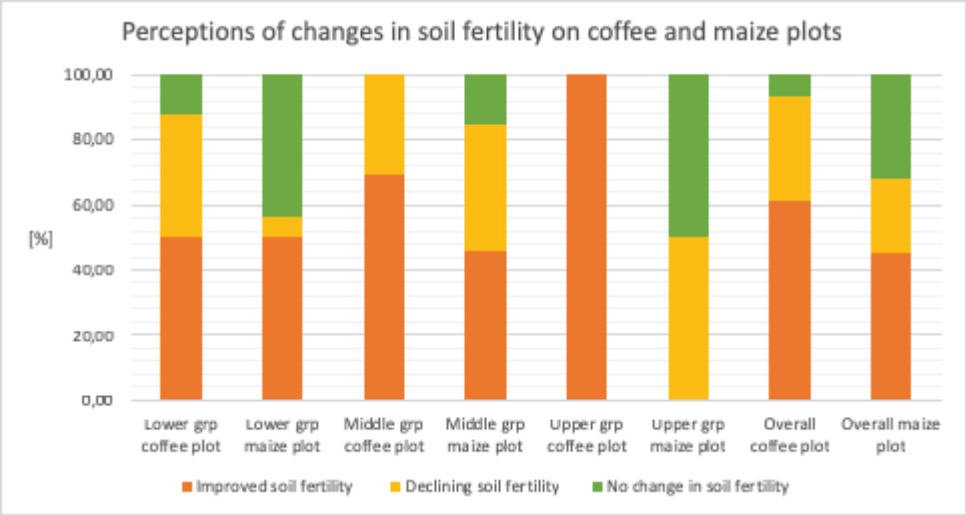

Figure 7. Wealth groups and perceptions of changes in soil fertility on coffee and maize.

When perceptions of soil fertility improvement and declination are compared against the different wealth groups, it is evident that a smaller proportion of farmers in the lower group perceive their coffee soils to have improved compared to those in the middle and upper groups (Figure 7). More people in the lower group also perceive fewer changes in the fertility of their soils, which could indicate stagnation, or possibly that those from the lower group are not as aware of changes compared to those from the middle and upper groups.

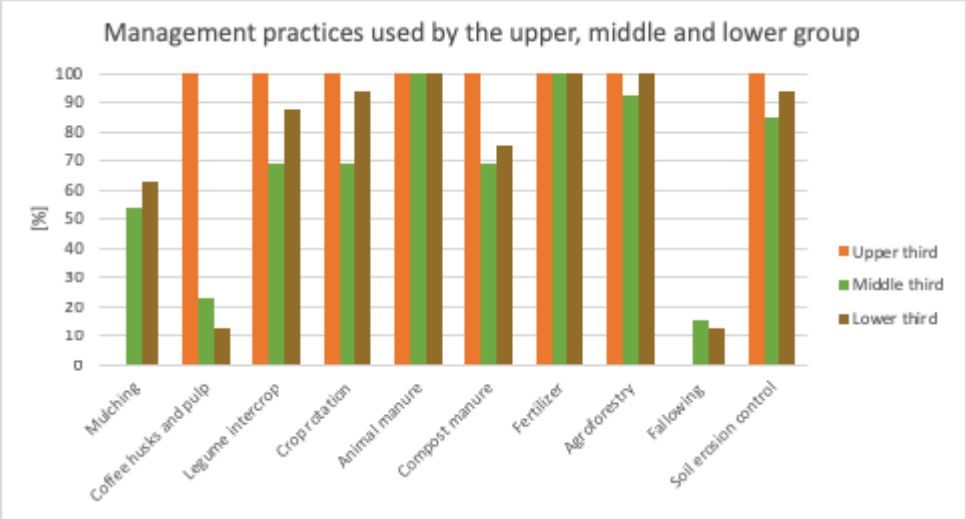

Figure 8. management practices used by the three wealth groups.

As suggested when presenting Tables 5 and 6, there may be differences in the management practices between the three wealth groups, affecting soil fertility. However, according to Figure 8, we don't observe relevant differences other than leaving fallow not being practiced among the upper third, even with a higher acreage of land. Also, the use of coffee husks and mulching practices look to be differing between the wealth groups.

4.5 Challenges Related to Soil Fertility

There were a range of various challenges relating to soil fertility which were mentioned among the key informants and the nine interviewees.

Institutional Influence and Access to Resources:

Resources as a limiting factor for achieving better soil fertility and desired yields was a main theme which was repeatedly brought up by interviewees during the semi-structured interviews. Almost all interviewees, except those in the upper third, voiced some sort of concern which had to do with not having enough manure, or commented on how if they had more manure, they would use that instead of buying chemical fertilizers. One interviewee explained how he has *"always been willing to add manure in the coffee plantation, but it's never enough. For the maize the manure is little, but I add the little manure and fertilizer I get"* (QR 01). Ash was also mentioned as a resource which was deemed to be important for soil fertility management but was limited in volume and therefore not used as much as farmers thought to be necessary. Lime as an alternative to ash was described as expensive, and one interviewee mentioned how it used to be available at the coffee cooperative, but that is no longer the case now (QR 22).

Many farmers seem to be caught up in a vicious and continuous cycle as yields are often insufficient to obtain a loan at the cooperative for the inputs necessary to improve soil fertility or crop health, and therefore improve coffee yields, which is the key to obtaining the loan for the inputs in the first place. Even if one does have sufficient yields to be able to purchase on loan from the coffee cooperative, they do not always have the inputs one is looking for available at the right time. This is problematic because the application of inputs is time-sensitive: they must be applied at specific points of the crop growth process. One interviewee explained the problem quite logically: *"Time wasted is never recovered, so I cannot recover the time again even if I get the fertilizer down the road"* (QR 22). Farmers often solve this by buying inputs at an agrovet shop, but here it is not possible to buy on credit, so the farmers need a sufficient cash income

from their coffee sales. Almost all interviewees discussed how the payouts for coffee are insufficient, fluctuating and sometimes come late.

Access to knowledge was another topic mentioned by many which seemed to create barriers and challenges to farmers in achieving optimal soil fertility and crop health. Many farmers mentioned how agricultural extension officers used to frequently visit households, but don't anymore. When asked how easy it is to acquire information needed to reach his farm's full potential, one respondent answered that *"It was easier 8 years ago when we had agricultural officers around. Nowadays it's a bit challenging"* (QR 30). In a key informant interview with the agricultural officer, this in fact was confirmed to be the case; due to lack of funds, the agricultural officer now is forced to work on farmers direct demand only.

A wide gap in knowledge on fertilizer application between different households can be observed. While some people claim to lack information on which fertilizers to use, other seem to know or have special calendars for management of coffee. Many interviewees do not apply lime or ash because they lack information about it.

Especially older farmers explain how the soil fertility of the area has been affected by land scarcity and regulations. When asked about previous management practices, one farmer say: *"When the land was not scarce like today, I used to leave one side of the farm, and farm on the other during the short rain. And once the long rain, then I left this one, and farmed the one that I left fallow."* (QR 22). Another farmer explains in more detail: *"In the past, we used to cultivate anywhere we want, but the boundaries came, and everyone was given a place to settle. Since then, everyone plants in their farmland every season, so there has been a lot of changes. The bushes that were there in the past used to prevent soil erosion, but now a day we have cleared everything, so the topsoil has been carried away. So those who do not apply manure on their lands, experience infertility … because of the overuse of the land"* (QR 28).

Box 1: A case of contradictions and conflicting observations

During a key informant interview the extension officer clearly states that most farmers are aware that extension services are now demand driven and that they do ask for service. Farmers, on the other hand, generally did not seem to know why the extension officers were not coming anymore, nor did they know where or how to contact the officer. Most interviewed farmers are not receiving extension services anymore, but there are a few selected households which claim to have a reputation and therefore receive visits by industry officials and advice on their coffee berries once a year. The extension officer criticized farmers for simply using their neighbours as sources of information, instead of seeking herself out, or accumulating knowledge by attending agricultural seminars. One farmer pointed out that these seminars are usually far away, and one must plan ahead or walk far, if he or she wishes to attend these events. As an example, the agricultural officer stated how she advise farmers not to use DAP, but one interviewee described that he uses DAP because it is what he observes others to use. While some farmers state to profit from the seminars provided by the extension services, other farmers seem to simply not know that there are trainings provided a few times a year.

The extension officer believes in the importance of soil analysis and states that she strongly advises farmers to partake in soil analysis before applying anything to their plots, but according to her, farmers do not know the necessity of doing soil analyses and they believe it is tedious because the samples have to be taken far away. These analyses are available at ksh1,000 and anyone who is willing could usually afford this price. She says that exhibitions are offered for farmers by KARI, where the farmers can come and have their soils tested, but there have never been enough participants. In regard to soil sampling, the extension officer also states that there has been a company contracted who took soil samples and the money, but never returned with the results, which might have discouraged farmers. This fits with the interviewees statements who claim to still be waiting for the results and having lost motivation in taking soil analysis. Nevertheless, there seems to be conflicting beliefs, since most interviewed farmers confirmed that they see the importance of soil analyses and would like to partake in one, even to the price of ksh1000 but they have never heard of that possibility or been told where or how to do it.

5. Discussion

Forsyth *et al.* (1998) describe the notion of the downward spiral of poverty directly causing environmental degradation and vice versa, which in regard to soil fertility is seen as the narrative of resource poor African farmers depleting the soils they depend upon. Rather than assuming this to be the rule, Forsyth *et al.* (1998) argues that it is important to ask oneself under which conditions this narrative operates, by looking at the diverse ways of environmental change and how it is valued by different people, as well as the definition of poverty and how institutions influence the relationship between resource poor people and the environment (Forsyth *et al.* 1998).

Despite the overwhelming amount of literature from major institutions which describes the crisis of soil degradation in Sub-Saharan Africa (as described in Chapter 1), Scoones (1998) suggests that measuring natural resource sustainability can in reality be difficult, as in doing so it is critical to link indicators of resource depletion, such as of soil degradation, to the resilience of systems and whether resource changes actually result in a long-lasting decline of environmental services. This can be linked to the question of whether lower nutrient contents in the soil, which can be directly influenced by management practices and are therefore not permanent, actually represent soil degradation. Robbins (2012) argues that selecting criteria for land degradation is a political choice shaped by what is deemed important by the researcher. He claims in reference to Blaikie and Brookfield (1987) that degradation can also sometimes be *"the loss of one capacity in exchange for another"* (Robbins, 2012, pp. 107). The way in which environmental change is understood can redefine the concept of degradation. According to Forsyth *et al.* (1998) rural populations often contribute in maintaining and improving landscape productivity, and changes in agricultural landscapes have been shaped over centuries and therefore cannot be easily referred to as degraded. Therefore, it can be argued that many local practices in Kibugu such as terracing, agroforestry and organic fertilizer application may mitigate negative effects of crop production on soil fertility, such as soil erosion and nutrient depletion. From our data it can be deducted that farmers do what is possible to improve soil fertility and most of them have actually reported increased soil fertility in their coffee plots, which might be reflected in their high coffee yields compared to the national average.

This study does not have a time baseline and therefore is limited to use only space as a comparable aspect in regard to soil fertility, which makes it difficult to make a statement about

whether soil degradation took place. Nevertheless, by comparing our data to the study of Murage *et al.* (2000), who measures some of the same parameters in Nitosols, we did not find differences indicating low soil fertility. Total C measurements were substantially higher than what Murage *et al.* (2000) defines as TOC indicator values for soils perceived to be productive, and even though these parameters are not directly comparable, it points in a direction. Although pH levels measured for Kibugu can be considered as low for crop production, another study looking at the pH of Nitosols in Ethiopia under different land use systems such as agroforestry systems and annual cereal cultivation show similar pH levels compared to the values found here, indicating that the acidity can be related to the soil type rather than low soil fertility (Elias, 2017).

The significant difference in total C and N values between coffee and maize which was found in this study can partly be attributed to coffee being a perennial crop and it therefore being managed slightly differently. Elias (2017) also found a significant difference in total N between agroforestry and cereal systems, with values of 0.22% and 0.15% respectively, which are defined as low according to other literature (Landon, 1991) and are also lower than measurements for Kibugu of total N of 0.36% for coffee and 0.32% for maize.

