IMPROVING SMALL-SCALE DAIRY FARMS' MILK PRODUCTION

through sufficient quality and quantity of self-produced roughage

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Thesis

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Preface

In front of you lies the preliminary research proposal 'Improving small-scale dairy farms' milk production through sufficient quality and quantity of self-produced roughage'. This preliminary research proposal has been written as part of my last year of the study animal husbandry at the Aeres Hogeschool in Dronten the Netherlands where I follow the minors Agricultural Development in Emerging Countries (ADEC) and Plant Breeding and Seed Production (APSP). This assignment has been conducted together with SNV in Kenya.

I am interested in the agricultural sector and since my last year I am interested in development work, my passion is the agricultural sector in which I have been working for the last four years. By choosing the minor ADEC I can combine these two interests. By doing my research at SNV I have been able to perform well. I have conducted my preliminary research proposal during my internship with SNV with fun and interest.

For all the accompaniment, support and all the knowledge they have given me I would like to thank Jos Creemers, Anton Jansen and all the members from the SNV team in Kenya that have helped me gather the information I needed. Also, I would like to thank the many farmers for their time and willing cooperation during the research.

Imre van der Kolk

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Contents

Abstract

Small scale farmers in Kenya face low milk yields from dairy cows. One of the causes is the low quality and quantity of roughage on small-scale farms. During , production, conservation and utilization still many factors cause low production and loss of quality of roughage which leads to lower intake of the cows. It is of importance that milk yields increase because dairy production from small-scale farms makes up 35% of the dairy production systems in Kenya and around 80% of the milk in Kenya is produced on small-scale farms (FAO G. S., 2018).

Overall in all Kenyan farming systems the dairy production is influenced by seasonal fluctuation of roughage production. Roughage is because of this of lower quantity and quality, especially during the dry season. Next to this it is known that poor feeding, poor management and lack of knowledge leads to wastage of roughage (Alonso, 2018; Ltd., 2012).

The main question that this research tried to answer is: 'How can small-scale dairy farmers improve the quality and quantity of production, conservation and utilization of the self-produced roughage to sustain higher milk production?'

During this research 16 small-scale farms have been visited and roughage has been judged on the basis of a score card and questionnaires have been held. The expectation was that low quality and quantity of roughage causes a low milk production.

The results have shown that farms with high quality roughage produced a higher milk yield than the average of all 16 farms. This could mean that high quality roughage has an influence on milk production. The quantity of roughage also seemed to have a small influence on milk production. Results showed a positive trend between quantity of roughage and milk production per cow per day. The results indicate a small correlation between these variables. The variables acres under fodder and milk production per cow per day showed a negative regression line with a correlation coefficient (R^2) close to zero indicating almost no correlation between the two variables.
The results from the two variables number of milking cows and milk production per cow per day showed a positive regression line with a correlation coefficient close to zero indicating almost no correlation.
On 100% of the farms the milk production has increased after the training. Quality and variety of fodders has also improved due to the training.

It is recommended, when further research is performed, other aspects on farm, such as dry matter intake, should be included in relation to milk production.

1. Introduction

In the introduction the general aspects of Kenya and dairy farming will be described. There will be a description about the population, the climate, dairy consumption and -production and dairy cattle being held. Also, the different dairy systems will be described. Furthermore, the difficulties of sufficient quality and availability of roughage on small-scale farms in Eastern Kenya will be described. This information is used to identify the problem and describe the knowledge gap. Based on this information the research question and related sub-questions are formulated.

1.1 Dairy sector in Kenya

The Kenyan dairy sector is very diverse and different types of animals account for the milk production. Milk production is more favourable in specific areas which ensures that these areas are more populated than others. This chapter will explain the climatic conditions, the amount of dairy cattle, the milk production and -consumption of the country over the years. Also, different types of dairy cattle and an overview of the dairy sector is explained.

Kenya lies in East-Africa and had 49.7 million inhabitants in 2017. The size of the country can be compared to that of France. The country is very diverse in its climate- and soil types. In the highlands (from 1000 to more than 3000meter height) the climate is relatively moderate and hence more suitable for forage and dairy production. The average temperature during the year is less than 15 to above 20°C with rainfall of 800 to 2000mm, spread out over one or two rain seasons. The soil in the highlands is more fertile and often from volcanic origin. In the lowlands it is dry and warm. The climate in the highlands is therefore favorable for dairy farming (Ettema, 2013; Senerwa, 2016).

Dairy production in Kenya accounts for 14% of agricultural Gross Domestic Product (GDP) and 3.5% of national GDP and plays a part in the livelihoods of the majority of small-scale farmers through income, food and employment. In Africa, Kenya is the second highest milk producer and the highest milk consumer. The average consumption per person in 2013 of 115 liters per year has increased to 145 litres per person per year in 2016. The major reason therefore is the annual population growth of 5%, urbanization, rising incomes and changing lifestyles. In 2016 Kenya produced a total of 4 million tonnes of milk. Most of this milk was produced by small-scale farmers (FAO, 2017; Senerwa, 2016). The average annual milk production is low compared to developed countries and is estimated to be 2920 kg per lactating cow per year (Senerwa, 2016).

In Kenya different species are responsible for milk production, this consists of cattle (18 million), dairy goats and camels (3 million). The milk produced in Kenya from cows is 76% and the rest comes from camels and dairy goats. The production of camel milk in Kenya is the second highest in the world. Per year there is an estimated production of 0.94 million litres camel milk in Kenya (FAO G. S., 2018).
In Kenya over 3 million dairy cattle are being held, this is mainly composed of pure black and white Friesians, Ayrshires, Guernsey, Jersey and various crossbreeds. The improved dairy cattle, which are improved breeds and their crossbreeds, provide 60% of the national milk output and the indigenous zebu cattle for about 25% of the cattle milk output (Muloi, 2018; Omore, 1999).
Next to the favorable agro-ecology, people in the highlands also have a tradition for consuming milk. In these areas 73% of the small farms are engaged in dairy production practicing zero-grazing. In the less populated areas animals are grazed and stall fed (Odero-

Waitituh, 2017; Van de Steeg, 2010). Further on the different farming systems will be explained further.

1.2 Dairy systems in Kenya

In Kenya there are three main dairy farming systems. These systems will be described in this chapter. It is important to understand these systems for a better understanding of their purpose and contribution to the Kenyan dairy sector.

Dairy systems in Kenya are divided by livestock stakeholders into intensive (large- and small-scale), semi-intensive and extensive. In table 1 the division between the different systems and their proportions is shown. Intensive and semi-intensive comprise for about 85% of all the dairy farms.

TABLE 1 DIVISION OF DAIRY PRODUCTION SYSTEMS IN KENYA (FAO G. S., 2018)

Dairy production systems	Intensive		Semi-intensive	Extensive	
	Large scale	Small scale	(semi-grazing)	Controlled dairy production systems	Uncontrolled dairy production systems
Proportion of farms (%)	5%	35%	45%	10%	5%
Number of cows	>20	1-20	1-20	>50	10-50
Milk production (litres/cow/day)	15-30		<6	4-11	

The intensive dairy systems can be divided into small- and large-scale systems. Within these systems dairy cattle are being held under free-grazing, tethering or zero-grazing systems. Within the free-grazing system dairy cattle is allowed to freely graze without pastures or fencing. When farmers use tethering cows are fixed within a limited area to graze. Within zero-grazing dairy cattle is being housed in a barn, where feed can be controlled. The intensive dairy systems are mainly driven by a growing demand for milk and dairy products. In intensive systems the feed is mainly from high quality, purchased or grown on own farm to ensure consistent production of milk (FAO G. S., 2018).

The number of animals held ranges in small scale systems from 1-20 cows and in large scale systems from more than 20 cows. The small-scale systems in rural areas have an average of 1-3 dairy cows and in urban and peri-urban areas 7-8 dairy cows. There are numerousness large scale systems that keep more than 20 cows. The dairy production from small-scale system makes up 35% of the intensive system and can mainly be found in the county of Mount Kenya and central Rift Valley. In these small-scale systems the milk production per cow ranges between 15 and 30 litres per cow per day. In these regions the farms are a combination of cows and crop production. Different breeds are used in intensive systems, which are mostly exotic dairy breeds such as Friesian, Ayrshire, Fleckvieh, Guernsey and Jersey (FAO G. S., 2018).

The lowest milk production is realized in smallholder free-grazing systems compared to the other systems. Within the free grazing system, the milk yield is 1,510 litres per cow per year and is 28,8% lower than zero – grazing systems. Within the zero – grazing the highest cost of production is achieved of 15 Ksh per litre (Karanja, 2003). The supplements that are fed within free-grazing systems are purchased feeds and account for the largest proportion of the

total production cost of 21%. The free grazing system has the lowest production cost of 10,50 Ksh per litre. The production per year in the zero-grazing systems is about 2,122 litres per cow, with an average of 2 cows held (Karanja, 2003).

Even though dairy production from small-scale farmers contributes for 80% of the total milk production and 70% of the marketed milk, the productivity remains low (Karanja, 2003). A small proportion is used for household and fed to calves, primarily milk is produced for market. In figure 1 it is shown that from the total production of the small-scale dairy production, around 45% is consumed on-farm, divided into consumption by household and fed to calves, and 55% is marketed because of surplus (Kashangaki, 2018). More than 80% of the marketed milk on small-scale farmers is sold to informal markets (Karanja, 2003). Despite the fact that the informal markets are important to many livelihoods, developing countries have failed attempts in adjusting to international policies on food safety because governments are developing and implementing regulations that criminalize and try to repress the informal sector (Alonso, 2018).

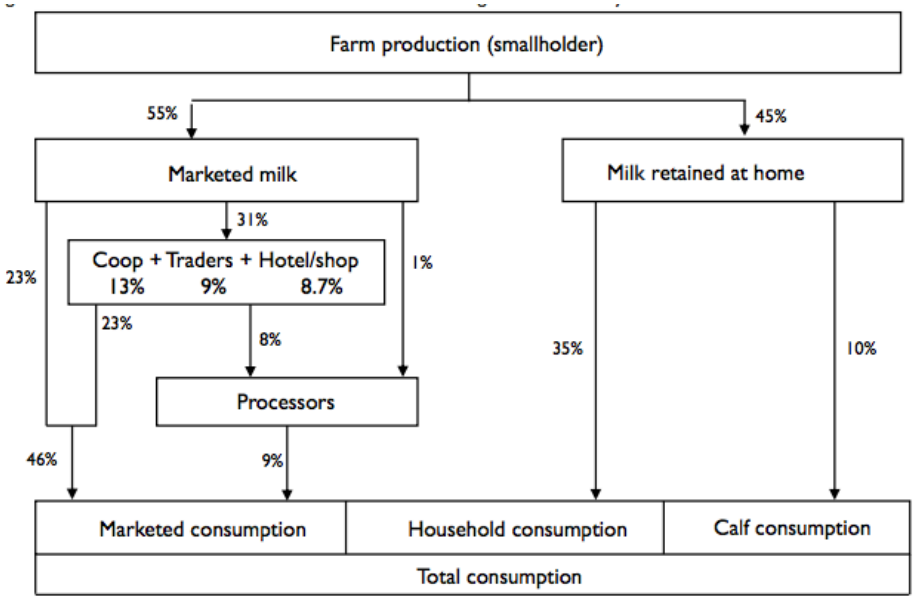

Figure 1 – Flow chart of milk marketing channels of small-scale farmers dairy cattle production in Kenya (Kashangaki, 2018).

The semi-intensive systems are the largest of the five dairy systems as mentioned in table 1. Approximately 45% of the dairy systems are semi-intensive dairy farms located in Mount Kenya, central and North Rift Valley and regions in the coast. Dairy cattle are often held with other animals such as chicken, goats, sheep, donkeys and in some cases pigs. In combination with the animals also crops are grown.
Semi-intensive grazing management involves tethering cattle, free grazing and keeping cattle in paddocks or enclosed in the evening where supplementation of feed is provided (FAO G. S., 2018). The size of the herd ranges from 1-20 cows consisting of crosses and exotic breeds such as Friesian, Bos indicus (Zebu, Sahiwal and Boran), Ayrshire, Guernsey and Jersey. The milk production is on average less than 6 litres per cow per day. Mainly the milk is consumed at home, about 40% of the farms do not market the milk. The excessive milk is hereby sold raw within the informal market, from where 40% of the farms are selling to neighbors. The use of natural grass, improved pastures and post-harvest grazing is most used within semi-intensive grazing systems. The constraints in the semi-intensive systems are the seasonal

influences on pasture and productivity. There is large variation during the different seasons which confines production and productivity (FAO G. S., 2018). Most cows in smallholder farms have high potential because of good genetics, but they are not able to reach a high milk production due to poor quantity and quality of roughages, poor infrastructure, low technical skills and low access to veterinary services (Odero-Waitituh, 2017).

The production of the extensive system is based on animals held in pastures where grazing is controlled (large farms) and uncontrolled in marginal and communal systems with few animals. In controlled systems animals are being held in paddocks or strip grazing on natural and improved pastures. Unlimited supplementation is being fed. Within uncontrolled grazing systems free grazing is applied and limited supplementation. Mainly exotic breeds and crosses of indigenous breeds are being held. This system holds a few number of farms keeping a substantial amount of the dairy cows. It is agreed that 3 percent of the farms keep 35% of the dairy population. Extensive farms mainly occur in the North and South Rift Valley, eastern and coast regions. The size of the herds ranges from 10 to more than 50 animals, where 10 cows are held in uncontrolled grazing systems and more than 50 cows in controlled grazing systems. Milk production ranges between 4 and 11 litres per cow per day. The quality of milk is high and is often sold in niche and markets of high quality. The constraints the extensive systems faces are the increasing number of people that are settling on what used to be communal fields causing declining land for grazing (FAO G. S., 2018).

The intensive, semi-intensive and extensive systems are distributed among Kenya and therefore also the amount of dairy cattle (figure 2). As it can be seen in figure 2 and mentioned before, the semi-intensive systems dominate the dairy production systems followed by the small-scale intensive systems.

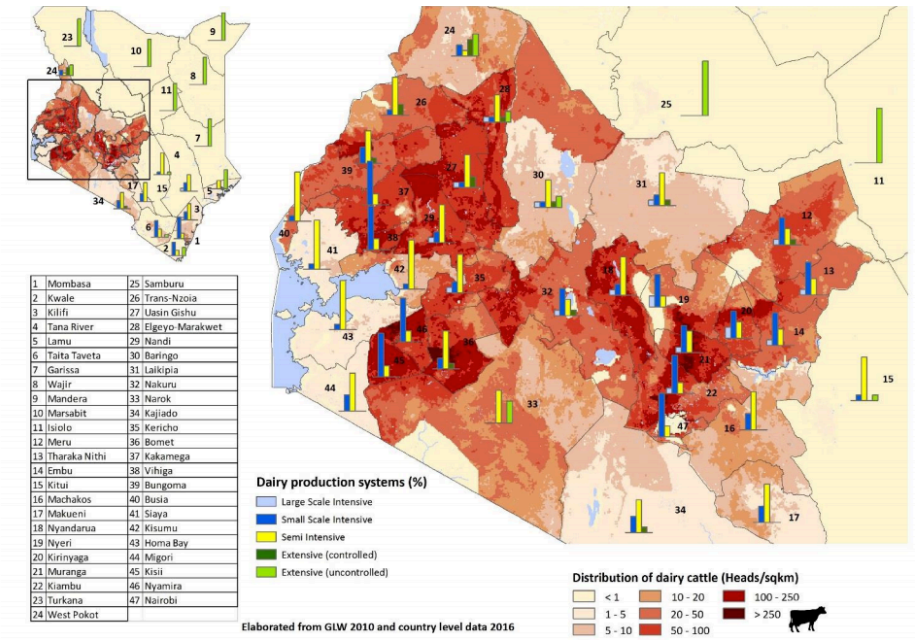

Figure 2 - Distribution of dairy cattle in Kenya and the different systems (FAO G. S., 2018)

As it is shown in figure 2 dairy cattle are mostly distributed in West-Kenya and Northwest of Kenya. Also, the small-scale and semi-intensive systems are most common in these regions. In the West of Kenya the dairy farmers are mostly located in Uasin Gishu(27), Bomet(36), Kisii(45), Nyamira(46). In the Northwest they are highly populated in Nyandarua(18),

Muranga(21) and Kirinyaga(20). In the Eastern province the small-scale and semi-intensive dairy farmers are high populated in Meru(12) and Tharaka Nithi(13) (FAO G. S., 2018).

