Animal Production Society of Kenya

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Theme: “Framing The Issues, Challenges And Opportunities In Livestock Sector In The 21st Century”
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Appreciation

We wish to express our appreciation to the main sponsors of this year’s Symposium and Annual General Meeting to:

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"Framing the issues, challenges and opportunities in livestock sector in the 21st century"

SPEECH BY DR. JACOB O. MIARON (PhD), CBS PERMANENT SECRETARY MINISTER FOR LIVESTOCK DEVELOPMENT DURING THE OFFICIAL OPENING OF THE ANIMAL PRODUCTION SOCIETY OF KENYA (APSK) ANNUAL SYMPOSIUM AT GOLF HOTEL, KAKAMEGA ON 11TH APRIL 2013.

The Chair Person
Director of Livestock Production,
Director Kenya Agricultural Research Institute,
Director Kenya Wildlife Services,
Managing Director, Kenya Dairy Board,
Vice Chancellor, Egerton University,
Members of the Animal Production Society of Kenya,
Distinguished guests,
Ladies and gentlemen,

It is a pleasure for me to be with you here today as you once again assemble for this year’s annual scientific symposium. Your choice of theme “Framing the issues, Challenges and Opportunities in Livestock Sector in the 21st Century” clearly depicts where we are at the moment and where we intend to go. The theme therefore attempts to help in identifying the key issues, challenges and opportunities in the livestock sector and coming up with possible solutions.

Madam Chair, APSK continues to be among the professionally sustained associations that have been very active over the years. Since its formation the society has operated with objectives, which relate very well with the ministry’s as we all are aiming at improving outputs of livestock and their significance in the human livelihood. The association continues to address issues that continue to challenge the industry which is very dynamic.

I would like to emphasize that the ministry recognizes and appreciates professionalism in livestock development. We are aware that we cannot achieve meaningful development in the livestock sector, without making use of our professionals. It is in this regard that I wish to express my appreciation to the APSK for participation in the development of policies that shape the direction of the Livestock Industry. Further, it is worth noting that the Kenyan Constitution recognises the role of the professionals in development of the country and therefore provides an opportunity for APSK fraternity to contribute effectively in the devolved government. That is, the animal scientists and other livestock expertise will have to actively play a major role and participate in our development planning and implementation. I however challenge members of your society to come up with recommendations on the type of structures and framework that are necessary to put animal agriculture professionals in their rightful place in the scheme of our development agenda and in the realm of other professionals. As professionals, you should be able to advise us on the way forward in this important subject.

Madam Chair, allow me to now turn into other areas of relevance to your deliberations in this forum. About 80% of Kenya is arid or semi-arid and can only efficiently support livestock production. For this reason therefore, the importance of livestock in Kenya’s economy cannot be overstated. According to the Kenya National Bureau of Statistics (KNBS) Human Census results we have about 17.5 million heads of cattle of which 3.5 million are dairy breeds, 27 million goats, 17 million sheep and, 31 million chickens among other livestock species. Livestock is the only source of livelihood in the ASAL, where over 70% of Kenyans ruminant livestock are found: providing food security; employment and support for other social obligations in those areas. In the high potential areas, dairy and poultry production competes favourably with other agricultural production such as horticulture, tea and coffee and may be the best enterprises in terms of providing a stream of regular and stable income throughout the year. With the expected increase in the role of livestock production in Africa, the demand for livestock products is expected to rise and therefore livestock is going to provide the engine for growth in agriculture sector.

Ladies and gentlemen, the government appreciates the importance of livestock contribution in the growth of our economy and we have done everything possible to provide the relevant environment for the sector to achieve its potential. The dairy farmers in the country are now not only getting good price for their milk but also are getting paid on time. Our livestock farmers especially those in the marginal areas are now enjoying access to market for their livestock and we
My ministry is working to ensure that livestock not only contributes effectively to our national economic growth but also that we lead in livestock production and marketing in this region and Africa. We want to be world class in our efficiency and productivity especially in dairy and meat sub-sectors. In marketing, we are going to focus more on promotion of value addition near the production points in the rural areas. This will not only improve the price our farmers get for their livestock but will also boost the contribution of livestock in employment creation for the rural population.

Previously, professionals majored on the production of livestock products without consideration of the marketing aspects. It is becoming increasingly important to address marketing and social aspects that affect various aspects of production. Adoption of the Value chain concept has allowed for the incorporation of different players making the value chain more effective as well as assisting more farmers to get value for their products.

Ladies and gentlemen, we are not only faced by challenges of animal diseases but also have other challenges such as livestock feeds and feeding, livestock markets and marketing, livestock products quality, among others. Most of our livestock are not getting adequate and quality feeds. The challenge is to produce adequate livestock feed, pasture, forages, fodders and commercial feeds which do not unnecessarily make livestock products expensive. Availability of quality and cheaply produced feeds will make it possible to produce high quality animal products. I am however confident that we are equal to the challenges facing the livestock industry and I am happy you will be deliberating on some of them through your sub-themes, that is: technology development, transfer and adoption; feeds and feeding; animal genetic resources and improvement; bio-technology and animal production; socio-economics; and marketing and value addition.

Through your deliberations, I am sure the issue of supply and demand of livestock and livestock products will also be addressed. We have so far been able to produce enough livestock products that meet our local demand and have some surplus for export. We have focussed our efforts toward producing enough and creating surplus for export and we are more and more becoming export oriented. We however cannot participate effectively and efficiently in the export market if we do not position ourselves for it through appropriate technologies and having in place relevant institutions to go with it. We need our professionals, those in my ministry and other institutions, to provide us with scientific and professional advice that give us the edge – over our competitors.

Madam Chair, in recognition of the professionals in Animal production in the country, I wish to express the ministry’s full support for the Animal Production Society of Kenya (APSK) hosting of the 2014 All Africa Conference on Animal Agriculture (AACAA) to be held in Nairobi. I therefore hope that my ministry will fully be involved in the planning for this very important event.

Ladies and gentlemen, allow me now to end my remarks by thanking you for organizing this important symposium and inviting me to preside over it. I believe you are going to have fruitful discussions and the proceedings you produce will contribute to our livestock industry development efforts. I am looking forward to receiving the proceedings of your deliberations.

It is now my pleasure and humble duty to declare the 2013 Animal Production Society of Kenya (APSK) annual symposium officially open.

Thank you.
Alternative Feed Development
ABSTRACT
Silage making is an easy method of feed conservation for dry season feeding strategy. The quality of silage depends on the material ensiled, the bacterial activity, the efficiency of removal of air and also the drainage of any leachate. Introduction of easily available lactobacilli would significantly improve the quality of silage because the undesirable microorganisms are outcompeted by the lactic acid bacteria. Sauerkraut has already been used as inoculums in making over 25 tones of silage in one farm in Mumias East District and the farmer was very impressed and is actually able to the same on his own. The feed intake and milk production improved and the farmer now has enough silage and hay for his dairy cattle throughout the year. Replication and up scaling of this technology could provide a simple and cheap source of the bacterial inoculums for successful silage making. This paper therefore presents a step by step approach in extracting of LP or in preparing a Lactobacillus Plantarum solution for use in silage making under dairy farming systems in Kenya

Key words: Lactobacillus plantarum, Silage, inoculums

INTRODUCTION
Lactobacillus plantarum is one of the probiotic lactic acid lactobacilli (LAB). It is found in various habitats in plant and animal systems. It is fastidious and acid tolerant, gram-positive and non-spore forming, grows between 15°C and 45°C, homofermentative, non-gas producing and anaerobic but aero tolerant, its only significant metabolic product is lactic acid (McDonald et al., 1990). Some strains of L. plantarum, especially strain 299V, have been found to produce bacteriocins which inhibit proliferation of other food borne pathogenic microorganisms.