There was no significant correlation between the chemical soil measurements and the "wealth level" of farmers. Nevertheless, an increase across wealth group gradients in all tested chemical properties in coffee can be observed. Especially P parameters show large differences between groups, indicating that there could be a correlation between resource access and different management practices, but further investigation would be needed. According to De Vries *et al.* (2007) the critical limits for total dissolved Cu concentration in soils depending on pH and C content ranges between 10 to 50mg/kg, which can already have ecotoxicological effects. Another study finds the effective concentrations of copper limiting plant growth around 356 mg/kg (Mondaca *et al.* 2017). These values are far below what was found in the sample with the highest Cu concentration, indicating that concentrations of 450 mg/ kg are likely to have toxic effects in the environment.

According to Forsyth (2003), Eckholm (1976) argues that population growth leads smallholders to intensify agriculture to unsustainable levels, which leads to soil erosion and the loss of land

and water resources. Interviewees in Kibugu talked about agricultural intensification over time, which makes it hard for them to leave their fields fallow any more due to land scarcity. The traditional subdivision of lands with each generation are putting additional pressure on land and are reducing farm sizes (Yageta *et al.* 2019), which was also observed in the field. Nevertheless, other sustainable soil erosion control practices such as *Fanya Juu,* ditch digging, mulching and napier grass planting are commonly practiced. Farmers in Kibugu are finding and learning new ways of increasing their income (e.g. by planting macadamia trees) and improving soil fertility (e.g. by making compost). The intensification of agriculture, therefore, evidently goes hand in hand with the intensification of management practices which are in favour of soil fertility.

In a study carried out in Kitui County, a neighbouring county of Embu with a different soil type, Yageta *et al.* (2019) asked about soil fertility indicators in an open question, which resulted in texture being the best indicator for soil fertility and colour the second most used indicator. In contrast to this study, we found crop yields and indicator weeds to be strong indicators that farmers relate to soil fertility. We asked farmers to mark from a list of indicators, instead of allowing for a qualitative answer. Farmers were asked to expand on soil fertility indicators in the SSIs but yields and indicator weeds were still the most mentioned indicators. Yageta *et al.* (2019) also found that most people associate black or red soils with high fertility and infertility was associated with light brown colours, which was also found in our study. In Yageta *et al.*'s (2019) study, a significant correlation was found between farmers perceived soil fertility indicated by soil colour and texture, and physio-chemical data in pH, TOC and phosphorus among others. Also, Murage *et al.* (2000) found a positive correlation between perceived productive soils and higher pH, organic matter content and other parameters looking at Nitosols in the Kenyan Central highlands. Productive soils in the Murage *et al.* (2000) study were associated by all farmers with crop yields, which correlates with our results from Kibugu, and were followed by the parameters of soil tilth, water retention and soil colour. All farmers questioned in Kiambu district attribute low soil fertility to inadequate use of organic and inorganic fertilizers and removal of crop residues (Murage *et al.* 2000). The study of Murage *et al.* (2000) also suggests chemical and biological soil properties to be influenced by management practises, which could not be observed in our study due to the complexity of evaluating many different simultaneous management practices potentially influencing distinct soil properties. However, our results show that the lower and middle wealth groups brought up challenges in relation to access to inputs, although this was not clearly reflected in the chemical properties of the soils.

While soil degradation cannot be measured in a study like this, another type of degradation comes to the surface. The structure of the institutions such as the coffee cooperative and agricultural extension services seem to be aggravating a sort of social degradation, through the limitations to farmers access to inputs and knowledge. This downward spiral of not having and thereby not getting, and not knowing and thereby not 'growing' seems to make it difficult for farmers to improve their situation.

Box 2. Reflections on the methodology
For future investigations, soil samples should if possible be collected in a way that is consistent with the crop management cycles. Secondly, quantitative data on yields and amounts of fertilizer and manure applied could have been asked in the questionnaire. Being more certain on the kind of data we wanted from the beginning, could have resulted in more consistency and relevance in the results, and made for a more fruitful discussion on management practices connected to soil fertility. Thirdly, while we believe we collected quite valid data on farmers' livelihood assets, the point system which was used to pool farmers into wealth groups was not perfect. In retrospect it may have been more reliable to use a framework for this methodology, even though this did not occur to us until it was too late to change this aspect of our study. Finally, this study is strong in its use of mixed methods within an interdisciplinary approach. It portrays a holistic picture of soil fertility perceptions, management practices and scientific soil evaluations discussed within a wide variety of literature.

6. Conclusion

Farmers in Kibugu generally perceive their soils to be fertile, and this is reflected in the chemical properties of their soils being generally high in total nitrogen, total carbon and water-soluble phosphorus, but also low in pH. Looking at the difference of chemical properties between coffee, a perennial cash crop and maize, an annual subsistence crop, significantly higher levels of total nitrogen and total carbon are measured in coffee. Also, more farmers perceive an increase in soil fertility in their coffee plot rather than in maize and according to farmers evaluations, yields were the most important indicator of soil fertility change, followed by indicator weeds. No significant correlation was found between farmers perceptions and the measured soil properties.

All questioned farmers stated to apply both animal manure and inorganic fertilizer to their fields and manure application resulted to be the most important management practice for soil fertility in farmers' perceptions. Other parameters and comparisons, like differences between wealth groups and management practices were either not significant or not tested statistically due to restrictions in sample sizes.

Although we did find land scarcity to be an issue in Kamavindi sub-location, we at the same time found that farmers were participating in many soil fertility-enhancing practices to help mitigate soil degradation.

While this study does find some minor connections between soil chemical properties and wealth groups, we do not find this to be significant enough to confirm the literature which considers resource poor farmers to be the perpetrators of soil degradation. Instead, we recommend an institutional reform among the coffee cooperative, so as to give farmers greater access to inputs and an opportunity to step out of what we observe to be a "poverty trap". Other recommendations include putting in an effort to increase the pH in the soil in order to make it more suitable for plant growth by increasing the availability of the nutrients. This could be done by mixing lime or ash into the manure before applying it to the fields.

Literature contributions from Forsyth *et al.* (1998), and Scoones (1998) among others highlight the complexities of measuring and assessing environmental degradation and shed light on how we can look at the narratives from leading institutions with a different point of view. They help us to see that even if we can make an assessment of soil fertility in a certain context, which is challenging as it is also dependent on the bias of the researcher, it is much more difficult to assess how this relates to the greater picture of soil degradation. This study is therefore one piece of the puzzle that challenges the crisis narrative of soil degradation by resource-poor farmers in Sub-Saharan Africa.

7. Acknowledgements

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9. Appendices

9.1 Methods applied

31 questionnaires
9 semi-structured interviews including farm mapping exercise
5 key informant interviews
11x2 soil samples collected and analyzed as described in section 4
11 transect walks

9.2 Raw data from soil samples

sample site	Date	Crop	No.	pH	Phosphorus [mg P/kg]	Nitrogen [%]	Carbon [%]	Copper [mg/kg]
qn01	07.mar.2019	maize	1	4.01	5.99	0.33	3.47	
qn01	07.mar.2019	coffee	2	3.89	4.43	0.34	3.03	67
qn02	07.mar.2019	maize	3	4.84	5.41	0.28	2.04	
qn02	07.mar.2019	coffee	4	3.9	3.37	0.32	2.72	28
qn09	08.mar.2019	maize	5	4.96	10.60	0.32	2.53	
qn09	08.mar.2019	coffee	6	4.65	2.71	0.32	2.56	105
qn11	08.mar.2019	coffee	7	4.26	3.32	0.35	3.09	
qn17	08.mar.2019	maize	8	4.62	4.07	0.32	2.65	
qn17	08.mar.2019	coffee	9	4.66	16.02	0.38	3.25	57

qn22	07.mar.2019	maize	10	4.58	4.41	0.31	2.52	
qn22	07.mar.2019	coffee	11	4.36	3.12	0.31	2.59	16
qn25	07.mar.2019	maize	12	4.21	2.50	0.31	2.45	
qn25	07.mar.2019	coffee	13	4.36	8.16	0.38	3.32	25
qn28	06.mar.2019	maize	14	4.3	1.78	0.3	2.32	
qn28	06.mar.2019	coffee - new	15	4.79	11.99	0.31	2.35	24
qn28	06.mar.2019	coffee - old	16	4.08	3.11	0.37	2.93	96
qn30	06.mar.2019	maize	17	4.82	4.91	0.35	2.9	
qn30	06.mar.2019	coffee	18	3.85	4.73	0.35	2.68	49
qn31	08.mar.2019	maize	19	4.45	10.81	0.33	2.64	
qn31	08.mar.2019	coffee	20	4.11	12.69	0.4	3.57	
qn32	12.mar.2019	maize	21	4.49	6.99	0.38	2.98	
qn32	12.mar.2019	coffee	22	4.92	21.32	0.47	3.9	450
qn11	08.mar.2019	maize	n/a	n/a	n/a	n/a	n/a	n/a

9.3 Colour coded semi-structured interviews

Colour codes:
Coffee as a cash crop
Other livelihood assets
Changes in Soil Fertility in Coffee
Change in Soil fertility in maize
Yields
Soil erosion
Nutrient management in coffee
Nutrient management in Maize
Other inputs and management
Agroforestry
Challenges
Limited Resources
Institutional Influences

Interviewer: Line (LM), Oscar (OS) and Carol (CA)
Translator: Amy
Interviewee: 01
Transcribed by: Geraldine

OS: You said that you have been farming maize and coffee for the past seven years can you tell us a bit about your experience.
interruption
01: Farming is not bad but a lot of challenges for example in maize the yields are low not enough for even domestic use. Coffee farming also has its challenges because even when spraying pesticides the berries fall off because they are not sure about the sprays.
CA: Where do you get your pesticides and fertilizers from?
01: Sometimes from the agro vet and other times from the cooperative.
CA: Do they advise you on which ones to apply and how to use?
01: I just go there and say what I want, get what's available. I go to the agro vet with my own knowledge and only get advice on alternatives.
OS: So you get your pesticides from the agro vet or from the cooperative?
01: sometimes you go to the cooperative but find no pesticides so you purchase from the agro vets.
OS: When you get from the cooperative do you get any advice
01: No, use own knowledge.
OS: Can you tell us the names of the pesticides you use on your farm.
01: Ranger, Thunder *laughs*
OS: What else
01: Can't remember any.
OS: If I may ask why did you personally choose to farm maize and coffee?
01: Coffee is good and when he was growing up his family was growing coffee so he didn't have a choice than to continue growing coffee. These other crops like maize are just alternatives and help him to make money since he sells the surplus.
OS: You consume maize in your household.
01: Yeah.....Yeah....He also can't wait for the maize to dry since there monkeys that come to eat them.

OS: Okay...Can you describe your soil for us on the maize and coffee plot.
01: His soil is just the normal red soil and fertility is dependent on application of manure and fertilizer.
OS: So the colour is the same for both plots
01: Yeah...and changes after adding manure it darkens.
OS: Since you started farming for the 7 years has soil change in colour and productivity
01: For the 7 yrs. I've been farming for coffee hasn't changed thus now practicing small scale and horticulture.
OS: In your questionnaire you stated that fertility in your coffee plot has declined and that of your maize plot has stagnated neither improving nor declining, can explain why
01: He has always been willing to add manure in the coffee plantation but it's never enough. For the maize the manure is little but he adds the little manure and fertilizer he gets.
OS: aahh! Maybe you could tell us what you harvest was for coffee was last seasons for comparison
01: The previous year he gathered 300Kgs (2017) and in (2018) he gathered 400Kgs but can't say it was a good harvest since most was lost during cold berry fall.
LM: Your area or?
01: Yes just my area.
LM: How many stems
Interrupted by a phone call
OS: Your coffee farm in a good harvest how many kilos do you get?
01: I can even manage 700-800 Kilos.
LM: Inaudible
OS: For clarification how many stems of coffee do you have?
01: I don't know
OS: Maize yields on you maize plot
01: It's difficult since he didn't count
OS: Was it more or less from you last season
01: Yeah *Laughs*
OS: Are your management practices in your coffee and maize farm the same or different.
01: Yeah
OS: So you can tell us exactly what you do in your coffee farm
01: Like I do mulching
CA: That's for both r just for coffee
01: Just for coffee
OS: What else do you do in your coffee plot?
01: I prune the coffee and add manure when it's available.
CA: When you say you only add manure when its available does it mean there are times you don't get the manure.
01: only add manure on the coffee plot when its available but throughout for the maize plot.
OS: Do you add coffee husks Kinyago' *Laughs*
01: Only in the Napier grass since it doesn't hold water compared to manure.
OS: aaah you said you don't irrigate you coffee farm
01: Yeah
OS: Do you use compost.
01: Yes but not likes its planned
OS: Do you plant trees
01: Yeah scattered in the coffee farm.
OS: What kind of trees.
01: Macadamia, Grevillea, one Blue gum.
OS: Do you have soil erosion control practice.

