Integrated & Climate Smart Innovations for Agro-Pastoralist Economies and Landscapes in Kenya's ASAL (ICSIAPL)




FORAGE PLAN FOR OLOSENTU RANCH, NAROK COUNTY

Jos Creemers, Felix Opinya
ProDairy East Africa Ltd

Nairobi, March 2022

TABLE OF CONTENTS

LIST OF TABLES

LIST OF MAPS

LIST OF BOXES

CHAPTER 1: BASELINE

1.1. Farm profile

Description	Response
Owner (Surname)	Mrs. Otwala
Year of inception	1988
Location	Shankoe Ward, South from Kilgoris
Sub-County	Transmara West
Agro ecological zone	Semi-Humid
Rainfall	1,450 mm
Size farm (acres)	1,000 acres (400 ha)
Home steads, roads and water dam(s)	100 acres (40 ha)
Herd size / composition	700 heads of Sahiwal cattle including young stock (40 milking)
Milk production	2 litres/cow per day
Total day production	73 litres/day
Feeding system	Free range grazing
Other livestock (sheep & goats)	300 shoats
Breeds of cattle	Sahiwal
Number of finished animals per year under these production systems:	Free grazing: All Semi-zero grazing: None
Category of cattle on supplementary feeding	Lactating cows
Sales price per kg live weight (LW)	KES 160 / kg LW
Acres of natural pasture	800 acres for grazing (320 ha)
Number/size of paddocks	None
Water points in paddocks	None
Water source	Dam
Acres of cultivated improved pasture	10 acres Rhodes grass
Home paddocks	10 acres Star grass
Acres different forage/food crops	Total 100 acres such as: Rhodes grass, Maize
Preserved forages	Hay/bales (weight/bale): None Maize silage/tonnes: None
Ration cows	Free grazing: Cows in milk:
Water availability	Dam/m3 metres Borehole/yield Storage tanks/total m3
Electricity	National grid (3 phase)
Other facilities	Milking parlour Feed station for milling, grinding and mixing feed ingredients
Stores/haybarn	Store for feeds
Biogas unit (Type and m^3)	N/A
Bio security	None
Spray race / Cattle Dip	Cattle Dip

1.2. Background

Olosentu Ranch has partnered with ICSIAPL to set up demo plots for improved forages. Forage crops planted include Rhodes grass, Panicum and forage legumes such as Sunn hemp, Desmodium, and Lucerne. The Rhodes grass are mainly planted for grazing and hay making, although with varying success rates. It is possible to grow forage sorghum and forage maize for silage though the ranch is yet to try. The level of mechanization on the 800-acre ranch is limited to a tractor, trailer and disc plough. The ranch mainly grazes their cattle on natural grass and in the recent past set up an on-farm feed mill to supplement grazing; which mainly uses sunflower seed meal, wheat bran, molasses, minerals and crop residues. Although they stock the Sahiwal breed for beef, 40 breeding cows, all in their early lactation stage are being milked. The ranch does not have formal sales agreements and sell animals for slaughter to dealers through the common meat marketing channels.

CHAPTER 2: FARM DESCRIPTION

2.1 Location

Olosentu ranch is located in Shankoe Ward, west of Kilgoris in Trans Mara West Sub County county, Narok County.

Map 1: Shankoe Ward where Olosentu Ranch is located (in red)

2.2 Ecology

The climatic condition of the area generally warm and temperate. Even in the driest month there are lots of rain in Kilgoris. More specifically, Kilgoris receives an average annual rainfall of 1439 mm and annual temperature of 18.4 °C.

Precipitation is the lowest in July, with an average of 38 mm. Most of the precipitation here falls in April, averaging 214 mm (see annex 2). February is the hottest month of the year with an average temperature of 19.3 °C while July is the coldest month, with temperatures averaging 17.6 °C. Throughout the year temperatures vary by 1.7 °C. Between the driest and wettest months, the difference in precipitation is 176 mm. April is the month with the highest relative humidity (76.35 %) while October is the month with the lowest relative humidity (60.96 %). The month with the highest number of rainy days is April (16.6). The month with the lowest number of rainy days, 6.7, is July (see annex 1).

Olosentu ranch is situated on a plateau and high-level structural plain in a semi humid agro ecological zone (see annex also referred to as the UM 2 - 4 = Coffee-Maize Zone at times transitioning and mixing (depending on soils and microclimate) of zones UM 2, 3 and 4 with a very long cropping season and intermediate rains (see annex 3).

The soils (annex 4) are mostly imperfectly drained, very deep, very dark greyish brown to black, very firm, cracking clay, with a topsoil of friable, clay loam, with a humic topsoil: verto-orthic Gleyzems.

In some isolated areas, the soil (annex 4) may be imperfectly drained, moderately deep, brown to dark yellowish brown, mottled, friable, gravelly sandy clay loam; in places rocky and shallow: gleyic Acrisols, partly paralithic and rocky phase.

Cultivating lands for forage crop production is challenging because some of the lands have red soils with hard pans of murram under the topsoil varying from 10 – 40 cm deep. On most of these lands, white coloured stones can be found, at 20-40 cm depth, which are brought to the surface during (deep) ploughing. The occurrence of stones on top of the soil limits mechanization of harvesting activities because it damages farm implements.

The grey- back soils mostly have deep workable topsoils but are quickly waterlogged during the growing season (wet season). The disadvantage is that good, palatable and productive, quality grasses do not grow well in waterlogged areas.

2.3 Integrated pasture grazing management

Integrated management of natural grassland at Olosentu Ranch involves livestock grazing management, intensive rehabilitation of the natural grassland, forage cultivation and harvesting for hay making; although so far restored, cultivated Rhodes grass pastures are used from limited areas and size. Wildlife (zebras, giraffes and elephants) at times do enter the ranch in search of water or grazing vegetation. All management actions related to livestock grazing, hay and improved forage production, and rehabilitation of natural grassland, are conducted for the purposes of improved livestock production. In the ranch, there is no intension to restore the natural landscape with the goal to conserve wildlife and biodiversity within the ranch.

The grazing management targets appropriate stocking of healthy livestock predominantly a Sahiwal dual purpose herd. The approach for grazing management is “rotational” grazing which is planned based on animal days of forage available after accounting for grazing wildlife consumption when relevant during periods of the year.

The livestock is rotationally grazed among grazing zones/paddocks according to forage availability. Whether an area is to be grazed or rested from grazing is decided by the management in accordance with light or heavy past grazing and the locations of (movable) bomas and water points.

Ideally the grazing management increasingly utilizes short-duration, high-impact restorative grazing, targeted resting, and targeted grazing and browsing, according to management and rehabilitation needs. In line with this an increase of the number of watering points and the introduction of mobile bomas in combination with re-seeding immediately after the boma is replaced can contribute towards rehabilitation of natural grassland.

Some areas, although limited, are used for improved forage production and harvesting of hay. Intensive rehabilitation is conducted in some areas, especially in areas degraded by major encroachment of unpalatable grasses, such as *Sporobolus indicus, Solanum incanum* and other species, into the grassland. Currently, soil from a nearby road construction site is brought into the ranch. This soil is added onto the existing layer of topsoil and covering the invading species. The expectation is that the increased layer of soil will improve the potential for rehabilitation of natural grassland. It needs to be considered that this soil, which originates mainly from existing roadside is contaminated with seeds of invasive species such as *Sporobolus indicus* and *Solanum incanum* and possibly other invasive, unwanted species thus bringing with it the risk of a pool of seeds from invasive

species. In addition, without disturbing the underlying subsoil of murram or establishing draining infrastructure, water logging may only improve slightly for a short period. Starting a land improvement program which is a combination of subsoiling (see annex 7, 8) and draining infrastructure (see box 1) connected to water dams, pans for rainwater harvesting will have a more lasting effect on potential of land for pasture and forage crop development. Wildlife management is not applicable other than some wildlife species coming to graze and water with the cattle during shorter, dry periods of the year.

2.4 Livestock and types of operations

1. Cow-calf (breeding herd) production is the first stage of the beef production process. An average of about 2.2-3 years elapses between the breeding of a beef cow or heifer to the time their offspring are ready for slaughter. Heifer calves may be retained for herd expansion or replacements, sold to other livestock keepers as replacements, or sold together with the bulls/ steers to farmers who fatten/finish the animals through grazing or in a feed lot ready for slaughter.
2. The Sahiwal breed being a dual-purpose breed, the ranch milks approximately 40 cows on average during the year. This group of animals are kept closer to the farm homestead and structures. Here some permanent boma's with Star grass (*Cynodon dactylon*) is available and supplementary feeding is given before and/or after milking.
3. A beef production system is implemented from the time calves are weaned until they are placed in a feedlot. During this period the live weight gains are accomplished as economically as possible by making maximum use of forage grasses growing in Olosentu ranch. During periods of scarcity, in addition to grazing, some supplementation feed may be given to the herd. An optimal weaner – bull beef plan will induce up to 150 kg of weight gain in the weaned bull/heifer calves. The weight gain during this period comes primarily in the form of muscle and frame development, with little from fattening. Little, if any, supplementation with hay, silage or grain is used during this period.
4. The intention is to finish animals in a feedlot on hay/concentrate and/or silage diets to achieve a higher (maximum) weight gain in the shortest period. For this purpose, bulls raised on the ranch can be grouped to achieve high returns. The ranch has put a feed milling station in place and purchases and partly grows forages such as Sunflower (*Helianthus annuus*) as feed ingredient for an on-farm produced concentrate.

2.5 Beef cattle and breeding purpose

Beef cattle are divided into two different groups: maternal breeds vs terminal breeds. Generally, maternal breeds are known for their milk production and mothering ability while terminal breeds are known for their growth and meat producing ability. Some breeds are also known as dual purpose breeds because they combine muscling for meat production with excellent maternal characteristics. Crossbreeding can help the management of Olosentu ranch to combine the best attributes of individual breeds.

At Olosentu Ranch most of the herd consists of Sahiwal cattle and the goal is to keep a purebred herd. Sahiwal is a dual-purpose breed with good maternal characteristics and can be used as the maternal breed. Crossbreeding, so far, has not been practiced but for finishing group of bulls a terminal breed with higher growth rate (live weight gain) (e.g., Boran) and early maturing characteristics may be economically interesting. The area, being semi humid has the possibility to use crossbreeding as a herd

improvement program? in the direction of milk production as well as beef. In the future a terminal, early maturing (exotic) breed such as Simmental could be used for finishing/fattening bulls.

To identify animals branding is used to show animals are owned by Olosentu Ranch. For identification of individual animals currently the use of an individual cow identification system is being discussed. This will be essential to make tracking and tracing in a herd recording system for individual animal performance possible. Breeding technologies such as artificial insemination (AI) have been tried and are on a limited scale used but are generally not successful.