Due to the above mentioned characteristics, and its worldwide distribution in nature, grains, green plant material, dairy, meat products and in animal mucosal surfaces, the bacteria has been widely studied and found to have the potential of being used as a bio-preservative, a starter culture for fermented food and beverages, treatment of some infections and also being used as live vaccine (Enan et al., 1999; Herias et al., 1999; Jeevaratnam et al., 2004; Corsetti et al., 2008; Duangjitchoren et al., 2008; Long et al., 2008; Lu et al., 2008). The L. plantarum makes 52% of the lactobacillus flora in the rectal and the oral mucosa of human beings (The bacteria were first isolated from oral mucosa). Their presence lowers the gastro intestinal tract (GIT) pH and inhibits proliferation of pathogenic microorganisms.

The L. plantarum is capable of fermenting all common sugars (except rhamnose) thus, having the ability to digest any industrial carbohydrate waste such as potato processing waste, agricultural waste, vegetable pickling waste, cheese manufacturing waste (whey), packing house waste, sugar refinery waste (molasses) etc (Bonnie, 1978; Wang et al., 2001). It is commonly found in sauerkraut, pickles, brined olives, Korean kimchi, Nigerian ogi, sourdough and other fermented plant material, and in some cheeses and fermented sausages. It is also present in saliva. L. plantarum has been widely utilized in fermentation processes in both livestock and human food preservation. It has been found to make over 66% of the lactobacilli utilized in silage making from rice straw (Gibson et al., 1958; Beck, 1972; Ennahar et al., 2002). Research studies have shown that use of bacterial inoculums in silage lead to significant improvement in dairy cattle dry matter intake (DMI), live weight gain, Milk production and feed efficiency. For good results, bacterial inoculants should contain at least L. plantarum (http://www.dairyextension.com.au/). It is one of the bacterial species that can hydrolyze tannins by use of the tannase enzyme, thus help sheep and goats to digest tanniferous leaves which they feed on. Tannins are widely distributed in the plant kingdom. The bacteria has the capability of decolorizing molasses waste water before being released to the surface water (Salminen and Rintala 2002; Tusunee and Suntud, 2008). L. plantarum is widely used in food and wine industry because of its capability to inhibit growth of pathogenic bacteria and lowering of pH due to the lactic acid production.

The main environmental concern in intensive livestock farming is bad odour, ammonia emissions and the nitrates in the livestock waste water. This is particularly serious in middle and large scale dairy, poultry and pig housing units. L. plantarum is the preferred bacteria for acidifying manure in which ammonia is fixed and carbon dioxide is emitted thereby reducing the nitrogen loss and bad odour in manure. The retention of nitrogen allows the manure to have a high nitrogen content which is one of the macronutrients that are required by plants. The manure is then processed into high quality manure dry pellets (Laneijer, 1992). This bacteria is also used in the treatment of poultry manure for cattle feed. L. plantarum reduces the enterobacterial and enterococci counts in the poultry manure. This makes the manure safer for use as a livestock protein source (El-Jalil et al., 2001; 2008). The use of the poultry droppings as dairy cattle feed allows the farmers to reduce the cost of commercial dairy meals and pellets and hence increase their incomes in addition to cleaning the environment. The microorganism for this study was isolated from sauerkraut which is common food stuff since time in memorial in most parts of the world in various names such as Lahan tursusu in turkey, Kimchi in Korea, Tsukemono in Japan, Atchara in Filipines, Suan cai in China, Sayur asin in Indonesia, etc. Sauerkraut contains high concentration of lactic acid and lactobacilli. The Lactobacilli, mainly L. plantarum, produces lactic acid as the only significant metabolic product, the acid lowers the pH of the GIT and prohibits proliferation of food borne pathogenic microorganisms. Sauerkraut is also an excellent source of vitamin C, contains anti cancer agents
“ITC and sulforaphane and Isothiocyanates” It is also known to treat gastro intestinal conditions, clean the liver and remove hangover, some studies have reported it to be as effective as Viagra. (Wikipedia, the free encyclopedia).

Most communities serve sauerkraut directly without warming in order to allow the people to ingest living Lactobacilli. The bacteria then survive the acidic conditions in the stomach and upper section of the digestive. It exhibits the probiotic properties in the lower part of the digestive system. The lactic fermentation in sauerkraut occurs in a series of overlapping stages or sequences. These stages and the succession of microorganisms associated with each stage have been very well studied.Remarkably, the fermentation almost always follows the exact same pattern. The first stage is marked by growth of Leuconostoc mesenteroides. This organism is salt-tolerant and has a relatively short lag phase and high growth rate at low temperatures. It metabolizes sugars via the hetero-fermentative pathway, yielding lactic and acetic acids, CO2, and ethanol. The acidic environment created by growth of L. mesenteroides not only inhibits non-lactic competitors, but it also favors other lactic acid bacteria. The production of CO2 also contributes to making the environment even more acidic which again favors the more anaerobic lactic acid bacteria. Eventually, L. mesenteroides is itself, inhibited, and within four to six days, this organism is barely detectable. In the next stage or primary, homolactic, or non-gaseous phase, the decrease in the Leuconostoc population coincides with the succession of several other lactic acid bacteria, most notably L. plantarum and, to a lesser extent, Lactobacillus brevis. They are quite stable in this acidic environment and dominate the fermentation during this period (especially L. plantarum). Finally, within two weeks, as the pH decreases, only the acid-tolerant L. plantarum is able to grow (Hutkins, 2006). Sauerkraut preparation is an example of cases where Indigenous Technical Knowledge (ITK), is scientifically explained and proven to work. Such activities persist in the society for long time.

The broad objective of this study was to isolate and obtain a pure culture of the microorganism and use the same to determine the toxicity of Chromium (III) organic compounds. Specifically, the isolation and purification of the microorganism was aimed at:

i. Using the defined quantities of the cells of an identified microorganism for use in toxicology research

ii. Exploring the potential of using the microorganism as inoculums in silage making.

**MATERIALS AND METHODS**

**Sauerkraut preparation**

Cut a white cabbage (Brassica oleracea), into two and remove core, then cut the leafy part into thin strips. Weigh 400 g of the shredded cabbage and mix thoroughly with 10 g sodium chloride. Tightly pack into a 400 mL beaker to remove as much air as possible and create an anaerobic environment. Cover the beaker with a polythene sheet and reinforce with a piece of newspaper and tightly tie with plastic rubber bands, then cover with aluminum foil. Place the set up on a bench at room temperature for 14 days. Use a sterilized needle and syringe to aseptically get the sample from the beaker to avoid any air entering.