01: It's not so steep but there small benches.
LM: How do you manage your maize farm?
01: Manure and mulching
OS: Do you practice legume intercropping
01: No
OS: Crop rotation
01: Yes
OS: Any trees in your maize farm
01: Just one
CA: Why do you plant these trees?
01: i don't plant trees they just grow own their own
OS: Do feel that the trees are useful.
01: Yes I use the leaves as mulch and building the cow shed
OS: any soil erosion control measures for your maize plot.
01: No and the maize plot is under irrigation.
LM: Do you experience any challenge with the irrigation.
01: Only gets the water twice a week and never enough and when they use the sprinklers the top soil gets compact thus watering straight to the plant.
OS: What irrigation method do use.
01: Directly with a horse pipe.
OS: Off all the practices you use which one do you think greatly improves your soils fertility
01: Application of manure because healthy plants are less susceptible to pests and diseases so with manure one won't need to use pesticides.
OS: Which one do you use more is it the manure or the fertilizer
01: Fertilizer
LM: Is it more expensive or difficult to get the fertilizer or manure.
01: Fertilizers are cheaper since you can get in small quantity compared to manure.
OS: which fertilizers do you use for your coffee plot?
01: CAN, 17:17
OS: What else?
01: The others are boosters.
OS: Where do you get them from?
01: Mostly from agro vets and sometimes cooperatives.
OS: When you get fertilizers for your coffee do you use them for your other crops.
01: No, just for coffee and the fertilizers in the cooperatives are not available at the right time.
LM: Do you use lime or ash?
01: Never used since he lacks information about it.
OS: Would you say you know how to use your fertilizers.
01: He uses own knowledge but open to new information but feels he does really know how
CA: Do you think that could be a contributor to your low yield and poor soil fertility.
01:*difficult question not answered*
OS: What fertilizers do you use for your maize plot?
01: I use DAP and top dress with NPK and special
OS: did you use DAP for your last season
01: all through
OS: Have you received information from friends or media on use of DAP
01: No it's just what he grew up seeing people using*laughs*
OS: you said you get information about farming from observation, traditional knowledge and media.
01: Yeah
OS: Ever had your soil analyzed.

01: No
OS: Do you feel that you are able to easily acquire information you need to manage your farm
01: not really
OS: What do you think is keeping you from your farms full potential?
01: Knowledge .Knowledge on how and when to do apply fertilizers, type of seeds.
OS: What other challenge
01: Climate change.....but that's everywhere and finances like for buying fertilizers, manure and pesticides. Cooperatives fertilizers are more expensive which are given at a loan.
OS: Being a member of the cooperative how do you feel about the pay
01: Not happy since you just take your harvest and just wait and hope and there are a lot of uncertainties.
OS: Price varies
01: Yes....depending on the global market and the cooperative
OS: how long does it take to get paid for your coffee?
01: 6 months
CA: Could you imagine a better system to sell your coffee
01: The other alternative is brokers which buy at lower price but ready money .Coffee has so many cartels in between the value chain so if this middlemen can be eliminated
OS: As a member a cooperative how often do get training
01: Rarely
OS: Anything you would wish to do to better your soil fertility
01: Unless advised, he thinks all his doing the best. He heard that planting other crops together with coffee improves fertility thus planted bananas

Interview no. 2

IT: You said you've been farming maize and coffee for 7 years, can you tell us a little about the process and your experience in farming coffee and maize?
NO 2: When I first started farming my farm was all bushy so I cleared the bushes and was using fertilizers only but the crops were not yielding well so I bought cows and started using both manure and fertilizer. The coffee started doing well. I apply manure in March. After the rainy season I top dress using fertilizers. I also mulch
IT: Why did you choose to grow coffee was it already here or did you make the decision to grow it?
NO 2: I started farming coffee because of money. It wasn't very profitable but after using manure, the returns increased. I afterwards planted macadamia for cash too.
IT: Why did you choose to grow maize?
NO 2: It's just a small portion I grow for household use.
IT: Would you say either coffee or maize is most important for you or do you have other crops you consider important?
NO 2: I grow bananas and pineapples which are also important for me but Coffee and macadamia are most important for income.
IT: Can you describe your soil and any changes you've noticed in them?
NO 2: There's a lot of change since I started using manure
IT: When you don't use manure, what is your soil like?
NO 2: In areas without manure, soil is light brown in colour and crops don't do well, are mainly weak.
IT: Are there any changes to the soil texture?
NO 2: Texture is quite loose
IT: How do you know if your soil is fertile or not?
NO 2: Yields are good and some weeds like amaranth come out in perceived fertile areas

IT: You indicated that soil fertility had improved for both your maize and coffee plots, why is that?
NO 2: I don't burn weeds after weeding but leave them on farm, I mulch, there are trees in my farm and my farm is blessed by God.
IT: Can you tell me more about the type of trees that you grow and why you grow them?
NO 2: I grow them mostly because of shade because coffee requires shade. However I also need to prune them because too much shade destroys coffee
IT: Are there any trees you grow specifically for soil fertility?
NO 2: I grow mostly Grevillea
IT: Could explain a bit about the specific processes you employ in coffee management?
NO 2: I use benches and plant grass (not Napier) along them to prevent soil erosion. I also plant pineapples and use manure and mulching. I also spray and prune.
IT: Do you use any chemical fertilizers for your coffee?
NO 2: Yes
IT: Which ones do you use?
NO 2: Foliar feeds, Copper to prevent leaf rust (pesticide). I spray foliar and apply manure.
IT: Do you think these pesticides affect your soil fertility?
NO 2: If you use the right spraying procedures, it won't affect the soil. I also use a special calendar that guides me on how to apply pesticides and fertilizers and other management practices for coffee production.
IT: Have you been following the calendar practices for a long time?
NO 2: Yes they are my standard practices. I also receive visits from field officers who advise on how to manage my coffee. They come mostly in November to advise how to ripen the berries.
IT: How do you access these officers? Do you contact them to come to you?
NO 2: I don't contact them, they just drop by. They usually come around looking for random farmers with good coffee farms so I think they are just directed to my home by the cooperative and other farmers. My farm is called *kwa mkulima* (the farmers place) and I think it has a proper reputation that's why they come often.
IT: So are these people marketers or NGO persons or coffee traders?
NO 2: They are officials from Osho industries who are input traders but I don't buy fertilizers from them
IT: Does their advice add value to your production?
NO 2: Yes very much. I even have a certificate recognizing my farming techniques
IT: Do you use any irrigation for your coffee?
NO 2: No
IT: Do you use coffee husks and pulp for your coffee
NO 2: No
IT: Compost
NO 2: Yes
IT: Machinery
NO 2: No
IT: What management processes do you employ for your maize?
NO 2: Just like coffee I plant maize with a mixture of manure and fertilizer but I do not mulch
IT: Do you do legume intercropping with your maize?
NO 2: I plant maize exclusively in a plot but I rotate with potatoes in different reasons.
IT: Do you irrigate your maize?
NO 2: Yes
IT: What chemical fertilizers and pesticides do you use for your maize?
NO 2: I use DAP and mix it with CAN on a ratio of 1:1 kgs but I mostly use manure. Last season I used the same management but my maize was attacked by the fall army worm. I then sprayed

with a pesticide whose name I can't quite remember. The mixture however gives me good yields generally.
IT: Which of these practices do you think increases your soil fertility the most?
NO 2: Manure is the best
IT: Do you teach other farmers to farm like you do?
NO 2: Everyone is trying to upgrade. I can only advise those who are ready to learn. Sometimes farmers are picked by organizations to train their colleagues but I've never been selected.
IT: Do you feel you are easily able to access new information about farming?
NO 2: It's easy to access information especially from the media
IT: Do you think there's any challenge keeping you from reaching your farms' full potential?
NO 2: The major problem is financial. Sometimes I can't use fertilizers or pesticides due to lack of money. Also the coffee payouts sometimes come late
IT: Is there anything else you think you can do to improve your soil besides what you're already doing?
NO 2: I can't do anything further aside from manure application
IT: How many kgs of coffee did you harvest last year?
NO 2: 3000kgs from 1acre. But im looking forward to 4000kgs this season
IT: What about maize?
NO 2: It's a small portion so I harvested a 15 kg bucket
IT: When you get fertilizers from cooperatives, do they give officers to follow up on your usage?
NO 2: No
IT: Do you receive any training from the cooperatives?
NO 2: Yes 3-4 times a year especially on fertilizer application. Fertilizer is however given according to your yields. Those with little yields do not receive any.
IT: Do you apply lime or ash on your soil?
NO 2: I use lime to minimize acidity in my farm though some people wrongly use it as fertilizers
IT: Do you feel the coffee payout is fair?
NO 2: It fluctuates and that is every farmers worry. Sometimes it's too little to cover production costs.

Transcription of interview no: 09

Interviewer: Oscar (OO), Line (LM) and Kathi (KA)
Translator: Dennis
Interviewee: 09

Transcribed by: Geraldine
OO: So from your previous interview you stated that you've been farming maize and coffee for over 30 years can you tell us more about your experiences.
09: Farming maize and coffee has helped her really much because she has used it to educate her children and can't complain about it*she has used money from coffee to buy a cow (wasn't translated)
OO: Why did you choose to farm coffee?
09: Coffee isn't tiresome in management and harvesting as compared to tea, she had once planted tea but did away with it plus her children are all grown up and has no one to assist her in her farm thus doing away with the tea.
LM: it mean you uprooted the tea
09: She had a uprooted the tea and planted coffee instead.
LM: Was it difficult to transfer from tea to coffee since the soil can be different
09: The portion that is now under coffee that was previously under tea is doing well. The coffee adapted and has harvested one season.

LM: She has harvested on season and has the harvest been good
09: Very nice
OO: How many KGs of coffee do you harvest?
09: She harvested 2000kg and the range over the past seasons has been between2000-2500kgs.But this season she harvested 2000kgs because of the berry fall.
OO: So the best you have harvested is 2500kg
09: the best she has harvested is 2500kg
OO: This is on three quarters of an acre
09: yes
00: The maize that you plant do you only use it for subsistence purposes or do you also sell it
09: Maize is only for their own consumption they don't sell.
00: How many bags or Kilograms of maize did you get in the last harvest?
09: 3 debes and a debe has 20kgs so 60kgs
00: And is that your best harvest
09: It has been consistent over the years, 3 debes each harvest.
00: Can you describe your soil in general
09: For the last 3 years she hasn't been content her soil there parts of the farm that have some thread like things .Such that when you hold the soil like this*demonstration*It appears as if the soil is suspended on threads.
LM: On roots or
09: Root like structures that hold the soil and she doesn't know what they are. She doesn't understand what's happening since there are no plants there and the coffee around that portion has yellowish leaves and the coffee fall prematurely
00: That's in the coffee farm
09: yes
LM: Have you seen any color change in your soils
09: She has been observing the color of her soils and she has noticed something strange since the soil on this side of the farm*points to the northern side*is reddish and loose and anything planted on that side does well compared to the other side
LM: Has there been any difference in the way you manage the soil of the two sides, the fertilizers you apply
09: She treats both sides evenly, even when it comes to application of fertilizer so she doesn't know what is causing the difference.
OO: The thread like structures that you notice in your coffee portion do you also notice them in your maize portion.
09: Even in the maize plot there are patches that you find soils with the thread-like structures. She thought it was caused by erosion so she planted cover crops like sweet potatoes.
00: Is there a difference in the maize health pattern between the two sides.
09:In the maize plot sometimes the soil is not so good on some parts and whenever she plants maize there is part maize will do so good and another part it with have stunted growth .
00: How do you tell your soil is fertile?
09: *interruption* Soil color for example the coffee portion the soil is darker compared to the maize portion where it's brown
OO: Do you grow trees in your coffee farm
09: Yes I have Macadamia and Grevillea Trees.
00: Did you plant them or did they grow by themselves.
09: She has planted the macadamia but the Grevillea grows by itself.
OO: Is there a specific reason why you planted the macadamia trees.
09:*laughs*Macadamia is equally profitable like the coffee
OO: Apart from benching are there any other soil management practices.
09: On the edges of the bench she has planted grass