Normally on a beef ranch the sole source of income comes from the calves produced each year. So, it is important that cows produce a calf at least every 12 months. The ranch management must be conscious of selecting, as well as keeping productive cows who will produce a calf every year without assistance, maintain their body condition without becoming overly thin or fat, and raise a calf with an average weaning weight that meets the goals of the ranch management.

2.6 Herd size and composition

The herd composition is not known other than that there are 700 head of Sahiwal cattle and 300 shoats. However, it is advisable that at least a monthly overview as shown in the table 1 below is produced for management purposes while more detailed overview can only be produced with an effective individual cow identification system in place.

Table 1: Example of herd composition overview

Breeding herd	**Monthly count**	**End of year count**
Number of cows in herd		
Number of breeding bulls		
Number of calves born		
Male		
Female		
Dead		
Number of calves weaned		
Male		
Female		
Replacement stock		
Number of heifers (1-2 years)		
Number of heifers (>2 years)		
Number of bulls on pasture		
Number of bulls (1-2 years)		
Number of bulls (2-3 years)		
Number of bulls (>3 years)		
Number of bulls in feed lot		

Targeted live weight at sale is 400 kg. Currently bulls are not supplemented and finished on grazing pasture only. Supplementation with a concentrate mixture has been tried but found not to be cost effective due to high concentrate : forage ratio that needed to be used to achieve fast live weight gain. This did not justify the costs taken into consideration the prices per kilogram of liveweight for the bulls at point of sale. The ranch is not making use of castrates (steers) though steers have an advantage over bulls in that they can be run in larger mobs and are more suited to extensive farming systems.

Bigger herds (mobs) can be mixed together easily and steers have fewer behavioral problems than bulls. Some disadvantages of steers are that they may cost more to purchase on a KES/kg basis, have slower growth rates than bulls, and can have grading problems with too little or too much fat cover (when delivering directly to meat processors) and hence discounts on final sale price.

When diversifying to a feed lot system, to maximize growth performance, the management of the ranch needs to make sure there is adequate pen and bunk (feed fence) space for growing and finishing cattle. If space per animal is limited, then consider decreasing animal numbers or making barn renovations to increase space. Limited pen or bunk space will reduce the feed intake of less dominant animals compared to more dominant animals, because cattle function in a social order. Thus, overcrowding feedlots has negative effects on animal performance. Purchasing of concentrate ingredients in the future needs to be based on filling the gap of the available forage grasses (herbage) grazed by the animals and the relation between price and nutritive value of the feed ingredients. The feed formulation tool Rumen8 can assist to determine economical price ranges of feed ingredients and the best optimized ration.

When diversifying to dual purpose herd, to optimize milk production, the management of the ranch needs to make sure there is improved and adequate (temporary, electrified, paddocked pasture available for, preferably 24 hours per day instead of the 2 hours grazing on small paddock with predominantly Star grass. This will reduce the need for supplementary feeding with commercial feed ingredients which are generally too expensive at the current milk production levels (2 – 5 litres/cow/day). The space for supplementary feeding, though limited, of the Sahiwal herd in lactation has already been created and is in use (see annex 5), limited space and the feed bunk or feeding trough reduces feed intake of less dominant animals compared to more dominant animals.

In Olosentu ranch sheep and beef cattle are farmed together. From a management viewpoint sheep and beef cattle farms are relatively complex with the same pastures/designated grazing areas having to meet several different feed requirements, including feeding ewes and beef cows, finishing lambs and bulls for slaughter. However, the number of sheep kept are limited to 300 mainly Dorper sheep breed. The sheep are served with Dorper rams. The long-term objective is to have a flock of Dorper sheep. The cultivated, with Rhodes grass improved paddocks give the impression that they are not only over grazed with cattle but that particularly sheep keep the grass too short which hinders fast re-growth. The Rhodes grass is not given enough time to recover and animals are removed from the paddocked pastures remaining with too little pasture stubble.

2.7 Performance levels

Currently 40 animals are milked and in the future the ranch may consider milking some Sahiwal cattle for the local milk market. Milk processors are increasingly interested to collect milk in the semi-arid areas and Olosentu Ranch with a herd over 700 head of Sahiwal cattle is well positioned to supply milk to the processors. The total herd production now stands at 73 litres of milk per day which is an average of approximately 2 litres of milk per cow per day. Improved grassland and availability of conserved, better-quality forages can easily triple the current production level.

Mortality rates per animal category over the last years are low but no exact figures are known.

Based on the interview with the managers and other key persons on the ranch, it is concluded that there is no functional system in place for individual cow identification. This limits the possibility for an effective analysis of the ranches results and progress in term of herd performance. The key performance indicators such as annual mortality rates per animal category, the number of animals present per animal category during the animals count end of month/year, number of animals sold and other key performance indicators such as calving interval, number of cows bred, number of cows in calf, growth rate, morbidity, (in)voluntary culling, average age of the herd, etc. are not available.

2.8 Handling facilities, farm mechanization and fencing

One of the most important facilities in a cow-calf enterprise is a holding boma, crush and a chute. These are essential for normal management and health maintenance practices (e.g., vaccination and deworming), as well as for pregnancy testing or assisting a cow at calving. Currently there is 1 water points/troughs, 1 cattle crush, no weighing station, 1 cattle dip, 1 milking parlour with feed lot, 1 loading ramp, feed milling and mixing station, office buildings and stores.

The ranch further has a New Holland tractor, trailer, disc plough. For all other mechanized services, the ranch borrow/rents the implements or must hire contractors. The ranch does not make use of synthetic fertilizers and only uses animal manure for fertilizing the soil.

2.9 Water supply, facilities

Water is possibly the most important nutrient because it impacts feed consumption. Poor-quality water or not enough water can decrease feed intake and result in decreased animal performance. The ranch can supply water using anything from buckets to troughs to giving animals access to water (see annex 4) reservoirs or water pans. However, the key is that water should always be fresh, clean, and available or as frequently made available during the day.

In total the ranch has 1 water dam. The water sources therefore are limited and in the dry season the animals have to walk long distances to a watering point. The cattle are tracking 4-7 km every day to a get access to water. During drought there is intense competition of the available water with wildlife, in particular zebra and elephants, who are attracted by the water.

2.10 Strategy to improve water availability and water quality

Surface runoff is the water flow that occurs when the soil is infiltrated to full capacity and excess water from rain, melt water (hailstones), or other sources flows over the land. This is a major component of the water cycle, and the primary agent in water erosion but it is the main ‘source’ of water for Olosentu ranch.

Rainwater harvesting is the accumulation and storing of rainwater for reuse before it reaches the aquifer. It has been used to provide drinking water, water for livestock, water for irrigation, as well as other typical uses. Rainwater collected from the roofs of houses can make an important contribution to the availability of drinking water. It can supplement the subsoil water level.

2.10.1 Draining waterlogged land for crop production

The aim/objective of agricultural land drainage is the optimized agricultural production related to (i) reclamation of agricultural land, (ii) conservation of agricultural land (iii) optimization of crop yield, (iii) crop diversification (iv) cropping intensification and (v) optimization of farm operations.

The function of the field drainage system is to control the water table, whereas the function of the main drainage system is to collect, transport, and dispose of the water through an outlet preferably into a dam, pan or reservoir. In Ololsentu ranch, a surface field drainage system is meant to function as regularly as possible to prevent undue waterlogging at any time.

Surface drainage is the orderly removal of excess water from the surface of land through improved natural channels or constructed ditches and through shaping of the land surface. Surface drainage applies primarily on flat land where slow infiltration, low permeability, or restricting layers in the soil profile, or shallowness of soil over rock or deep clays, prevent ready percolation of rainfall, runoff, seepage from uplands, or overflow from streams through the soil to deep stratum. The land surface - to be drained should have a continuous fall to the field ditch and the field ditch should have a continuous grade to the field lateral. The water surface in the field lateral at design depth should below enough to drain the field.

The field surface drainage systems, which start functioning as soon as there is an excess of rainfall and operates entirely by gravity. They consist of reshaped or reformed land surfaces and can be divided into: (a.) bedded systems, used in flat lands and (b.) graded systems, used in sloping land. The bedded and graded systems may have ridges and furrows.

Ditches for surface drainage are usually designed to remove the runoff produced by an ordinary rain in time to prevent damage to the crops grown in the drainage area. Surplus water running over farmland will keep it saturated for longer, reducing crop and pasture growth and increasing problems such as pugging and tractor mobility. An area should only have to deal with the rainfall falling on it, not also the rain that fell on the area's further upslope. Therefore, adequate surface drains need to be installed along fence lines, laneways, depressions etc, so that surface water can be controlled more effectively. Care must be taken to ensure that potential problems such as scouring and erosion are not created by concentrating flows. In some cases, surface drains will need fencing off so they can be protected from stock and tractor damage.

Box 1. Design of an open drain system

Of all the different types of surface drainage systems ditches or open drains will be the most appropriate. The open drains vary in size and length and can be simply categorized as follows:

Shallow surface drains (up to ~0.3m deep) formed by hand shovel or "levelling blade" (annex 5 see picture 4) are most useful for removing ponded water from shallow depressions to larger drains or streams. They are generally not suitable for draining large flat areas. They tend to be temporary in nature since they are often pugged by animals, silt up quickly, over grow with less desirable species, wrecked by machinery in wet weather and so on. They are very inconvenient for feed out or passenger vehicles and fodder conservation equipment.

Medium sized drains (0.3m to ~ 1m deep) made by excavators or specific drainage machines are usually "V" shaped with a flat bottom with enough slope (gradient) to ensure that the water is removed quickly but not cause scouring of the drain walls or bottom. This is usually not a problem because they are used on the flatter areas. The velocity of water flow should be slow on the sandy and sandy clay loam soils and can be quicker on the clays and clay loams. The slope or batter of the drain banks should be such that the banks do not collapse when wet. Each soil type has its own natural slope that will not collapse and machine formed banks should be similar or even less steep. Clays may have a batter of 1:1, silty and clay loams 1:1 to 1:1.5, and sandy loams 1:1.5 to 1:2, while looser sandier soils should be 1:2 to 1:3+. The size of open drains depends on the amount of water to be removed or intercepted and formulae are available to calculate the required design parameters. The time to construct open drains is when the topsoil and sub soil is soft enough to dig but water presence is not a problem, usually in October.

The main drainage systems consist of deep or shallow collectors, and main drains or disposal drains. Deep collector drains are required for subsurface field drainage systems, whereas shallow collector drains are used for surface field drainage systems, but they can also be used for pumped subsurface systems. Disposal drains are main drains in which the depth of the water level below the soil surface is not bound to a minimum, and the water level may even be above the soil surface, provided that embankments are made to prevent inundation. Disposal drains serve surface field drainage systems. Deep main drains can gradually become disposal drains if they are given a smaller gradient than the land slope along the drain. The technical criteria applicable to main drainage systems depend on the hydrological situation and on the type of system.