The milk production per region (figure 3) differs because of climatic conditions and the distribution of dairy production systems as can be seen in figure 2. These two figures show a similarity in dairy production systems and milk production. The number of cows from figure 2 can be linked to the milk production in figure 3.

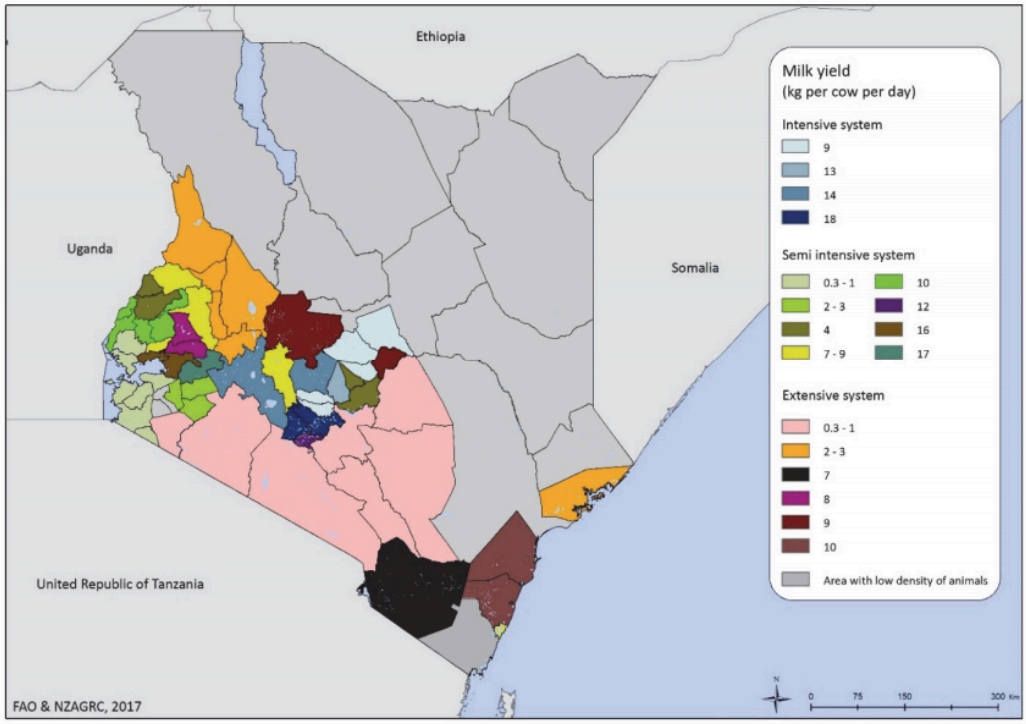

Figure 3 – Milk yield per cow per day per region in Kenya (FAO, 2017).

1.3 Roughage on small-scale dairy farms in Kenya

There is done research on roughage production, conservation and feeding on small-scale farmers in this chapter. Because small-scale dairy farmers contribute for a large part of the total milk production it makes them important to the dairy sector. The focus is on the quantity and quality of roughages on-farm.

Overall in all Kenyan farming systems the dairy production is influenced by seasonal fluctuation of roughage production. Roughage is because of this of lower quantity and quality, especially during the dry season (Alonso, 2018; Ltd., 2012). Because of this the availability of feeds is low during the dry season which makes feed expensive to buy for farmers. The small-scale farmers face many restrictions such as poor feed quality and quantity, inadequate storing facilities for the preservation of feed and a lack of water for the animals (Lukuyu B. F., 2011). Because the small-scale farmers are the largest and contribute for over 80% of the total milk production in Kenya, they are of importance to have a sufficient milk production (Omore, 1999).

Even though there is a growing demand and many opportunities for milk and dairy products in Kenya. The small-scale farmers still face many restrictions with feeds to sustain a high and profitable milk production, such as access to land and water. Another reason for not feeding enough and high-quality feed to livestock is because of low knowledge on composition and

use of locally available feed resources. These problems are created by lack of access to and high cost of feed (Lukuyu, 2011; Ettema, 2013). Poor feeding, poor management and lack of knowledge leads to wastage of roughage and high costs. Many farmers feed crop residues, such as maize stover, which is the main leftover during the dry season. Large amounts of crop residues, such as cereal straw and stover, legume crops straw and hulls, sugar cane tops, cassava leaves and sweet potato vines are left in the field after harvest and fed to livestock. The main reason for feeding these crop residues are the availability and the low cost during the dry season. Studies showed that maize stover is the most fed crop residue to dairy cattle on small-scale farms with a zero-grazing system. It is of low quality for the dairy cows because it is not harvested in the right stage, the post-hard grain stage, and therefore has a low digestibility and nutrient content. A small percentage of the small-scale farmers fed the maize stover without chopping it. The low quality of these crop residues cannot meet the requirements of dairy cows to have a sufficient milk production (Lukuyu, 2011; Syomiti, 2011).

Handling and storage of maize seemed to be the largest problem. Next to the energy from maize dairy cows need protein for sufficient milk production, also defined as crude protein (CP). Next to the maize stover the farmers fed Napier grass. Even when the Napier grass was cut in the right stage it could not meet up to the protein requirement of the dairy cows. Napier grass consists of 10% crude protein when harvested in the right stage, where a dairy cow requires at least 16% of crude protein (Syomiti, 2011).
Molasses is used by many farmers to improve palatability, but this does not increase protein content. Soaking dry residues in water has been proved to improve intake because digestibility increases (Syomiti, 2011).

From a study performed by ILRI Kenya during the dry season, it was found out that dairy farmers mainly underfed dairy cattle by ‘feed rationing’. Feed rationing was done by lowering the amount of feed for the dairy cows whereby not enough feed was provided for the cow. Because of this the main cause of low milk production is under-feeding. Small-scale farmers found out the need to widen the feed base by implementing high quality forage varieties of grasses and legumes. The acreage under planted fodder was also increased by these farmers to obtain sufficient amount of feeds (Lukuyu, 2011).

1.3.1 Production of feed

The low quality during the dry season, of both energy and protein fodder, comprises of high levels of fibre, it can therefore not meet the required intake of the dairy cattle to obtain a sufficient milk production (Nyaata O. Z., 2000). Insufficient availability and quality are major restraints that smallholders with zero-grazing systems cope with. Zero-grazing farms are the farms that show intensification of smallholder farms. Cattle are not grazed anymore; they have changed from free-grazing to zero-grazing systems. More forage is grown on-farm and more forage is purchased than in free-grazing systems. Because of this intensification, there will likely be a higher demand for fodder on small-scale farms that practice zero-grazing in the future (Udo, 2016). The motivation of the farmers to grow own roughage increases because of the seasonal experiences, increased demand and improved incomes (Nangole, 2013).

The lack of knowledge on production, management, feeding, storing and conservation of roughage is the second most important cause of the production of low quality and quantity of roughage on small-scale farmers (Lukuyu, 2011). Because of lack of knowledge, roughage is wasted during the wet season which leads to high costs for conserving feeds such as silage

and hay. Land is decreasing for fodder production because more land is being used for food crops and because of increasing human population (Lukuyu, 2011). Less available land for fodder production causes an increase in production of crop residues. Because small-scale farmers lack knowledge on utilization of these feeds they are poorly used as animal feed (Syomiti, 2011).

1.3.2 Conservation of feed

The conservation of feed is applied more often by the farmers to protect themselves against the low availability and quality of fodder during the dry season. It is important to have enough access to sufficient quality and quantity feed because it is crucial for the production of milk from dairy cattle (Nangole, 2013).

A study conducted by the KARI on 136 small-scale dairy farms in Eastern Kenya was performed to assess feeding practices, feed availability and strategies. It showed that the small – scale farmers are dependent on own-grown roughage, primarily Napier grass and crop leftovers. Storing methods were improper to maintain the quality of the feed. More than 90% of the farmers noticed seasonal fluctuations of feed availability with the highest peak in September and October. The study revealed that the most used method to lower the feed scarcity during the dry season was to conserve feed followed by purchasing roughage from other farmers. According to this study the feed scarcity could best be tackled by maximizing the feed conservation of surplus feed during the rainy season. The methods that are most simple and cost effective are the use of a box baling and tube silage (Njarui, 2011). Simple methods like these will help the farmers to make better use of crop residues during the dry season and therefore decrease feed shortages and create higher quality feeds during the dry season and enhance the milk production.

1.3.3 Maize conservation

From a study performed by SNV it can be concluded that the problems with storage of maize lie with the following points:

- **Poor covering:** After the harvesting of maize the farmers are instructed to cover with a certain amount of soil or soil bags on top, but they tend to not implement this correctly which results in a poor quality of the silage. Because the covering involves insufficient amount of soil on top it leaves the plastic exposed to birds, animals, the sun and can thence get holes which allow air into the silo. The air allows microbes to start working which results in molding of the silage.
- **Poor covering plastics:** The farmers are used to using 2-meter-wide strips of plastic from hardware. These are not appropriate for silage making because they are not airtight and in some places they allow air to enter the silo which results in losses of the silage.
- **Poor feeding from the pit:** The management of pits is poor. The silage is not taking out of the pit correctly, loose silage is left in front of the pit hence causing heating up and rotting. Because at the open end of the silo the silage is not taking out in a straight line and with plastic on it, it destroys the quality and silage is spoiled.
- **Locating silo from the farm:** Some farmers have their pits far away from the farm and they only take out silage once a week and bring it to the farm. In the second week molds have already formed at the open end of the pit because the silage pit is not closed correctly again.
- **Poor feeding speeds:** The feeding speed is below 30cm per day which is too slow and causes molding and rotting of the silage (Jansen, 2018).

1.3.4 Feeding

Roughage for dairy cattle can be classified into two sources: energy and protein feeds. Home-grown protein roughage on small-scale farms are sweet potato vines, bean straws, lucern, omena, sunflower, white clover legumes such as desmodium or fodder trees such as calliandra, leucaena, mulberry and sesbania. The use of home-grown fodder trees, such as legumes, reduces the cost of bought protein in the ration. Protein is needed for bacterial growth in the rumen and for milk production. The on farm produced energy roughage comes from most grasses such as Napier, Guatemala, giant Setaria, Rhodes and Kikuyu grass. The energy is required for body maintenance, milk production, growth, weight gain and reproduction (Kashangaki, 2018). Small-scale farmers buy feed off farm such as Napier grass, hay, silage and natural grass. This ensures the farmers of feed availability during the dry season. For the farmers these feeds are expensive during the dry season (Lukuyu, 2011).

Maize stover is important to the small-scale farmers as a feed resource. It has been mentioned in a report by *McLeod et al. (2001)* that maize stover, is the second most important livestock feed on small-scale farmers in Kenya. The most important livestock feed for small-scale farmers is Napier grass. Out of all the crop residues it is suggested that the use of especially maize stover will remain high and likely increase in the future. Farmers lack knowledge on the low nutritive value of maize stover and therefore there is a need to expand the knowledge of small-scale farmers on how to feed maize (Syomiti, 2011).

Next to the roughage, concentrates have to be fed because of the energy content. The concentrates famers and milling by-products use are brands, wheat pollard and dairy meal. Brand and wheat pollard are grain concentrates and therefore energy sources. Dairy concentrate is commonly called dairy meal.
A lot of farmers complain about the high prices of dairy meal (KSh 700-850 per 70kg bag) and rather choose for the cheaper cereal by-products of KSh 550-600 per 70kg bag (Omore, 1999). The largest proportion of the feed expenses are purchased fodder, which is 67% (Omiti, 2006). The feed expenses take in consideration the external services, hired labour, fodder production, concentrates purchase, fodder purchase and other costs. Most Kenyan dairy farmers, 82-88%, use dairy meal as energy concentrate and 49-54% use maize bran (Omiti, 2006). The amount of concentrate fed to cows fluctuates around two kilograms per day through the lactation and is mostly fed during milking (Omore, 1999).

1.3.5 Practical training for small-scale farmers

Because small-scale farmers have lack of knowledge on roughage there has been more attention to practical dairy training for small-scale farmers since 2013. These trainings have been provided by SNV. SNV is the Netherlands Development Organization and operates in different African countries through agricultural projects. One of its agricultural projects in Kenya is the Kenya Market-led Development Programme (KMDP). This provides trainings performed in collaboration with ProDairy and Global Agricultural Development (GAD). It is devoted to the constraints small-scale farmers face, such as the feeding strategies and the resources that are used. Regular visits and trainings from experts to assist farmers are aimed to improve farm management. The objective of the training is to help small-scale farmers improve their milk production and livelihoods, hence, to create a higher income and therefore a higher living standard. KMDP is funded by the Embassy of the Kingdom of the Netherlands, located in Nairobi. The KMDP consists of two phases, KMDP-I and KMDP-II. KMDP finished in December 2016 and phase 2 runs from October 2016 until June 2019. The first pillar has the theme: Creating a vibrant Kenyan Dairy Sector (2019). KMDP-II is

focused on the theme 'from Aid to Trade' and has five intervention areas. One of these areas is on feed and fodder, from which data can be useful to this study (2019).

On each involved farm there has been done a baseline study by SNV to map the situation. The farmers are being followed up after the training. Consultancy on these farms is done by experts from SNV. The first phase has increased an annual milk production of 4.4% on the farms and because feeding practices are improved quality of feed has improved (2019).

The quality and quantity of roughage on small-scale farms has been improved due to the project. It has been measured by the amount of milk produced by the cows and also by judging the quality and quantity that is fed. But despite the fact that there has already been much improvement on roughage production, storage and feeding there are still difficulties with obtaining a high-quality feed for the dairy cows to improve milk production. Besides the quality small-scale farms also still face an inadequate amount of feeding (2019).

1.3.6 Main question and scope

The key areas that farmers should focus on when improving feed quality and availability are production, utilization and conservation of roughage (Lukuyu B. F., 2011). Because milk production on small-scale farmers in Kenya is caused by insufficient quality and quantity of feeds there is need to improve this. By doing preliminary research many constraints have been found such as lack of knowledge and under-feeding dairy cattle which both result in low milk production. To improve this on small-scale farms first the factors that cause the low quality and quantity during production, utilization and conservation need to be tracked down. Therefore, the main question followed by several sub questions have been set up like shown below.

The main question is: How can small-scale dairy farmers improve the quality and quantity of production, conservation and utilization of the self-produced roughage to sustain higher milk production?

The following sub questions will be used in this research to be able to answer the main question.

- **Sub question 1:** What are the factors that cause the low quality and quantity during production?
- **Sub question 2**: What are the factors that cause the low quality and quantity during conservation?
- **Sub question 3:** What are the factors that cause the low quality and quantity during utilization?
- **Sub question 4:** What are interventions to improve the production, conservation and utilization of roughage to obtain a higher milk production?
- **Sub question 5:** What changes are there in milk yield after the proposed interventions in production, conservation, utilization.

The low quantity and quality of feeds on small-scale farms is mainly due to seasonal fluctuations, inadequate storing facilities, inadequate knowledge and high cost of feed. This research will focus on roughage production, utilization and feeding on small-scale farms in Kenya to promote the milk productivity. The bottlenecks will be evaluated concerning the

lack of quantity and quality roughage causing a low milk production. The aim is to increase sustainable production and quality of milk through improved roughage.

1.3.7 Delimitation

About 80% of the milk in Kenya is produced on small-scale farms and are largely located in Eastern Kenya, as shown before in figure 2. This region is dependent on dairy farming because it is crucial for the rural development concerning poverty reduction and food- and nutrition security. In the region of Eastern Kenya the demand for milk and milk products is increasing due to the growing population and improved incomes in the rural-urban areas. Because of this milk demand increases and thus demand for fodder. In this part of Kenya especially small-scale farmers are unable to provide sufficient quantity and quality of feed to dairy cows. Small-scale farmers in Eastern Kenya often keep more animals than can be fed from own land. The fodder production is limited because of low rainfall, long and dry season and frequent droughts. Both quality and quantity cannot meet the animal production potential and therefore there is need to improve this to obtain a higher milk production (Njarui, 2011). Because of this the focus of this study will be on small-scale farms with zero-grazing in the Eastern province of Kenya (Bingi, 2015).

This study will not focus on the cost of roughage production and the cost price of milk because the focus is on achieving a higher milk production by having a higher quality and quantity of roughage. It will therefore not calculate any costs.