00: Which is not Napier grass
09: Not Napier
00: Is your coffee portion the portion under irrigation.
09: No only the area under Napier grass.
OO: Do you have trees in maize portion too
09: Just one Grevillea tree that grew recently
OO: What management practices that she uses on coffee that she uses for maize too
09: Management of coffee and maize are quite different because she doesn't need to control soil erosion on the maize since it has been grown on a relatively flat area. Only application of fertilizer.
OO: Of all management practices you employ in your maize and coffee plot which improves your soil fertility the most
Interruption
09: Out of all the practices she thinks that application of animal manure makes her soil fertile better than all the other.
OO: Is the manure from own farm or purchased
09: Gets from her own cows.
OO: This maize farm have you fallowed
09: She leaves the plot under coriander she has divided into slots she leave the slot fallow and rotates either maize, beans or coriander.
KA: For how long does she leave the slots fallow
09: One season and a season is like 6 months.
OO: Apart from crop rotation do you do legume intercropping.
09: NO
OO: Do you mulch your maize farm.
09: Never knew one could practice mulching on the maize*laughs*
OO: Which fertilizers do you use for your coffee plots?
09: 17:17, CAN and if she can't get it she uses 23:23 meant for the maize.
KA: Why is she unable to get the others?
09: This fertilizers we are given at the cooperative so you can go and miss these fertilizers also one is given fertilizer depending on the KGS harvested so you could have harvested KGS that don't qualify you to get any fertilizers.
OO: What's the minimum KGS?
09:100kgs
OO: So if you have below 100kgs you do not qualify
09: You are given about 25kgs of fertilizer which is really little.
OO: Apart from the cooperative anywhere else you get your fertilizers like the agro vets
09: She buys at the agro vet when she needs extra or fertilizer is scares at the cooperative.
OO: Do you use these17:17 and CAN that's primarily for the coffee on other crops.
09: Any leftovers of these two fertilizer if stored for a whole season will go bad so she has to use it on her maize.
OO: So on your maize you use 23:23 and leftovers, so any other fertilizers you use.
09: Only uses those since she doesn't want to us the DAP on her maize only uses it for potatoes.
KA: How much manure do you apply on your coffee?
09: A debe per stem that's like 20kgs.
KA: How many times a year.
09: Once a year
KA: And in maize
09: She uses 2 maize stems one Kg per season.
OO: Do you use pesticides.

09: Yes, for the maize because of worms but can't recall the name of the pesticide. She uses DARCONYL for the coffee to prevent premature berry fall, Copper and Similoon for worms.
OO: Do you get these pesticides from the cooperative.
09: Buys from the agro vet and has only gotten from the cooperative countable times.
OO: Any time you get pesticides from the cooperative do they teach you how to use them.
09:Don't have to teach every farmer so one is given a paper with instruction of use
OO: When you receive these fertilizers and pesticides are there officers from the cooperatives that follow up on the use.
09: They just call for seminars but no strict follow up.
OO: How many times an year do the cooperative call for the seminar?
09: Once a year.
OO: How regularly do you have extension officers visit your farm?
09: like one year ago she was visited by extension officer.
OO: Have you ever called or sought extension service.
09: No*laughs*
OO: Do you feel you can easily acquire information you need to improve your farming
09: She goes to the cooperative and it's rare
KA: You said you have never done soil fertility why is that
09: She has no knowledge on soil analysis
OO: What challenges do you face that prevent you from reaching your farms full potential?
09: She uses fertilizer but still low yields so the problem is the soil
OO: What do you think you can do further to improve your farming?
09: Whatever she has done to the farm is her best and she doesn't think that there's anything else that can be done.
KA: We talked to the extension officer and you can do soil analysis for Ksh1000 and if she knows about it and if she thinks it too expensive.
09: Frankly, she's never heard of anything and she likes the idea of undertaking analysis and she has no idea where to take the soil. She says that she will benefit from the soil analysis so the Ksh 1000 is not a big amount to her.

Transcription of interview no. 11
IT: You've been farming maize and coffee for over 30 years, could you tell us a bit about the process and your experiences
NO 11: I add manure and fertilizers for coffee and also spray them. I also prune and the yields are average
IT: Average for both maize and coffee?
NO 11: For coffee.
IT: What was your coffee harvest last season
NO 11: Yields have dropped this season to 1500kgs from last season's 2000kgs in ½ an acre
IT: What are the best yields you feel you could get from ½ an acre?
NO 11: 4000kgs average
IT: What about maize?
NO 11: This is the 3rd time I'm planting maize and its doing quite well. Last season I harvested 8 bags from just ½ an acre. (1 bag = 90 kgs)
IT: How does it compare to the previous harvest?
NO 11: First time I planted maize I did not harvest anything due to lack of rains. The second time I harvested 2 sacks and now 8
IT: Why do you choose to farm coffee and maize?
NO 11: Coffee brings money but only once a year, maize is good for subsistence use but I sold six sacks the previous season to a school and use 2 for domestic purposes
IT: So what importance is coffee for you apart from money generation

NO 11: No other use apart from money generation and sometimes firewood from pruned coffee twigs
IT: Can you generally describe the soils in your farm in terms of fertility
NO 11: Soil is fertile for the maize plots but infertile for the coffee plots
IT: Ever since you started farming maize and coffee have you noticed changes in your soil colour?
NO 11: For coffee plots, soil was red but is changing to dark due to manure addition though some parts persistently retain their red colour despite addition of manure.
IT: How do you judge if your soil is fertile or not?
NO 11: In perceived infertile plots, she plants beans and they don't grow at all and there's also a difference in the health of coffee trees in the plots she considers fertile and the infertile ones.
IT: Could you briefly take us through the management practices for your coffee farm
NO 11: I add manure and fertilizers; I also prune and spray my coffee
IT: You stated that you have trees in your farm. Did they just grow by themselves or did you deliberately plant them?
NO 11: I deliberately planted them
IT: kind of trees do you have in your coffee farm?
NO 11: Grevillea, macadamia,
IT: Why do you plant those specific species of trees?
NO 11: There are some trees that destroy coffee eg eucalyptus which has long roots and Napier grass don't do well around them so I choose to plant these instead of risking with eucalyptus.
IT: So do you plant the same kinds of trees in your maize farm or do you have different species or no trees at all?
NO 11: I can't plant trees in the maize farm because it is leased the farm is dry, even the lessor had no trees at time of leasing.
IT: Apart from benching what management practices do you employ to prevent soil erosion in your coffee farm?
NO 11: There's no too much surface runoff in the coffee farm so its only benches and grass.
IT: What about the maize farm?
NO 11: The maize farm is flat so I have not used any soil erosion control technique
IT: So what kind of fertilizers do you use for your coffee?
NO 11: NPK (17:17) and CAN
IT: Where do you get these from?
NO 11: From the cooperative society only. I've never purchased chemical fertilizers for coffee from the agro vets.
IT: Do you use these coffer fertilizers for other crops in your farm too?
NO 11: I use CAN from the cooperative and mix it with DAP from the agro vet shop for the maize farm
IT: Do you undertake soil analysis in your farm?
NO 11: No
IT: Do you feel you are able to easily acquire information you need for the management of your farm?
NO 11: Information is easily accessible. I have a resource person a former extension officer and a farmer
IT: Do you receive any trainings from the cooperatives?
NO 11: Yes but I have never attended any because I'm always busy.
IT: When you get fertilizers from the cooperatives, do they have officers who monitor how you use them?
NO 11: No
IT: And what challenges do you face that keep you from realizing your farm's full potential?
NO 11: Management. There's not enough manure and therefore I use fertilizers.

IT: When you talk of management as a challenge what specific aspect of management specifically is the issue?
NO 11: Coffee management is not for women but the men even though sometimes they do it poorly and the woman cannot step in to assist thereafter. It is considered interference.
IT: Is that your personal or community perception? **NO RESPONSE**
IT: How's the pay for coffee produce?
NO 11: It's fair
IT: Besides what you are already doing what is it that you could do further to improve your soil management?
NO 11: I only manage the maize farm and what I do is enough. The rain is the only variable I can't control. The man is in charge of the coffee farm but he spends most of his time drinking and can therefore not manage the coffee farm productively.
IT: Do you feel it would make a difference in how the coffee farm is managed if he wasn't drinking?
NO 11: Yes he could be doing more and better in management
IT: Is there anything you do in the coffee farm when he's doing nothing on it?
NO 11: I don't interfere in coffee management because I don't share in the returns. I prefer the maize farm because it supports the household and educates the children

Transcription of Interview No. 17

Interview with Dennis as a Translator. Dennis translates questions to Interviewee but Interviewee answers in English. Dennis sometimes only clarifies some things.
Interviewer: Kathi (K), (Tori (T))
Interviewee: 17

IK: Okay, so during the questionnaire we did, you told us that you have been farming coffee for 34 years and maize for a lifetime. And can you tell you us just a little bit about your experience with that over time? How has it changed?
17: It is improving. When...- at the time I started picking coffee, at that time it was not very good but now, it is making good because the kilos that I am picking before, now it is increasing.
IK: How much has it increased?
17: Before I was approximately picking 500kg but now I am reaching 2000kg. And I have 200 stems.
K: Mhm okay. Is it because you think you are doing something different now than you did before?
17: Yes. That is something different because this time I am spraying severally and putting manure. Many times every year I am putting manure and I dig there. Then I mix the soil with manure.
K: So, you put manure once a year or more often?
17: Yeah, yeah. Like this time - it is the time for digging. So I put manure there and I mix it by digging, so that the soil can mix with the soil.
K: And how much manure do you put for one stem?
17: Like one wheelbarrow.
D: One wheelbarrow is like two buckets. 17 times two - like 34 kgs.
K: Okay. And why do you choose to farm maize and coffee?
17: Why we plant coffee, it is because it is a cash crop and at the time the... - our children are going to schools we pay our fees with that money of coffee. That is why I like the coffee.
Phone rings
K: Do you want to pick up the phone? If it's important...yeah you can go and pick it up - no worries. You can always...- it's no problem. I didn't realize it was a phone. *Laughs*

17: It's my sister calling me...
Longer pause and Interviewee talking on the phone
K: Is everything okay? Okay, I think you were telling us about the reasons for planting coffee and that it is because it helped you pay for school fees.
17: Yes, that is why I like coffee. Because it allows us to pay or childrens school fees.
K: Yeah and what about the maize? What kind of importance does maize have for you?
17: Yes it it important, but not for selling - for our use here.
K: Okay and what have been the yields for maize for last season?
17: 2 Debes.
D: One debe is like 20kgs - so she harvested 40 kgs.
K: And has that amount been increasing over time or decreasing?
17: Increasing. Because the time I was come to this place, even the maize was not making well, because the soil it was not very good. But this time because I was adding manure there, it is doing well.
K: Aha okay, thank you. Can you describe your soils and how have they changed?
17:Ya ya. Before it was very light and looked brown, but now it is becoming like black.
Coughs...ya.
K: Ok so I would like to ask you how it is that you manage your coffee farm. Maybe you can explain that a bit? You said in the questionnaire that you use manure and do mulching..do you also use compost or chemical fertilizers on the coffee?
17: I spray..putting manure, pruning..yeah and weeding.
K: Okay, what and how often do you spray?
17: Like...let me say it will depend with the weather, because when it is very cold we spray many times so that the berries cannot fall. And when there is no.. - at the time it is not very cold we spray like 4 times or 5.
K: Okay and do you have agroforestry in your coffee field? And if yes, which trees do you have there?
17: Yes. Grevillea and Moringa and Bananas.
K: Mhm. Do you think it is helping for soil fertility to have the trees?
17: Some, like Moringas because of its leaves. So when the leaves fall, they decay very fast and they make manure..they improve the humus in the soil. And it is even used for mulching.
K: Nice, okay. And do you do soil erosion control in your coffee?
17: Yes.
K: What do you do?
17: By digging terrrazes. That is called "Fangaju", ya. *Talking Kikuyu to Dennis*. Because our coffee is "congested"? (close spacing of coffee), it is not doing well. Because it "caught", when we plant napier grass...
D: She said that there is a type of grass that farmers normally plant to hold together the soil, they plant at the edges of the terrazes. She is saying that she has not planted because the coffee is so congested. So she has just made terrazes.
Talking in Kikuyu
Okay, there is a place where it is very steep on her farm and she has planted nappier grass, because nappier grass is a good soil controlling crop.
17: Even at the river bench. We plant nappier grass along the river for preventing the sliding.
K: Yes, but not in the coffee plot, just..-
17: Just along the river, ya.
K: Okay. And now, how do you manage your maize plot? What do you do there?
17: I dig terrrazes, then I put manure and I plant the maize there. Then I mix with beans because it is not a big land, so I must mix because I want beans, I want maize and my family is not big, that is why I mix..ya.
K: Yes, okay. How much manure do you use on the maize field?