Disadvantage of open drains

- They need regular cleaning (sediment and weeds).
- Can be dangerous to animals, machinery, and people (if unfenced).
- If fenced, cleaning is more difficult.
- Fencing adds extra cost and maintenance.
- Tend to become deeper and wider if not maintained by professional machinery operators.
- Not suitable for sub-surface drainage.
- Loss of ground.

In some areas of Olosentu Ranch levees or graded banks will be needed; these are surface channels, often formed on sloping land, in such a way that the earth removed forms a bank or levee on the downslope of the channel. Where used on slopes, the main purpose of graded banks is to prevent surface runoff from building up volumes and velocity that may cause erosion. The banks must follow the contour of the slope with a gradual decline so that water flows constantly and does not build up in depressions, thus rendering land below susceptible to "landslips". The outfalls of the graded banks may possibly lead to dams for water collection for irrigation, stock water, etc. Bank spacing will depend on slope gradient, amount of water to be collected, outfall locations, slope topography and amount of rainfall.

Dimensions: spacing's of about 30 - 50 m for slopes with gradients of 50 - 120 have proven acceptable in most areas. Each bank should service a total area of up to about 3 hectares, with length not exceeding about 400m. The channel will be at risk to erosion immediately after construction until a grass cover is established. Care must be taken on slopes that may have shallow topsoil over dispersive subsoil, as severe erosion is possible in these soil types.

Grading or laser levelling (see annex 8) is a relatively new practice used on irrigation farms to even out and speed up the water flow off flood irrigation bays. Although not common, laser leveling could be used on the "flats" areas in high rainfall zones to ensure water moves off quickly and does not remain in depressions.

2.11 Land preparation

Land preparation for pasture establishment is insufficient (annex 5, picture 6). The land is too rough and unlevelled after land preparation. This may work for maize crop, where after planting the crop can be manually weeded or sprayed with back sprays and where cutting maize crop at a stubble height of 30 cm or higher is a common practice. Pastures are often planted using the method of broadcasting the seeds and manual weeding with hoes is not possible or at least impractical. While mechanical harvesting requires machinery that is in close contact with the land (tedders, drum/disc mowers) and cutting the grass at a stubble height of not lower than 5 cm. This requires careful seedbed preparation to avoid excessive weed growth; and a fine, level tilth which gives the vulnerable grasses a head start after emergence and allows mechanized harvesting of the grass for hay or grass silage without the fear of contaminating the grass with (too much) soil.

Seedbed preparation needs to be done well before onset of rains. If the piece of land is prone to obnoxious weeds e.g. *Sporobolus indicus* (Rat's tail grass), *Digitaria abyssinica* (African couch grass), *Solanum incanum* (Bitter apple) and others, herbicide spraying (see annex 6) is advisable to systematically control these weeds which would otherwise be difficult to control after germination. Chisel plough to about 25-30 cm depth (see annex 7) and cultivate the land (chisel or tine cultivator) to obtain a fine soil tilth necessary for seeds that are small. Ideally the prepared seed bed will be slightly compacted with a roller to avoid movements of seeds into deeper levels of the soil. Preferably, avoid sloping and uneven land to minimize likely variations in performance. Further, the location should be well guarded to avoid animals grazing before pastures grasses or pasture mixes have developed a strong root system, dense sward and canopy.

2.12 Pasture establishment

A combination of management practices has resulted in most of the pastures (natural grassland) which the consultant was able to look at being invaded by *Sporobolus indicus* (estimated at > 2000 plants per ha). The more palatable grasses in between were grazed down by cattle and sheep to very low (dangerous) levels that the grasses cannot recover (fast) enough within a reasonable period of time leading to open swards, with increased risk of invasion by unwanted plants such as *Sporobolus indicus* and soil erosion.

The area where 40 lactating Sahiwal cows are kept (milking area), night paddocks and paddocks for temporarily grazing 2-3 hours per day, gives a reasonable impression that pastures can be rehabilitated if paddocks receive a good amount of animal manure, which fertilizes the soils in the paddocks resulting in a dense sward of Star grass (*Cynodon dactylon)*. The farmer mentions that this pasture grass is very well liked by the cows during the short period which they get access to the pasture. The pasture is weed free including free of *Sporobolus indicus.*

In the waiting area around the milking parlour feed troughs for supplementary feeding have been constructed and excess animal manure is available in plenty. In some patches Star grass is establishing itself and spreading. It can be observed in this area, based on manure scoring that the dairy cows appear to have an energy and protein shortage in their daily ration. Though Star grass may not be the grass of preference when establishing improved pastures, it shows that well drained, healthy, fertilized soils can suppress obnoxious, invasive species.

For good growth and persistence all grasses should be managed well. Good and preferably fast establishment is the basis for good performance. Nutrients removed or lost should be replaced, in particular nitrogen being important for grasses, but high yielding grasses require other nutrients as well, depending on soil fertility. In this respect mixtures of grasses and legumes can be important, with cutting often, offering more opportunities for combination with forage legumes. Grazing or cutting management should be adapted to the species, looking for a good compromise between quality (harvesting at young stage before grass becomes too stemmy) and quantity (less frequent cutting, but lower green leaf content and quality). Grazing too short (less than 5 cm stubble) should be avoided as much as possible, because of potentially severe damage to re-growth (damage to buds or young sprouts), the more so under less favourable conditions. Higher sward density and grass length can contribute to weed control. Re-growth is faster if some green material is left (preventing over-grazing). But a too long stubble after grazing decreases utilization and quality of available grass, because a high consumption of green leaf is most important for animal productivity.

2.12.1 *Sporobolus indicus*

Sporobolus indicus (see annex 5 picture 3,9*)* is a typical prairie and savannah grass but occurs in other open habitats in warmer climates. It is generally considered to be an inferior pasture species, as evidenced by names like "poverty grass", wire grass or smut grass. Total *Sporobolus indicus* biomass keeps increasing under continuous grazing. It is native to eastern, southern and tropical Africa but can be experienced as an invasive tussock grass in farms and ranches. It is a grass of low palatability and regarded as a very serious weed. The tough fibrous nature of *Sporobolus indicus* causes loosening of teeth? in cattle grazing this species. It is dispersed very easily by several mechanisms and once established it can quickly dominate existing pastures, causing loss of productivity and reduced land value. Its presence may also be an indicator of reduced soil fertility and pasture mismanagement. Control on extensively grazed properties is problematic and every effort must be made to prevent its introduction to clean properties. The spread of *Sporobolus ssp*. can occur through movement of machinery, fodder, livestock or animal skins. Regionally, as well as these mechanisms, dispersal can be affected by water, wild animals, vehicles and even people's clothing.

S. indicus favours sites with compacted soil, such as road verges and tracks, but will also invade pastures, especially those sites receiving water run-off. The species is well suited to growing in soils of low fertility and its occurrence in pastures may indicate that the level of soil fertility has fallen below that required by the more palatable and nutritious grasses.

Seeds of *S. indicus* can be distributed in mud, animal faeces and flowing water. Mature seeds become sticky when damp and are dispersed by attachment to animal fur, clothes, vehicles and machinery. Seeds are also distributed as contaminants of soil, seed and produce. In pasture areas, potential of spread is high via pasture seed and hay, adherence directly or in soil attached to milk tankers, fertilizer trucks, slashers, and other farm machinery, and in drainage channels.

It is important to prevent infestation of clean pastures with *S. indicus.* The seeds are very easily moved on animals, vehicles, people and fodder so strict property hygiene (bio security) is essential. Landowner in areas likely to become infested must be alert to new infestations and eliminate these as quickly as possible. It is also important to maintain existing pastures in a vigorous and dense condition to increase competition for any weed seedlings that might establish.

Viable seeds *of Sporobolus spp.* can take several days to pass through a cow's digestive system and a minimum quarantine period of 5 days is recommended before cattle which have grazed in infested pastures are introduced to new pastures; a quarantine field should be especially reserved for such cattle.

Eradication of this grass is extremely problematic even at a property level. There are no documented cases where *S. indicus* has been eradicated from an area of any appreciable size. Herbicide-treated pastures can be over-sown with suitable species to prevent reinfestation by *S. indicus* and to restore pasture quality. Where *S. indicus* infestations are relatively small, plants can be hand chipped, bagged and removed from pasture for burning or similar destruction. Movement control and property hygiene are critical elements in mitigating the effects of this weed. Every attempt must be made to prevent its introduction into clean areas. Measures include being certain that any seed or fodder brought on to a property is not infested, thoroughly cleaning machinery and vehicles, or refusing entry onto clean areas of machinery that has been in infested areas.

Integrated weed management operations minimize the detrimental effects of *S. indicus*. These options include strict hygiene to prevent initial infestations, early detection of infestation, maintaining competitive pastures of non-Sporobolus species, minimizing overgrazing, grazing strategies to prevent *S. indicus* maturing and appropriate herbicide application.

Box 2. Managing *S. indicus* at Olosentu Ranch

- Control isolated plants and stop seeding. The cost of prevention is far less than ongoing costs of *S. indicus* control.
- Contain the spread of *S. indicus* by making 10 to 20 metre buffers along roadways, waterways and inside property boundaries. Always practice property, vehicle and equipment weed hygiene. Avoid moving through *S. indicus* areas when seeds are sticky, after rain or heavy dew. Only use reliable sources of fodder, pasture seed and agricultural contractors and equipment hire.
- Apply the correct calibrated dose of flupropanate* for effective control — 1.5 grams per square metre for granular and 2 millilitres per litre for liquid flupropanate. Too much will kill surrounding competitive pasture grass. Too little will not kill *S.indicus* tussocks. S. indicus mortality and residual effect depends on intensity and frequency of subsequent rainfall. Soil type and density of organic ground cover may also affect effectiveness of flupropanate.
- When spot spraying with glyphosate at a rate of 20ml per litre, trickle it down into the centre of *S. indicus* tussock to prevent damaging nearby beneficial, competitive pasture grass. In open paddocks, wick wiping can selectively apply either or both herbicides to *S. Indicus* with minimal damage to nearby beneficial pasture species. May require three or more wipes over 18 months.
- Abide by grazing withholding periods when applying herbicides. Fourteen days for spot spraying and four months for broadacre or aerially applied flupropanate. Slaughter withholding period is 14 days on clean feed after grazing in a flupropanate-treated paddock. Check herbicide label for withholding periods for lactating cows and goats. Glyphosate has no withholding period. Budget for ongoing *S. indicus* follow up for many years. The residual activity of flupropanate treated areas may last six months to two years, whereas *S. indicus* seed lives for more than ten years in the soil.
- Quarantine cattle for seven days to prevent the spread of *S. indicus* seed into clean areas.
- Promote pasture competition to control *S. indicus*. Pasture grasses and legumes with runners (e.g. Star grass) are more effective than tussock grasses (e.g Rhodes grass) in outcompeting *S. indicus*. Be aware of plant-back periods for certain improved pasture seeds after applying flupropanate herbicide.
- Heavy graze or slash when *S. indicus* plants are young and palatable, to reduce S indicus plant size, minimise seeding and assist pasture competition.
- Goats find *Sporobolus indicus* grass palatable and are used to control the species in Australia (Holst et al., 2001).