In Eastern Kenya, the research population consists of 16 farms located in Meru. This region is favorable for dairy farming because of its climatic conditions where crops can be grown for own roughage and can hereby give a good overview of how the potential farmers can improve in these areas. These farms were also chosen because of practical reasons. Farmers were willing to cooperate and share farm details and experiences. These are also the farms that are being followed up by experts from SNV, because of this it was convenient to get in contact with them and some of the data is already available within the database of SNV.

The observed farms are a reflection of the small-scale dairy farmers found in Meru. It is a good reflection because all farms are zero-grazing systems which represents an intensification of smallholder farms. This step to intensification means there is more demand for own-grown roughage. Thus, increase in milk production will result from better feeding practices on these farms, as can be found in paragraph 3.2.1. Therefore, it gives a good reflection of how small-scale farmers perform

1.4 Reading guide

In the second chapter material and method will be explained. The study site will first be explained and information on the animals and farms will be given. There will be given an explanation of how the research has been prepared and what was needed to do so. Different methods will be explained to gather information needed to answer the research question. For each sub question the methods of gathering and analyzing data will be explained. Also, the analyzation of data has been explained. In chapter three the planning can be found.

2. Material and method

Different details of the study site will be described, the information of the farms and the method on collecting and analyzing data for each question is worked out in this chapter.

2.1 study site

The farms that were being evaluated during this study are located in Meru (figure 4), which lies in Eastern Kenya. It has a total coverage of 6,936 square kilometers. The population consists of 1,356,301 million people. The soils are derived from volcanic rocks and hence fertile. The average rainfall per year is 1300mm in the highlands and 380mm in the lowlands. The temperature ranges from 20 to 33^{0}C. Soils and climatic conditions in the highlands are favorable for dairy farming (Munya, 2014).

Eastern Kenya can be divided into two ecological zones; Upper-Midland (UM) and Lower-Midland (LM). Farmers respectively keep an average of 1.2 dairy cows in UM zones and 2.6 dairy cattle per household in LM zones. Most of the land is used for crop production with almost no land left for grazing. An average of 2.12 hectares in UM zones per 1.2 dairy cow and 4.48 hectares in LM zones per 2.6 dairy cow was recorded (Njarui, 2011).

Figure 4 – Location of Meru in Kenya

2.2 Small-scale farms

Data was collected in Meru County from February to May 2019 on small-scale dairy farms, who are a part of the intensive dairy systems. The farms had a combination of cows and crop production, such as defined in paragraph 1.2.

Sixteen small-scale dairy farms in Meru County were randomly selected from the SNV database with 182 farms. Meru has been outlined in figure 5, where each farm was geo-referenced using GPS (figure 5).

The 16 small-scale dairy farms mostly kept Holstein Friesian or crossbreeds with Guernseys. The averages of these farms are shown in table 2. The land under dairy ranged from 1 to 4 acres. The land under fodder ranges from 0.75 to 4 acres. The total land size ranged from 2 to 14 acres. The number of lactating cows ranged from 1 to 6 cows. As can be found in annex 2, the total herd size ranged from 4 to 15 cows and the total milk production ranged from 0 to 56 litres.

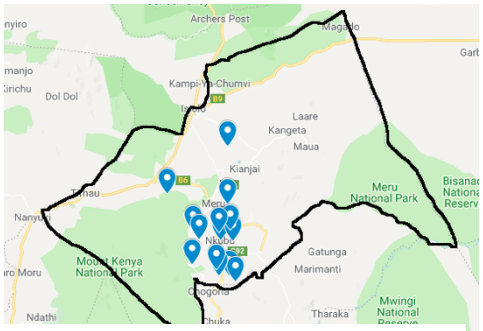

Figure 5 – Map of the study sites in Meru County, Kenya

TABLE 2 ***TOTAL AVERAGE OF ALL 16 FARMS***

Average land under dairy	Average land size under fodder	Average total land	Average lactating herd size	Average herd size	Average milk production	Most common home-grown fodder
1.9 acres	1.67 acres	4.34 acres	2.7 cows	6.7 cows	28.18 litres	Maize, Napier grass

2.3 Method

The goal of the methodology is to give a prescription of how the research will be conducted and how the results have been collected. The methodology substantiates the methods that are used to answer the main sub questions and thereby the main question. It will give the research validity and reliability.

The method that was used to answer the research question was mostly practical, in the form of field research. Field research was done by visiting farms and gathering data of these farms. Observations, interviews, data analysis and literature reviews were performed. Desk research was applied to analyze different peer-reviewed reports and reports from SNV.

Farm observations

To get a good overview of how the farms are performing the observed farms will be visited three times. The data on the first farm visit has been collected through a baseline study performed by SNV conducted in January 2019, which can be found in annex 1. The baseline study includes aspects of the farm, such as acres of land, milk production in litres, herd size and fodder production. The baseline study provides information on the status of the farms. The data from the remaining visits is to be documented in the same format as the baseline study. This data, especially the milk yield can be looked at and any changes can be seen. With the remaining farm visits there will be looked at the improvement of quantity of feed, but also the quality. There will be looked at if any interventions have been implemented, if this has improved the quality and quantity of feed and how it affects the milk yield.

The quality and quantity are tracked by judging the roughage on the farms. In table 3 the criteria for judging the roughage is worked out. The same methods were used in each farm. Next to that by observing the farms on practices and feeds the quality and quantity can be assessed, by judging the roughage as how it is explained in table 3. To find out the factors causing the low quality and quantity of the roughage the management of the farmer will be looked at and feeding & storing strategies will be evaluated. It is done by judging the quality and quantity of the roughage in storage and in the feed troughs. The roughage in storage is judged on moisture content, smell, color, size of chopping length and contamination of any kind (weeds, plastic, dirt). The roughage in the feed troughs is judged on moisture content, molds, length, amount, smell.
The different observing methods that will be used are on the basis of the following criteria for judging the quality roughage in silage and in feed troughs: *bad or moderate or good*. The observation criteria for judging the quantity of roughage in the feed troughs will be: *inadequate or moderate or adequate.*
The production of roughage will be evaluated and recorded through looking into the different types of fodder grown on own-land. What are the possibilities concerning soil type, land size and water availability? This information will be retained from the questionnaire.
Data around sub question 1,2 and 3 is collected through the questionnaire (ann. 2).

TABLE 3 *CRITERIA FOR JUDGING ROUGHAGE ON – FARM*

	Bad **quality**	Moderate **quality**	Good **quality**	Inadequate **quantity**	Moderate **quantity**	Adequate **quantity**
Characteristics	• Molds/deviating color • Bad smell[1] • Too much moisture[2] • Chopped sizes of 10-15cm • Many whole kernels[3]	• Much moisture[2] • Chopped sizes of 5 – 10cm • Few whole kernels[3]	• Moisture content is low[2] • Chopped sizes of 2,5 – 5 cm • Good smell[1] • Almost no or no whole kernels[3]	• Almost empty or empty feed trough	• Many leftovers • No sufficient amount of 'edible' feeds	• Almost no to no leftovers • Sufficient amount of 'edible' feeds • Through looks 'filled'

Note: 1 indicates: Smell:

- Bad smell: Strong acidic smell
- Good smell: Not a strong smell, smells 'fresh'

2 indicates: Moisture content:

- Too much moisture: There is much water coming out of the feed when wringed between fingers.
- Much moisture: There are drips of water coming out of the feed when wringed between fingers.
- Moisture content is low: When feed is wringed between fingers no moisture comes out

3 indicates: Kernels

- Many whole kernels: There are no kernels are almost no kernels crushed
- Few whole kernels: There can be seen some whole kernels, more kernels are crushed than whole kernels
- Almost no or no whole kernels: A few whole kernels here and there, but 90% should be crushed

Data records

Data around sub question 5 is collected by looking into the farm records on milk yield in kilograms per cow per day and comparing them with results from the baseline study. Next to this the effect of the implementation of the changes of feed quality and quantity is also looked at. Such as enough and good quality roughage for the cows in the feed troughs and in storage. What is the effect from this in relation to the milk production?
The milk yield at the different farm visits will be reported and put into a graph so that changes can be perceived.

Interviews

Data around sub question 4 is collected through looking into the possibilities on the farm, such as arable land size, soil type, existing silage pits for example with cement walls or dug out pits, housing for storage of roughage, housing for feeding (feed troughs), use of chaff cutters and use and possibility of planting different feeds (e.g. legumes, maize and grass).

This will be recorded from performing the questionnaire. These possible interventions to address feed constraints will be put together in a table with the current situation of roughage on the farms to see the possibilities. The constraints will be put into a different table together with the reason or the causing factor to see what the possibilities are and where the main difficulties lie. The focus will be on what can be improved on these constraints to improve the quality and quantity of feed so that it's sufficient for the cow to produce a higher milk production and so that it is sustainable too.

Next to the baseline study and the judgment of the feed quality and quantity on each farm there will be done a questionnaire (ann. 2) to give an overview of the current situation. The questionnaire includes: herd characteristics, land details, roughage production, roughage conservation and feeding. The questionnaires will be completed through interviews with the farmers themselves. The answers from the farmers in the interviews will be recorded and will be helpful next to the baseline study to work out information further into detail.
This questionnaire will give a good overview of the roughage quality, quantity and it provides information on the milk production in kgs/cow/day at each visit. Hereby changes in roughage quality and quantity and milk production can be recorded.

Literature review

Existing literature has been reviewed through Google Scholar and ScienceDirect. Mainly peer-reviewed articles on small-scale dairy farms in Kenya that are no older than 10 years were used.
The keywords mostly used were; roughage, feed, dairy farming, Kenya, small-scale farms, conservation, production, zero-grazing, restraints, trends. Several progress and status reports from SNV have been used about roughage and milk production improvement on small-scale dairy farms in Kenya.

Data analysis

Analysis of data from the baseline study, the questionnaire and the judgements on farm is done through putting data into tables and graphs. For example, milk yield is first put in a table in Excel and later on will be converted into a graph. The quality of the roughage will be recorded in Excel and later put into a graph. Later on, these two graphs can be put into one graph to see the relationship between them. This will also be done with milk yield and roughage quantity. Because of this the research questions can be answered.

3. Research planning

Date	Tasks	Performed by
January	Perform the baseline study on the 16 farms	SNV team members
11 – 15 February	Attend the training in Meru and visit farms	Imre, Jackson, Fred
18 – 22 March	Visit several farms in Meru	Imre, Jackson, Fred
24 March	Process and analyze data	Imre
30 April 2019	Finish the literature review	Imre
19 – 22 May	Last farm visits in Meru	Imre & Julius
23 May	Process and analyze data in research	Imre
14 June	Finish thesis	Imre

4. Results

In this chapter data collected with the farm questionnaire and -research is presented and analyzed. Several methods and tools such as charts are used in the analysis.
These results give an indication of the factors causing low quality and quantity of roughage and possible relations between the constraints.

In May the data has been collected as explained in chapter 2. All the farmers were willing to cooperate and answer the questionnaire.

In table 4 and 5 the results of judging the quality and quantity of roughage on each farm is presented. The quality is moderate on most farms and the quality is adequate on eight farmers and moderate on eight farms.

The average milk production for the farms that have a moderate quality roughage is 17.27 litres per cow per day and ranges from 9 to 25.3 litres per cow per day (see Table 5). For the farms that have high quality roughage the average milk production is 17.5 litres per cow per day and ranges from 11.3 to 24.2 litres per cow per day (see Table 5). The average milk production on the farms with a moderate quantity of roughage is 16.9 litres per cow per day and ranges from 6.7 to 25.3 litres. On the farms with and adequate quantity of roughage the average milk production is 16.3 litres per cow per day and ranges from 11.3 to 24.2 litres

TABLE 4

QUALITY AND QUANTITY RESULTS

Quality	Number of farms	Average milk production in litres per cow per day	Quantity	Number of farms	Average milk production in litres per cow per day
Low	1	6.7	Inadequate	0	0
Moderate	11	17.27	moderate	8	16.9
High	4	17.5	adequate	8	16.3

4.1 Causes low quality and quantity during production

The results of judging the fodder production on the fields are shown in this chapter. Factors that will be discussed in this chapter are use of insecticide and water and the causes of wastage of improved fodders and low yield of roughage grown.

The most common fodder crops in May 2019 were maize and Napier grass as can be seen in table 5. These will be discussed in this chapter. Annex 5 shows two more detailed tables from April 2018 and May 2019. Compared to April 2018 farmers have improved in variety of crops grown for animal feed, acres under fodder and milking cows which is shown in chapter 4.4.

Table 5

Different fodders grown on each farm

Farm	Maize	Brachiaria grass	Napier grass	Rhodes grass	Panicum grass	Sweet potato	Desmodium	Caliandra	Sorghum
1	x	x	x	x					
2	x	x				x	x		
3	x	x	x						
4	x	x	x			x			
5	x		x			x		x	
6	x		x			x		x	
7	x		x			x			
8	x	x	x			x	x	x	
9	x		x			x	x	x	
10	x		x			x			
11	x		x			x	x	x	
12	x		x		x	x			
13	x	x					x		x
14	x		x						
15	x		x			x			
16	x		x			x			

1. When maize on the field was inspected it was discovered that maize was damaged on all the farms because of worms and insects. Farmers controlled worms and insects poorly because insecticide was not used correctly. The results show how farmers have used insecticides.

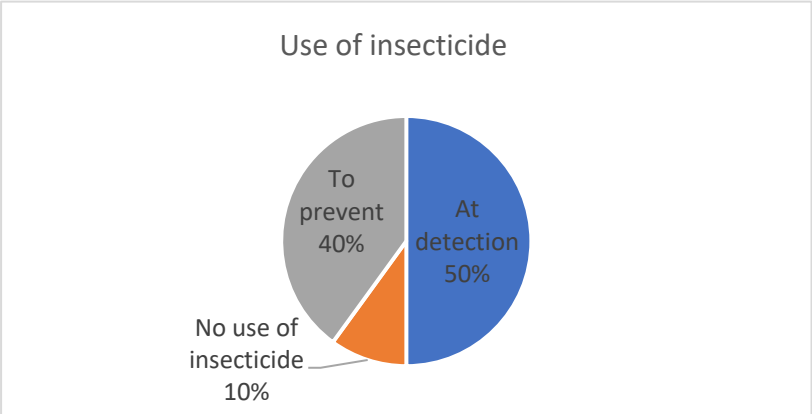

Figure 6 Use of insecticide in maize

Insecticides were used by 90% of the farmers in maize to treat and prevent the infestation of the fall army worm and stemborer. Half of the farmers (50%) applied insecticides when insects were detected. From this only 10% used insecticides against stemborer and 40% used insecticides against fall army worm. The remaining 40% of the farmers applied insecticide to prevent fall army worm and 0% did not spray any insecticides to prevent stemborer.

1. All 16 farmers mentioned to cope with water scarcity. Figure 7 shows how farmers use water to grow crops.

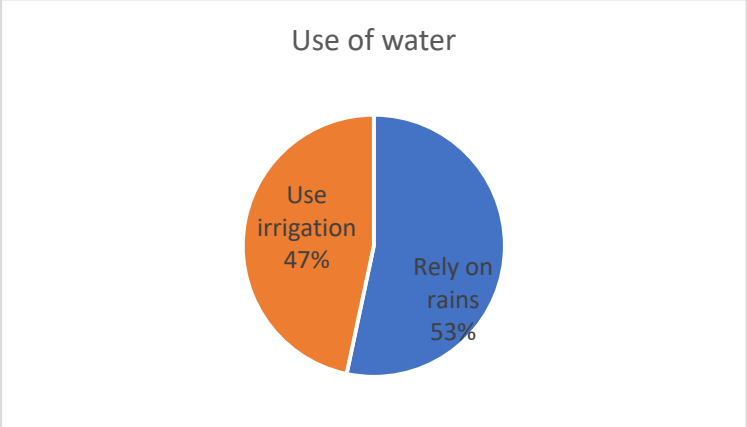

Figure 7 Use of water

The results show that in total 8 out of 16 farmers rely on rains and 7 use irrigation. Irrigation is applied when rains are not sufficient or directly after sowing. From the 7 farmers that use irrigation, 3 (20%) have water stored.

2. Out of the 16 farmers, 12 farmers have planted improved fodders, such as caliandra and different varieties of Rhodes and Brachiaria grass. Especially during the wet season there are several reasons farmers find it difficult to maintain and cut the plants in the right stage. Because of this quality and quantity of fodders is wasted on the field.