17: On the maize..a 1000kgs.
Talking in Kikuyu with Dennis
17: Like ten wheelbarrows. 40 times ten. 400kgs.
K: Okay so do you put it around the stems?
17: No, it is spread around evenly..not only around the roots.
K: Okay yes perfect. So which chemical fertilizers do you use for coffee and which ones for maize? Is it the same or different ones?
17: That is different. We use that one called 20-20-0 and 17/17 for coffee. And CAN.
K: Okay and for maize?
17: For maize we use 23/23 and sometimes we mix with DAP. At the time of the weeding we supply CAN for top dressing.
K: And where do you get your fertilizers from?
17: For coffee we get it in the factory of the cooperative and for maize we buy it.
K: At the shop?
17: Yes.
K: Okay so you said you get your information on agricultural practices from friends and family, media, extension services, the cooperative and chemical dealers..Has this changed the way you farm?
17: Ya. The last time people coming are called "Techno saf". Techno saf. And I have a certificate.
K: You have a certificate..which certificate?
17: Techno saf. For training ya, ya.
D: So she is saying that that knowledge from tecno saf, where she did the training and the media has helped her to know what practices to do on the farm,
K: Aha, nice okay. So you also had extension services here?
17: This time I have not seen them..
*Talking in Kikuyu"
D: So they used to come but recently she has not seen any here.
K: Aha okay. And do you undertake soil analyses? Have you done this before?
17: I dont have..
K: Would you like to do it?
17: Sure.
T: Why havent you done soil analyses before?
17: *Laughs and says something in Kikuyu*. I have not planed to do so but I know it is good, but I have no..-
K: Why haven't you done it..is it because it is expensive..?
17: Not very much. It is the time but will do so. Because I know it is good to know how our soil is.
K: Okay. Do you think you can easiliy acquire the information you need for managing your farm?
Talking in Kikuyu
D: The people who can help are not really available when she needs their help.
K: Okay..what do you think is keeping you from reaching your farms full potential?
17: Because at the time I want to put fertilizer, when I go to the factory..it is not there and I have no money to buy at that time so that time have passed and was supposed to do that. That is why my crops instead of increasing it's decreasing.
K: Aha. So you are saying its money?
17: Money. It's money problem. And at the time when i want to spray, I cannot spray for myself, I must look for somebody to do that job.There is times when I have no money and it is very cold - it is make my coffee berries to drop.
Talking in Kikuyu

D: So I hope you remember, the husband is gone and she is saying that if the husband was here they would help each other.. So maybe if her husband was here, the kgs would be high- the yields would be higher, because the workload has been placed on her.
K: Yeah, so now you are doing everything by yourself?
Kikiuyu talking
D: Yeah, you know what she hires labour, maybe she can't do it all by herself and she says that sometimes she doesn't get a person to work for her, so she waits until she is not very busy so she can spray her coffee. There is no one to hire.
K: Mhm okay. Are there any other challenges you have with coffee or with maize?
Kikuyu talking
D: No, thats all.
K: Besides what you are already doing,what do you think you could do to improve your soil management?
Kikuyu talks
D: She is saying only soil analysis. She thinks thats the only remaining bit, yeah.
T: And do you use ash or lime on your coffee or maize?
Kikuyu talks
17: Only once.
K: And why?
17: I dont know why. But money depends.
T: Did it change anything when you used it?
17: It is good. *Kikuyu talking*
D: She noticed a positive change when she used.
17: Sometimes it is *inaudible* because it is not very expensive.
T: So its just that you havent had the capacity..?
17: I am planning..because it is not expensive, easily to apply..I dont know why not doing that.
K: Where will you get the lime from?
17: Buying at the shop. Because it is not expensive.
K: And you said you sometimes dont have money to buy the sprays..but cant you get it on a loan from the coffee cooperative? Do you do that sometimes..get inputs on a loan from the cooperative?
Kikuyu talking
D: So its just this agrochemicals for spraying, you can take them from the factory on a loan and the fertilizers..ya. And you will be given according to your kilograms - the kilograms you have sold. You have to reach at a certain standard so you will be given fertilizers. The more kgs you have, the more fertilizers you will be given.
K: Okay good. Thank you very much. Is there anything else you would like to say about soil fertility on your farm?
17: Thank you for coming to us. We have educated and we have -..I want to say it is good for you coming to us because we have learned something.
K: Thank you, we have too.
T: We have too a lot.
17: *Inaudible*
K: Thank you very much.

No. 22
Translated by Dennis
Transcribed by Tori

IT: So, you've been farming maize and coffee since 1960. We were wondering if could tell us a little bit about your process and experience with it?

22: Farming has been beneficial to me, because I use the money from the coffee to educate my children. And also the maize is a source of food to my family, so I have been using it to feed the family. So I think that farming has been so beneficial to me.
IT: Ok, and has it gotten…- has the process become easier or harder since you started farming?
22: Farming has gotten harder because initially, we used to just plant maize and leave it, but now we have to use inorganic fertilizers and so many things. So right now, things have gotten harder than they initially were.
IT: Yeah. Ok, and what were your yields for maize and coffee last year?
22: So for coffee I harvested 200kgs. For maize we didn't harvest anything because the rain was so great that there were floods. So we harvested nothing.
IG: And previously was it still the same amount at 200kg, or was this an increase or a decrease?
22: The yields have decreased because there are times which I harvest more than 200kg.
IG: So like how much did you used to harvest, in kg?
22: There was a time when I used to harvest like 800kg.
IT: Oh wow. And just a little bit more about soil and soil fertility. Can you describe your soil and how it has changed since you started farming?
22: The soil has changed. I have been using fertilizer and manure. And that is evident because the yields have been decreasing, so I think that my soil has been changing maybe negatively.
IT: Mhm, yes. Soo, you have indicated that you have a decline in crop yields and that's an indicator for change in your soil fertility. You also talked about…- in the questionnaire you talked about indicator weeds and a change in the color of the soil, and also poor growth and poor crop health. Can you talk a little bit about that?
22: For the crop yields, they have decreased. And the issue about soil color - initially my soil was a bit darker, and now it's getting lighter. It's getting reddish.
IT: And this is for coffee of maize?
22: The change is both in coffee and in maize.
IT: Ok yes. So you're experiencing worse crop health in both coffee and and maize as well? Or just lower yields?
22: Yes.
IT: Yes ok, also worse crop health in coffee and maize as well? Or just lower yields?
22: Yes
IT: Also worse crop health
22: Yes.
IT: Ok, yes. Ok for coffee, can you explain your management practices? Just your process in managing coffee? What you do, what you use- which inputs you use?
22: For the management practices, I have made these trenches, and the terraces so as to prevent soil erosion. And I have also planted napier grass to hold the soil together. I use manure and inorganic fertilizers.
IT: Yes. And, any type of agroforestry? Trees within the coffee plot?
22: Macadamia trees. I have a section where I've planted macadamia trees.
IT: You have a section where you've planted macadamia trees?
22: Just trees, but the macadamia trees are planted within the coffee.
IT: Ok, the macadamia trees are planted in the coffee.
22: Yes.
IT: Ok and the macadamia is a source of income? Or any other reasons why you've planted them in your coffee plot?
22: Macadamia is a source of income.
IT: Yes ok.
IK: About the inorganic fertilizer, when have you started using that, or have you always been using that since you started farming? And how did that impact [inaudible]

22: I really can't recall when I started using fertilizer, but initially when the fertilizer had not been invented, we were just using manure. But now, the use of fertilizer has improved the fertility of my soil. It has been improving.
IT: Yes. And do you use any lime or ash on your coffee plot?
22: I have been using ash, but you know the ash is just little so I use it on a very small area. And for the lime, there was a time when the cooperative provided us with lime, but now they don't give it.
IT: Ok. And so back to the fertilizer, what type of fertilizer do you use on your coffee, and where do you get it from?
22: We are advised to buy 17-17 for the coffee, and 23 for the maize.
IT: And where do you get it from? The fertilizers from?
22: The coffee cooperative is the one that gives us fertilizer. But when you don't have so much kgs for the coffee, they can't give us, so you have to buy for yourself.
IT: Ok. And for the maize? Where do you get that fertilizer from?
22: For the maize I buy it from the shop. From the agro-vet.
IT: Yes. And do you use any of the leftover fertilizer on the other crops?
22: I only use the fertilizer for the purpose of coffee and maize, and if there is any leftover, I just keep it so I can use it next time.
IT: Yes. And about maize, can you tell me about your management practices that you use for maize?
22: I use manure, animal manure and fertilizers on the maize.
IT: Mhm. And any compost?
22: I've learned about using compost manure recently. So I have made one, and now I'm going to use it on the maize.
IT: Alright, cool. And do you have any trees intercropped, or nearby your maize plot? Any agroforestry?
22: There are no trees. Just bananas.
IT: Just bananas. So the maize is only intercropped with bananas? Or anything else?
22: Just bananas.
IT: Just bananas. Ok. And what about…- anything for soil erosion control?
22: I don't experience so much soil erosion because the land is flat where I plant maize. So I have tried to control soil erosion by planting napier grass just on the river banks.
IT: Ok, yes. And you marked in the questionnaire that you use irrigation in the maize, can you tell us a little about that system?
22: When it's dry, I have water that I use for irrigation.
IT: Where do you get the water from?
22: The irrigation is part of the Kamavindi project. So Kamavindi project.
IT: Ok, Kamavindi irrigation project.
22: And we get the water from the nearby river. We have tapped the water from river [inaudible]. Just the river down here.
IT: Ok. And you mentioned in the questionnaire that in the past you used fallowing in your maize plot. Can you tell us a little about that?
22: When the land was not scarce like today, I used to leave one side of the farm, and farm on the other during the short rain. And once the long rain, then I left this one, and farmed the one that I left fallow.
IT: Mhm. But today you don't do it because the land is too scarce, is that right?
22: Yeah.
IT: Ok. And in the map, you actually mentioned that you intercropped the maize with beans.
[Pause]
IG: Maize, beans and bananas.

IT: Maize, beans and bananas. Could you clarify if it's just maize and bananas, or if it's also beans?
22: So I just intercrop maize and bananas, and have a portion for beans.
IT: A separate portion for beans, ok. So, out of all these practices you mentioned for maize and coffee, which of these practices do you think improve the soil fertility?
22: I think that application of manure has been a lot of benefit to the farm, because I think that fertilizer has a lot of scary things that I think will cause soil degradation.
IT: Yes. And how much manure do you use on your coffee and maize? And how frequently?
22: We use manure twice a year, during the long rains and short rains. But if there is no manure we might choose once a year during the short rains, then we'll try to apply fertilizer, during the other season.
IT: Ok. And how much fertilizer at a time?
22: Just on the coffee?
IT: On both.
22: I use one bag of fertilizer on the coffee, which is 50kg. 50kg of fertilizer on the coffee. And on the maize, I use a half of the bag, so like 25.
IT: 25kg. Yes, ok.
22: And the fertilizer that I apply on the coffee, it is different from the one I apply for the maize, so even the quantity of application of fertilizer is different. It's different different.
IT: Yes ok. [pause] In the questionnaire, you mentioned that you get information about different practices from friends and family, the media, it's also traditional knowledge, and from traders and input dealers, yes? How has this changed your management practices? Or influenced your management practices?
22: When I go for those agricultural shows and seminars, or when I listen to radio, I'm [inaudible] about…-for recent to give an example, I'm told what fertilizer to use on the coffee, what fertilizer to use on the maize, on what quantity, and I'm given the prescription. So I think that this education has help so much in the family.
IT: Ok, great. And you said that you undertook a soil analysis 3 years ago, and that you understood the results. How have these results affected the way you manage your farm?
22: I didn't understand the results..-
IT: You did NOT understand the results
22: And even if I could understand the results, I would not have believed in them because they took a sample from just one corner of the farm.
IT: Yes, ok. And do you feel that you are able to easily acquire information you need to manage your farm?
22: If I need to know something about agriculture, to get any knowledge - any kind of knowledge, I can contact those agricultural officers…- because when we go for seminars they normally give their telephone numbers.
IT: Ok, yes. And what do you think is keeping you from reaching your farm's fullest potential?
22: Because of lack of money…- like now when I'm advised of using a particular fertilizer and I have no money…- ok even if I get the fertilizer later the time will be gone. Time wasted is never recovered, so I cannot recover the time again even if I get the fertilizer down the road.
IT: Ok, so besides lack of money, are there any other challenges you face in your production of maize and coffee, and your soil fertility?
22: Sometimes the rainfall is high, and there is a lot of soil erosion, and the rain oftenly destroys the terraces. So, I have to keep repairing them over and over again. And I have no one to help me repair them, so I feel that it's a lot of work repairing the terraces.
IT: Yeah ok. Yes. And besides what you're already doing, do you think you could do anything else to improve your soil management?
22: If you can be able to take a sample of my soil, so I can know the problem with my soil, that is the only think that I need to do.