(* Note that flupropanate may not be available, in that case Glyphosate can be used following the same procedures)

2.13.2 Pasture rehabilitation

Small, more fertile parts (such as night paddocks), of existing natural pastures may be transformed into Star (*Cynodon dactylon)* /Kikuyu (*Pennisetum clandestinum*) grass pastures, because they are proven to be relative successful close to the milking parlour, through soil improvement and rotational grazing, possibly supported through transplanting (the toppings of an existing pasture can be spread). Also, the seeds of other pasture grasses can be spread once the night paddocks are moved. Star grass requires nitrogen and a soil phosphorus (P) content of at least 15 ppm (legumes requires 20 parts per million (ppm)). Results of soil sampling and analyses will indicate additional nutrients required. But use of fertilizer nitrogen (N), particularly for rehabilitation, is probably too expensive, on still too open pastures unless applied manually in (very) small doses close to Star grass/Kikuyu grass.

However, the use of nitrogen and phosphorus (P) is more feasible if used on maize preceding pasture renovation, on well drained land, residual nutrients being used by new pastures. To prevent too early (over-) grazing of young leaves and killing of the new Star grass (*Cynodon dactylon)* /Kikuyu (*Pennisetum clandestinum*) grass plants (and other good species), well managed rotational grazing is required on parts to be improved, (most probably) requiring (electrical) fenced paddocks. To give new plants time to establish, grazing should be postponed for a period of 12 months (also for renovation) depending on growing conditions. However, larger and less suitable areas of natural pasture may be rehabilitated through over-sowing of legumes, in particular fine stem stylo *(Stylosanthes guianensis* tolerating poorer soils) or *Desmodium ssp and Glycine neonotonia wightii* (these require better, well drained soils). The legumes provide additional nitrogen (=N), provided that soil contents of phosphor (=P) and potassium (=K) are not too low and improve forage quality (protein content in particular). But maintenance of the productivity of Star grass (and legumes) requires good grazing management, including the prevention of building up of dead plant material (the matrass effect) of Star/Kikuyu grass.

Rehabilitation requires improved soil fertility (in particular N/P) and rotational grazing. A small plot/window with extra fertilization will give indications about N/P quantities. Rotational grazing will require the use of zones and (virtual, electrical, or permanently fenced) paddocks of suitable size for fields to be improved, preferably limiting the maximum grazing period to about 3-5 days per rotation. At present a herd of Sahiwal cattle and a flock of shoats are used to graze the natural grassland. Cattle and the sheep are kept in separate night boma's, rotated to collect the manure. The main reason to confine the animals at night is security as from a production / growth point of view it would be better to allow them 24-hour grazing.

2.13.3 Establishment of new cultivated pastures (renovation)

This involves establishment of newly planted more productive intensive pastures, preferably planted after maize. The best option for grazing, already proposed to Olosentu Ranch, is probably one of the improved Brachiaria or Panicum varieties with legumes, if it proves to be sustainable and productive at this altitude (altitude at about 1800 m.). Legumes improve the quality of grass pastures and will thereby also reduce concentrate supplementation required. Once well established, it requires little or no expensive nitrogen fertilizer, unless legume content decreases too much. But additional phosphorus, and possibly potassium or molybdenum, also depending on soil fertility, is required (about 100 kg DAP or a similar NPK fertilizer per ha per year once established).

Without legumes an additional annual fertilization, next to farmyard manure, with CAN or Urea may be required to realize the projected (net) consumable yield of minimum 8000 kg dry matter (DM) per ha per year, also depending on soil fertility. It will not be easy to maintain the productivity of grass/legume mixtures. It requires a good balance between grass and legume (preferably about 30-40% legume) and demands very good management. Too little or too much legume will affect productivity and quality. Grass fertilized with N (from manure and/or fertilizer) is easier to manage but is more expensive and increases market dependency (also for concentrates), while milk and meat produced from grazed grass is minimal at high stocking rates.

2.14 Supplementary feeding

Supplementary feed ingredients such as molasses, maize bran, wheat bran and sunflower seeds have been used in ranch in the recent past.

Most of the herd only gets Magadi soda salt and/or other mineral supplements.

CHAPTER 3: SWOT ANALYSES – OLOSENTU RANCH

Strengths	Weaknesses
• Known as a good ranch driven and managed by a woman entrepreneur. • The board is represented by all family members. • Hardworking owner. • Thinking ahead and entrepreneurial minded-company. • Availability of sizable land. • Increasing its outreach program (linkages with Sirwai self-help group). • Able to start forage related projects to generate more income from livestock. • A suitable and sizeable herd is existing for low input pasture-based livestock farming.	• Grazing land has been invaded/overtaken by Sporobolus indicus grass. • Number of and distance to watering points. • Lack of substantial investments in scaling of the enterprise. • Lack of knowledge on farm forage production and pasture rehabilitation. • Vulnerable to advise which promises quick gains -> ineffective or unnecessary investments. • Shortage of quality, nutritious, grazing land. • Level of mechanization is very low for an 800-acre ranch. • Agricultural service contractors are not within easy reach.
Opportunities	**Threats**
• Family (children) interested to re-generate the ranch as a successful pasture based, ruminant livestock enterprise. • Land is available. • Possibility to harvest run off rainwater. • Suitable and improved forage species are now within reach. • Forage demo plots are established.	• Invasive species reducing the available area with good quality grasses. • Water sources, availability and number of watering points. • Expertise to turn around existing situation not available. • Lack of resources and knowledge to bring the 800 acres to scale. • Lack of suitable seeds to assist with rehabilitation of grassland.

CHAPTER 4: STRATEGIES

2.15 Current feeding strategy and rations for the Sahiwal cow in lactation at Olosentu Ranch

For this theoretical model, the dual-purpose cow model in Rumen8 total ration formulation software was used and the rations are shown in table 2 below. We selected a representative cow from the herd at Olosentu ranch and made the following assumptions based on observations during the ranch visit.

Sahiwal 400 kg cow, Early lactation, 60 days, not in calf, grazing, 2.5 km per day, area is undulated, 4.8 kg, 4.0% F, 3.0% P. (about 1.7 kg is milked on average by the owner for sales). Milk price 35 Kshs/kg, live weight (LW) Change - 350 g/day, Body Condition Score (BCS) 3.0 (Pennsylvania State University (PSU. Scoring 1-8), Cow can graze on pasture to satisfaction (Rumen fill 3). Assuming the cow can graze selectively in the pastures available the current ration of the cow will be as follows.

2.15.2 Current situation for the suckling herd

For the current situation the ration ingredients, nutritional parameters and the cost in Kshs. per ton are tabulated below.

Table 2. Current feed ration for Olosentu's Sahiwal cows in milk

Current	Star grass	Smut / Wire grass	Supplementation
Feed supply (kg)	9.31	7.1	3.10
DM (%)	30.6	41.4	86.7
ME (MJ/kg DM)	8.8	7.0	10.5
CP (%)	9.9	7.0	22.7
NDF (%)	69.0	78.5	31.7
Cost (Ksh./ton)	500	200	26557

On the current ration the cow has a dry matter intake (DMI) of 2.1 as percentage of live weight (LW), the feed costs are 88Kshs/cow per day, milk income (which includes milk for the calves) 168 Kshs/day, Margin above feed cost is 79 Kshs/day. Feed cost are 53% of the milk income. Enteric methane production of 276 g/cow and intensity of 57.7 g CH_4/L milk produced.

2.15.3 Proposed/recommended ration for the suckling herd

This target improved ration after improved forage grasses and legumes are used for grazing. The same representative cow from the dairy herd is used. Sahiwal 400 kg cow, Early lactation, 60 days, not in calf, grazing, 2.5 km per day, area is undulated. Due to availability and quality of the improved pasture the cow is now able to produce 12.5 kg, 4.0% F, 3.0% P. (about 7.5-8.5 kg can now be milked on average at peak production by the owner for sales). Milk price 35 Kshs/kg, LW Change reduces to -250 g/day, BCS 3.0 (PSU. Scoring 1-8), Cow can graze on pasture to satisfaction (Rumen fill 3). Assuming the cow can graze selectively in the pastures available the current ration of the cow will be as follows.

For the recommended ration after interventions the ration ingredients, nutritional parameters and the cost in Ksh. per ton are tabulated (table 2) below.
Assuming the same cow can graze selectively in the pastures available the ration of the cow will then be as follows:

Table 3. Recommended ration for the Sahiwal cows in milk at Olosentu ranch

Improved forages	Supplementation with mineral mix	B. Cayman (C.I. 8 wks)
Feed supply (kg)	0.1	52
DM (%)	95.0	25.2
ME (MJ/kg DM)	-	8.9
CP (%)	-	21.9
NDF (%)	-	40.6
Cost (KES/tons)	79500	2000

On the recommended ration the cow has a (predicted) Dry Matter intake of 3.3% as percentage of live weight (LW), the feed costs increase and are 110 Kshs/cow per day but no dairy meal is needed only supplementation with a mineral mix. Milk income 438 Kshs/day, Margin above feed cost is 327 Kshs/day. Feed cost are 25% of the milk income. Enteric methane production of 285 g/cow (higher DMI) and intensity of 22.8 g CH_4/L milk produced. This is a reduction of 61% CH_4/L milk produced. The cost of pasture grazing (Brachiaria Cayman) is higher than before (in the current situation) because of establishing the grass and the use of (virtual or permanent) paddocking.

Table 4. Summary business case for balanced feeding for the Sahiwal suckling herd at Olosentu ranch

Parameter	Current	Predicted/ Recommended	Difference	Percentage
Feed cost (Ksh)	88	110	+22	↑25%
Milk income (Ksh)	168	438	+270	↑160%
Margin above feed cost (Ksh)	79	327	+248	↑314%
Milk production	4.8	12.5	+7.7	↑164%
Enteric Methane Intensity (CH_4/L)	57.7	22.7	-35	↓ 61%

Based on the analysis above, it has been demonstrated that although improved feeding using a balanced ration that is determined scientifically will lead to 25% increase in feed costs, there is a positive return to the farmer which includes a 160% improvement in milk incomes, 314% increase in margin above feed cost, 164% increase in milk production and a 61% decline in Enteric Methane Emission Intensity (CH_4/L).