**Medium for isolation**

Bacteria cells are routinely maintained in Man Rogosa Sharpe (MRS) medium with the following composition; (g/L of sterile water): Peptone 10.0; meat extract 8.0; yeast extract 4.0; D (+) glucose 20.0; di-potassium hydrogen phosphate 2.0; Tween® 80 (polyoxyethylene (20) sorbitan monooleate) 1.0 mL; di-ammonium hydrogen citrate 2.0; Sodium acetate 5.0; magnesium sulfate 0.2; manganese sulfate 0.04; agar (not present in MRS broth) 14.0. The pH was adjusted to 6.5 by adding 1.0 M sodium hydroxide. The volume of medium prepared for all the experiments that required observation of colour change and the turbidity is fixed at 500 mL to maintain a consistent medium colour.

**Isolation procedure**

Autoclave the medium at 121oC for 20 min and allow to cool to 38oC-40oC. Test tubes, each containing 10 mL of MRS medium are aseptically inoculated in laminar air flow chamber with 1 mL of the aliquot from the fermented cabbage and incubated anaerobically at 37°C for 48 h. One loopful of each culture are streaked on MRS agar plates. The inoculated plates are further incubated anaerobically at 37°C for 48 h. Colonies develop after about 12 h of incubation, after incubation for 24 h, distinct white colonies are sub cultured in MRS agar plates. Pure cultures are considered to have been achieved after three successive subcultures on MRS agar plates. Transfer a single colony into fresh sterile liquid medium to obtain a pure culture.

**RESULTS AND DISCUSSIONS**

**L. Plantarum M-1 Identification Results**

**Colony Characteristics in Agar Plates**

The colonies were white or pale cream, concave, round and smooth edged.

**Gram Test**

The cells absorb the crystal violet colour, meaning that they are gram – positive. Catalase Test; No burbles. Microscopic Images; The light microscope blue straight and curved rods

**Physical Characteristics-negative**

Tannase Activity; - pale green colour indicating presence of the tannase enzyme. Resistance to Ciproflaxacin; Resistant tests of L. plantarum. Sugars Fermentation; - grow in D-glucose, α-Glucose, α-Lactose, D-Sorbitol, Sucrose, Mannitol and starch.

Gas production; No gas sproduction

**Growth curve**

The growth curve of L. plantarum M-1 in anaerobic conditions, at pH 6.5 and temperature of 37°C. The generation time at exponential growth period is 48 min. The number of cells at mid lag phase = 3.625 x 108/mL. The results above enabled the classification of the bacteria as follows;

**Kingdom:** Bacteria
**Division:** Firmicutes
**Class:** Bacilli
**Order:** Lactobacillales
**Family:** Lactobacillaceae
**Genus:** Lactobacillus
**Species:** L. plantarum
Figure 1: *Lactobacillus plantarum* M-1 Isolation and Growth

**CONCLUSION**

The fermentation of cabbage has been proven to predominantly yield *Lactobacillus plantarum* which is safe inoculums for silage making to provide the desirable microorganisms for silage making. Subsequent sauerkraut preparations in summer showed that under higher temperatures, the fermentation yields a pure culture of *L. plantarum*.

**RECOMMENDATIONS**

This research opens up other area of research and data collection to provide information on the bacterial community in local environment, performance of animals after consumption of the silage made with the inoculums and others made using the normal methods. Further research is recommended to generate quantitative data on change in dry matter intake and milk production using a large herd of milkers. The fermented cabbage is used as human food in many parts of the world, it is therefore expected to be safe for dairy cattle consumption, and the use of the bacteria as inoculum for silage making should be up scaled in dairy farming in Kenya. The inoculums should be introduced just after application of the molasses solution before addition of more material for ensiling. This should be done as quickly as possible so that the bacteria are not exposed to air for more than 5 minutes (it was earlier observed in on fluorescence microscope that the shiny white mobile bacteria would change to immobile green rods after about 5 minutes). The inoculums have been used on maize silage so far, more data is required to assess the performance of the inoculums in silage made from other materials such as Napier grass, kau kandi, etc. This technology also presents an opportunity for an alternative utilization of cabbages in times of excess when prices nosedive and farmers incur losses.

**Use of *L. plantarum* as an inoculum in Kenya**

The author has used one farmer in Mumias East district to demonstrate on the use of inoculum on maize silage where 30 selected potential dairy farmers were involved. Only this farmer with 3 milkers, a bull and 2 heifers has picked up the technology. Preliminary reports from the farmer indicate a general increase in feed intake and a 1-2 litres increase in milk production. The farmer used 50 medium size cabbages in a 50 litre plastic container to make enough inoculum for 5 tons of silage.

**REFERENCES**


EVALUATION OF MILK PRODUCTION OF DAIRY GOATS FED ENSILED SUGARCANE TOPS WITH MULBERRY AND CALLIANDRA CALOTHYRSUS

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ABSTRACT

A study was conducted to compare the effects of feeding Morus alba (Mulberry) with Calliandra calothyrsus (Calliandra) legume forages as protein supplements to a basal diet ensiled sugarcane tops. Twelve (12) dairy goats (Toggenburg, Alpine and their crosses) were used to measure feed intake and milk yields. Sugarcane tops silage was offered as a basal diet and supplemented with Mulberry and Calliandra each at two levels of 200g and 300g. The total DMI was significantly higher (P<0.05) in the supplemented groups than the non-supplemented group but not different among supplemented groups. The total DMI was lower (P<0.05) for the none-supplemented animals. Daily milk yields ranged from 0.12 to 0.28 kg/d. Total milk yields were similar across the groups. However, the highest total milk yield was produced by the group fed 300g Mulberry. Does fed diet D (200g Calliandra) had the highest DMI although milk yield was highest for does fed diet C (300g Mulberry).

Key words: Sugarcane top silage, dairy goats, Mulberry leaves, Calliandra, milk yield

INTRODUCTION

One of the major setbacks of the livestock industry is high quality pasture. The amount of high-quality pasture is usually sufficient during the rainy season but, as maturity advances, the nutritive value decreases (Shayo and Msangi, 1989). During the dry season, available feed resources such as hay, maize stover and sugarcane tops are usually unable to provide sufficient nutrients for reasonable livestock productivity, and livestock generally lose weight, become susceptible to diseases and have reduced breeding performance. Ensiling the sugar cane tops would improve digestibility resulting to higher milk yields and growth rates. Supplementation of low quality grass based diets with legumes has been shown to increase dry matter intake and animal performance (Kaitho, 1997).

The goat’s potential to produce milk is utilized for purposes of supplementing income and/or self support of the family, at subsistence level with very little or no commercial production. Goats have a greater efficiency for milk production per unit body weight and also show higher survival rates than cattle (Ndikumana et al., 2000). They show considerable milk output ability in spite of their relatively higher metabolic rate and lower relative capacity for dry matter intake. Feed efficiency in milk production is higher for goats since they have an advantageous ratio of body weight to milk yield. Coupled with the lower maintenance needs and higher conversion of nutrients into milk, the goat seems the more efficient milk animal (Devendra and Burns 1970).

In Western Kenya, the Toggenberg and Alpine breeds have produced two litres of milk per day per goat though a few farms have realized four litres hence there has been a strong demand for such animals, and that even poorer farmers are able to support and benefit from these goats through formation of farmers groups. This study was conducted to determine the feeding value of supplemented ensiled SCT. Specifically, the study was designed to determine voluntary feed intake and milk yield of dairy goats fed ensiled sugarcane tops supplemented with Morus alba and Calliandra calothyrsus.

MATERIALS AND METHODS

Study site
It was the same as for experiment on growth rates.

Animals
Twelve (12) Toggenburg dairy goats at different lactation stages were used. They had an average weight of 34.8 kg.