IT: Ok, great. Is there anything else you'd like to add, before we finish?
22: I would really appreciate that you help me, that I understand that you are students, so I don't expect anything from you, because I know you are doing this for the sake of your studies.
IT: Ok, thank you so much

Transcription of interview no 25

Interview in english for most part
Interviewer: Tori (IT)
Interviewee: 25

Transcribed by: Line

IT: You told us that you have been growing maize and coffee for about 12 years. Can you tell us a little bit about that experience and the process from when you started growing those crops until now?
25: Coffee farming mostly is *inaudible* improving but for maize because of the fertility of the soil the harvest is a little problem. We get a little harvest from one farm.
IT: Okay. And it has been like that from the beginning? That you have only been able to get a little bit of maize?
25: from the beginning the harvest was a little bit high.
IT: It was harder and now it has gotten easier?
25: its slowing down
IT: Okay. Its slowing down now? Okay. And why do you choose to farm coffee and maize?
25: Because it is the only crop that is mostly grown in this area. It is for coffee and tea. *inaudible*. Coffee farming is not like farming of tea, it is a little bit easier to farm coffee.
D: So he is saying, in this area you only have two options for cash crops, you either grow tea or you grow coffee. So, its the choice of the farmer. You can grow both or grow one. So he decided to grow coffee.
IT: why did you choose to grow coffee instead of tea?
25: I have just choses through that coffee is more easy to farm than tea. You earn more than tea.
IT: You earn more than tea. Yes. What kind of importance does coffee and maize have?
25: You know, he farms maize for food and coffee for cash, for income. It has taken me far.
IG: I have a question. You said that the yields have been decreasing. Do you have estimates on the amount of kg's it has reduced from?
25: By the time i started it was about, I was taking about 200-300 kilos for coffee, up til now I can even pick 2000 and above.
IT: 2000 kilos? A year? Wow. Thats amazing. So would you say that it is profitable for you?
25: profitable? Per kilo you can even be payed 100 shillings per kilo. Its alright, eh.
IT: Nice, sounds very nice. So can you talk a little bit about your soil and the fertility of your soil? Just how has it changed since you started farming?
25: The fertility is easier. Acording to how the farmer is active on improving it, mostly we improve the *inaudible* of the soil by adding more manure. Like me I add yearly.
IT: yearly?
25: yes
IT: And how much manure do you add?
25: One wheelbarrel per stem.
Clarifying: One wheelbarel is two buckets and a bucket is 17 kg's. 17*2=34 kg. Per stem. A year
IT: So you apply it throughout the year?
25: throughout the year.
IT: And which fertilizer do you use?

25: You know *inaudible* according to the time. Like now we are going to receive the fertilizer... the nitrogen, the CAN.
IT: And where do you get your fertilizer from?
25: from where we take our coffee you know *inaudible* bring fertilizer. *inaudible*
IT: Okay, so from the coffee cooperative, the factory. Yes. And how do you determine if your soil is fertile or not? What shows you that your soil is not fertile?
25: Now like in coffee we never know, we never look at the fertility of the soil, we normally continue applying what is possible to do. If it is time for fertilizer we never *inaudible* whether it is fertile or not, we just apply fertilizer if any or manure. We continue, it continues.
IT: And for the maize you indicated last time we talked, you said that there was no change in the fertility of your soil for maize. Can you talk a little bit about that?
25: you know for maize sometimes the soil is exhausted because we never, I told you again, we never do crop rotation because the farm is so small. That is why the soil is exhausted by planting the same crop repeatedly.
IT: Okay, so you said that you have seen stunted growth on your maize plots, is that right?
25: Stuntet growth means, plants are growing slow in stead of *inaudible*. Slowly.
IT: ITs growing slow. Okay. Is there anything else other than improved coffee yields that shows you that your soil is fertile for your coffee plot? Can you talk a little bit more about the indicators like improved growth or indicator weeds, that you have mentioned before? Can you talk about what you see in your coffee plot that shows you that your soil is fertile?
25: You know, even the bananas we plant in coffee, we mix with another coffee farm,*inaudible* they normally improve. The bananas, the macadamias, the fruit trees, *inaudible* are grown in that farm, The soil is sooo fertile they also improve because the first time we have come in this area we planted bananas and we inject to *inaudible* the pinapples *inaudible* this area. But up to now even if we plant it in this season the next season we will be eating some bananas. Because the soil is so fertile.
IT: Okay, nice. Can you tell me a little bit how you maintain your coffee? You do some intercropping right? We saw you do bananas and anything else? Macadamia?
25: Macadamia. There is also fruit trees that does quite well.
IT: yes, for erosion control you?
25: I make terraces.
IT: You make terraces. And anything else or no?
25: particularly those to prevent erosion.
IT: okay. In your maize you said that you intercrop everything with what? In your maize plot you said it was intercropped with beans and what else?
25: beans. *Inaudible* doing some sweet potatoes. Sweet potatoes I plant them in this area.
IT: Anything else than sweet potatoes?
25: In that farm no, nothing else
IT: Okay. And anything for soil erosion control?
25: Anything else? We use terraces *inaudible* any farms, we dig some terraces to prevent erosion.
IT: Okay, in the maize as well?
25: In the maize, there is no erosion in that farm. Its flat.
IT: Its flat, okay. And what kind of practices did you use in your maize and your coffee do you feel improve your soil fertility?
25: Its only adding that manure because you know the soil in this is aciding because of the use of fertilizer, so we use manure to reduce the acidity of the soil.
IT: You use the manure to reduce the acidity in the soil? Yes, okay. Do you use any fertilizer in your maize crop?
25: You know that one come yearly, you can not plant maize without the fertilizer. You cant do it.

IT: And where do you get the fertilizer from?
25: from the shop.
IT: from the shop?
25: that of our maize, we get it from the shop.
IT: And which one do you use.
25: I only use DAP, 23-23.
IK: I thought you can't get the DAP any more?
IG: That is for the Agricultural Officer, she likes vouchers to get fertilizers from cooperatives, but I think for the shop you dont need a voucher.
IK whispers: I'm thinking also about lime and ash.
IT: So you get the fertilizer from the shop?
25: from the shop *inaudible* The foods. You know we have no anywhere we take for the foods. Just eating. Plant it for our own use. So we have nowhere to get the inputs. So we buy from the shop.
IT: And do you ever use any of the left overs on any other crops?
25: What?
IT: *repeat* from coffee or maize on other crops?
25: We normally take the one that we have and use it in coffee.
IT: Okay, jaer. And do you ever use any lime or ash?
25: No no. I have not ever used that.
IK: Can I ask, why do you use the DAP?
25: You know we use fertilizers which improve the harvest. That DAP and the 23 we mix it together. It makes the crop grow faster.
IT: Do you know what your yield is of maize? What it was last season?
25: Areas are so small you know. He harvest something 2 debes. A debe is 17 kg's. Like the buckets of the manure.
IT: You said before that you get information about your management practices from friends and family, the media, and farmers (...) seminars and that kind of things.
25: and even the media
IT: and even the media. Do you feel that this has changed the way that you farm?
25: yes *inaudible* of course. We normally * the methods we used before by *inaudible*
IT: you get the information when you are at the seminar?
25: yes. We learn something new then we come and we put it into our farming.
IT: You haven't taken soil analysis I guess, before?
25: No I have not done it before.
IT: Do you feel that you are very easily able to acquire the information you need to manage your farm?
25: Sometimes the input comes hard because if they dont bring them where we pick them. And you dont have money to buy, you know you have to wait until the *inaudible*, sometimes they come late and your farm, sometimes even the crop you plant are destroyed.
IT: What comes late, Im sorry?
25: Mostly the coffee. Sometimes when the rain falls there is that *inaudible* that comes that impact coffee, so if they dont bring the chemical we need we get a lot of losses.
IT: and what about the information that you need, the knowledge you need, to be able to manage in a way that you are producing the most possible? Do you feel that you have access to that sort of information that helps you develop your farm as much as possible?
25: They are not easy to get because sometimes we need to walk far, and you can not make it by yourself. You have to go, sometimes we are planned by the society where we take coffee, they sometimes plan to us to go somewhere to get some knowledge. So if they are not planned you cannot ... You can go to a farmer somewhere near you who has improved his farming and learn something and use it in your farm.

IG: I have a question, you said that havent been undertaking any soil analysis. Is there any reason to why not?
25: There is this one because, you know like the other meeting we have attended … they say they come and repeat the *inaudible* to come and take it for analysis. Up to now we are waiting, they have not come. So in this area there is no where you can take your soil to the analyst.
IT: What do you think are the main challenges that are keeping you from reaching your farms fullest potential?
25: Mostly with coffee, not with me only, with other farmers, what makes us not improve farming is what we get is poor payments. If they pay us well, we can even *inaudible* because in this area, they say that there's a stem of coffee introduced that the kg's are even 40, 50 and they have more than 250 stems, even multiplying by 50, they make 5000kg and above. So what makes us go slow, is the poor payments.
IT: Do you feel that is the same for you or just for other people?
25: what?
IT: *repeat* this challenge of poor payments?
25: Poor payments, even for others and for me, that is where the major reason (is).
IT: Besides all the management practices you mentioned that you are doing already, is there anything that you think (…) that you wish you could do, that would improve your soil even more?
25: that it can improve more? Apart from applying manure and fertilizer I have nothing else I can do better than that *laughs*
IT: Did you have something to add?
IK: Do you know there is a possibility to take soil analysis, I think it costs 1000 shilling?
IG: We have been told that you can take a soil analysis to karo. Have you ever considered it?
25: I have not yet done, but *inaudible* when we were in a meeting here the chairman and those people who take the soil for analysis, but they have not come and we have seen that one sample they will charge you 2500. For a sample. But they have not yet come.
IK: did you do that?
IT: No. But they havent come. So if they were to come, do you think that you would? Would you be willing to pay that much?
25: *indicating no* I have not yet wanted to do that. My soil is not so bad. I can see there is no much problem in it.
IK: So it is 2500?
25: 2500
IK: not 1000.
IT: I think that is all we have to ask you. Is there anything more you would like to add before we close?
25: *asks question, not relevant to study*

Transcription of Interview no 28

Interviewer: Geraldine
Interviewee: 28
Translator: Amy
Interview is translated from kiembu to english
Transcribed by Line

IG: You have been farming maize and coffee since 1960, so can you tell us a little more about your process and experience with that?

28: I have never been employed and I rely on maize for subsistence and for selling, so I cannot complain, because I have been sustaining me and my family since I started.
IG: Apart from using the maize for subsistence, is there any other reason you chose to grow maize?
28: I harvest coffee in december and after selling we are payed in june, so maize stand up for the time that we are not in any form of income because the produce from the maize farm is sold and we are able to utilize it to do other farmwork.
IG: And for coffee is there any other reason why you chose to farm coffee?
28: Coffee came with the colonialists and when they first introduced coffee in Embu a person with 50 coffee stems was one of the richest. I have used coffee to educate my children. We were given checks at the factory where the school fees would be deducted after the payout. So I have a family of 10, wife and 8 kids and all the kids none of them have been sent out of school, thay have all studied using coffee.
IG: Can you describe your soil and how your soil have changed over the years?
28: In the past, we used to cultivate anywhere we want, but the boundaries came and everyone was given a place to settle. Since then everyone plants in their farmland every season so there has been lots of changes. The bushes that were there in the past used to prevent soil erosion, but now a day we have cleared everything so the topsoil has been carried away. So those who do not apply manure on their lands, experience infertility and *inaudible* because of the declining *inaudible* because of the overuse of the lands.
IT: I guess that is true for him as well.
28: It is also happening at my land although I have been applying manure. I cannot compare it to the past.
IG: Last time you stated that declining yields is one of the ways you know that your soil is infertile, declining coffee yields. Can you tell more about it?
28: I realised declining in soil fertility in 2017 where I harvested 400 kgs of coffee during that season, but this year, it went up to 1000 and something, so I am judging from the 400 kg's because this time I added manure, that is why I have harvested that much.
IG: You also indicated that you have seen a few indicator weeds in your coffee plot that is a sign of declining soil fertility. Can you tell us more about the indicator weeds?
28: I am not sure whether it is the impact of the long sunny period or it is because of manure application, because the indicator weeds were mostly at the areas where I applied manure, but the areas where I did not apply there were no weeds, so that is why I judged it badly.
IG: You also stated that you have been observing poor coffee health. Can you tell us more about that?
28: If you are comfortable I can take you to the fields. Some of the coffee plant have yellow leaves like these flowers but the neighbours are all green, so that is why I think they are not healthy.
IG: and for your maize plot, you indicated that you observed no changes in fertility. Can you tell us more about this?
28: At the maize plantation we add manure every planting period, like today I have some workers who are taking manure down there, that is why maybe there has not been any change.
IG: One of the main management practices you stated that you practice is mulching. We would like to know more about mulching, the reason to mulch?