2.16 Current feeding strategy and rations for the Sahiwal bulls for finishing at Olosentu Ranch

For this theoretical model the beef model in Rumen8 total ration formulation software was used and the rations are shown in table 4 below. We selected a representative bull from the herd at Olosentu ranch and made the following assumptions based on observations during the visit on the farm.

Sahiwal 300 kg bull, grazing, 2.5 km per day, area is undulated, sale date is when bull reaches 400 kg. Price per kg live weight is 160 Kshs/kg, LW Change 200 g/day, BCS 4.0 (PSU. Scoring 1-8), days to sale 500, bull can graze on pasture to satisfaction (Rumen fill 3). Assuming the bull can graze selectively in the pastures available the current ration of the bull will be as follows. If the bulls are kept in a feed lot faster growth rates on the same ration can be achieved but this will require some mechanization to mow the pasture and deliver the fresh grass in the feedlot.

2.16.2 Current situation for the finishing bulls

Table 5. Current feed ration for Olosentu's finishing bulls

Current	Grass cocktail next to Wire grass	Smut / Wire grass	Supplementation finishing mix
Feed supply (kg)	6.5	2.4	2.13
DM (%)	30.6	41.4	82.2
ME (MJ/kg DM)	8.8	7.0	11.4
CP (%)	9.9	7.0	10.4
NDF (%)	69.0	78.5	19.9
Cost (Ksh./ton)	200	200	23835

2.16.3 Proposed/recommended ration for the finishing bulls

Improved ration after improved forage grasses and legumes are used for grazing. The same representative bull from the Sahiwal herd is used. Sahiwal 300 kg bull, grazing, 2.5 km per day, area is undulated, sale date is when bull reaches 400 kg. Price per kg live weight is 160 Kshs/kg, LW Change 750 g/day, BCS 4.0 (PSU. Scoring 1-8), days to sale 133, bull can graze on pasture to satisfaction (Rumen fill 3). Assuming the bull can graze selectively in the pastures available the current ration of the bull will be as follows. If the bulls are kept in a feed lot faster growth rates on the same ration can be achieved but this will require some mechanization to mow the pasture and deliver the fresh grass in the feedlot.

For the recommended ration after interventions the ration ingredients, nutritional parameters and the cost in Ksh. per ton are tabulated (table 6 below).

Assuming the same cow can graze selectively in the pastures available the ration of the cow will then be as follows:

Table 6. Recommended ration for Olosentu's finishing bulls

Improved forages	Supplementation with molasses/mineral mix	B. Brachiaria grass (Cayman)
Feed supply (kg)	1.55	25
DM (%)	76.5	25.2
ME (MJ/kg DM)	12.1	8.9
CP (%)	4.8	21.9
NDF (%)	0.4	40.6
Cost (KES/tons)	20296	2000

On the recommended ration the bull has a (predicted) Dry Matter intake of 3.0 as percentage of live weight (LW), compared to 1.9% in the current ration, the feed costs increase and are 82 Kshs/bull per day, but no dairy meal is needed only supplementation with a molasses/mineral mix. Income from live weight sales is 120 Kshs/day, Margin above feed cost is 38 Kshs/head/day. Enteric methane intensity of 210 g CH_4/kg live weight gain.

Table 7 below shows that improvements in forage management practices and quality, even though an investment is required to achieve the better-quality forage (better practices / technology), goes hand in hand with increased growth rates (275% increase), higher feed efficiency (60% increase) and reduction of feed cost as compared to income from live weight sales (275% increase of margin above feed cost). At the same time the predicted enteric methane emission intensity reduces with 65%.

Table 7. Summary business case for balanced feeding for the finishing bulls at Olosentu ranch

Parameter	Current	Predicted/ Recommended	Difference	Percentage
Feed cost (Ksh)	54	82	+28	↑52%
Income from live weight sales (Ksh/d)	32	120	+88	↑275%
Feed efficiency (Ksh Feed / Ksh LWG)	1.70	0.68	+1.02	↑60%
Margin above feed cost (Ksh/head/d)	-22	38	+60	↑273%
Live weight change rate	200	750	+550	↑275%
Enteric Methane Intensity (CH_4/kg)	608	211	-397	↓ 65%

2.17 Pasture and Conserved forage projection

2.17.2 Suckling herd (with calf at foot)

After the intervention to improve the pastures at Olosentu ranch we recommended that the cows could have a feed intake of 13.1 kg DM/cow/day from pasture. This equals 52 kg fresh grass. We assume that when animals are put to graze the pre-grazing height is 30cm (= 3 500kg DM/ha), after grazing the post grazing residual is 15cm (1 700 – 2 000kg DM/ha). The pasture available is 1500 – 1 800kg DM/ha per grazing. On one hectare of improved pasture the cow could graze for 126 days or 25 cows can graze one hectare for 5 days. At a pasture growth rate of 75 kg DM/ha/day (60-90kg DM/ha/day) the rotation length is 22 days (20 – 25 days during growing season longer in dry season) 10.5 paddocks of 1 ha would be needed to strip graze the 25 cows with and electric wire fence during the wet period of 280 days with abundant grass growth

The ranch can graze 50 Sahiwal suckling cows (with calf at foot) on 21 ha of improved pasture (see cost price calculation for establishment and mechanization in annex….). At a slower growth rate or if silage of hay needs to be available for the remaining 85 days more land is need. For the 50 cows 13.1kg DM is needed per day which comes to 1105 kg DM/day from hay. For the period of 85 days * 1105 kg DM/day is 93925 kg DM is needed. When haymaking the yield per ha will be 2500 kg DM/ha because the residue (stubble height) is lower at 5-10 cm (1000-1250 kg DM/ha). The total area for haymaking would then be 93925/2500 = 37.57 ha. If 1 ha can be harvested 4 times in a year, then an extra 10 ha improved pastures are needed for haymaking. Total 31 ha is needed.

2.17.3 Youngstock

Youngstock (150) have a grazing demand of 19 kg of fresh grass which equals 4.8 kg DM/head/day from pasture. Assumed youngstock is grazed on the same quality pasture or slightly lesser quality as the suckling herd 69 head can graze 1 hectare for a period of 5 days. A growth rate of 0.4-0.5 kg/head/day is achievable over a period of 12-18 month on grass and hay only before the finishing period. At the same pasture growth as above 10.5 paddocks of 1 ha would be needed to strip graze the 69 head with and electric wire fence during the wet period of 280 days with abundant grass growth.

The ranch can graze 138 head of youngstock on 21 ha of improved pasture. For a feed stock for 85 days for the 138 head 4.8 kg DM is needed per day which comes to 663 kg DM/day from hay. For the period of 85 days * 663 kg DM/day is 56,355 kg DM is needed. When haymaking the yield per ha will be 2500 kg DM/ha because the residue (stubble height) is lower at 5-10 cm (1000-1250 kg DM/ha).

The total area for haymaking would then be 56,355/2500 = 22.54 ha. If 1 ha can be harvested 4 times in a year, then an extra 5.6 ha improved pastures are needed for haymaking. Total 26.6 ha is needed.

2.17.4 Finishing bulls

The bulls for finishing have a grazing demand of 25 kg of fresh grass which equals 6.3 kg DM/bull/day from pasture. Assumed the finishing bulls are grazed on the same quality pasture as the suckling herd 52 finishing bulls can graze 1 hectare for a period of 5 days. At the same pasture growth as above 10.5 paddocks of 1 ha would be needed to strip graze the 52 bulls with and electric wire fence during the wet period of 280 days with abundant grass growth.

The ranch can graze 104 Sahiwal finishing bulls on 21 ha of improved pasture. For a feed stock for 85 days for the 104 bulls 6.3 kg DM is needed per day which comes to 655 kg DM/day from hay. For the period of 85 days * 655 kg DM/day is 55,675 kg DM is needed. When haymaking the yield per ha will be 2500 kg DM/ha because the residue (stubble height) is lower at 5-10 cm (1000-1250 kg DM/ha). The total area for haymaking would then be 55,675/2500 = 22.27 ha. If 1 ha can be harvested 4 times in a year, then an extra 5.6 ha improved pastures are needed for haymaking. Total 26.6 ha is needed.

CHAPTER 5: PROPOSED ACTIONS FOR IMPROVED RANCH MANAGEMENT

5.1 **Short term (0-1 year)**

- Develop a map of the ranch divided in to zones and paddocks.
- Increase the number of watering points to reduce walking distance.
- Set aside 98 ha, which is meant for commercial hay production for grazing to relief the cultivated and newly established improved pastures when grass growth is slower than anticipated.
- Take soil samples for analyses.
- Start to cultivate and prepare the first phase of 25 ha of improved pasture land (see annex 11,12,13).
- Restructure and reduce the herd to allow easy rotations planning and avoid overgrazing of new pasture land.
- Be keen on farm hygiene (bio security including re-infestation of *S. indicus* on cultivated land).
- Invest in (purchase) solar powered mobile electric wire fence.
- Develop at least a monthly overview plan to keep track of herd composition for improved management.
- Purchases on concentrate feed ingredients to be based on available forage grasses (herbage) and relation between price and nutritive value of the feed ingredients.

5.2 **Medium term (1-3 years)**

- Create infrastructure of logical grazing platform(s), internal road, watering points.
- Maintain clean and vigorous pasture growth.
- Give each individual animal its own identification (tag, sensor, ear notching).
- Link all animals to a digital database.
- Set up and maintain a pasture calendar (digital or manual).
- Expand the cultivated pastures according to this plan.
- Invest in (purchase) farm machinery for haymaking.
- Keep tight bio security on the ranch to keep spread of S. indicus to a minimum.

5.3 **Long term (3-10 years)**

- Further maintain clean and vigorous pasture growth.
- Further restructure herd up to approximately 500 heads.
- Review pasture planning based on experience and use every year and adjust accordingly.
- After year 5 further continue to establish 70-98 ha (42-50% of hay for own use).
- Start cross breeding with early maturing beef breeds e.g. Boran, Simmental.
- Set up commercial feed lot.