Treatment Diets
Ensiled SCT was used in the experiment as the basal diet. The forage supplements were offered twice daily before feeding of basal diet. The treatment diets were as follows:

A. SCT ensiled with Molasses
B. SCT ensiled with Molasses + 200g Mulberry
C. SCT ensiled with Molasses + 300g Mulberry
D. SCT ensiled with Molasses + 200g Calliandra
E. SCT ensiled with Molasses + 300g Calliandra
F. Fresh sugarcane tops

Experimental procedure and design
Twelve dairy goats (Toggenburg, Alpine and their crosses) were allocated the dietary treatments in a double 6 x 6 Latin square design with each period of the experiment consisting of a 7 day adaptation and a 14 day data collection period. The ensiled sugarcane tops were offered as a basal diet ad libitum by giving a weighed amount twice a day at 8.00 hours and 14.00 hours so that there was some left over in the next feeding. Mulberry and Calliandra calothyrsus were used to form the supplements. Incremental levels (0, 200 and 300g/head/day) of Mulberry and Calliandra calothyrsus were offered. Milking was done twice daily at 5.30 hour and 17.00 hours and milk production of does monitored for a period of two months by measuring milk using graduated cylinders for precision. This was done by trained personnel.

Digestibility study and rumen liquor collection
During the last 7 days of the feeding trial, goats fed each diet were used to measure diet digestibility. Urine and faeces were collected for N and faecal DM analysis in the
last 7 days of the trial. Urine was collected over 25ml of 1% sulphuric acid and a sample refrigerated pending analysis. 10% of total faecal output per animal was dried in an oven at 600°C for 48 hrs and stored for later analysis. At the end of the collection period, the urine and faecal samples for each animal were bulked, mixed and a sub sample obtained for DM, N determination. During the last three days of the trial, 50ml rumen liquor was extracted from the goats in the morning before feeding using a stomach tube at 0, 3, 6 and 12 h after feeding. The pH of the sample collected was measured using a pH meter. 15ml of the sample was strained using a clean cotton cloth, 1 ml 7.5M sulphuric acid added then stored until analyzed for rumen ammonia nitrogen (NH3-N).

Statistical analysis
Data from the experiment was subjected to analysis of variance using the general linear model (GLM) of the SAS computer package (Statistical Analysis Systems 1998). Treatment means was separated using Least Significant Difference (LSD).

RESULTS
The forages had higher CP contents than the sugarcane tops (Table I). Mulberry had high levels of ash unlike Calliandra. Calliandra also had the highest concentration of TET as compared to Mulberry.

Table II shows the daily feed intake and milk yield. Total dry matter intake (DMI) of the basal diet ranged between 1291-2190 g/d. Supplementation as in the previous experiment had a significant effect on feed intake compared to the control group (diet F) which had the lowest intake of 1291 g/d. The group fed diet D had the highest DMI of 2190 g/d. Similarly, overall milk production was better for the supplemented groups. Total milk yields ranged from 2.6-5.9 kg with the group on diet A having the lowest milk yield. The results of rumen pH, NH3-N are shown in Table III.

DISCUSSION
Dry matter intake results in this study are in agreement with the work done by (Saddul et al., 2005) who found Mulberry suitable as a supplement, particularly to low quality roughages, in providing a source of rapidly available nitrogen to the rumen microbes, which improves roughage degradability and intake. Milk yield results are also in agreement with Ba et al (2005) who found that milk production increased with increasing the levels of Mulberry offered to goats. Rojas et al (1994) as well found milk increases from 2.0 to 2.5 kg/d when Mulberry supplementation went up from 1.0 to 2.6% of live weight on DM basis.

The daily dry matter intake (DMI) was between 1291 and 2189 g. The animals supplemented with forage legumes consumed more feed than those in the control (diet F) and unsupplemented (diet A) groups. The group fed 200 g Calliandra had the highest total DMI while the control group had the lowest. In this study, it was found that animals did not have any reluctance in accepting Mulberry as feed. Increasing the amount of Mulberry resulted to an increase in DMI. This is similar to results for the growth rates.

The daily milk yields were low as the does could produce between 1.5 to 2 kg of milk at peak lactation. Daily milk yields ranged from 0.12 to 0.28 kg/d. Total milk yields were similar across the groups. However, the highest total milk yield was produced by the group fed 300g Mulberry. From figure 2 it can clearly be seen that does fed diet D (200 g Calliandra) had the highest DMI although milk yield was highest for does fed diet C (300 g Mulberry). Milk yield was low for both the groups which were not supplemented (diets A and F). However, milk yield was higher for the control group (3.4 kg) than for the group fed ensiled SCT without supplementation (2.6 kg) despite the fact that feed intake was lower for the control group than the latter. The highest milk yield was seen in the group fed 300g Mulberry (diet C). Since Mulberry leaves are rich in nitrogen, sulphur and minerals (Singh and Makkak 2002) their use for ration supplementation could increase the efficiency of utilization of crop residues in ruminant feeding systems. Ba et al.,

TABLE I- CHEMICAL COMPOSITION (% DM) OF FEEDSTUFFS USED IN THE EXPERIMENT

<table>
<thead>
<tr>
<th></th>
<th>DM</th>
<th>OM</th>
<th>Ash</th>
<th>CP</th>
<th>CF</th>
<th>EE</th>
<th>NDF</th>
<th>ADF</th>
<th>ADL</th>
<th>TET</th>
<th>P</th>
<th>Ca</th>
</tr>
</thead>
<tbody>
<tr>
<td>FRESH SCT</td>
<td>96.37</td>
<td>93.06</td>
<td>6.94</td>
<td>4.71</td>
<td>41.20</td>
<td>3.05</td>
<td>87</td>
<td>45</td>
<td>24</td>
<td>Nil</td>
<td>0.19</td>
<td>1.46</td>
</tr>
<tr>
<td>SCT SILAGE</td>
<td>93.96</td>
<td>91.85</td>
<td>8.15</td>
<td>10.10</td>
<td>31.09</td>
<td>34.09</td>
<td>78</td>
<td>46</td>
<td>18</td>
<td>Nil</td>
<td>0.16</td>
<td>1.78</td>
</tr>
<tr>
<td>MULBERRY</td>
<td>95.33</td>
<td>84.63</td>
<td>15.36</td>
<td>19.35</td>
<td>11.51</td>
<td>40.66</td>
<td>46</td>
<td>40</td>
<td>36</td>
<td>0.5</td>
<td>0.18</td>
<td>1.69</td>
</tr>
<tr>
<td>CALLIANDRA</td>
<td>95.30</td>
<td>99.85</td>
<td>1.5</td>
<td>20.60</td>
<td>19.67</td>
<td>12.69</td>
<td>59</td>
<td>53</td>
<td>29</td>
<td>4.0</td>
<td>0.16</td>
<td>2.78</td>
</tr>
</tbody>
</table>

DM = dry matter, OM = organic matter, CP = crude protein, CF = crude fibre, EE = ether extract, NDF = neutral detergent fibre, ADF = acid detergent fibre, ADL = acid detergent lignin, TET = total extractable tannins, P = phosphorus, Ca = calcium.