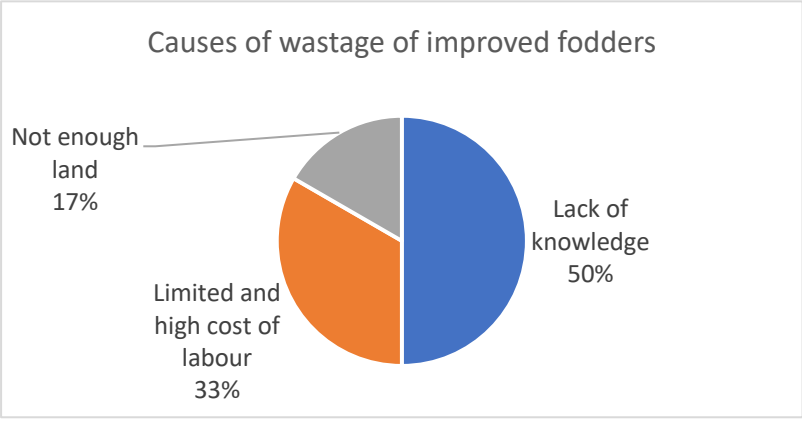

Figure 8 Causes of wastage of improved fodders

As the results show that 50% of the 12 farmers, which are 6 farmers, do not have enough knowledge about growing and harvesting improved fodders. Even though knowledge was low about these improved fodders two farmers planted Napier grass strips to prevent erosion

and maintain the quality of the soil. Out of 12 farmers 4 (34%) farmers mentioned to have limited and high cost of labour to produce forages. Next to this 16%, 2 farmers didn't have enough land.

3. Low quantity of roughage is produced on the fields. This includes fodders that farmers grow such as maize and different types of grasses. Figure 9 shows the major causes.

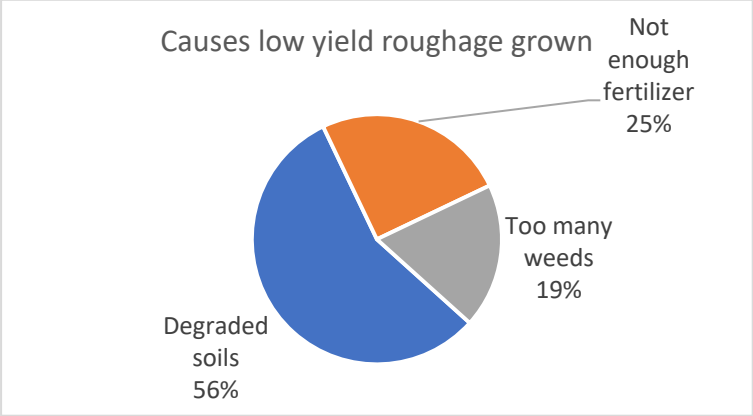

Figure 9 Causes low yield roughage grown

The results show that out of the 16 farmers, 9 farmers (56%) grow crops on degraded soils, 25%, 4 farmers do not use enough fertilizer and 19%, 3 farmers let too many weeds grow.

4.2 Causes low quality and quantity during conservation

In this chapter the constrains and causes of low quality and quantity of maize and/or Napier grass silage will be discussed. Constraints that were discovered are that maize silage contains many whole kernels, long leafy parts and molds. Napier grass silage was of low quality and closing the maize silage took several days. It was discovered that rainwater can enter the pit and costs of inputs are high for conservation of feeds.

1. When maize silages were investigated, a sample was taken out from different places in front of the pit. It was discovered that many silage pits contained whole kernels and long leafy parts. On all the 16 farms this was seen. Kernels contained more than 50% milk and. Cobs were sometimes found as whole or chopped in half.

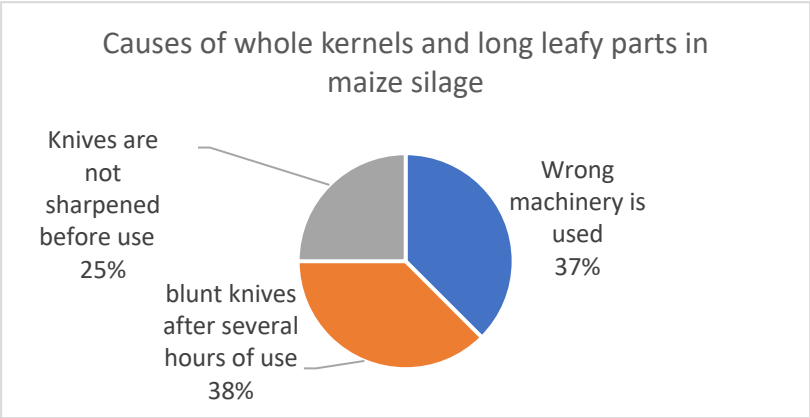

Figure 10 Causes of whole kernels and long leafy parts in maize silage

As the results show for 38%, 6 farmers, the knives of the chopping machine became blunt after several hours of use. Next to this 6 out of the 16 (37%) farmers used wrong machinery. The results also show that 25%, which are 4 farmers, did not sharpen the knives before using the chopping machine.

2. Another discovery was made during the investigation of maize silage pits. Molds in the maize silage pits were discovered. There was discovered that 12 out of 16 farmers have molds in the maize silage.

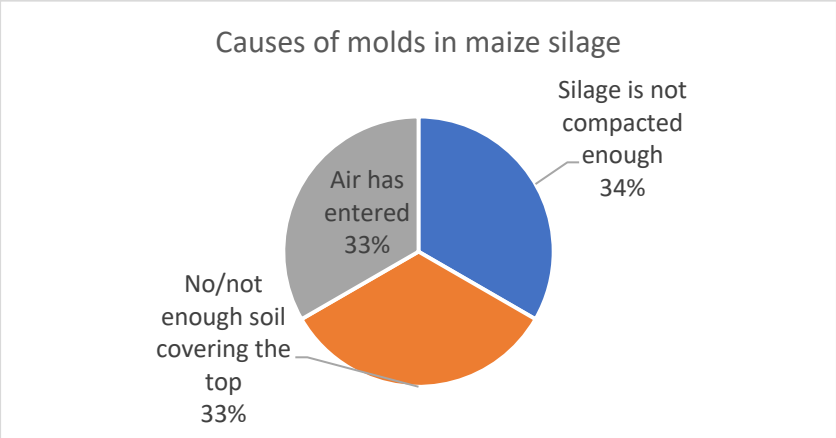

Figure 11 Causes of molds in maize silage

The results show that on 33% of the farms, which is 4 out of 12, air has been able to enter the silage pit. Another 33%, 4 farmers do not use enough or any soil on top and molds are caused because 33%, 4 farmers have not compacted the silage well enough.
Air had entered the silage because the pit was not protected from animals, such as rats and mice, the plastic was not pulled tight enough over the pit and old plastic sheets with holes were used to cover the silage.

3. When Napier grass silage were investigated it was discovered that it consisted of low quality. Smell was putrid and silage was wet and heated up. It was discovered that Napier silage consisted of a low quality on 10 out of 16 farms.

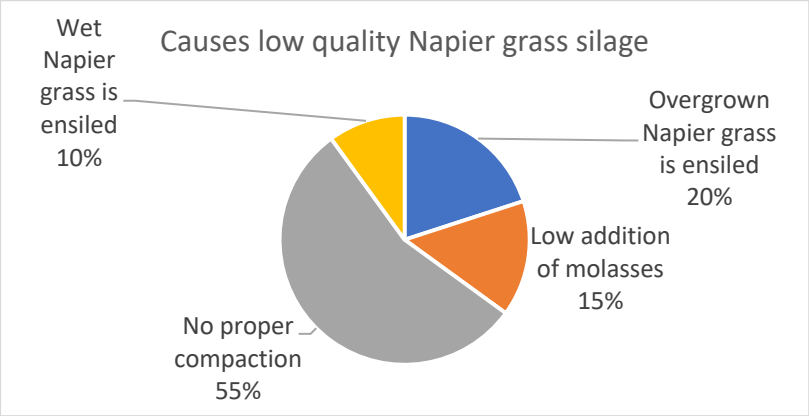

Figure 12 Causes low quality Napier grass silage

Most farmers did not compact the silage properly, which is 55%, in total 5 farmers. Napier grass that is higher than 1 meter has a lower nutritious value, but was ensiled by 20%, which

are 2 farmers and 2 farmers (15%) did not add enough molasses during ensiling. The least of the farmers, which is only 1 farmer, ensiled wet-chopped Napier grass.

4. When farmers were questioned about conservation of fodders such as Napier grass or maize, they mentioned finishing the silage pit was not done within one day. This was mentioned by 10 farmers.

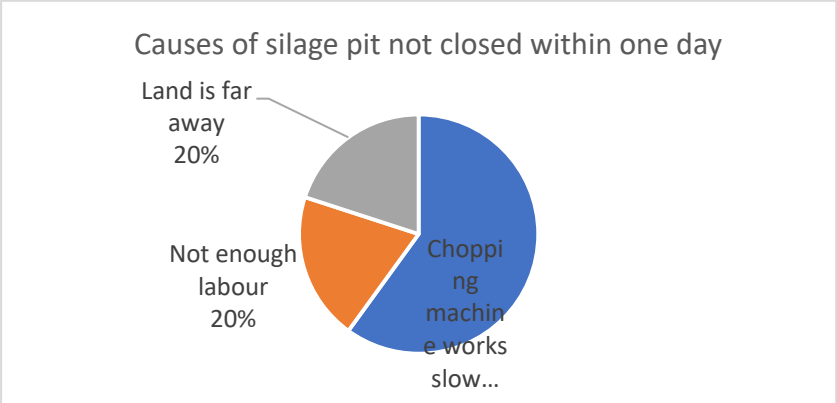

Figure 13 Causes of silage pit not closed within one day

The majority of the farmers, which are 6 farmers, have a chopping machine that works slow, therefore it takes several days to chop all the material. On 2 farms (20%) land is far away, because of this transportation of all the fodder takes several days. For another 20%, 2 farmers, it is not possible to get enough labour to chop the fodder and seal the pit within one day. Farmers reported during the farm visits that they were mostly dependent on hired labour because young family members did not live on the farm anymore.

5. Farmers mentioned that conserving feeds is expensive. High cost of inputs for conserving feeds was mentioned by all 16 farmers. All the farmers mentioned labour, hiring machinery and transportation were expensive during conservation. Farmers did not know how expensive, but it was mentioned that these costs add to the costs of conservation. Farmers thought labour to be the most expensive compared to the other costs.

6. During heavy rains or in the wet season farmers noticed silages started losing quality because of water entering the silage pit. Water damage was mentioned by 12 out of 16 farmers.

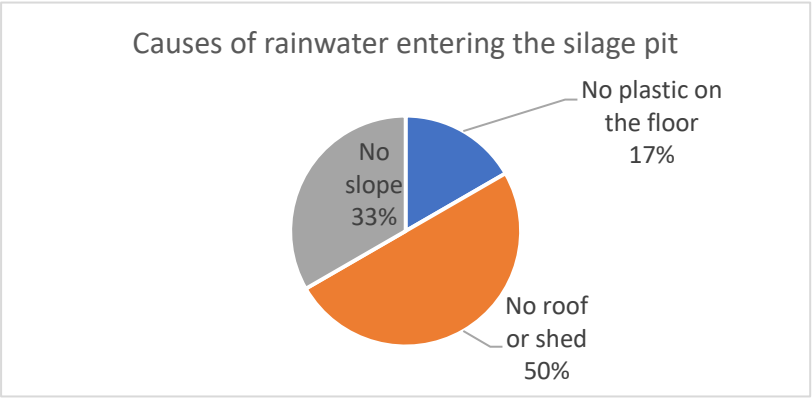

Figure 14 Causes of rainwater entering the silage pit

Majority of the farmers (50%) did not built the pit under a roof or in a shed which allowed heavy rains to enter the silage in the front. The silage pit was not built on a slope by 33% of the farmers. Only 17%, 2 farmers did not use plastic on the floor to prevent contamination with sand or water.

4.3 Causes low quality and quantity during utilization

Constraints and the causes during utilization are mentioned in this chapter. The results of the constraints shown in this chapter are the silage that loses quality during feeding, feed that is of low quality in the feeding troughs and that feeding troughs contain molds.

1. When feeding out of silage farmers noticed that after feeding from the silage pit several times, silage had declined in quality. This was mentioned by all 16 farmers. The time after opening the pit and decrease of quality differed per farm, this was because feeding speed was not the same every week. Figure 15 shows the results from interrogating the farmers.

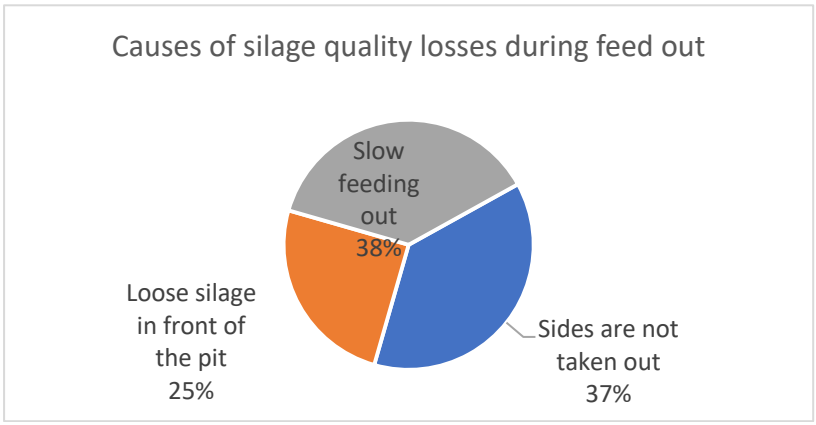

Figure 15 Causes of silage quality losses during feed out

The results show that six out of 16 farmers maintained a too slow feeding speed and the sides were not taken out by another six farmers. By four farmers loose silage was left in front of the pit which attracted animals, such as rodents. Loose silage started rotting which also stimulated the face of the pit to start rotting.

2. When feeding troughs were investigated low nutritious value feeds were discovered at eight farms. This was noticed because smell was acidic, and moisture dripped out when feed was squeezed in hand.

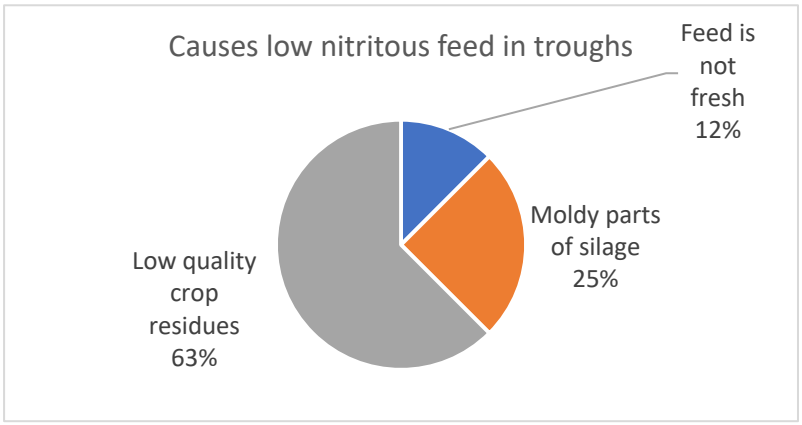

Figure 16 Causes low nutritious feed in troughs

Out of the eight farmers the low nutritious value of the feeds in the troughs is caused by that five farmers added low quality crop residues to the roughage and because 12%, which is one farmer does not provide the cows with fresh feeds and because 25%, which are two farmers, fed moldy parts of the silage.

3. From the 16 farmers that are included in this research it was discovered that two farmers were using wooden feeding troughs which were not cleaned well.

4.4 Milk yield

Milk production has been compared to the quality and quantity of roughage on each farm. In annex 5 the difference between May 2019 and April 2018 on each farm for several aspects such as number of acres under fodder and number of milking cows are shown. There has been tried to find a possible relation between these aspects and the milk production.

Table 6 shows the results of the score system for judging the roughage on each farm. On most farms roughage consisted of moderate quality meaning the roughage contained moisture when wringed between fingers, chopped pieces of 5-10cm and whole kernels. On half of the farms roughage was of moderate quantity meaning the trough contained many low-quality leftovers and an insufficient amount of edible feeds. On the other half of the farms roughage was of adequate quantity meaning almost no leftovers were found, the trough contained a sufficient amount of edible feeds and the trough was filled.

In total four farms (no. 2, 5, 9, and 12) have both a high quality and adequate quantity of roughage with a milk production of 24.2, 18.8, 15.6 and 11.3 litres per cow per day. The farm (no. 7) recorded with the highest milk production of 25.3 litres per cow per day consisted of moderate quality and quantity. The roughage on the farm (no. 10) with the lowest milk production of 6.7 litres per cow per day was of low quality and moderate quantity.