Table 8. Final herd size (approximate) and land use for 300 ha

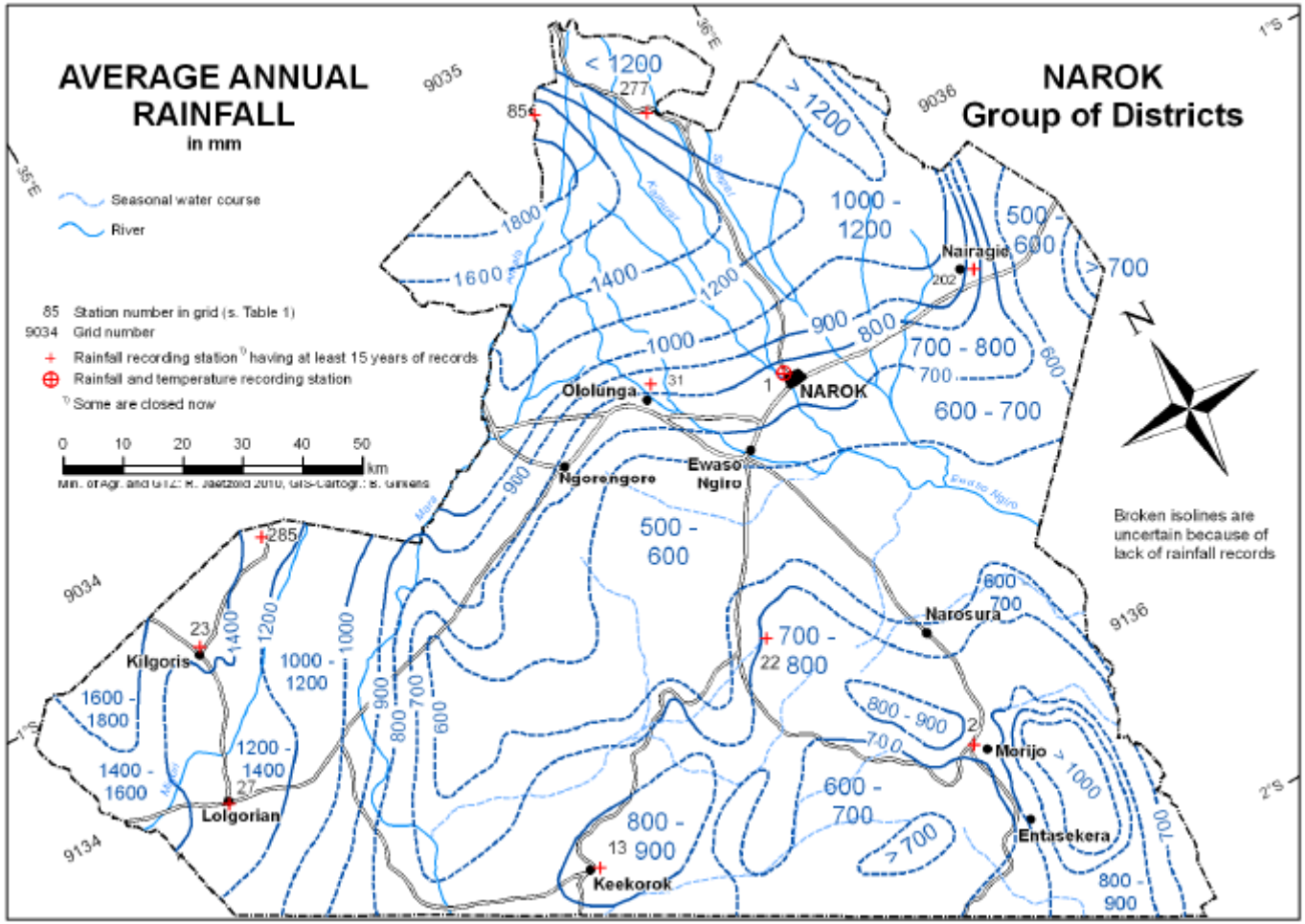
	Suckling cow (with calf at foot)	Cows in calf	Young stock	Replacement stock	Finishing bulls	Total
Number of head	125	50	165	81	84	**505**
Grazing (ha)	52.5	21	25	16.5	17	**132**
Hay making (ha)	25	30	6.5	4	4.5	**70**
Commercial Hay making (ha)						**98**

CHAPTER 6: ANNEXES

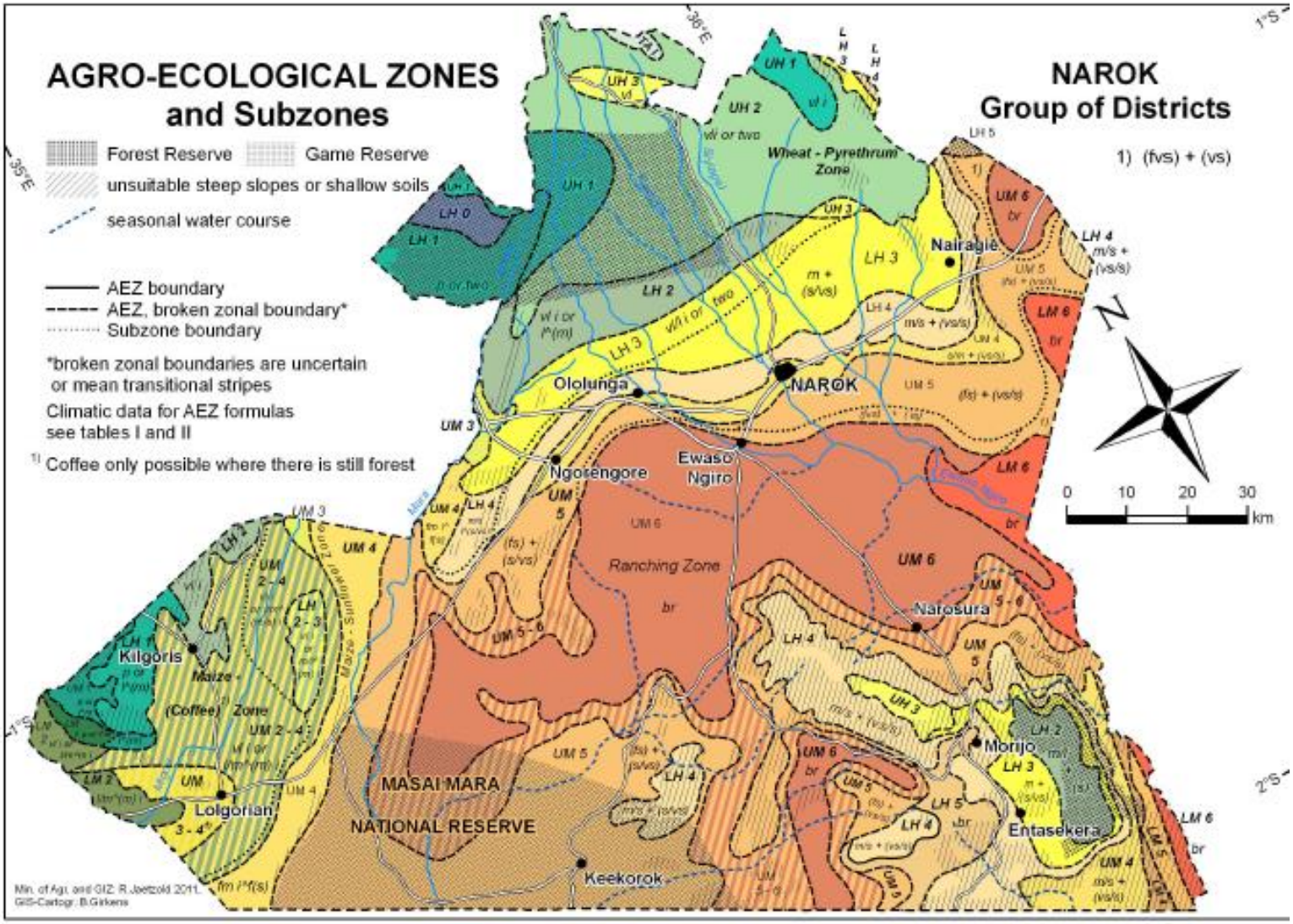
Annex 1. Long year average rainfall, mean, maximum and minimum temperature in Kilgoris

	January	February	March	April	May	June	July	August	September	October	November	December
Avg. Temperature °C	18.3 °C	19.3 °C	19.1 °C	18.5 °C	18.2 °C	17.8 °C	17.6 °C	18 °C	18.5 °C	19.1 °C	18.2 °C	18 °C
Min. Temperature °C	13.2 °C	13.6 °C	14 °C	14.3 °C	14.1 °C	13.3 °C	12.8 °C	13.1 °C	13.5 °C	14.2 °C	13.7 °C	13.4 °C
Max. Temperature °C	24.2 °C	25.6 °C	25.2 °C	24 °C	23.5 °C	22.9 °C	22.9 °C	23.5 °C	24.4 °C	25.2 °C	24 °C	23.5 °C
Precipitation / Rainfall mm	144	94	152	214	122	69	38	58	64	96	195	193
Humidity (%)	73%	64%	69%	76%	73%	69%	64%	63%	62%	61%	74%	75%
Rainy days (d)	10	8	11	12	10	7	5	6	6	7	12	12
Avg. Sun hours (hours)	9.3	9.9	9.3	8.7	9.1	9.1	9.2	9.3	9.7	9.9	8.8	8.7

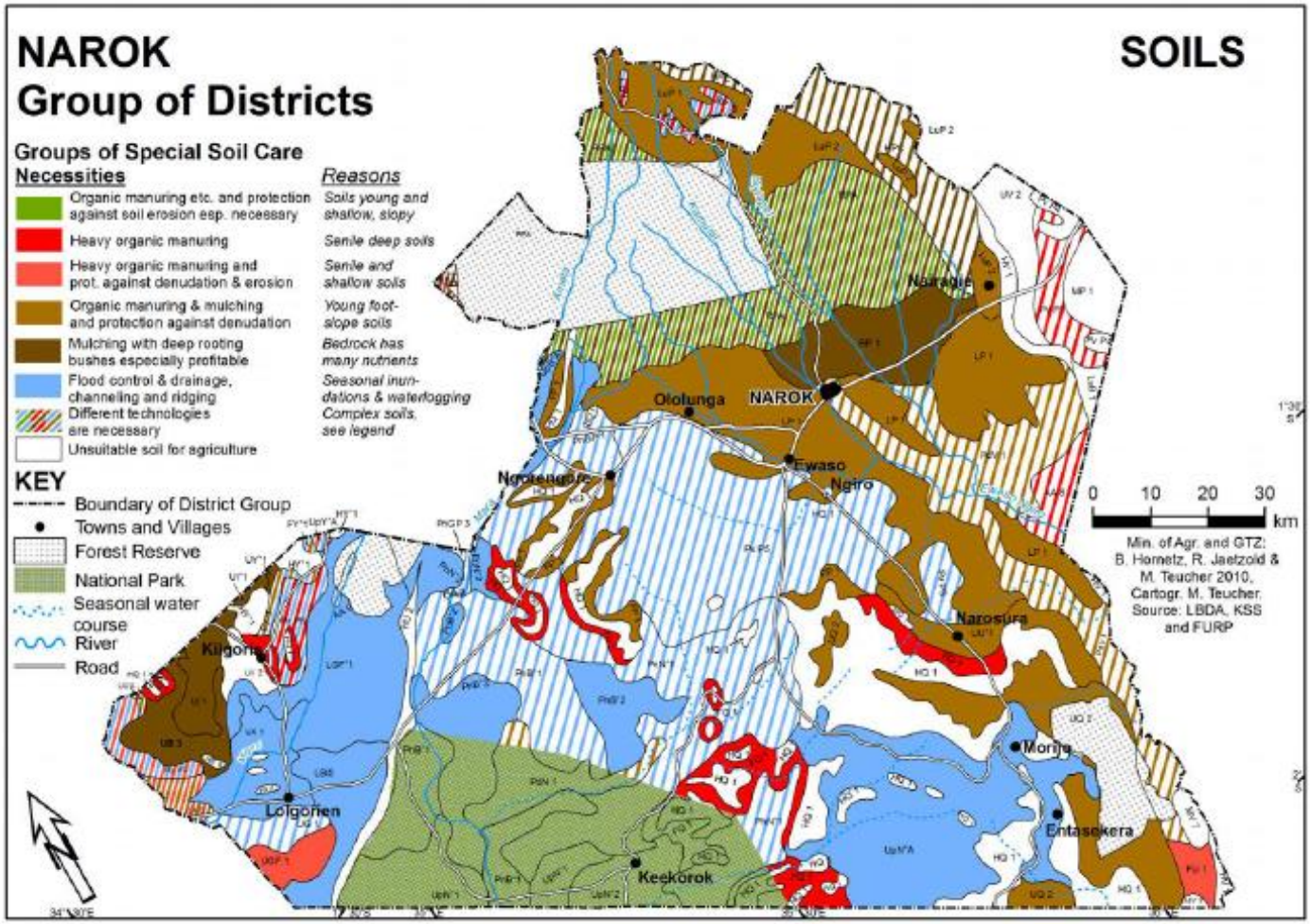
Annex 2. Map isolines of average annual rainfall in Narok