28: I prune bananas and instead of burning the leaves, I take them to the coffee plantation and for napier grass I use the stems because the cows cannot eat the hard parts, so when it dries hard I take it to the coffee plantation so that when it rains the soil can retain moisture and the weeds cannot overgrow.
IG: You also stated that you use animal manure. We would like to know how much of the animal manure you use per coffee stem and other ways you apply the manure in this coffee farm?
28: For the older stems, I use a bucket, it is 15 kg's, but for the younger ones I use very little because the roots are not so many compared to the older ones.
IG: we also want to know how often and when do you apply this manure?
28: Manure is mostly applied in january and february, so that the april rains can get it there and if I apply enough manure it can stay for 3 years without applying again.
IG: You also stated that you use chemical fertilizer in your coffee plot. We would like to know when you apply it, how often, which one?
28: I apply two types of fertilizer. The CAN and 17-17. So the CAN is applied in april I appy CAN, then in october the 17.
IG: you also stated that you practice agroforesty. We would like to know which trees, what are the spacing of the trees, how many trees do you plant in your coffee farm?
Amy: What do you call that tree?
IT: hmm, we don't know. We will find out.
Amy: Okay, he plants that. And this one.
28: Mostly I plant such kind, the one that I have shown you, and this one, and at the area where we have talked of napier grass, I planted this kind of trees, more than 20, but they are young, they were planted at the last planting period.
IT: Okay, those types?
28: This types.
IT: And why?
28: This tree makes the best timber, and furniture that is made of this mixed with eucalyptus is the best, even my cupboard in the house is made of this. So I love this because of its good timber.
IK: Do you know what it is called no?
28: In kiembu. I don't remember the name.
IK: but did you say moringa?
Silence
IT: What is going on?
Amy: he is going to ask his wife.
IK: I think I understand moringa
Chatting between team and clarifying.
28: mthuru in kiembu.
Amy: I know it, it has some black fruits, I dont know what it is called.
IT: So how do you spell it? (look up notes, gets written down)
IG: Is there any differences in soil fertility that you have noted in the places where you have planted the trees?
28: I have just planted the trees, so they are still young, so I cannot talk of the changes.
IG: You also say that you practice some soil erosion control and terraces. Can you tell us more about it?

28: At the terraces I have planted grass so that even if rainwater passes through it cannot carry away the topsoil, because it cannot pass through the grass. I have also made trenches for the rainwater to pass through so it can not go to the maize plantation.
IG: Did the land have the terraces before you got it?
28: I made them on my own
IG: So have you noticed any changes?
28: the topsoil is no longer carried away by the rainwater, and even if it is, it settles on my land in stead of going to far away places.
IG: When you were mapping you said that on the maize plot you practice crop rotation. So we would like to know if that boostes soil fertility compared to the coffee plot where there is no rotation?
28: At the coffee plantation, manure is applied after every 3 years, but for the maize plantation we apply manure when planting beans then again when planting maize so the land is a bit fertile because of the continuous manure application.
IG: so you wouldn't relate the crop rotation to extended soil fertility?
28: Crop rotation is beneficial because what beans eat is not the same as what maize eat, so when I plant beans here they will eat up their nutrients but they will retain the maize nutrient, so when I plant maize again, there food is still there.
IG: You also state that you use animal manure on maize plots, can you tell us more about it? The intensity and after how long?
28: I apply every planting season. I dig holes for planting maize and in every hole I plant two seeds. So I carry the manure with the bucket, then i fetch my hands in, put it in the hole.
IG: From the number of practices that you stated, crop rotation, animal manure, agroforestry, soil erosion control, which one do you think improves soil fertility the most?
28: The terraces work best, because they prevent soil erosion, so after making the land fertile by applying manure, the soil will still be retained. So that may be the best.
IG: You say that you use chemical fertilizer. So where do you get this chemical fertilizer from?
28: I buy at the shops. For the maize I buy fertilizer at the shop, but for the coffee I get it from the cooperative.
IG: And this fertilizer from the cooperative, do you use it on any other crops?
28: I only uses it at the coffee plantation because it is best for coffee, and not for the others.
IG: What about the fertilizer you get from the shop to use on maize, does the same fertilizer, does you use it on other crops?
28: I either store it for the next planting period, or when I am weeding I do top dressing with it.
IG: The last time you said that you get information about your management practices from your friends and family, the media and agricultural extensioners, so how has this information changed the way you farm?
28: It has because whatever I am thought I apply on my land, so that we can make changes and especially the media has been very helpful because what we learn in the media we apply on the land and make changes.
IG: You said you undertook som soil analysis and you were told to be applying lime, so has these analysis, apart from the advice you were given, has it changed the way you manage your farm?
28: I applied the lime as adviced and after using lime, the next harvesting season I realised the changes (clarified to be positive changes).
IG: Do you feel that you easily acquire the information you need to be managing your farm?

28: The cooperative take a longer period before they can educate the farmers, but access to information through the media is quite easy.
IG: what do you think is keeping you from reaching your farms full potential?
28: Climate change has been a major problem and the amount you harvest from your plantation determines the input that you are able to get from the society, so if you do not have enough, you will not access the fertilizers and the other inputs that you require. So money has been a problem and the yields are also a problem.
IG: so you mention climate change and financial resources as some of the challenges. Are there other resources that you face?
28: In the past I would do all the labour, but since 2016, I got sick, so I cannot do most manual jobs and the labour is quite expensive at this place, some times I depend on my sons to do it and they have their own farms. So I mention cancer as one of the issues that I am facing. It has utilized a lot of my friends.
IG: You stated quite a lot what you are doing to manage your soils like agroforestry, animal manure. Are there other things you think you can do so as to improve your soil, or try to conserve, which you are not able to do?
28: I have tried my best I am not complaining, so I don't see anything else I could wish to do.
IG: Is there anything you would like to add?
28: I am waiting for the results, so maybe you can determine if there is anything else I can do apart from what I am doing.
(End)

9.4 Synopsis

Degradation or Conservation of Soils: a Case on Soil Fertility, Perceptions, Management Practices and Livelihood Assets Among Farmers in Kibugu, Embu Region, Kenya

Synopsis for Field Work

Picture © Kenya Soil Survey

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Index

1.Introduction

Soil fertility describes the soil's ability to facilitate plant growth, the soil's nutrient composition as well as its texture and pH, which all support plant nutrient uptake. Infertile soils are not able to support high yields, and as high crop yields are needed to sustain and feed a growing world population, soil fertility is important for crop production, food security, livelihoods and in relation to the bigger picture, conflict mitigation.
Vlek et al. (2010) states that measuring soil fertility at large scales is complex and there is little to no complete data on soil fertility on the national and global scale because of missing long-term quantitative comparative data. Nevertheless, there is a strong scientific discussion on soil fertility and its causes and it is known as a widespread problem (Oldeman, 1992).
One side of the discussion argues that the phenomenon of soil fertility loss is mainly a social issue of human land use as a result of an increasing demand for agricultural products and practices such as land clearing and deforestation (Vlek et al., 2010).
Sub-Saharan Africa has experienced strong land degradation compared to the rest of the world, which according to Nkonya et al. (2016) and Sanchez (2002) is due to lacking government investments in natural resource protection, diminishing traditional practices and a high annual nutrient depletion from soils without sufficient nutrient replenishment, partly due to high costs of mineral fertilizers. Also the colonial administration has had its share in soil degradation in Kenya (Mackenzie, 1991). Low soil fertility is a direct major biophysical cause of low food production and presenting a cause of food insecurity and poverty in eastern Africa, including in Kenya (Charles K.K..& Gachene G.K., 2003; Sanchez, 2002).
On the other hand, soil degradation has the potential to be solved if the underlying aspects are understood and acted upon (Vlek et al., 2010). Sanchez (2002) argues that many households in Kenya, and other Sub-Saharan countries use diverse combinations of fallow periods, biomass applications and agroforestry components with good results concerning soil conservation.
According to Jaetzold et al (2005-2012) the issue of soil infertility is also reflected in Embu county. This study will use the context of Kibugu to investigate the current situation and its connection to farmers management practises for soil fertility by looking at maize and coffee, two common crops for cash and for food.

2. Background

2.1 Climatic settings and agro-ecology

Because of its location on the foothills of Mt. Kenya, Embu county is a very diverse agro-ecological county. It ranges from the hot and dryer low zones with less than 600mm annual precipitation to the cold and humid upper highlands with more than 2000-2500mm precipitation. The climate is dominated by two rainy season, the first starting in mid-march and the second in mid-october. The volcanic soils from the mountain are generally fertile. In Kibugu, the area of interest, which lies North of the town of Embu, the soil types are nitisols and andosols, known as being well drained, dark red or brown, clay soil with an acidic humic topsoil layer, and the area is relatively steep (Jaetzold *et al.* 2005-2012, Muya *et al.* 2008).

The agroecology of Kibugu is classified as the Upper Midland zone, where coffee and tea are especially suitable crops. Both tea and coffee are major cash crops in the area together with passion fruit, french beans and snow peas. Often, inorganic fertilizers are applied to cash crops and are often distributed by authorities and deducted from produce value. Vegetables like kale, tomatoes and irish potatoes, and fruits like avocado and mangoes are sold in local markets and some even in Nairobi (Jaetzold et al. 2005-2012). For Kibugu, this trade can be expected to have increased since the construction of the tarmac road connecting the village with the town of Embu (Google Earth satellite images 2017-2018). Food crops for subsistence are maize, yams, beans, cassava and arrowroot. These are most often fertilized with manure (Jaetzold *et al.* 2005-2012).

Different soil fertility and soil erosion measures are taken in this area, which is comprised of steep slopes and experiences heavy rainfall (Jaetzold et al. 2005-2012). *Fanya juu* terraces are a widespread practice in Kenya to mitigate soil loss. It means “make it up” in Swahili and is a method where a ditch is dug along the contours and the soil spill is thrown uphill to form a ridge, which is then stabilized by Napier Grass (*Pennisetum purpureum*), a C4 perennial grass often used as fodder for cattle (Thomas and Biamah, 1991) or with *Calliandra calothyrsus*, a multipurpose tree which also provides fodder and soil fertilization (Jaetzold *et al.* 2005-2012). On steep slopes hedgerows can also be effective in decreasing erosion through terrace planting and their extensive root networks which improve water interception (Muya et al. 2008).

Traditionally, crop rotations, the incorporation of plant residues by ploughing, occasional application of manure in planting holes and short fallows were all part of farmers maintenance of soil fertility in maize fields. Fallows and crop rotations are seldomly seen anymore in high population density areas like Kibugu, as farm sizes have decreased. Also, incorporation of plant residues compete with the need for fuel and fodder (Crowley and Carter, 2000; Jaetzold *et al.* 2005-2012). Maize-legume intercrops are commonly used as well as legume trees and manure from livestock are often applied to home gardens and to close or mid-distance maize fields

(Castellanos-Navarrete *et al.* 2015; Jaetzold *et al.* 2005-2012). Those who can afford it use inorganic fertilizer to improve soil fertility. The practice of “niche matching”, the selective use of soils for specific crops, are common in many parts of Eastern and Southern Africa (Crowley and Carter, 2000).

According to a report of the Embu BGBD project, farm sizes in Embu county range between 0.4 and 1.2 hectares. However, farm sizes are becoming smaller and land use intensification can be observed as well as nutrient depletion (Jaetzold et al. 2005-2012; Muya *et al.* 2008) .That intensification can be seen in a increased use of inorganic fertilizers and pesticides, frequent application of fertilizers and shorter fallow periods (Muya *et al.* 2008). In the Upper Midlands, farm inputs are widespread, but in the lowlands less so, and if, only for perennials and cash crops (Jaetzold *et al.* 2005-2012). Simultaneously inadequate management practices can be linked to a decline in soil fertility and hence a decrease in productivity of the land. Apart from scientific and technological innovations in soil conservation management practices, farmers knowledge of ecosystem interaction and perceptions on soil fertility and productivity changes are essential to maintain soil fertility (Muya et al., 2008). Additionally, Muya et al. (2008) finds that low soil fertility in certain sites in Embu county, including Kibugu, can be attributed to high acidity and aluminium toxicity. Aluminium toxicity affects soil fertility as it affects root growth and therefore limits the plants uptake of nutrients and water.