Table 6

Results of quality and quantity at the farms including milk production

Farm	Quality	Quantity	Milk production per cow per day (litres)
1	moderate	adequate	21
2	moderate	moderate	15.6
3	moderate	adequate	13
4	moderate	moderate	20
5	high	adequate	11.3
6	moderate	adequate	14
7	moderate	moderate	25.3
8	moderate	moderate	21.3
9	high	adequate	24.2
10	low	moderate	6.7
11	moderate	moderate	15
12	high	adequate	18.8
13	high	adequate	15.6
14	moderate	moderate	22.5
15	moderate	adequate	12.3
16	moderate	moderate	9
			Average: 16.6

Figure 17 shows the results of the difference in acres when May 2019 and April 2018 are compared. Acreage under fodder has increased with an average of 3.25 acres per farm ranging from 0.25 to 11 acres. Only on farm 6 and 16 the acreage remains the same. Farm 5 has the least increase with 0.25 acres under fodder and the farm that has increased with the most acres under fodder is farm 3, with 11 acres.

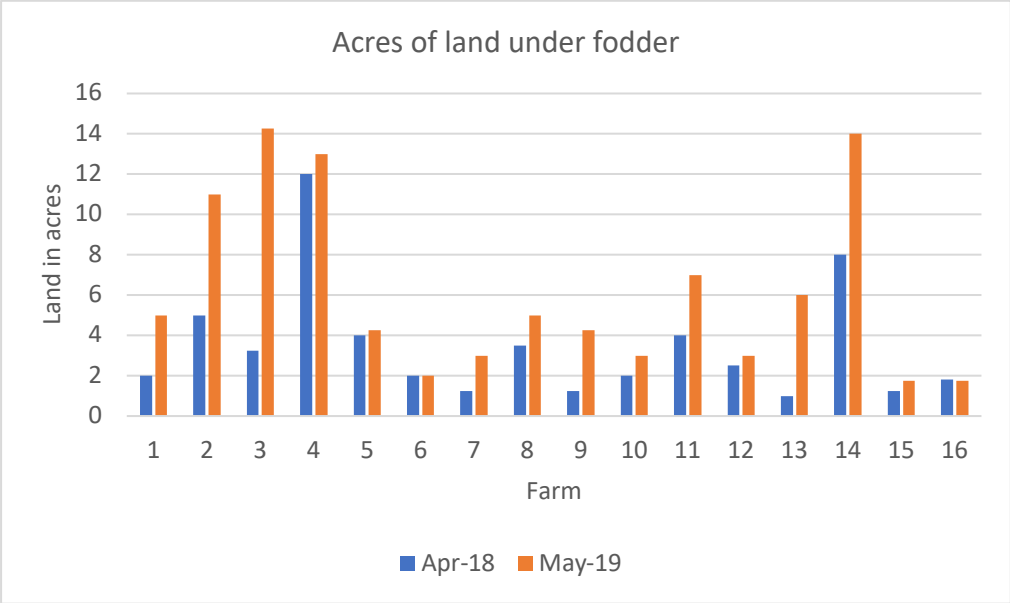

Figure 17 Acres of land under fodder

From annex 5 it can be seen that the quality of the roughage has improved on each farm. In April 2018 all the farmers fed leftovers or overgrown Napier grass as can be seen. In May 2019 the feeds have mainly changed to maize silage, sweet potato vines and Brachiaria grass.

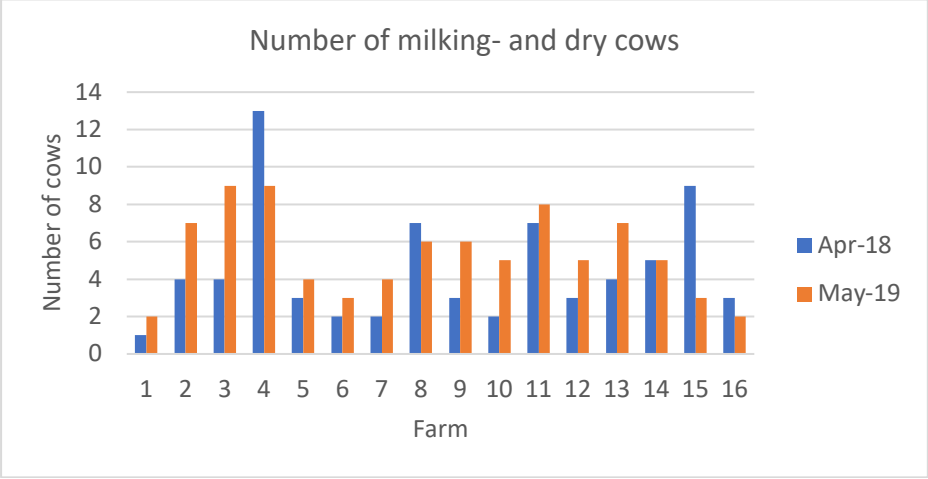

Figure 18 Difference in number of milking- and dry cows

As can be seen in figure 18 not all farms have increased in milking cows. For the farms that have increased it has been calculated that the average milking cow per farm has increased with 2.7 cows in May 2019 compared to April 2018. This ranges from an increase of 1 to 6 milking cows. From the 16 farms (no. 4,8, 15 and 16) have decreased in number of milking cows, ranging from -1 to -4. Only farm number 14 remained with the same number of milking cows.

The farms with high quality roughage also had the highest average milk production, which is 17.5 litres per cow per day and the farm with moderate quantity of roughage had the highest average milk production of 16.9 litres per cow per day.

In annex 6 it is shown how much all the farmers feed of the different roughages. The most used roughages among the farmers are fresh Napier grass and maize silage, recorded in May 2019. These have been put into a graph, shown in figure 19. The farmer from farm 5 was not aware of the amounts, therefore this farm has been left out and figure 19 counts 15 farms.

From figure 19 it can be seen that farm 11 feeds the highest quantity of maize silage and Fresh Napier grass and therefore the highest amount in total. Farm 2 and 9 also feed 30 kg of fresh Napier grass per cow per day. Farm 4 feeds the lowest amount of fresh Napier grass which is 3kg in total. On farm 1 and 2 a mix of Napier, Rhodes and Brachiaria grass is fed. Farm 5,8,9,14 and 15 feed sweet potato vines ranging from 0.5 to 2.5kg. Farm 13 feeds sorghum or maize depending on what is available.

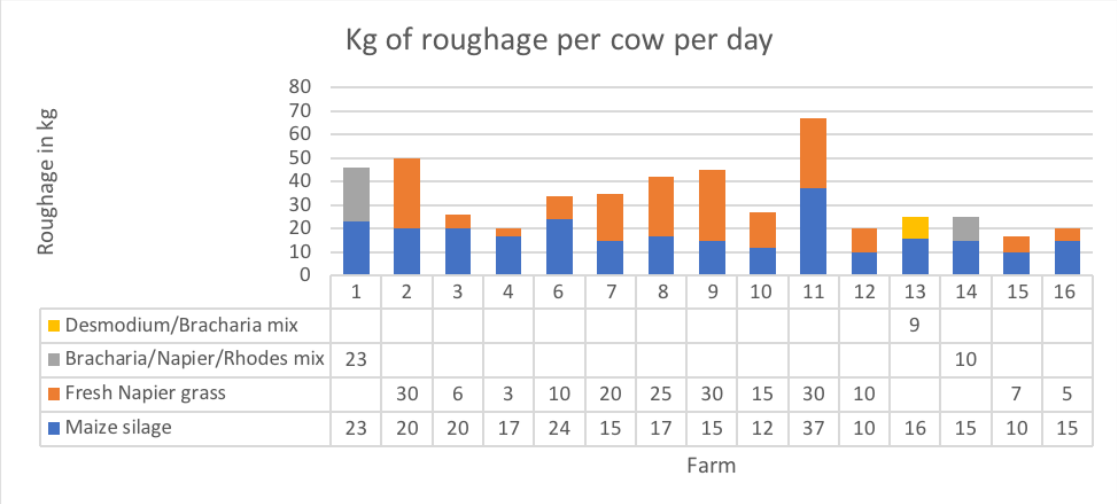

Figure 19 Kilograms of roughage per farm per cow per day

In figure 20 the results of the milk production per cow per day is shown. The milk production per cow per day has increased for every farm when May 2019 is compared to April 2018. The highest increase is on farm 8 with a total of 13.8 litres. The lowest increase is on farm 10 with a total increase of 1.7 litres.

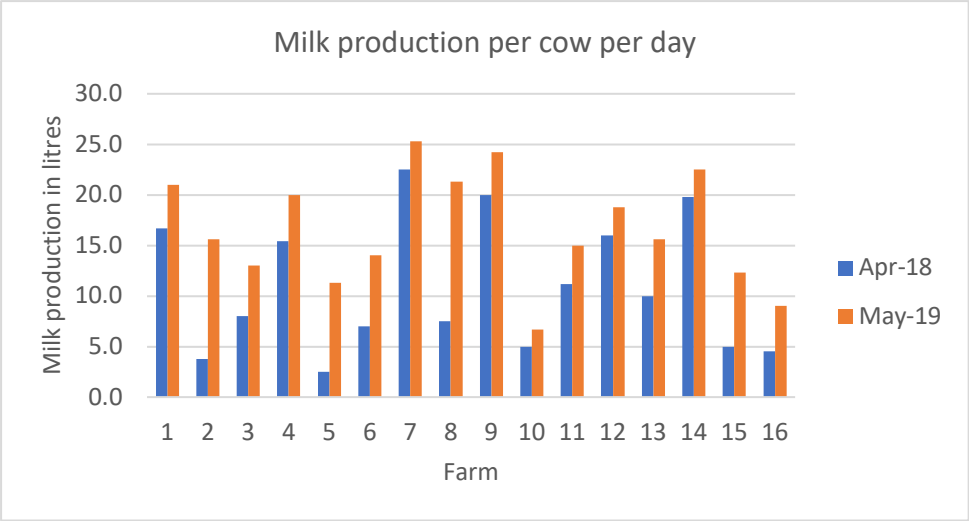

Figure 20 Milk production on each farm per cow per day

Figure 21 shows a negative regression line. The results from this research show a correlation coefficient (R^2) of 0.0003. This can be seen as a very small correlation between acres under fodder and milk production. Also a lot of spread (variation) around the trendline is shown and there are outliers clearly standing out, which has an impact on the way the line is defined. The farms with high acreage under fodder do not have a higher milk production than farms with fewer acres under fodder.

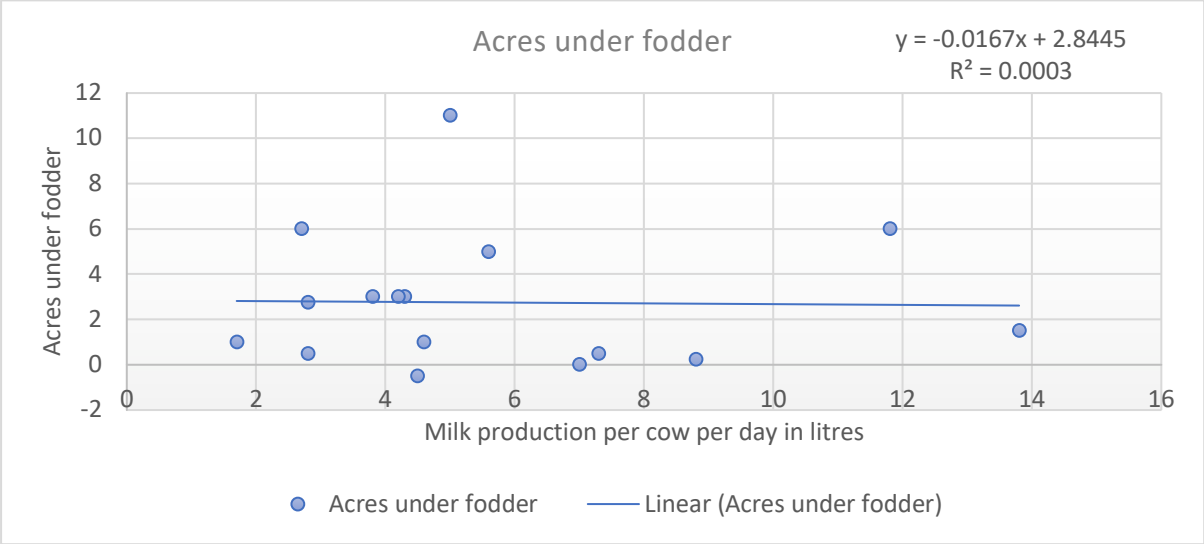

Figure 21 Correlation between acres under fodder and milk production per cow per day

Figure 22 shows a positive regression line, with a correlation coefficient (R^2) of 0.0147 which indicates a positive, but very low correlation between number of milking cows and milk production. Also a lot of spread (variation) around the trendline is shown, which indicates a low relation between the factors.

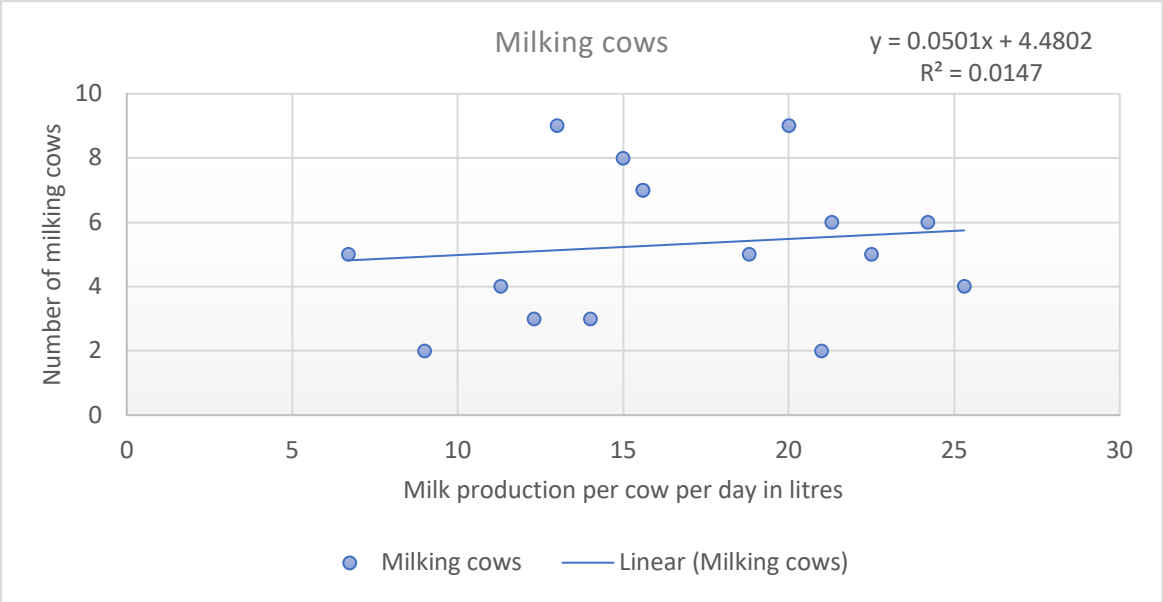

Figure 22 Correlation between number of milking cows and milk production per cow per day

In figure 23 there is a positive regression line shown of feed quantity. This indicates a positive correlation, but because the correlation coefficient (R^2) is 0.1283 the correlation is very small between feed quantity and milk production per cow per day.