Annex 3. Agro Ecological Zones and Subzones in Narok



Annex 4. Soils in Narok



Annex 5. Pictures

Picture 1. Night paddock with star grass
Picture 2. Improved with Rodes grass. Left Sporobulus is still visible whil Rhodes grass has been overgrazed already
Picture 3. Pasture grassland invaded with Sporobolus indicus
Picture 4. and 5. Feed milling station
Picture 6. Land and seebed preparation for maize is not sufficient when establishing (improved) pastures.
Picture 7. Stainless steel feed bunk ready to be installed.
Picture 8. Wick wiping manually
Picture 9. Pressurised wick wipinp

Picture 1

Picture 2

Picture 3

Picture 4

Picture 5

Picture 6

Picture 7

Picture 8

Picture 9

Annex 6: Chemical control of *Sporobolus indicus*

Chemical control of *Sporobolus indicus*

Two active synthetic substances are available for chemical control of S. indicus, flupropanate and glyphosate. These can be used by spot spraying, by boom spraying or by pressurized wick wiping (annex 5 see picture 8 & 9). Spraying should be carried out in low rainfall months.

Flupropanate can be applied as granules to sites where plants have been grubbed out or as a liquid solution spot spray where population densities are low to medium (1-2 plants/10 m2). Scout plants at the periphery of population clumps should be targeted first before progressing inwards. Where weed populations are dense (>2000 plants/ha):

(i) arable land should be cultivated and cropped for several years, with spot spraying of headlands.

(ii) marginal arable land should be cropped for fodder for a couple of seasons using reduced tillage to minimize soil erosion, with spot spraying of headlands.

(iii) non-arable land should have aerial application of flupropanate granules or boom spraying with flupropanate liquid formulation.

(iv) steep or broken land needs precision aerial application of flupropanate granules. There are grazing withholding periods for both dairy and beef cattle when flupropanate is applied to pasture: at least 14 days after spot spraying and at least 4 months after boom spraying or aerial application of granules.

Annex 7. Improved mechanization for conservation agriculture

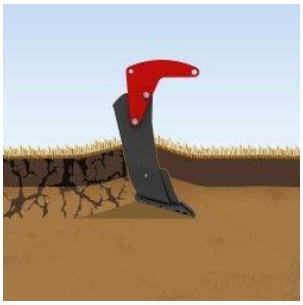
Mechanization

- Sub-soilers
- Chisel tine cultivator
- Seedbed, spring tine, cultivator

Deep restructuring

The Helios provides soil restructuring to 60 cm. It eliminates the results of extreme climate conditions as well as ground compaction resulting from grazing.

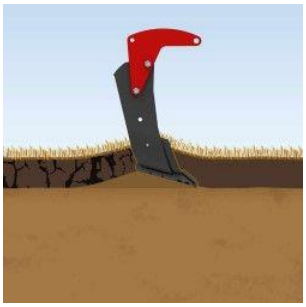
It allows air and water to circulate again to bring life back into the soil. Living soil is essential to cultivation.



Intermediate loosening

From 25 to 35 cm deep, it eliminates poor soil preparation due to the same tool being used too often at the same depth (base effect).

Plots where tubers are intensively grown can be very uneven in terms of compaction. They are made worse by areas of grubbing-up. The Helios recovers these areas.



On the surface

At less than 25 cm of depth, the Helios prepares for root establishment.

The Michel blade performs this task without disrupting the surface and without pushing fine soil down.

On the other hand, the Cracker tine vigorously mixes the surface horizon.

Annex 8. Examples of mechanization for conservation agriculture available in Kenya.

Picture 1: Chissel plough with crumbling role

Picture 2 Sub soiler with crumbling role

Picture 3: Sub soiler with crumbling role

Picture 4 Leveling blade

Picture 5: Chissel plough with crumbling role

Picture 6 Spring tine cultivator

Annex 9. Margin analysis of Brachiaria Cayman grass production

Brachiaria Cayman Grass Production and Margins Analysis													
Product	Description	Unit	Number	Unit cost	1st Harvest	Ratoon 2	Ratoon 3	Ratoon 4	Ratoon 5	Ratoon 6	Ratoon 7	Year 1	N Supply
Establishment Cost:													
Land lease	Annual lease	Acre	1	6000	0	0	0	0	0	0	0	0	
Planting material	Cuttings	kg	1	6000	3,000							3,000	
Ploughing	Acre	Acre	1	3,000	3,000							3,000	
Harrowing	Acre	Acre	1	2,000	2,000							2,000	
Fertilizer	DAP (50kg)	Bags	1	3,300	3,300							3,300	9
Labor	Planting	Man days	5	400	2,000							2,000	
Spraying	Weeding	Acre	1	1500	1,500							1,500	
Chemicals	2,4 D Amine	Acre	1	1500	1,500							1,500	
Sub-total					16,300							16,300	9
Maintenance Cost:													
Fertilizer application	CAN (50kg)	Bags	2	3,000	3,000			3,000				6,000	27.0
Manure	FYM/Compost (4MT/acre)	Pick up	8	1,000	4,000			4,000				8,000	24.0
Labor	Weeding after every cutting	Man days	24	400	0	3200		3200		3,200		9,600	
	Fertilizer application	Man days	4	400	600			600				1,800	
	Harvesting and transport	Man days	70	400	4,000	4,000	4,000	4,000	4,000	4,000	4,000	28,000	
Sub-total					11,600	7,200	4,000	14,800	4,000	7,200	4,000	53,400	69.0
Total cost					**27,900**	**7,200**	**4,000**	**14,800**	**4,000**	**7,200**	**4,000**	**69,700**	
Unit cost	Per kg fresh cut			1.99	9.30	1.44	0.67	2.11	0.57	1.03	0.57	1.99	
	Per kg DM		200	g DM /kg	46.50	7.20	3.33	10.57	2.86	5.14	2.86	9.96	
Output revenue	Per kg DM (max 14 t/acre)		7,000	1.65	3,000	5,000	6,000	7,000	7,000	7,000	7,000	35,000	kg fresh
Gross margin					-24,900	-2,200	2,000	-7,800	3,000	-200	3,000	-34,700	
Source: USAID Kaves 2017method. Updated and adjusted ProDairy 2021													

Annex 10. Nutritional values, unit cost, yield, DM yield, ME yield, CP yield per hectare

Nutritive value	***Dry Matter***	***Metabolisable Energy***	***Crude Protein***	***Neutral Detergent Fibre***	***Unit Cost (KES)***			***Potential DMI***	***Yield Fresh (ha)***	***DM Yield (ha)***	***ME Yield (ha)***	***CP Yield (ha)***
Production	***g/kg***	***MJ/kg DM***	***g/kg DM***	***g/kg DM***	***per kg DM***	***per MJ***	***per kg CP***	***% of LW***	***ton***	***kg***	***MJ***	***kg***
Brachiaria Cayman cutting interval 6 wks (42 days)	200	8.9	216.0	385	10.0	1.12	46.10	3.38	87.5	17,500	155,750	3,780
Brachiaria Cayman cutting interval 3 wks (22 days)	200	8.9	216.0	385	10.0	1.12	46.10	3.38	105	21,000	186,900	4,536

Annex 11. Land preparation of virgin land (breaking) for forage production (grazing and hay making)

Land preparation for forage production			Pilot period -1 EURO = 125 KES			Business period	Year 4	Total	Year 5	
Year 1: Pilot of 25 ha at Olosentu ranch			25	ha	1	Year 2-3 Extension of pilot	add 50 ha	Total area (ha)	add 25 ha	Total area (ha)
	EURO		EURO		EURO			75		100
Land preparation	**Cost/ha**		**Cost 25 ha**		Total Cost 25 ha					
Survey/marking electric fencing	30		750							
Ploughing/clearing	250		6250							
Leveling and surface drains	80		2000							
Planting material grass	70		1750							
Panting/sowing	60		1500							
Weeding 1x	60		1500							
Misscellaneous	20		500				inv yr 4		inv. yr 5	
Total cost/ha land prep.	570		14250		14250		28,500	42,750	14250	57000
Machinery						**Machinery**				
Tractor					48000	Second tractor	48000	96000	0	96000
Mower 2,40 m					15000	Second mower	15000	30000	0	30000
Rake rotational					4800	Second rake	4800	9600	0	9600
Baler	22000	1			22000	Second baler	22000	44000	0	44000
Trailers					7500	Trailers for transpot	7500	15000	0	15000
Front loader and trailer for manure spreading						Manure spreader	0	0	0	0
						Ferilizer spreader	5000	5000		5000
Store and machinery storage	4,000				4000		0	4000	0	4000
Total investments machinery					101300		102300	203600	0	203600
Total investment in forage production Pilot period					**115550**	**Investments**	**130800**	**246350**	**14250**	**260600**