DM = dry matter, OM = organic matter, CP = crude protein, CF = crude fibre, EE= ether extract, NDF = neutral detergent fibre, ADF = acid detergent fibre, ADL = acid detergent lignin, TET = total extractable tannins, P = phosphorus, Ca = calcium.
TABLE II-DRY MATTER INTAKE (DMI) AND MILK YIELD OF LACTATING DOES FED ENSILED SCT SUPPLEMENTED WITH CALLIANDRA AND MULBERRY

<table>
<thead>
<tr>
<th>Parameter</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F (control)</th>
</tr>
</thead>
<tbody>
<tr>
<td>DMI (g/d)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total DMI</td>
<td>1804a</td>
<td>1827a</td>
<td>2179b</td>
<td>2190b</td>
<td>1769c</td>
<td>8 1291d</td>
</tr>
<tr>
<td>Total milk yield (kg)</td>
<td>2.6b</td>
<td>4.4ab</td>
<td>5.9a</td>
<td>5.5a</td>
<td>4.5ab</td>
<td>3.4b</td>
</tr>
<tr>
<td>Daily milk yield (kg)</td>
<td>1.2d</td>
<td>2.1b</td>
<td>2.6a</td>
<td>2.2a</td>
<td>2.0b</td>
<td>1.4c</td>
</tr>
</tbody>
</table>

Letters with similar superscripts are not significantly different while letters with different superscripts are significantly different.

TABLE III- RUMEN NH3-N 0H% AND RUMEN PH OF LACTATING DOES FED ENSILED SCT SUPPLEMENTED WITH CALLIANDRA AND MULBERRY

<table>
<thead>
<tr>
<th>Parameter</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rumen pH 0h</td>
<td>7.560</td>
<td>7.783</td>
<td>7.895</td>
<td>7.655</td>
<td>8.150</td>
<td>7.774</td>
</tr>
<tr>
<td>Rumen pH 3 h</td>
<td>7.320</td>
<td>8.590</td>
<td>8.24</td>
<td>7.635</td>
<td>8.590</td>
<td>8.038</td>
</tr>
<tr>
<td>Rumen pH 6h</td>
<td>8.510</td>
<td>8.517</td>
<td>8.325</td>
<td>8.418</td>
<td>8.415</td>
<td>8.730</td>
</tr>
<tr>
<td>Rumen NH3-N 0h (mg/l)</td>
<td>4.3</td>
<td>1.5</td>
<td>8.5</td>
<td>4.2</td>
<td>3.5</td>
<td>7</td>
</tr>
<tr>
<td>Rumen NH3-N 3h (mg/100ml)</td>
<td>8</td>
<td>8</td>
<td>12</td>
<td>4.5</td>
<td>3.2</td>
<td>14</td>
</tr>
<tr>
<td>Rumen NH3-N 6h (mg100 m/100 ml)</td>
<td>36</td>
<td>140</td>
<td>37</td>
<td>72</td>
<td>2.5</td>
<td>45</td>
</tr>
<tr>
<td>Rumen NH3-N 12h (mg/100 ml)</td>
<td>24</td>
<td>19</td>
<td>3.5</td>
<td>42</td>
<td>18</td>
<td>35</td>
</tr>
</tbody>
</table>

Nitrogen intake tended to increase on supplementing with legumes implying additional nitrogen supply in the diet. However, there were no significant differences in N intake among the supplemented groups. The group fed Calliandra had the highest faecal N loss. This could be due to the high tannin levels in Calliandra which form complexes with N. Nitrogen retention has been found to increase and decrease with inclusion of tannins in the diet (Barry et al., 1986; Reed et al., 1990 as cited by Merkel et al., 1996), hence the protein tannin complexes are protected from rumen degradation but released further down the digestive tract and digested. Faecal N loss was low in groups fed Mulberry meaning that most of it was degraded in the rumen. Urine nitrogen loss was highest for the group fed SCT silage without supplementation. There was no significant difference in urine N loss among treatment diets.

CONCLUSION
This study demonstrated that SCT can be used as a dry season feed as long as supplementation is done using locally available forage legumes. It also demonstrated that the feeding of mulberry leaves, which have a high crude protein (about 20% of DM) and low crude fibre (about 12% of DM) content, resulted in a high apparent digestibility of the feed when fed to dairy goats. Mulberry leaves have the potential to be used as a supplementary feed for increasing milk production under crop residue-based livestock systems. Diet C which produced the best milk yield results can be recommended to farmers as supplements to crop residues.

REFERENCES

[1] Ba N.X., Giang, V.D and Ngoan, L.D. 2005. Ensiling of mulberry foliage (Morus alba) ad the nutritive...


EFFECTS OF YEAST CULTURES (SACCHAROMYCES CEREVISIAE) ADDITION TO UREA TREATED AND SUPPLEMENTED WHEAT STRAW ON INTAKE AND MILK YIELD OF DAIRY COWS

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1Egerton University, Faculty of Agriculture, Kenya,
2Kenya Agriculture Research Institute (KARI),
#Corresponding author: obebeb@yahoo.com

ABSTRACT

Two experiments were designed to determine the effect of adding yeast culture to urea-treated and urea-supplemented wheat straw diets on nutritive value, rumen fermentation (In Sacco DMD, pH, NH3-N and VFA), dry matter intake, milk yield and milk quality. Treatment diets of wheat straw with 4% urea and 6% molasses were formulated to upgrade non-protein nitrogen levels and fibre degradation of the straw. Yeast cultures (Saccharomyces cerevisiae) were included at 0 and 10g/ day in a mixture with commercial dairy meal to improve on fibre degradation and milk yields. The two experiments included: an in sacco DMD trial with three steers to determine effect of urea treatment or supplementation and yeast culture addition on intake and rumen degradation parameters. A 3x2 factorial arrangement was designed for this experiment. Secondly, feeding trial with eighteen (18) lactating cows in a 3 x 2 factorial arrangement at two levels of yeast culture (0 and 10g/day) and three types of urea interventions: no intervention (WS), addition of urea to straw at the time of feeding (USWS) and 7 days incubation of straw with urea (UTWS). Urea treatment or yeast culture addition to straw had no significant effect (p>0.05) on in sacco dry matter degradability. Addition of yeast culture to WS increased pH (p<0.05) but not NH3-N. Yeast culture increased NH3-N of UTWS (p<0.05). On the other hand, addition of yeast culture to USWS lowered pH to below 6 at 6 hr. Both urea (treatment and supplementation) and yeast culture treatments had no effect (p>0.05) on dry matter intake, milk yield and milk composition but they increased (p<0.05) propionate yields.

Key words: urea treatment, urea supplementation, wheat straw, yeast cultures, dairy cows

INTRODUCTION

Crop residues represent a large feed resource base for ruminants but remain underutilised and certainly not commercialized for a number of reasons. They are bulky to store and expensive to transport over long distances. They have low nutritive value, attributable to high degree of lignification and high cell-wall content (Staniforth, 1979). The chemical composition and digestibility show great variation depending on crop varietal differences (Reed et al., 1986) and agronomic practices (Staniforth, 1979). In practice, however, most smallholder farmers feed crop residues without any form of supplementation or treatment, consequently impacting adversely on animal production performance. In the case of urea-ammoniation, urea releases ammonia after dissolving in water. For practical use by farmers, urea is considered safer than using anhydrous or aqueous ammonia and it provides a source of nitrogen deficient in straw (Horton and Nicholson, 1981). Numerous investigations involving the use of urea on wheat straw have been reported in literature, not only in vitro (Sirohi and Rai, 1999; Park et al., 1995) and in situ (Currier et al., 2004), but also in field trials (Horton and Nicholson 1981). Pradhan et al., (1997) showed that addition of calcium hydroxide (Ca (OH) 2) to urea improved the IVMD. Yeast action can utilize part of free sugar in the rumen and limit a fermentation shift due to rapid degradation of these compounds. Saccharomyces cerevisiae can secrete some metabolites that are useful for other ruminal microorganisms. Yeast cultures contain B vitamins, amino acids and organic acids, particularly malate, which stimulates growth of other ruminal bacteria that digest cellulose (Callaway and Martin, 1997). Malate has been shown to be a potent growth promoter for lactate-fermenting bacteria in-vitro, but is not sufficient to increase the number of ruminal bacteria in vivo. This study investigated the ways to improve the nutritive value of wheat straw before feeding, which was in some form of treatment and/or supplementation.