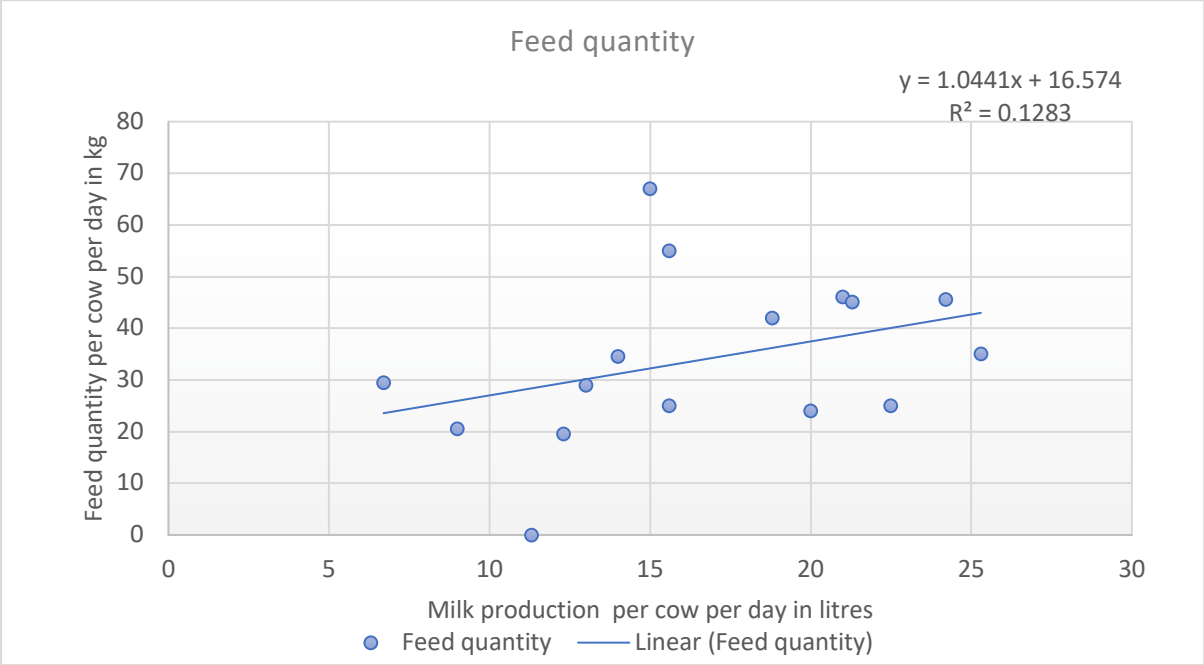

Figure 23 Correlation between feed quantity and milk production per cow per day

From all the farms the average milk production from April 2018 and May 2019 is given table 7. This is the average of all 16 farms from the total production per day.

As the results show in table 7 the average milk production has increased in May 2019 with 18.13 litres.

TABLE 7

Average difference of milk production in litres per day per farm

April 2018	May 2019
43.31	61.44

During the farm visits farmers mentioned they have learned about feeding, conservation and production. Farmers mentioned knowledge about feeding has improved because they have learned feeding protein and energy fodders and the right quantities to dairy cows. About conservation farmers mentioned they learned to conserve feeds such as maize and Napier grass. Farmers said to have learned to make silage pits and hay. About production farmers mentioned to learn to grow different varieties of fodders and find a better balance between crops for household and fodders for animals.

5. Discussion

The main objective of this study was to identify the constraints farmers face that cause the low quality and quantity of roughage during production, conservation and utilization causing low milk production among smallholders. The results have to be interpreted carefully because data and number of farms is limited and because data from April 2018 was collected by employees of SNV where no one has checked if the data collection was done in the same way for each farm.

In May 2019 different farms have been included in the research, only four farms are the same as given in the baseline study. This is because the farms were chosen randomly during the preliminary research to get an overview of the small-scale farms in Meru in general. The farms that have been included were most suitable to visit and were willing to cooperate which increases the methodological quality of the research.

The interventions that farmers have adopted have been investigated and new interventions are proposed. The expectation was that the improvement of both quality and quantity of roughage does have an effect on the milk production. It was thought that the milk production would increase.

The farmers have been interviewed and helped out by making their farm available for research. The roughage in the fields, conserved roughage, roughage during feeding in troughs and taken out from the silage has been judged. During the research there was severe drought and serious water shortage in the study area in May 2019 which could have influenced the outcomes.

To substantiate results some articles have been used that are older than 10 years which can influence the reliability of the results. These have been used because no other resource was found.
Performing desk research was very reliable because peer-reviewed articles and articles from SNV were being used. These have been published and contain evidence on real data and therefore increase the validity of results.

5.1 Evaluation of the factors causing the low quantity and quantity during production

The most common constraints found during production were; wrong use of pesticides, not enough maize ensiled to feed throughout the whole year, water scarcity, low acreage under fodder and low quantity of roughage.

The results in chapter 4 show that 0 to 10% of the farmers use insecticides against stem borer which corroborates with previous studies that proved that only 5% of the small-scale farmers in Kenya use insecticides against stem borer (Gianessi, 2014). Farmers reported losses up to 30% in the field due to pests and diseases. Farmers said maize that was heavily affected by diseases were not suitable for conservation.
The farmers said that neither the use of insecticide at detection and for prevention did help to prevent or remove the infestation with the fall army worm and stem borer. Farmers said it did reduce the infestation but the plants that were affected had stunted and poor growth, reduced yield and were more susceptible to other diseases and weather circumstances. When farmers used insecticide for treatment it is likely that there was not used enough and that is was not

repeated enough times because farmers could not tell the exact amount or how many times it was applied.

Water scarcity is another factor causing low quality and quantity during production and eventually causing low milk production too (Lukuyu B. A., 2009).
Even though conservation of water is applied, farmers reported this was not enough to irrigate during the dry season to provide crops with enough water for a good growth. More than half of the farmers were not able to irrigate because of prolonged drought and changing weather circumstances which the farmers said it has been becoming a problem the last years. The farmers reported to have a poor establishment of the maize and reduced further growth. Studies show that rising temperatures in combination with variability in season-to-season rainfall division have an impact on factors that influence the yield of maize, such as length of growing season and seed germination (Omoyo, 2015).
It was mentioned by farmers that yields of maize are higher when irrigation is applied, especially directly after planting when there are no rains. Farmers rely on rains because they have no storage tank for water, do not have a water source nearby or because the river/stream is dried up. Farmers that rely on rains are susceptible to weather fluctuations and farmers said yields are lower during the dry season than during the rainy season which corroborates with a previous study that proved when water is deficit maize suffers and cannot produce to its maximum yield level (Barron, 2004). Because of this, farmers are forced to feed low quality feeds which results in lower milk production. On the other hand within the same study it states that rainfall does exceed the water requirement of maize during the seasons and that shortage of water is caused by poor distribution of water. Maize therefore does not suffer from water scarcity but of poor distribution of water during the seasons, probably caused by changing weather due to global warming (Barron, 2004; Kabirizi, et al., 2015).

Farmers said it is difficult to grow improved fodders because knowledge is poor about growth and maintenance of these crops. Because of this fodder on the field is wasted, especially during the wet season. Farmers reported that during the wet season losses on the fields are caused by heavy rains causing molds in the crops. Due to a previous study it is reported that during the rainy season one of the largest causes of spoilage are molds, especially when moisture conditions are high. These molds can lead to yield losses and eventually economic losses because of mycotoxins (Lanyasunya, 2005).
From a previous study it was found out that knowledge of small-scale farmers in Kenya about alternative nutritious plants is low (Wachira, 2015). In this study the fodders that were mentioned were lucerne, caliandra and leucana which corresponds with the results. Because of low knowledge about growing improved fodders the farmers also have developed lack of skills such as planning events for when to cut and conserve feeds (Kabirizi, et al., 2015).
Farmers said because of creating Napier grass strips the yields are higher and the soil quality remains higher which is confirmed by a study done on fodder production on smallholder farms where contour strips of Napier grass performed well as a barrier to soil erosion (Nyaata O. Z., 2000).
Farmers mentioned to not have enough land to plant, they said land is changing to be used for crops that are grown for human consumption. This is being confirmed by a study from the Michigan State University. In this study it is being mentioned that population is increasing and because of this land for crops is being lost which turns into land for food production (Kabirizi, et al., 2015).
All the farmers mentioned labour is expensive and difficult to get which which led to lack of motivation and eventually to wastage of quality and quantity. Even though farmers were not able to mention how expensive labour was they said costs of labour adds to the production

costs of fodders which does not stimulate to be more productive. Farmers mentioned not enough labour is available during the peak season because workers that are available are too old and cannot perform well enough. Farmers prefer younger workers, but many are not motivated and interested in farming. Due to a study labour availability is affected because youth moves from rural to urban situations where wages and job opportunities are higher (Kabirizi, et al., 2015).

Farmers cannot maximize the yield of improved fodders. A previous study shows that Eastern parts and North-Eastern of Kenya suffers from worse land degradation than other parts of Kenya. It proves that 12.3% of the land is severely degraded, 52% moderately degraded and 33% of the land is vulnerable to land degradation (Mulinge, 2016). In annex 7 a map with land degradation hazard areas of Kenya is shown with a circle in the middle indicating Meru as severe and a very severe area. This map is based on a soil survey.
The maximum yield could not be achieved because no adequate quantity of fertilizer was used. It was said by these farmers that fertilizer is expensive and therefore less was used which resulted in lower yields. When the farmers were interrogated it could not be found out how expensive fertilizer was.
It seemed that when farmers did use fertilizer many weeds established and suppressed the growth, particularly of maize. Farmers said this is because it is difficult to get enough labour for weeding. According to a study this would lead to delayed weeding and yield losses as the farmers reported (Terry, 2002).

5.2 Evaluation of the factors causing the low quantity and quantity during conservation

The most common factors during conservation that caused a low quality and quantity of roughage were whole kernels and molds in the maize silage, low quality Napier grass silage, ensiling which takes several days, high cost of inputs and rain that can enter the silage pit.

Because kernels were not broken into multiple pieces and long leafy parts were found in the maize silage compaction and quality were poor. A chaff cutter was used, which is more suitable for chopping grass. Kernels contained more than 50% milk and therefore because of liquid, losses occurred easily during conservation. This decreases the quality and digestibility of the maize silage (G. W. Roth, 2001). It was found out that most farmers only have a chaff cutter available, but because of a project performed by SNV it was able for some farmers to share a chopper with other farmers. Because of this the machine has been used by a different farmer and the knives were not sharp anymore. These farmers did not sharpen the knives before use which resulted particularly in long parts of leaves and unchopped parts of cobs. These long parts and cobs are not digestible for the cow and resulted in too many leftovers in the trough. After using the chopper for 4-8 hours the knives of the chopper were not sharpened which resulted in different chopping lengths of the leaves and stem. Well chopped maize was ensiled with bad chopped maize, which was visible in the silage and because of this the total quality of the silage decreased because air could not be forced out enough (Amuda, 2013). For the farmers it is not possible to hire a larger machine, such as a one-row harvester, that can perform better. This is not affordable, or the plot is not large enough.

During the farm visits farmers mentioned farm workers do not work correctly and silage is because of this not compacted well enough preventing good fermentation. Also holes in the plastic were found which were created by rodents. This allowed air to enter, causing heating up and growth of molds. It was mentioned in a previous study that this affects the quality of

the silage in terms of loss of dry matter, decreases the nutritional value and palatability of the silage and eventually lower the feed intake by the cows (Emmanuel Kossi Tangni, 2013). On other farms no soil or less than 15cm soil was covering the top of the pit which led to heating up of the silage and decline of quality (Moran, 2011).

During the farm visits low quality of Napier grass in silage was found caused by no proper compaction. This does not stimulate fermentation and dry matter losses occur. The farm workers don't take enough time to trample down the silage and some of the farm workers only trample down by foot and do not use a sufficient weight. Overgrown Napier grass, higher than 1 meter, gives low digestible silage for the cow. A small amount of the farmers did not exactly know how much molasses was added, the amount diluted with water was guessed and likely resulted in too low addition of molasses to the ensiled Napier grass. Wet Napier grass was ensiled resulting in low quality silage and causing wastage due to molding. Farmers stated during farm visits that this was caused by Napier grass that was layed out for wilting and had been rained on and ensiled after. This resulted, as described in a previous study as well, in heating up of the silage, resulting in decline in quality of the silage and a bad start of the fermentation process ('t Mannetje, 2000).

Ensiling takes more than one day. When questioning the farmers it was discovered that a large amount of fodder needed to be chopped with a machine that did not have the capacity for this to be done within one day. Some land is leased which can be further away from the farm. Transporting harvested fodder can therefore take several days because the farmer has to go back and forth several times. It is difficult for the farmers to get enough labour during the peak season when fodder is harvested. The farmers said it can therefore take several days to ensile fodder. In a previous study it was being confirmed that labour availability was being affected because the majority of the urban migrants are youth in Eastern Africa (Kabirizi, et al., 2015).

Farmers said to face high costs during conservation. It was mentioned by the farmers that hiring machinery, labour and transportation are expensive. The farmers could not mention during the farm visits how expensive these costs are. Only from a previous study it was discovered that from the total feed production costs, hiring machinery consists of the largest part, which is 25%. This is followed by labour, which is 11% of the total production costs and the lowest contribution is transportation which is 8% of the total production costs. These percentages are relatively low compared to what the famers mentioned as very expensive (Njagi, 2017). When the results are compared to the costs of labour, which the farmers thought to be the most expensive it shows that labour is not the highest cost, but the contributes for 11% to total feed production costs.

Damage occurred to the silage because of rainwater. Majority of the farmers did not have a roof or shed, which is also not always necessary, but will help to prevent heavy rains from spoiling the silage. It was noticed during farm visits that farmers who have built the silage in a shed, this will help keep rain out of the silage and will keep it cool as well. Many farmers did not built the pit on a slope to let (rain)water runoff. Therefore (rain)water becomes stagnant stimulating spoilage. No plastic was used by a small number of farmers on the floor under the silage to prevent contamination with dirt and water. Because of this silage can get spoiled from underneath causing rotting from the bottom into the silage. When water enters the silage pit, a previous study mentioned the moisture content and relative humidity increases resulting in leaching and quality losses, such as dry matter losses, energy content,

nutrients and possibly harmful mycotoxins are produced which can affect the quality and quantity of the milk production (Mike Rankin, 2008).

5.3 Evaluation of the factors causing the low quantity and quantity during utilization

The major constraints causing a low quality and quantity of roughage during utilization was that silage loses quality during feed out, low nutritious feed in troughs and the troughs contain molds.

When feeding from the silage pit farmers took out less than 15-30cm per day, which is too slow and heats up the silage causing molding and rotting in the pit. Especially in the corners molds were found. Due to a study it corroborates that when feeding out is slow or wrong, quality losses are higher, such as dry matter losses. Losses from 3.5 to 4% per day have been recorded by this study (Martin, 2003). Sides of the silage pit were not taken out and the front was damaged allowing air to enter. Animals were attracted because the front of the pit was not cleaned after taking out feed from the pit. These animals contaminate the silage leading to decline in quality (Martin, 2003).

During farm visits leftovers in the trough consisted mostly of large parts of the stem of maize and long parts of Napier grass leaves were found. Also parts of cobs of maize with kernels attached were left in the trough by the cow. These leftovers seemed to be left behind because it was unattractive for the cow. Moldy parts of silage were found, mostly because troughs were not cleaned in the corners often enough. These moldy feeds can contaminate the rest of the roughage in the trough and makes roughage unattractive for the cows to eat (Seiichi Chiba, 2005).
When quality was judged in the troughs during farm visits it was found out that feeds were not fresh. The smell was putrid and when it was squeezed in hand moisture dripped out which indicates that the moisture content is too high and quality is low (Seiichi Chiba, 2005).

It was discovered that when wooden troughs were used roughage heated up fast (SNV, 2017). Especially the bottom and corners were wet and contained molds and worms. The farmers mentioned it was not easy to keep the troughs clean and dry. This does not stimulate the quality of the feeds and the molds can also get mixed with the rest of the feed in the trough. Because of this it is more likely that the cow will have a lower intake because of lower quality of the feed (Seiichi Chiba, 2005).

5.4 Evaluation of milk yield before and after the training

Because SPSS has not been used to analyze the date, scatterplots have been used instead as a statistical analysis. Even though scatter plots have been used data has to be interpreted carefully. Therefore, next to the scatterplots, also scientific resources have been used to substantiate the results.

It cannot be said with certainty if the quality of roughage has an influence on milk production, but the farms with high quality roughage produce relatively high compared to the average of 16.6 litres per cow per day. Two out of four farms have a higher milk production than the average. According to the results of quality of roughage in relation to milk production, the quality of the roughage seems to have an influence on the milk production because low quality of roughage resulted in the lowest milk production and high quality of roughage resulted in the second highest milk production.

It is possible that there is a relation between feeding quantity and milk production. But because both a low feeding quantity and low milk production was recorded on one farm, this has to be interpreted carefully. On farm 16 the second lowest feeding quantity (20.5kg) was recorded and a low milk production (9litres) per cow per day was recorded.
The scatterplot showed a positive trend between quantity of roughage and milk production. Even though the trend is positive, the relation between these variables is very small.

It does not seem like land under fodder has an influence on milk production because farm 3 has the highest increase of acres and does not have the highest increase in milk production or one of the highest total milk yields.
The scatterplot showed a negative regression line between acres under fodder and milk production, which indicates there is almost no correlation between these variables because the correlation coefficient is close to zero.