** Note the cost of land preparation are higher than in annex 9 because all land will need to be cultivated for the first time (breaking) and that multiple chisel ploughing will be needed. Its further assumed that is some areas levelling and surface drains will be put in place.*

Annex 12. Machinery and labour cost for forage production (scaling from 25 to 100 ha)

Pilot phase : machinery cost for forage production

25 ha trial expansion to 100 ha			Purchase value	Depreciation %	Depreciation /yr	Mantenance /yr %	Maintenance /yr	Total anual costs
Machinery								
Tractor 1	95 HP		96000	20%	19200	4%	3840	23040
Mower 1	2.40 m		30000	20%	6000	5%	1500	7500
Rake 1	rotation		9600	20%	1920	5%	480	2400
Baler 1			44000	20%	8800	5%	2200	11000
Tipper Trailers 2			15000	20%	3000		0	3000
Fertilizer spreader 1			5000	20%	1000			1000
Manure spreading			0					0
Storage and small workshop			4000	20%	800	5%	200	1000
Anual machinary cost and cost/bale			**203600**		**40720**		**8220**	**48940**
Fuel costs 4 harvests/yr at 68 l/ha incl transport to storage	ha		75	**Total**	5625	1.1	Euro/lt	6188
Add for lubriacant 15%								928
Total machinary including fuel								**56056**

Estimation labour costs:	**ha**		**75**	
Labour costs 4 harvests/yr incl transport to storage		**Mandays**	**Total cost EURO**	
Mowing		300		Tractor driver
Raking		160		Assistant driver
Baling		300		
Transport/loading		600		
Miscellaneous/assistance		300		Miscellaneous labour
Total labour costs at 5 euro manday		**1660**	**8300**	

Annex 13. Profit and loss of forage production year 1 to year 5

Loan in year 4:					
	Purchase value	value in % of purchase	Book value	Cash	Loan
For machinary from pilot phase	101300	40%	40520	0	40520
Additional machinary and land clearing	102300	100%	102300	0	135000
Total loan needed					**175520**

Profit and forage production pilot phase 3 years 25 ha. Upscaling in year 4 and 5 to 100 ha			
	Unit Cost	year 4	year 5 (and after)
Name farmer	Olosentu Farm		
Crop/variety	Improved grassess for hay		
Revenues			
Area in ha		75	100
Revenues			
Yield in hay (tn) (yr 1 = 12, later 25)		900	2500
Revenues at euro 1.6/bale at farmgate	**1.6**	**96000**	**266667**
*Incl. own use at 50%			
Costs of inputs			
Maintenance pasture average costs	830	7470	9960
Feritlizer for replenishment of minerals	30	2250	3000
Manure application			
Fuel/lubricants (mach/labour sheet)		6188	8250
Labour costs (machinary/labour sheet)		8300	11067
Twine	2	1800	5000
Maintenance machinary		8220	8220
Land lease	50	3750	5000
Total direct costs		**37978**	**50497**
Overhead costs estimated			
Olosentu overhead: Staff and faciliteis		15000	15000
Loan and Interest costs at 14%	175520	24573	24573
Sub total cash expenses		77550	90069
Depreciation		40720	40720
Total costs		**118270**	**130789**
Nett profit/loss		**-22270**	**135877**
Cash flow			
Add to Nett profit/loss			
Depreciation		40720	40720
Cash flow		**18450**	**176597**
Amortization loan suppose			30000
Nett Cashflow			**146597**

Annex 14. Field visit to Olosentu Ranch for validation of Forage Master Plans and Demo Plots under SNV ICSIAPL (DeSIRA)

Summary and recommendations on observations on the trial/demonstration plots(annex 14 was added after the validation visit on 23rd February 2022)

Olosentu Ranch

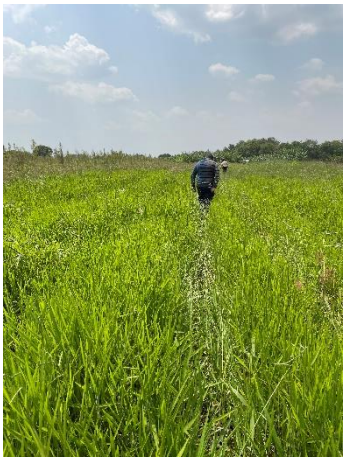
- All the forages were planted in the first half of November 2021. Good rains were experienced until to date.
- All forages (Panicum Siambaza, Sugargraze, Nutrifeed, Sunhemp, Brachiaria Hybrids), germinated and established. The nearby dam is filled with water but no support in the form of watering was needed to the forages.
- It was observed that in the demo plot established by Olosentu in collaboration with KALRO, next to the Brachiara Hybrids the Brachiara cultivars were established. In this demo plots Brachiaria Xaeres stood out.
- Preparation of virgin land – breaking – was done but the depth of cultivation was very shallow and needs to improve (see pictures and comments in Forage Master Plan). The challenges experienced by the owners in terms of land preparation are the high content of stones in the top en sub soil and areas where there is no fertile topsoil only marram. Land preparation needs to be improved (see annex 12 Forage Master Plan) and requires suitable farm implements which improve cultivation of the land without damages to the farm implements Due to the challenges (stones and fast re-growth of weeds) land preparation needs to start in due time before planting. Start breaking/preparation 6 months before planting.
- Cultivation needs to focus on retaining the available biomass in the rootable topsoil and only loosen the underground up to 30-45 cm, to retain water and allow water and air to penetrate with running off.
- In addition, apply 10 tons/acre of cow manure.
- The perennial Panicum Mombasa impressed it performed extremely well, good germination fast establishment and fast growth rate. The Brachiaria Hybrids germinated well and established but need weeding and gap filling. The annuals Sugargraze, Nutrifeed and Sunhemp germinated and are at a mature stage but the impression is that crop management was not optimum. Weeding and pest control (fall army worm), plant population and stage of harvesting are some aspects that need to be in time, right on the spot to target the maximum cost – benefit.
- Olesentu's biggest challenge is the high population density of Sporobolus and in the Forage master plan I mentioned that next to eradication through manual or chemical weeding it is thereafter important to use grasses when renovating pasture which germinate and establish fast to out compete Sporobolus which will re-establish. The canopy of Panicum Mombasa and of Brachiaria Xaeres where dens enough to achieve this and underneath the canopy very little and weak weedy plants could be detected. However, the biomass of P. Mombasa aswell as B. Xaeres are too mature to achieve a substantial difference in animal performance (production of animal protein). Through rotational grazing a balance needs to be created between grazing the herd at the right height (30-40 cm) of the grass and removing the herd when the residual height is no less then 10 cm. To allow fast re-growth. During periods of

slow re-growth (dry weather) a higher residual height (15 cm) may be required. In the next 5 years the condition of the newly established pastures needs to be leading when grazing animals. NOT the need to graze animals because there is a shortage of grazing pasture or hay. This requires that the stocking rate is at all times adjusted through animal sales or purchases depending on the grass at offer. Over grazing, and hollow pastures (open spaces in the pasture) will give Sporobolus the possibility to take over the grassland again. Grass re-growth can be manipulated through application of farmyard manure or synthetic (N) fertilizers, but the introduction of pasture legumes can also be introduced after some trials on a smaller scale.

Pictures 1-6 (left to right) below: Panicum Mombasa, Nutrifeed, Brachiaria Hybrids, Allan Twala in a field of Brachiaria Hybrids, Sugargraze, Braxhiaria Xaeres.





- Site allocation is crucial for successful forage establishment not only climatic conditions are important but also type of soil (stones, marram, black cotton) root-ability (hard pan), weed pressure etc.
- Knowledge on forage agronomy is not readily available.
- Farm implements to execute agronomic practices, forage harvesting and conservation are not readily available on the farm. This hampers timely action.
- In the table below a cost indication of a starter set of farm implements for forage production

Table 2.) Recommended set of farm implements for forage production at Olosentu and price indication.

Implement (Ataspar/Agromaster)	85-90HP	Unit price
Chisel plough fixed tine (with crumbling roller)	CPR7	€ 6,666.00
Spring tine cultivator (with crumbling roller)	TR2 13	€ 7,843.00
2 drum mower	TOB 185	€ 3,680.00
Hay rake (4 wheels)	OT50	€ 1,551.00
Hay baler	SY 2	€ 28,259.00
Forage harvester	CSM 150	€ 8,019.00
Total investment		€ 56,018.00

- From the above list, which is an example of new implements available in the Kenyan market, not all implements may be required which means Olosentu Ranch can have a good set of implements for forage production below a total investment of 56,000/= EURO
- Land preparation needs to start timely; some corrective fertilization needs to be done (e.g.; farm yard manure) and with effective and efficient farm equipment.
- Incorporation of biomass in the topsoil is recommended which requires a timely start. In case of invasive species or aggressive species it is recommended to cultivate the land before seed setting.
- Break the existing hard pan (compacted soil) and avoid creating a hard pan with the farm implements (e.g., disc plough).
- Fertilisation with farmyard manure before planting is advisable.
- Forage agronomic practices need to improve and can benefit from standard operation procedures and training/extension, next to better farm implements for the work at hand.
- Considering the above it seems more beneficial to invest in establishment of perennial forages rather than annual forages. Annual forages need to be planted and are exposed to the risk of crop failure every year (if rains delay/are not sufficient). Perennial forages once established go dormant but will re-grow once the rains re-appear; they cover the soil once a thick sward and canopy has formed thus retaining soil moisture longer. Besides, perennial forages will remain productive for 5-10 years thus reducing the initial investment of land preparation.
- The combination of fast establishing cover crops and the final forage crops (grass) may be considered.
- Supporting the forages with irrigation is not relevant at Olosentu and will increase cost of production unnecessary. When planting perennial crops which establish slowly, using an annual cover crop - may be a good strategy to supress weeds
- In Trans Mara suppressing weeds during germination and establishment is the most challenging. This clearly shows, in both cases the need for a timely, fertilized, well prepared seedbed.

- Weeding is an important cop management aspect in high rainfall areas and regularly it is observed that weeding frequency needs to increase. In some incidences the weeds outcompeted the forage crops.
- In Trans Mara the challenge faced is weed control, right stage of harvesting and most appropriate preservation technology. Particularly the Brachiaria Hybrids are sensitive to invasion of pest and fungi when left to mature and/or under stress (drought, low soil fertility)
- Due to the additional cost of land and seedbed preparation and keeping the ultimate feed cost within limits it is a.) recommended to use forages that perform well in the location (AEZ) of the farm and b.) use forages which give the best nutritive values possible (ME, CP, NDF) c.) manipulate the nutritive value of the forages through management practices (fertilization, stage of harvesting etc.).
- A detailed cost (cost per ton of dry matter) – benefit (possible average daily weight gain) analysis of the different forages in Olosentu can give more precise information on the forage strategies to follow.