MATERIALS AND METHODS

Diet preparation

Urea treated wheat straw (UTWS) was prepared in batches of 50 kg of straws each. For every batch, WS (wheat straw) was weighed and milled through a 20-40 mm screen (Williams et al., 1991). A solution of fertilizer grade urea (4% of wheat straw) was dissolved in 25L of water and then uniformly applied to the straw. The mixture was sealed in an airtight polyethylene bag (200 x 100cm) to avoid N escaping before the ammoniation is complete. This was incubated for 7 days at room temperature (Chenost, 1995; Smith, 2001) and stored until required for feeding. After incubation, UTWS was aerated prior to feeding to facilitate escape of free or untreated ammonia (Teshome, 2009). At the moment of feeding, UTWS was mixed with 6% molasses. Dairy meal was offered to all animals at 20% of wheat straw. It constituted 25.9% of the total ration on dry matter basis (Table I). It was fed to animals at the time of milking. Fortification of wheat straw with urea (USWS) was achieved by weighing, milling wheat straw as above. This was mixed with a solution containing urea (4% of wheat straw) and molasses (6% of wheat straw) and fed the same day. Dairy meal was offered during milking. Yeast culture (YC) (Saccharomyces cerevisiae) was added daily to the diet, mixed together with dairy meal. Every day, 10 grams of YC (Williams et al., 1991) was mixed with the amount of dairy meal to include to the ration and offered to the animals preferentially. Thereafter, UTWS and USWS (80%) will be fed to the animals. Molasses (6% of wheat straw) was added to all diets before feeding. All animals had ad libitum access to fresh water and minerals. The basal diet of wheat straw was offered to the animals ad libitum.
Experimental procedure and design
Three fistulated steers housed in individual pens were used for intake measurement, in sacco degradability analysis and rumen fermentation. Care of the animals was taken in order to meet welfare standards related to the use of animals for experimental purpose. The animals were dewormed to control internal parasites control and also sprayed to control external parasites. Water and mineral licks was provided ad libitum. A sample of a wheat straw was oven dried at 60°C for 48 hr, and milled to pass through a 20 mm screen. Two grams sample was put in nylon bags, (50x150 mm size, pore size 50 µm). The nylon bags, in duplicate, containing the substrate were incubated in the rumen of steers receiving each treatment diet for a period of 6, 12, 24, 48, 72 and 96 hr. The bags were added in sequence and at the end of the incubation period (96 hr) all the bags were removed and rinsed in cold water until no more brown color was visible. The bags were then oven dried for 48 hr at 60°C to constant weight and weighed to determine the weight loss. The zero hour degradability was determined by soaking the bags containing the sample in warm water (38°C) for 60 minutes and then squeezing them gently until no more brown color was visible before being dried. The in Sacco degradability was calculated using the exponential model of Ørskov and McDonald (1979). The experiment adopted a 3 x 2 Factorial arrangement corresponding to 3 main levels of urea intervention (WS, USWS and UTWS) with or without addition of yeast culture (0, 10g/day) making six experimental diets (Figure 1). Data from degradability trial was evaluated by GLM procedure of SAS (2008) in analysis of variance. The level of significance was set at the probability value of P < 0.05 and the means separation done using Tukey’s test. In the second experiment, 18 milking cows were used during 21 days (14 days of adaptation and 10 days of data collection) in a 3 x 2 factorial arrangement. All the cows were milked twice a day in the morning (06 00 hr) and in the afternoon at 17 00 hr. Milk yield was weighed and recorded every day throughout the study period. Every day, during the collection period, 20 ml of morning and afternoon milk samples from each cow was collected and kept for later analysis of milk fat, protein, Solids Not Fat (SNF) and total solid (TS) (Teshome, 2009). Data from feeding trial was evaluated by MIXED procedure of SAS (2008) in analysis of variance. The level of significance was set at the probability value of P < 0.05. The means separation was done using Tukey’s test with “pdmix800.SAS” macro of SAS (2008).

TABLE I - CHEMICAL COMPOSITION OF DIETS

<table>
<thead>
<tr>
<th>Ingredients (%)</th>
<th>Dietary composition (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>WS</td>
</tr>
<tr>
<td>Wheat straw</td>
<td>64.7</td>
</tr>
<tr>
<td>Dairy meal</td>
<td>25.9</td>
</tr>
<tr>
<td>Molasses</td>
<td>5.8</td>
</tr>
<tr>
<td>Urea</td>
<td>-</td>
</tr>
<tr>
<td>Yeast Culture</td>
<td>-</td>
</tr>
<tr>
<td>Chemical composition</td>
<td></td>
</tr>
<tr>
<td>DM* (%)</td>
<td>93.5</td>
</tr>
<tr>
<td>CP (%)</td>
<td>8.0</td>
</tr>
<tr>
<td>CF* (%)</td>
<td>40.22</td>
</tr>
<tr>
<td>ME (MJ/Kg)</td>
<td>7.16</td>
</tr>
</tbody>
</table>

*Values for DM and CF are only those of wheat straw

RESULTS AND DISCUSSION
Effect on rumen fermentation parameters
The table below presents results of the In Sacco dry matter degradability of wheat straw supplemented or treated with urea and with or without yeast culture. Urea intervention, yeast culture level and interaction between urea and yeast were found to affect (p<0.05) potential degradability. Effective degradability decreased (p<0.05) with urea treatment (UTWS) but was no affected by yeast cultures levels. The rate of degradation increased (p<0.05) with supplementation (USWS) and with urea treatment of straws (UTWS). The Lag time and soluble fraction (intercept) were affected (p<0.05) by urea intervention but not by the yeast culture addition. The interaction between urea intervention and yeast culture levels affected the degradable fraction (p<0.05).

UTWS showed the lowest degradability values. The low degradability values of urea treated wheat straw may be due to low hydrolysis of urea to ammonia leading to low degradability improvement of the feed material (Jabbar et al., 2009). Hence increasing the incubation time and the quantity of water might produce better results (Smith, 2001). However, criticized for its complexity and its low improvement in production when results are positive, these increments in water and incubation time might not contribute to fasten farmers’ adoption of urea treatment (FAO, 2011). The addition of yeast cultures to untreated wheat straw increased (p<0.05) pH in the rumen from 6.42±0.12 to 6.83±0.12. Even though the addition of YC to UTWS also increased the pH, the difference was insignificant (p>0.05). On the other hand, USWS did not respond significantly to the addition of yeast culture and showed instead a slight decrease in pH. On the concentration of NH3-N in the rumen fluid, yeast cultures increased NH3-N when added to UTWS (7.93 mmol/L) compared to USWS (7.34 mmol/L).