The results show that four farms have decreased in number of cows. One farm kept the same number of farms and 11 farms increased in number of cows.
It seems that the number of milking cows does not have an influence on increase in milk production because farm 8 had one cow less, but increased the most in milk production. Farm 10 increased the least in milking production but increased with 3 milking cows.
The scatterplot showed a positive regression line but almost no correlation is present because the correlation coefficient is close to zero.

On 100% of the farms the milk production per cow per day has increased. Also the average milk production per day has increased with 18.13 litres and therefore follows the expectation. Increase of milk production can be influenced by many aspects or events on the farm. The data is limited which makes it difficult to draw clear and reliable conclusions. There was drought and water shortage in the study area at the time of data collection which has affected growth of fodder in the fields leaving the farmers with less fresh feeds and forcing them to feed low quality and expensive bought feeds.

Quality of feeds has improved because before the training the most common feeds were overgrown Napier grass and leftovers, such as banana leaves and stems and maize stovers. The remaining plant was used for human consumption. All of the farmers did not make silage before the training. Farmers learned to make silage because of the training.

The variety of roughage production has changed to different varieties of high-quality grass, such as Brachiaria and next to this, desmodium, caliandra and sweet potato vines are used for protein fodder. Farmers mentioned to have found a better balance between crops for household and for animal feeds. It is possible that these factors could have contributed to increase in milk production.

5.5 Evaluation of method of research

When done further research it is recommended to include all aspects, such as housing, farm managers and young stock which are included in the training from SNV/ProDairy, so that changes are better traceable and because these events are an influence on health and well-being of the cows which can influence the milk production.

Because it is unknown if data has been collected the same way as the data for this research has been collected this can make the results more unreliable when these two datasets are compared to each other.

Not all the aspects that are included in the training from SNV are included in this study because this way there will be no delimitation. The aspects that have not been included could have an influence on the milk production too and therefore makes the results less reliable.

Because qualitative analysis was performed it had to be taken into account that during questionnaires answers given by farmers were sometimes 'socially desirable' (Verhoeven, 2014). By asking further and using conservation techniques it was tried to get the real answer to the question and increase the reliability and validity of the research. Because of this, questions had to be adjusted slightly and interrogating farmers was more difficult than expected.

Also lactating stage of the cows should be included when done further research so that milk production can be measured and compared in the same stage.

- Be certain to check if all the methods are the same when data is collected. Also when someone else has gathered data.
- The score system that was used for judging the quality and quantity of the roughage is recommended to be more extensive. Aspects such as acidity and temperature of the silage pits can be measured. Also dry matter intake (DMI) should be measured.
- A shaker box can be used to check the particle size distribution, chopping length and the different raw materials in the ration. This can be added to help judge the quality and quantity of the roughage.
- Because of the different weather conditions such as the wet and dry seasons during the year it is recommended to take in consideration to collect data in the same period, with the same period in between data collections or even on the same date when data is collected again after one year. This way data is based on the same circumstances and weather influences.
- To analyze data further and more specific SPSS can be used when done further research.

6. Conclusions and recommendations

The main question this research tried to address was: 'How can small-scale dairy farmers improve the quality and quantity of production, conservation and utilization of the self-produced roughage to sustain higher milk production?' This research aimed to identify the constraints on roughage production, conservation and utilization that small-scale farmers have to manage by implementing interventions on roughage to aim for a higher milk production.

Conclusions about production

The results obtained in this study have shown that factors causing low quality and quantity during production begin with the quality of land on which crops are grown. Because of increasing land degradation, land resilience has been reduced and the effects of drought and floods exacerbated. Many crops are grown on degraded, nutrient-starved soils, which causes a lower crop production.

The farmers often only apply a small amount of fertilizer, of which only a small portion is taken up by the maize plant. When farmers did use more fertilizer it led to more weeds, which, as a consequence, increases the need for hand-weeding, thus labor. For the farmers it is getting more difficult to get enough labor and therefore labor is limited and expensive.

Climate change, resulting mostly from global warming, has been among the major causes of reduced production of the roughage. Most farmers rely on rains and therefore most crops are rainfed, and therefore, susceptible to weather fluctuations. Next to climate change farmers lack water conservation technologies and facilities, resulting in a lower production of roughage.

Also because of lack of knowledge on how and when to use insecticides yields and quality of fodder was affected. Not many farmers sprayed adequate quantities against stem borer which seriously affected the maize.

Knowledge was also poor about establishment and maintenance of improved fodders, due to this forage is wasted during the wet season. Shortage of silage occurs because no good feed planning is made. As a result of poor knowledge farmers make no use of a proper planning and crops get infested with pests and diseases resulting in low yields and poor quality forcing farmers to buy expensive, low – quality feeds in the dry season

Conclusions about conservation

The results obtained in this study have shown that constraints during conservation are mainly caused by wrong preparation before ensiling.

Factors that caused a low quality and quantity mainly occurred due to use of wrong machinery or because poor maintenance was performed. Long leafy parts confined compaction of the silage and gave yeast a change to develop and stimulated growth of molds and decline in quality.

Maize was harvested in the milk stage, in this stage the plant and kernels contain too much moisture. The production of lactic acid will not be high enough causing the acidity to increase instead of decrease resulting in heating up of the silage and loss of quality.

Factors causing poor quality and quantity also lie around efficiency. It took too long for farmers to close the pit. When large amounts of fodder, that needed to be conserved, were located further away from the farm closing one pit took up to 4 days. This resulted in decrease of silage quality during conservation and fermentation.

The storage place was not always prepared well, pits were not built on a slope, no plastic sheet was used on the bottom or the silage was not sealed tight enough. Because of this feed was spoiled during storage. Environmental factors, such as moisture, temperature, light, and oxygen influence deteriorative changes and losses in silage. Good storage is important because the value of the feed that is fed to the cows depends on it.

Water and heat damage occurred because not enough measures were taken to let (rain)water run off and to exclude air. Quality was declined because growth of molds and leaching of nutrients occurred.

Silage was not compacted well enough by farm workers. Air was not excluded enough and poor fermentation occurred causing heating up and growth of molds. Quality of the silage declined in terms of nutritional value and palatability of the silage which can eventually lower the feed intake by the cows.

The results have shown that good storage is essential because the value of the feed that is fed to the cows depends on it.

Conclusions about utilization
From the results of this research it can be concluded that constraints during utilization mainly consist of wrong handling and management of feeds. Due to the absence of proper skills in feeding management, the roughage is not utilized in the best way, especially during the wet season.

According to the results it can be concluded that the rate of spoilage depends on several factors, including the feeding speed, method of removing silage and cleanliness of the pit. These factors cause aerobic spoilage and wastage when feed is removed from the silage. These factors allowed air to penetrate and silage to heat up.

When moldy silage is fed, it is possible this contains mycotoxins, which can affect the yield and quality of the milk production.

Due to the fact that low quality feeds in wooden troughs were found, it can be concluded that wooden troughs cannot be kept clean enough and therefore are not hygienic enough and contaminate feed.

Conclusions about milk yield
From results it can be concluded that it is likely that moderate quality of fodder is one of the limiting factors in milk production. Poor quality and moldy feeds reduce palatability and therefore dry matter intake. This leads to a reduced nutrient intake and low milk production.

There seems to be a small relation between quantity of roughage and milk production because of a positive trendline from the scatterplot. Adequate quantity of roughage ensures a high milk production.

With high quality and quantity of roughage dairy cows cannot only demonstrate their full genetic potential for milk production, but meet the nutritional requirements for maintenance, growth and reproduction.

As shown in the results the farms several aspects of the farms have changed when May 2019 and April 2018 are compared. Acreage under fodder has increased, number of milking cows, roughage conservation has been adopted and on all the farms milk production has increased.

Farmers also grow improved fodders and have more knowledge on what to feed the cows. Because of experience and attending the training farmers learned how to run a dairy farm. The farmers have gained noticeable progress after the training, but still face many constraints.

It can be concluded that is likely that milk production has increased due to improvement of quality and quantity roughage, but it was also discovered that many other factors and events can influence milk production which have not been included in this research.

6.1 Recommendations

For as far as possible the most common factors that cause a low quality and quantity of roughage during production, conservation and utilization have been found.

As a result of this exploratory research the following recommendations are made.
These recommendations are interventions small-scale farmers can implement to improve quality and quantity of production, conservation and utilization to sustain a higher milk production. The interventions were established by finding out the factors causing low quality and quantity in the first three sub questions.

The recommendations also answer the fourth sub question about the interventions farmers should apply.

6.1.1 Recommendations during production

According to the results the most important interventions to improve quality and quantity of roughage are mentioned in this chapter.

- During growth of the crop, pests and insects have to be controlled. This can be done best by using pesticides and insecticides according to recommended quantity and repetition.
- For farmers to overcome low yields because of changing weather circumstances and land changing for food crops, the following fodders are recommended:
    - Grasses and legumes such as Stylosanthes guianensis, Desmodium and Brachiaria varieties. These are easy to grow, maintain ,are high yielding and consist of a high protein content.
    - Fodder trees, such as Calliandra calothyrsus and Sesbania sesban. These are less affected by drought because of an extensive root system, require little land and labor. They can be planted along boundaries and do therefore not compete with land use. These plants are easy and cheap to harvest and they will last long. The fodder trees are also rich in protein.
- Because farmers lack knowledge and skills that are needed to grow and maintain alternative forages it is recommended that farmers gain knowledge and skills by following courses that teach practical skills.

- It is recommended to adopt water conservation so that irrigation can be applied when water is scarce during the dry season. Farmers can store rainwater in a tank on the farm. From this tank the water can be used for irrigation. About 20,000–40,000 litres per acre have to be stored to irrigate every 2-3 days.
- To prevent soil degradation it is recommended that farmers:
    - Use contour strips of Napier grass which can perform well as a barrier to soil erosion.
    - Prepare the seedbed by doing minimal tillage. The top of the soil has to be turned over, but no deep ploughing should be performed.
    - Adopt crop rotation. This can be done by changing the types of crops grown on the same piece of land every year or every two years depending on the type of crop. This will maintain the fertility of the soil and help to increase yields because diseases, pests and weeds are minimized.

6.1.2 Recommendations during conservation

The interventions mentioned in this chapter will result in increase in quality and palatable silage that increases daily feed intake of the cow, reducing losses.

- Use a chopper for chopping maize and use a chaff cutter for chopping grasses. This will chop the maize better and will also crush the kernels better.
- Sharpen knives of the chopper before use and after at least 4 hours of use. To cut fodder well to stimulate compression and fermentation of silage.
- It is recommended that farmers do not leave the farm workers alone during ensiling. Give the farm workers clear instructions or watch them during their activities to be certain of a well-prepared silage.
- To make good silage and stimulate fermentation and compaction it is recommended that:
    - Maize kernels are broken into several pieces and cobs are chopped into pieces as small as the size of a thumbnail or smaller.
    - Maize/grass is cut into small pieces of 1-2cm.
    - Compaction is done with a sufficient weight. A drum filled with water of at least 200 litres can be used. People can also be used to trample the layers, but next to this every layer of silage also has to be pressed down with a drum.
    - A plastic, polyethylene sheet is used to seal the silage airtight.
    - A plastic sheet is used on the bottom and along the sides of the pit before making silage. This prevents or reduces mycotoxins by reducing absorption of moisture during damp weather.
    - A cover of at least 15 cm of soil on top and sides of the pit is made.
    - Farmers dig slots along the sides of the pit to let (rain)water run-off.
- When silage pits are spoiled because of heat, water or damage by animals farmers can make use of tube silaging or box silaging instead. This is an easier and cheaper way of ensiling roughage which will result in good compaction of the roughage. It can be done with lower quantity roughage and less workers are needed.
- When the silage is conserved in a below-ground pit, metal panels can cover the pit to protect it from the sun, but also from animals damaging the plastic.
- It is recommended in areas with heavy rainfall and severe droughts to build a roof that can protect the feed/silage from rain and heating up, preventing spoilage.
- When Napier grass is overgrown, feeding it as hay might then be a better alternative.
- To create high quality Napier grass silage, dry matter content has to be adequate. Wilting it for one or two days will reach a dry matter content of 30%, especially when

molasses is added. It is not recommended to wilt Napier to a dry matter content of more than 30%, or wilting old stemmy material. This is because of higher weather risks and a proper compaction will be more difficult.

- It is recommended to harvest maize in the dough ripe stage. The dry matter content of the whole plant will range from 30-35% which increases digestibility for the cow and stimulate fermentation of the silage. In the end the silage is more palatable for the cow and will lead to a better rumen fill because of higher nutritional content.
- Additives can be added to maize and molasses to grass during ensiling to stimulate fermentation and reduce wastage in. To avoid leaching, molasses should be diluted in a ratio of 1:1. Additives should be added according to the required quantity.
- Silage pits have to be sealed within one day to avoid decrease of quality and eventually quantity because of wastage due to poor fermentation. Plan to make one pit per day and start with a new one the next day.
- For farmers to reach a higher harvesting capacity, smallholders can work together. When several farms grow maize in the same area, it can be grown on the same plot. This can provide the farmers with a higher harvesting capacity and lower input costs of harvesting and conservation. A one-row harvester machine can be used to harvest one field. It has the capacity to harvest 3 acres/day which can consist of 3 farmers with each 1 acre. A one-row harvester could improve the chopping length and crushing of the kernels.
- To prevent shortage and low quality of silage it is recommended that farmers make a feed planning. When there is plenty of forage, it has to be bought at a low price, conserved and used during the dry season when prices are high.
- It is recommended to conserve feeds on time during the wet season, so that no forage is wasted during this time of the year by reducing leaf loss and getting old quality of forage remains.
- To solve feed shortage, hay making is not always the best solution because necessity of securing machines and difficulty of drying grasses in the wet season. Ensiling fodder will be more feasible and effective because it is cheap and easy to prepare.

6.1.3 Recommendations during utilization

- To keep the feeding speed high enough long and small pits are better than short and wide pits. The farmers should maintain a feeding speed of at least 1 meter/week to avoid molding and rotting of the silage. This can be done by taking out approximately 15cm per day, depending on the herd size.
- Establish good silage management during feeding out of silage. It is essential to avoid heating up of the silage by making sure there is least possible disturbance of the face of the pit. It is recommended that famers use tools such as a fork hoe or jembe and take out silage by slicing along the whole length, including the sides, of the frontside of the pit.
- To feed enough quantity, roughage is recommended to be ad lib available for the cows. This means cows should have unlimited access to feeds.
- Troughs have to be cleaned every day and leftovers have to be removed so that fresh feeds do not get mixed with old feeds. The corners of the troughs have to be cleaned with a brush every day and possibly with water. Especially when the farmer uses wooden troughs this has to be done consequently.
- It is recommended to use feeding troughs with a smooth and easy to clean surface, this will reduce heating up of feed and maintain the quality of feed during feeding.
- To reduce low quality leftovers, fresh feeds have to be chopped into pieces of 2-4 cm before feeding by using a power-driven chopper, hand operated chaff cutter or a

panga, making feed more palatable and digestible. This will increase intake, fibrousness and digestibility for the cow.

- Most of the time, it is recommended to leave the face of the pit open to prevent heating up and rotting, unless heavy winds are blowing directly into the face of the silage. Resealing is only needed when feeding is stopped.
- When it is only possible to feed low quality roughage because of circumstances, such as drought. Low utilization of low – quality roughages can be increased by supplementing with a nitrogen supplement. Mixing roughage with nitrogen supplements such as sweet potato vine leaves can increase intake and therefore increase milk production. It will not increase the quality of the low-quality feeds.

6.1.4 Recommendations for method of research

- It is recommended to include the aspects that will also be discussed during the training. Such as young stock, housing and farm manager(s). These different aspects and events have an influence on the farm management and eventually on the milk production.
- Be certain to check if all the methods are the same when data is collected. Also when someone else has gathered data.
- The score system that was used for judging the quality and quantity of the roughage is recommended to be more extensive. The different scores for quantity can for instance be categorized in different weights.
- To adequately reason the quantity of roughage in relation to milk production, calculating the dry matter intake is of much added value to this research. This can be added to the score card.
- The measurement of quality can best be improved by measuring the temperature and acidity of roughage in the feeding trough and in the silage pit.
- A shaker box can be used to check the particle size distribution, chopping length and the different raw materials in the ration. This can be added to help judge the quality and quantity of the roughage.
- Because of the different weather conditions such as the wet and dry seasons during the year it is recommended to take in consideration to collect data in the same period, with the same period in between data collections or even on the same date when data is collected again after one year. This way data is based on the same circumstances and weather influences.
- To analyze data further and more specific, SPSS can be used when done further research.