2.2 Economy and Political Background

Kenyan agricultural sector contributes to 25% of the country’s GDP and employs approximately 65% of the people living in rural areas. According to Kabubo-Mariara (2015), it’s agricultural productivity is nevertheless constrained by institutional settings, access to markets and a growing population density. Many regions in Kenya are physically remote which negatively affects investments in soil conservation. Tenure security and market access are critical aspects to be tackled for successful adoption of soil conservation technologies (Kabubo-Mariara, 2015).

O Ndege (2009) claims that social and economic development in Kenya continues to be shaped by colonialism and post-colonialism. Technological agricultural development is concentrated to few urban areas such as Nairobi, Mombasa and Naivasha. Kenya’s agricultural production is not very diverse relying on few main commodities such as coffee, tea and flowers for export, which makes it vulnerable to external factors such as fluctuations in global prices. Despite structural adjustment programs, Kenya’s economy lacks sovereignty and as in colonial times, the market is today still used as an instrument for political control, through price regulations by the Kenyan state. Kenya’s economy continues to depend technologically, financially and commercially on many Western countries, Japan and also increasingly China. O Ndege (2009) argues that colonialism in Kenya has left its traces by contributing to the country’s inequality and poverty, as it supported rural-urban and class differences. The colonial state governed through authoritarianism provided a base on which the post-colonial social structures continue to exist (O Ndege, 2009).

2.3 Background on Maize

Maize (*Zea mays L.)* is worldwide the third most important crop (Martin, F.W., 1984), and is a major food crop in Kenya, making up 20% of agricultural production in the country. It is mainly cultivated by smallholder farmers and contributes to 25% of employment in the agricultural sector (Ouma O.J. et al, 2002). Maize is also one of the main crops in Embu and is grown by 58% of households (Mburu *et al.* 2016). Since 1955, 20 improved hybrid maize varieties have been sold on the Kenyan market. Many farmers in Embu district had adopted improved maize varieties by 1997s, but fertilizer use remained relatively low (Ouma O.J. et al., 2002). The maize yields in Kenya average 1.5 Mg/ha (FAOSTAT, 2017) but are often below 1 Mg/ha even though the potential is 6-8 Mg/ha (Kiboi *et al.* 2017).
A farm survey conducted in the different agro-ecological zones of Embu County shows a decline in both maize yields and in land acreage meaning that maize production per head is not enough to meet daily requirements. Maize and beans are still the most widespread annual food crop in all the climatic zones of Embu County (Jaetzold *et al.* 2005-2012; Mburu *et al.* 2016).

2.4 Background on Coffee

Coffee (*Coffea Arabica*) is an evergreen, perennial shrub originating from Ethiopia (Graf, A., 1978). Coffee is a dominant, high value cash crop in the field site exclusively grown for commercial purposes (Mburu *et al.* 2016). In Embu county coffee covers a stable area of 28% of the agricultural lands but are concentrated in the Upper Midland zones, also called the coffee-tea zones(Jaetzold *et al.* 2005-2012). According to Jaetzold *et al.* 2005-2012, coffee has lost its importance due to coffee-cooperatives neglect of payment to farmers but are still yielding around 850 kg/ha pro annum.

3. Research Objective

This study will depart from the ongoing discourse of soil infertility and land degradation in Eastern Africa. In the context of the debate between resource poor farmers being the perpetrators of soil infertility versus farmers actually being the caretakers of soil and having the knowledge and skills to maintain or even improve soil fertility through management practices, this study will investigate the production of maize and coffee in Kibugu, Embu County, Kenya. These two crops will be investigated as cases, with the aim of understanding the connection between soil fertility, farmers' management practices, and farmers' access to resources. Maize

and coffee are chosen because of their importance in Kibugu location as subsistence and cash crops respectively, and their different agricultural characteristics.

3.1 Research Question

What is the connection between soil fertility, management practices for maize and coffee, and farmer's access to resources?

a. What are farmers' perceptions of soil fertility, and how do these compare to our measurements of soil fertility?
b. Which soil fertility management practices do farmers choose for maize and coffee production and why?
c. What kind of access do farmers have to livelihood assets?

4. Methodology

Our research topic is inherently interdisciplinary: the sampling of soils and the analysis of them in terms of fertility will utilize the natural sciences, while comparing these samples to questions of farmer's access to and wealth of livelihood assets along with their perceptions of soil fertility will rely on the social sciences. For this reason, it will be necessary to employ a variety of mixed research methods to be able to gain knowledge from both disciplines. Because we as researchers come from different academic backgrounds, we plan for our mixed methods approach to also be able to compliment and integrate our different skill sets and academic knowledge. No specific methodology will necessarily outweigh the other in terms of importance; all methods will be equally significant for us to be able to produce adequate data for analysis and response to our research question.

4.1 Questionnaires

As a starting point, we will ask maize producing farmers to respond to a questionnaire regarding the availability of, their access to, and utilization of livelihood assets which may be necessary to achieve high soil quality and maximum food production. During the very first days of fieldwork, we plan to carry out 20 questionnaires using random sampling, which should give us quantitative data which we can use to identify farmers for semi-structured interviews.

4.2 Farm Mapping Exercise

After carrying out the questionnaires and identifying 10 households which we plan to investigate further, we will engage in a farm mapping exercise with those chosen households. In this exercise, we will ask farmers to map out their farm on paper, and in this way identify as many aspects of the farm as possible. If both male and female counterparts participate in maize and coffee cultivation, we will ask both subjects to participate in this exercise. We plan on this activity being a good way to initiate the interview process by giving space for our interviewees to start talking and getting familiar with us, as well as give an opportunity for farmers to “show” us the important aspects of their farms, which might otherwise be forgotten during a traditional interview.

4.3 Semi-structured interviews

The semi-structured interviews will give us an opportunity to expand on the questionnaire, and gain qualitative data which can help to explain the quantitative. Part of our research question addresses farmer and stakeholder perceptions of soil fertility in Kibugu, and we will therefore carry out semi-structured interviews with maize and coffee producing farmers to learn about how these farmers in actuality perceive their soils to be. Because coffee is most likely to be cultivated by men, and maize by women, we plan on asking both the man and woman of the household to participate in the interview. In this way we hope to gather the entire picture of perceptions of soil fertility and maize and coffee management practices, and to mitigate the potential for creating a gender bias. With these same farmers, we will ask questions regarding their management practises, and knowledge surrounding soil fertility management, so that we may gain an understanding of how farmer perceptions of soil fertility and management practices interact. We also plan to carry out semi-structured interviews with key informants such as the agricultural extension officer and a leader from the coffee cooperative, so as to gain knowledge of their perceptions of soil infertility and farmer management practices. Through the semi-structured interview process, we also hope to gain an understanding of the barriers farmers face in regards to soil fertility.

4.4 Soil Sampling

We will take soil samples from the interviewed farmers’ maize plots, so that we may analyze the soil for soil organic matter by C and N composit-isotope analysis, nitrate and the pH levels, soil bulk density and soil texture, which are all parameters which should be able to tell us about the soil quality. We plan on using composite sampling methods from 4 different spot on the maize plot, and to include the farmer in our process, as he or she may be able to help us identify important places to take soil samples from. This process will be a necessary step in our study to help us compare farmer perceptions of soil quality to how the soil quality is in reality. It also

might help us to understand which management practices that farmers carry out may be better or worse for soil fertility.

4.5 Participant Observation

Participant observations will be an important method to complement the questionnaire, interviews and soil sampling. If it is possible, we plan on observing farmer management practices (including soil fertility management practices) through participating in farm tasks. The extent to which we will be able to do this will depend on the time we have, but ideally we will spend time engaging in participant observations with each maize and coffee farmer which we interview.

4.6 PRA Transect Walk

We plan on conducting transect walks with the maize farmers, so that we have the opportunity for farmers to explain to us their methods and practices in a more visual manner. We plan on this being complementary to the interviews as the visual aid of walking through the plots, should give farmers the opportunity to remember certain aspects about their practices which they may have forgotten while sitting in place during the interview.

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Appendix

Appendix 1: Data Matrix

Overall Objective: To understand the connection between soil fertility, farmers' management practices for maize and coffee and farmers' access to resources				
Research questions/themes	**Sub-questions**	**Data required/outputs**	**Methods**	**Inputs**
What is the connection between soil fertility, management practices for maize and coffee, and farmer access to resources?	What are farmers' perceptions of soil fertility?	Farmers' perceptions of soil fertility The reasons behind soil infertility	10 semi-structured interviews with maize and coffee producing households	- Recorder - Notebook - Interview guide -Translator
	How do farmers' perceptions compare to our own measurements of soil fertility?	10 soil samples from maize and coffee plots in terms of total C&N, nitrate concentration, pH levels.	In field: -Soil Texture analysis field method (FAO 1990) - Nitrate Concentration Field Analysis	-Shovel -Auger -Metal ring, wood, hammer -Plastic bags -Permanent marker

		1 bulk density and texture test.	In Lab: - Total C and N Isotope-Elemental analysis - Soil Bulk Density (once) - Soil pH in water	-MilliQ water -Test tubes -nitrate strips -Reflectometer -GPS -Participation of farmer
	Which soil fertility management practices do farmers choose for maize and coffee production and why?	Farmers practices for maize and coffee production Farmer's knowledge of soil fertility management	-Participant observation -Semi-structured interviews with maize and coffee producing farmers -PRA Transect Walk	-Notebooks -Camera -Recorder -Guide for transect -Translator
	What kind of access do farmers have to agricultural resources?	Household data on resource availability, access, and utilization -Access to organic and inorganic fertilizers -Knowledge of soil fertility management practices -Access to land -Availability of and access to investment opportunities -Access to labour	-Semi-structured interviews with maize and coffee producing farmers -Questionnaire for maize and coffee producing households	-Notebooks -Recorder -Translator

Appendix 2: Tentative timeline

Date	Activity	Relevant persons	Notes
4/2-22/2	Synopsis writing First collaboration with Kenyan counterparts (online)	Kathi, Line and Tori All group members	
28/2	Meet with Kenyan counterparts for first time	All group members	
1/3	Travel to Kibugu and settle in	All group members	
2/3	Test and finalize questionnaire Decide on sample group for questionnaire	All group members Translator Others outside group for testing questionnaire	
3/3	Church service (morning) Carry out questionnaire	All group members Translator Questionnaire respondents	
4/3	Wangari Maathai Day (morning) Carry out questionnaire	All group members Translator Questionnaire	

		respondents	
5/3	Finish questionnaires Identify households to interview Begin farm mapping/interviews/PRA/Participant observations/Soil sampling	All group members Translator Interviewees	
6/3	Farm mapping/Interviews/PRA/Participant observations/Soil sampling	All group members Translator Interviewees	
7/3	Farm mapping/Interviews/PRA/Participant observations/Soil sampling	All group members Translator Interviewees	
8/3	Farm mapping/Interviews/PRA/Participant observations/Soil sampling	All group members Translator Interviewees	
9/3	Farm mapping/Interviews/PRA/Participant observations/Soil sampling Party (evening)	All group members Translator Interviewees	
10/3	Farm mapping/Interviews/PRA/Participant observations/Soil sampling	All group members Translator Interviewees	
11/3	Feedback meeting in Kibugu (morning)	All group members	

	Finish Farm mapping/Interviews/PRA/Participant observations/Soil sampling if not done Interview stakeholders	Translator Interviewees Agricultural extension officer Key informant from coffee cooperative	
12/3	Departure from Kibugu		

Appendix 3: Questionnaire

Note: tell the farmers about who we are and the aim of the study, any benefits, and risks.

Location: _____ Date: _____ Farmer code:_____
Photo number:_____Farmer name: _____
Additional information:_____

No	Question	Answer
1	Age of farmer	
2	Sex of the respondent *(observe)*	Male• Female•
3	Family size (total, and no. of children)	Total ____ Children ____
4	Formal education level	1. No education 2. Can read and write 3. 1-4 years 4. 4-7 years 5. 8-12 years 6. Higher education
5	Size of land (hectares)	_____ ha
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