Results from this study showed that rumen pH tended to be higher for WS+YC and UTWS+YC than WS and UTWS. This may be due to the effect of yeast culture as a booster
for rumen fermentation, in the case of WS and also to the alkali effect due to treatment with urea. These results are in agreement with the findings of Hristov et al. (2010) and Williams et al., (1991) on the effect of Yeast cultures. The addition of yeast cultures resulted in a decrease (p<0.05) in Total VFA production in the rumen. Urea treatment and yeast culture levels had effect (p<0.05) on production of acetate levels with highest production obtained for UTWS producing and lowest for WS. However, yeast culture was found to have an effect on individual VFAs production in the rumen. Acetate levels reduced with YC addition for USWS and UTWS, while propionate levels increased for the same treatments (USWS and UTWS). This situation confirms findings of other researchers who have found that high forage diets (low quality) yield high levels of acetate and lower propionate levels even if yeast cultures tend to reduce acetate and increase propionate levels (Ishler et al., 1996; Sutton et al., 2003).

**Dry matter intake, milk yield and composition**

Addition of yeast culture only marginally increased milk yield for untreated and urea treated wheat straw as shown in Table 4. However, a minor decrease in milk yield was noticed when urea supplemented wheat straw (USWS) was fed with and without yeast cultures, compared to the control (WS) and the urea treated wheat straw (UTWS). Milk fat content was not affected (p>0.05) by either the urea treatment or addition of yeast culture, though a slight decrease in milk yield was observed due to addition of yeast cultures to urea supplemented wheat straw and to untreated straw in comparison to urea treated wheat straw. There was also a slight increase in solid not fat when yeast cultures (YC) were added to wheat straw treated with urea (UTWS) compared to urea supplemented wheat straw (USWS). The low response of animals to the

### TABLE II- IN SACCO DRY MATTER DEGRADABILITY OF WHEAT STRAW SUPPLEMENTED OR TREATED WITH UREA AND WITH OR WITHOUT YEAST CULTURE SUPPLEMENTATION

<table>
<thead>
<tr>
<th>Items</th>
<th>WS Control</th>
<th>YC</th>
<th>USWS Control</th>
<th>YC</th>
<th>UTWS Control</th>
<th>YC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incubation time (h)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>39.95</td>
<td>40.66</td>
<td>38.94</td>
<td>38.96</td>
<td>31.96</td>
<td>37.47</td>
</tr>
<tr>
<td>24</td>
<td>45.35</td>
<td>46.81</td>
<td>56.24</td>
<td>54.88</td>
<td>42.09</td>
<td>37.45</td>
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<td>48</td>
<td>64.43</td>
<td>60.93</td>
<td>64.13</td>
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<td>72</td>
<td>72.89</td>
<td>72.48</td>
<td>66.93</td>
<td>68.86</td>
<td>61.05</td>
<td>60.80</td>
</tr>
<tr>
<td>Intercept</td>
<td>30.35</td>
<td>29.6</td>
<td>25.9</td>
<td>18.2</td>
<td>11.05</td>
<td>20.2</td>
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<tr>
<td>Potential Degradability</td>
<td>75.4</td>
<td>100</td>
<td>67.8</td>
<td>64.5</td>
<td>60.9</td>
<td>59.7</td>
</tr>
<tr>
<td>Effective Degradability</td>
<td>43.7</td>
<td>41.5</td>
<td>44.3</td>
<td>44.1</td>
<td>42.5</td>
<td>39.5</td>
</tr>
<tr>
<td>Rate of degradation</td>
<td>0.023</td>
<td>0.002</td>
<td>0.037</td>
<td>0.057</td>
<td>0.067</td>
<td>0.042</td>
</tr>
<tr>
<td>Lag time</td>
<td>2.1</td>
<td>0.9</td>
<td>4.5</td>
<td>5.2</td>
<td>6.6</td>
<td>6.9</td>
</tr>
</tbody>
</table>

### TABLE III- EFFECT OF ADDING YEAST CULTURES TO UREA TREATED AND SUPPLEMENTED WHEAT STRAW ON RUMEN PH AND NH3-N

<table>
<thead>
<tr>
<th>Treatments</th>
<th>WS</th>
<th>USWS</th>
<th>UTWS</th>
<th>WS+YC</th>
<th>USWS+YC</th>
<th>UTWS+YC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time post feeding</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>pH</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>6.61</td>
<td>6.32</td>
<td>6.54</td>
<td>6.73</td>
<td>5.83</td>
<td>6.53</td>
</tr>
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<td>2</td>
<td>6.44</td>
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<td>6.56</td>
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<tr>
<td>4</td>
<td>6.32</td>
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<td>6.62</td>
<td>6.8</td>
<td>6.49</td>
<td>6.89</td>
</tr>
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<td>6</td>
<td>6.31</td>
<td>6.36</td>
<td>6.63</td>
<td>6.47</td>
<td>5.55</td>
<td>6.86</td>
</tr>
<tr>
<td>Mean</td>
<td>6.42a</td>
<td>6.36b</td>
<td>6.58a</td>
<td>6.83a</td>
<td>6.03b</td>
<td>6.71a</td>
</tr>
<tr>
<td>SEM</td>
<td>0.12</td>
<td>0.12</td>
<td>0.12</td>
<td>0.12</td>
<td>0.12</td>
<td>0.12</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Rumen NH3-N (mmol/L)</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>8.1</td>
<td>8.3</td>
<td>7.85</td>
<td>7.5</td>
<td>8.1</td>
<td>8.3</td>
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<tr>
<td>2</td>
<td>8.0</td>
<td>7.7</td>
<td>7.4</td>
<td>7.15</td>
<td>7.75</td>
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<tr>
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<td>8.3</td>
<td>7.9</td>
<td>7.4</td>
<td>7.25</td>
<td>7.85</td>
<td>7.75</td>
</tr>
<tr>
<td>6</td>
<td>8.1</td>
<td>7.8</td>
<td>7.15</td>
<td>7.45</td>
<td>7.6</td>
<td>8.1</td>
</tr>
<tr>
<td>Mean</td>
<td>8.13</td>
<td>7.34</td>
<td>7.93</td>
<td>7.83</td>
<td>7.45</td>
<td>8.0</td>
</tr>
<tr>
<td>SEM</td>
<td>0.08</td>
<td>0.08</td>
<td>0.08</td>
<td>0.08</td>
<td>0.08</td>
<td>0.08</td>
</tr>
</tbody>
</table>

Means followed by the same letter in superscript are not significantly different. Means underlined in the same row are significantly different.
addition of yeast culture may be attributed to the dietary composition as it was very low in rapidly fermentable carbohydrates (low level of dairy meal and molasses in all diets) (Williams et al., 1991). The low intake of UTWS may be explained by its low degradability values (59.7% of potential degradability). Jabbar et al., (2009) reviewed the treatment of wheat straw with urea and found that although as low as 20% moisture and 2 days of incubation can be used for the treatment in the tropics, the level of urea hydrolysis and protein level increased with moisture content of the material with the optimum being at 100% moisture. They also found the effectiveness of the process increasing with time of incubation from one week up to eight weeks. Ambient temperature is also an important factor for effective ammoniation of the straw. These suggest that refining urea treatment for a better uptake by small scale farmers is important (FAO, 2012). Since inputs of labor, chopping, urea, polyethylene bags and water are relatively costly, they must be converted in decent output in terms of profit for farmers. The low Milk yield for all treatments was caused by the low quality of the diet and suggests that the diet should be maintenance diets for dry season, rather than for production. Although addition of YC showed the marginal increase with UTWS being the highest, milk yield was not significantly affected by urea intervention or yeast culture levels. These results differ from most other studies (Williams et al., 1991; Moallem et al., 2009; Erasmus et al., 1992). But the quality of the diet, especially the low net energy for lactation might have been the major limitation.