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Annex 1 – Baseline study

Farm	Location	Acreage under fodder	Land under dairy	Total land	Total herd	Lactating cows	dry cows
Mugambi Farm	Kariene	1.75	2	4	6	3	0
Giitu Farm	Kariene	1.25	1.5	4	6	2	0
Kinyua Farm	Kariene	1.25	1.5	2	6	2	1
Gitonga Farm	Kiungune	1.25	1.5	4	6	2	1
Francis Gituguti	Nkarine	1	1.5	3	11	2	1
Nkoroi Farm	Bubwi	1.75	2	5	8	4	2
Munene Farm	Kariene	2.75	3	5	15	6	1
Kiruja Farm	Nkuene	0.75	1	2	5	3	0
Muthoni Farm	Ndariani	1.5	2	3	4	3	0
Mlajasho Farm	Mweru	4	4	6	11	5	2
Mugwimi Farm	Njerune	1.25	1.5	6	4	2	1
Mutua Farm	Kaukune	0.75	1	3	6	3	0
Murimi Farm	Kiiune	3.25	3.5	4.5	5	3	1
Manjau Farm	Nkuene	1	1.25	2	5	3	0
Mbae Farm	Geeto	1.75	2	14	4	0	3
Kimathi farm	Kamramba	1.5	1.5	2	5	0	3

Farm	Current milk production	Milk sold	Used concentrates	Fodder types	Volume of fodder (kg)
Mugambi Farm	40	32	16	Nappier grass,maize	40
Giitu Farm	45	39	8	Maize,Nappier grass	15
Kinyua Farm	20	17	10	Maize,Nappier grass	0
Gitonga Farm	40	35	8	Maize,Nappier grass,Lucerne	15
Francis Gituguti	27	14	7	Green maize	50
Nkoroi Farm	45	35	20	Maize,Nappier grass,sweetpotato vines	0
Munene Farm	50	40	24	Maize,Nappier grass	3
Kiruja Farm	23	20	15	Maize,Nappier grass	8
Muthoni Farm	12	10	8	Maize,Nappier grass	0
Mlajasho Farm	56	53	35	Maize	65000
Mugwimi Farm	15	12	8	Maize,Nappier grass,sunflower	10
Mutua Farm	15	12	12	Maize,Nappier grass	0
Murimi Farm	35	28	15	Maize,Nappier grass	8
Manjau Farm	28	25	15	Maize,Nappier grass	3
Mbae Farm	0	0	12	Maize,Nappier grass	0
Kimathi farm	0	0	8	Maize	15

Annex 2 – Question list

Herd Characteristics
What dairy breeds does the farm have? (only first visit)
Number of lactating cows
Number of dry cows
Number of male calves (<12 months)
Number of females (<12 months)
Number of bulls (>12 months)
Number of heifers (> 12months)
What is the current milk production (kgs)
Land Details
What is the total land size for the farm (acres)?
What is the water availability? All year around or limited availability?
What is the soil type?
What is the total land size for the fodder type (acres)?
What is the total land size used for dairy farming (acres)?
What are the fodder types grown? Which varieties?
How many acres per variety of fodder type?
Roughage production
What tillage is being performed?
Is irrigation used? How often and how much?
Is manure or fertilizer used? Quantities?
Are pesticides/insecticides used? Quantities?
Is there any protection against other (loose) animals?
How is roughage harvested?
How is roughage transported after harvesting?
Roughage conservation
What method is used? Use of cement pits, dug out pits, bags etc.
What fodder types are being conserved?
What is the quantity of fodder conserved?
What is the quality of the roughage in conservation?
What is the quality of the silage? (airtight, size, molds, compacted, use of plastics)
How is silage taken out (covered again, dry, removal of molds and rotting parts, taken out evenly)
Feeding
What is the frequency of feeding?
What is the quality and quantity of the roughage being provided? (using table 3)
How much of each fodder type is fed per day/cow (kgs) (also using table…)?
Is there any use of concentrates? Quantities?

Are the different types of feed mixed?
Is the trough cleaned before feeding fresh roughage? Yes/no
Is the roughage easily accessible for the cows?

Annex 3 – Competences in Dutch

De competenties die ik tijdens het schrijven van mijn afstudeerwerkstuk verder zou willen ontwikkelen zijn: globaliseren, onderzoeken, samenwerken en zelfsturen. Deze 4 heb ik gekozen omdat ik in een internationale omgeving onderzoek doe veelal in een team waarin ik mijn kwaliteiten zo goed mogelijk naar voren wil laten komen. Hoe ik deze competenties tot niveau 3 wil ontwikkelen zal verder worden besproken in dit hoofdstuk.

Globaliseren

- Doordat je steeds met nieuwe mensen werkt uit andere teams leer je jezelf aanpassen. Ook doordat de omstandigheden steeds veranderen leer je hoe hier mee om te gaan. Alle bedrijven die ik ga bezoeken zijn nieuw voor mij, ik ken de mensen en de bedrijven nog niet. Door mijzelf open op te stellen en veel vragen te stellen toon ik mijn interesse en belangstelling en kan ik mijzelf verder ontwikkelen.
- Door mee te leven met het dagelijks leven in een ander land en de trends en ontwikkelingen van de veehouderij mee te maken.
- Doordat de cultuur anders is leer je nieuwe contacten te leggen en te onderhouden op een andere manier.

Onderzoeken

- Door verschillende boeren advies te geven en hierbij de gevolgen op lange termijn in te denken denk ik dat ik op deze manier aan deze competentie kan werken.
- Doordat kleinschalige boeren nu voornamelijk veel voor eigen huishouden produceren probeer ik met het advies dat ik kan geven vooruit te denken dan alleen de boerderij zelf en te denken aan de bevolking door hiervoor in de toekomst te kunnen produceren.
- Doordat de boeren het voornamelijk met de middelen moeten doen die ter beschikking zijn, moet er innovatief over oplossingen nagedacht worden. Door mijzelf in deze kleinschalige boer te verplaatsen denk ik dat ik veel kan bereiken.
- Ik ga vooral proberen advies te geven en de boeren proberen te overtuigen dat het de juiste kennis is die ik overdraag aan hun, want ik kan mij voorstellen dat de kleinschalige boeren weinig kennis hebben waardoor het moeilijk te begrijpen is voor hun hoe het op de juiste manier gedaan moet worden. Door mijn kennis te delen en mij hierbij in te leven in de situatie waar deze boeren voor staan. Voor hun kan het soms tegenstrijdig zijn omdat er weinig kennis is.
- Ik hoop met hoe ik de deelvragen geformuleerd heb de hoofdvraag te kunnen beantwoorden. Door discussies en gesprekken met boeren of experts van SNV aan te gaan denk ik dat ik veel onderzoek kan verrichten.

Samenwerken

- Doordat de cultuur anders is, is het goed om door de teamleden van SNV te laten zien hoe men met elkaar omgaat in deze cultuur. Niet alleen voor het belang van de boeren, maar ook voor de relatie tussen mij en de teamleden, ik denk dat hierdoor de samenwerking beter kan verlopen.
- Door voor een goede sfeer tussen de boer en de adviseur te zorgen denk ik dat er heel veel bereikt en respect verkregen kan worden. Dit kan gedaan worden door respect te hebben voor de situatie waarin de boer zit en respectvol en begripvol om te gaan met elkaar. Door onder andere interesse te tonen, maar ook door discussie aan te gaan.
- Door te overleggen en in discussie te gaan met de experts van SNV kan er gezamenlijk een advies gegeven worden aan de boer. Doordat de experts en de boer

elkaar al vaker gezien hebben is er een andere relatie tussen hen waardoor er door de expert aan mij verteld kan worden hoe advies gegeven kan worden en op welke punten gelet moeten worden.

Zelfsturen

- Doordat informatie en middelen soms beperkt zijn krijg ik inzicht in mijn eigen handelen en denken. Ik ga proberen hieraan te werken door op zulke momenten beslissingen durven te nemen en door door te vragen over de situatie.
- Doordat je soms risico's moet nemen leer je waar je eigen valkuilen liggen en hiermee om te gaan.
- Door mijn eigen mening uit te spreken tegenover andere teammembers denk ik dat ik mijn sterke punten het beste kan benutten doordat hierdoor eerlijk gecommuniceerd wordt met elkaar en iedereen elkaar feedback kan geven.
- Door een deadline te stellen kan ik tijdens het schrijven van mijn scriptie in de gaten houden of ik het op tijd af kan hebben. En zonodig de deadline aanpassen.

Annex 4 – Checklist report writing

Name: Imre van der Kolk
Group: 4dvb

*The assessment criteria marked with a * are 'killing points'. If the assessor has ticked more than five of them, you must improve the report on all insufficient parts. No killing points are allowed in the thesis/report.*

1. Use of English
- ☐ Contains no more than three grammatical, spelling and typing errors per thousand words; the report is then rejected*.
- ☐ Has an active writing style*
- ☐ Is professional, formal and objective *
- ☐ Is coherent (referral and linking words)*
- ☐ Contains correct punctuation*
- ☐ Does not contain the personal pronouns 'I/me/me, you/you/you, you, you, we/we/us' *
- ☐ Is attuned to the chosen target group*
- ☐ Has a uniform style*

2. The organisation
- ☐ The report has a logical structure
- ☐ Each chapter has a logical paragraph structure
- ☐ Each chapter has an introduction (except ch.1)

3. The report/ thesis
- ☐ Is free of plagiarism*
- ☐ The pages are numbered*
- ☐ Has a uniform format

4. The cover
- ☐ Displays the title
- ☐ Author(s) is/ are mentioned

5. The title page
- ☐ Title is specific*
- ☐ Author(s) is/ are mentioned in alphabetical order*
- ☐ Date and place of publication are mentioned*
- ☐ The sponsor/client of the report is mentioned*

6. The preface:
- ☐ Contains personal reason for writing
- ☐ Contains acknowledgement (”I” form permitted in the preface)

7. Table of contents:
- ☐ All parts of the report are numbered*
- ☐ The summary and appendices are included
- ☐ Table of contents is clear/ structured
- ☐ Page numbers are consistent

8. The summary:
- ☐ Is a concise version of the entire report
- ☐ Contains the conclusions
- ☐ Includes suggestions for further research
- ☐ Does not contain personal opinions
- ☐ Directly after the table of contents

9. The introduction:
- ☐ Is chapter 1*
- ☐ Describes the context, problem demarcation and justification*
- ☐ Provides content relevant background information*
- ☐ Contains the problem definition/research question*
- ☐ Includes the objective(s) of the research
- ☐ Contains a report

10. Material and method
- ☐ Describes the research method used
- ☐ Justifies the choice of the research method used
- ☐ Matches/is in line with the problem definition/research question*
- ☐ Describes the research variables/units
- ☐ Describes the method of data analysis

11. The (construction of the) core
- ☐ The chapters and the (sub)sections with a maximum of three levels are numbered *
- ☐ Chapters and (sub) paragraphs have a fitting title
- ☐ A chapter covers at least one page
- ☐ New chapters start on a new page
- ☐ Sentences are typed in sequence, without hard return within the paragraph
- ☐ Figures are numbered and have a fitting title, which is put below the figure.*
- ☐ Tables are numbered and have a fitting title, which is put above the table*
- ☐ Tables and figures can be understood independently
- ☐ Figures and tables are referred to in the text*
- ☐ Each appendix is specifically referred to in the content
- ☐ The text can also be understood without references

12. The discussion of results
- ☐ Includes the interpretation(s) of the results
- ☐ Contains a comparison with relevant literature
- ☐ Contains a review of relevant sources
- ☐ Valid argumentation is provided
- ☐ Contains a critical evaluation of own findings

13. The conclusions and recommendations
- ☐ Contains answer(s) to the research question
- ☐ are based on relevant facts and / or discussion
- ☐ Does not contain any discussion or information that does not appear elsewhere in the report text*

14. References
- ☐ References in the text are in accordance with APA standards*
- ☐ The source list conforms to APA standards *

15. The Annexes
- ☐ Are all numbered
- ☐ Each annex has an appropriate title
- ☐ Do not contain the author’s own analyses
- ☐ Are clearly structured/displayed

Annex 5 – Roughage and milking cows April 2018 vs May 2019

Farm in April 2018	Production	Conservation	Utilization	Acres of land for fodder production	Milking + dry cows
1	Maize	No silage	Banana leaves, maize cobs	2	1
2	Maize	No silage	Napier grass, maize stovers	5	4
3	Maize, Napier grass	No silage	Napier grass, beans, maize stovers	3.25	4
4	Maize	Maize silage (1 pit/year)	Napier grass	12	13
5	Maize, Napier grass	No silage	Banana stems and leaves, grass from the roadside	4	3
6	Napier, sweet potato vines, maize	No silage	Banana leaves, dried grass	2	2
7	Maize, Napier grass	No silage	Napier grass	1.25	2
8	Maize, Napier grass, desmodium	No silage	Napier grass, maize stovers	3.5	7
9	Maize, Napier grass, Lucerne	No silage	Napier grass	1.25	3
10	Maize, Napier	No silage	Napier grass	2	2
11	Maize	No silage	Napier grass	4	7
12	Maize, Napier grass	No silage	Napier grass, maize stovers, banana leaves	2.5	3
13	Maize, Napier grass	No silage	Napier grass, maize stovers	1	4
14	Maize	No silage	Napier grass	8	5
15	Maize, Napier grass	No silage	Napier grass, banana stems, maize stovers	1.25	9
16	Maize	No silage	Napier grass, banana stems and leaves	1.8	3

Farm in May 2019	Production	Conservation	Utilization	Acres of land for roughage production	Milking cows + dry
1	Maize, bracharia, Napier grass, Rhodes grass	Maize silage	Maize silage, Rhodes, Bracharia and Napier grass, dairy meal	5	2
2	Maize, desmodium, sweet potato, bracharia.	Maize and Napier silage	Maize, desmodium, sweet potato vines, bracharia, dairy meal,	11	7
3	Maize, napier, bracharia.	Maize silage	Maize silage, napier, bracharia	14 ¼	9
4	Maize, bracharia, napier, sweet potato.	Maize silage	Maize silage, bracharia, sweet potato vines, dairy meal	13	9
5	Maize, napier grass, sweet potatoes, caliandra	Maize silage	Maize silage, napier grass, sweet potato vines, caliandra	4 ¼	4
6	Napier, sweet potato, caliandra, maize	Maize silage	Maize silage, napier, sweet potato vines, dairy meal	2	3
7	Napier grass, maize, sweet potatoes	Maize silage	Maize silage, napier.	3	4
8	Maize, napier, sweet potato, bracharia, desmodium, caliandra	Maize silage	Napier, maize silage, bracharia	5	6
9	Maize, napier grass, sweet potato,	Maize silage	Napier grass, maize silage, sweet potato vines, dairy meal	4 ½	6
10	Maize, napier grass, sweet potato	Maize silage	Napier grass, maize silage, sweet potato	3	5
11	Maize, napier, sweet potatoes, caliandra, desmodium	Maize and napier silage	Maize silage, napier grass, dairy meal.	7	8
12	Napier grass, maize,	Maize and napier silage	Maize silage, napier grass,	3	5

	panicum grass, sweet potatoes		sweet potato vines, fresh grass		
13	Bracharia, desmodium, sorghum, maize	Maize and sorghum silage, bracharia hay.	Bracharia, desmodium, sorghum silage or maize silage, hay.	6	7
14	Maize, Napier grass	Maize silage.	Maize silage, Napier and Rhodes grass.	14	5
15	Maize, napier grass, sweet potato.	Maize silage	Napier grass, maize silage, sweet potato vines	1 ¾	3
16	Maize, sweet potato, napier grass	Maize silage	Napier grass, maize silage, sweet potato vines.	1 ¾	2

Annex 6 – Quantities of roughage per farm in kg

Farm	Maize silage	Fresh maize	Fresh Napier grass	Desmodium/bracharia	sweet potato	bracharia/Napier/Rhodes	Bracharia	Sorghum or maize	hay	Total
1	23					23				46
2	20		30			5				55
3	20		6				3			29
4	17		3				4			24
6	24		10		0.5					34.5
7	15		20							35
8	17		25				3			45
9	15		30		0.5					45.5
10	12		15		2.5					29.5
11	37		30							67
12	10	20	10					16	2	42
13				9						25
14	15					10				25
15	10		7		2.5					19.5
16	15		5		0.5					20.5

Annex 7 – Land degradation hazard areas in Kenya