**CONCLUSIONS**

Addition of yeast culture to urea-treated and urea-supplemented wheat straw basal diets did not significantly affect DMD, but they affected total VFA, rumen pH. This was particularly seen when yeast culture was added to untreated wheat straw and significantly increased rumen pH and ammonia. It further suggests that addition of yeast culture can be more beneficial than alkali treatment in improving rumen environment for low quality roughage diets. The addition of yeast culture to urea-treated and urea-supplemented wheat straw basal diet fed to dairy cows contributed to increase slightly dry matter intake, especially for untreated straw. But milk yield and composition did not change significantly for either treatment.

**RECOMMENDATIONS**

Further studies should be done to improve on the effect of yeast cultures in the rumen and to standardize urea treatment method for better uptake by farmers.

---

### TABLE IV- EFFECT OF YEAST CULTURE ADDITION TO WS, USWS AND UTWS ON TOTAL AND INDIVIDUAL VOLATILE FATTY ACID PRODUCTION IN THE RUMEN

<table>
<thead>
<tr>
<th>Diet</th>
<th>Acetate 0</th>
<th>Acetate 10</th>
<th>Propionate 0</th>
<th>Propionate 10</th>
<th>Butyrate 0</th>
<th>Butyrate 10</th>
<th>Other VFAs 0</th>
<th>Other VFAs 10</th>
<th>Total 0</th>
<th>Total 10</th>
</tr>
</thead>
<tbody>
<tr>
<td>WS</td>
<td>69.51</td>
<td>69.71</td>
<td>18.23</td>
<td>16.88</td>
<td>8.14</td>
<td>7.50</td>
<td>3.62</td>
<td>3.32</td>
<td>99.49</td>
<td>97.41</td>
</tr>
<tr>
<td>USWS</td>
<td>69.24</td>
<td>68.56</td>
<td>18.42</td>
<td>19.16</td>
<td>8.19</td>
<td>8.51</td>
<td>3.64</td>
<td>3.63</td>
<td>99.48</td>
<td>99.87</td>
</tr>
<tr>
<td>UTWS</td>
<td>70.06</td>
<td>68.34</td>
<td>17.14</td>
<td>18.24</td>
<td>8.28</td>
<td>8.81</td>
<td>3.68</td>
<td>3.92</td>
<td>99.17</td>
<td>99.30</td>
</tr>
</tbody>
</table>

Significance

- Urea intervention: 0.0012 * 0.0001 * 0.0001 * 0.0001 * 0.0001 *
- YC level: 0.0001 * 0.0098 * 0.0129 NS 0.5653 * 0.0013 *
- Urea*YC: 0.0001 * 0.0001 * 0.0001 * 0.0001 * 0.0001 *

Std Err mean: 0.17 0.17 0.07 0.07 0.03 0.03 0.04 0.04 0.18 0.18

Means underlined in the same row for the same variable are significantly different at 5%. NS= not significant. *: significant at p<0.05

### TABLE V- EFFECT OF ADDING YEAST CULTURES TO UREA-TREATED AND SUPPLEMENTED WHEAT STRAW BASAL DIETS ON MILK YIELD AND COMPOSITION

<table>
<thead>
<tr>
<th>Dietary treatments</th>
<th>DMI (Kg)</th>
<th>Milk yield (%)</th>
<th>Fat (%)</th>
<th>Solid not fat (%)</th>
<th>Protein (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>YC</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WS</td>
<td>12.42</td>
<td>13.18</td>
<td>2.76</td>
<td>2.79</td>
<td>4.97 4.31 7.73 7.61 2.81 2.77</td>
</tr>
<tr>
<td>USWS</td>
<td>11.26</td>
<td>11.10</td>
<td>2.30</td>
<td>2.54</td>
<td>4.89 4.00 7.66 7.14 2.79 2.6</td>
</tr>
<tr>
<td>UTWS</td>
<td>12.42</td>
<td>11.11</td>
<td>2.74</td>
<td>2.89</td>
<td>4.60 5.11 7.64 7.72 2.78 2.8</td>
</tr>
<tr>
<td>Urea intervention</td>
<td>0.3</td>
<td>NS</td>
<td>0.59</td>
<td>NS</td>
<td>0.64 0.08 NS 0.09 NS</td>
</tr>
<tr>
<td>YC level</td>
<td>0.79</td>
<td>NS</td>
<td>0.69</td>
<td>NS</td>
<td>0.33 0.12 NS 0.08 NS</td>
</tr>
<tr>
<td>Interaction</td>
<td>0.63</td>
<td>NS</td>
<td>0.96</td>
<td>NS</td>
<td>0.27 0.1 NS 0.08 NS</td>
</tr>
<tr>
<td>SEM</td>
<td>0.99</td>
<td>1.22</td>
<td>0.40</td>
<td>0.49</td>
<td>0.40 0.49 0.12 0.14 0.43 0.53</td>
</tr>
</tbody>
</table>

*Dry matter intake expressed in terms of metabolic body weight (KgLWT0.75). NS = not significant. SEM = standard error of means
ACKNOWLEDGEMENT
I wish to acknowledge my family, the Department of Animal Sciences of Egerton University, my supervisors, the East African Agricultural Productivity Project and KARI-N’joro for their support.

REFERENCES
THE POTENTIAL QUALITY, MODE OF FEEDING AND CONSTRAINTS OF FEEDSTUFFS IN MBEERE DISTRICT OF EASTERN KENYA

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1Kenya Agriculture Research Institute, Kiboko Research Centre, PO Box 12, Makindu, Kenya, 2University of Nairobi, Department of Animal Production, P.O. Box 29053-00625, Nairobi, Kenya. *Corresponding author

ABSTRACT

A study was conducted to determine varieties, utilization mode and feed value of feedstuffs in smallholder dairy farms in Mbeere District, Eastern Kenya. Data, from 33 farms, under two dairy production systems, Evurore and Siakago Divisions, were collected during May to July, 2007. It covered farms with stall managed lactating cows, where data on breed, age, parity, milk yield, feeds and their daily intake, mode of feed conservation and feed conservation structures for roughages were recorded. Arsyshire, Friesian and their crosses were the breeds reared. Cows were fed roughages and concentrates on an as is basis at 20.2 kg and 3.3 kg respectively in Siakago and 16.5 kg and 2 kg respectively in Evurore (range, 7-38 kg/day for roughages; 2.0–8.0 kg/day for concentrates). Some 25% of farmers fed roughages in unprocessed form while 75%, processed the roughages. Forages were conserved in open or under roofed hay barns. Some farmers, 30%, conserved the harvested grasses and cereal and legume crop by-products in baled bundles. Silaging was not used to preserve forages. During dry periods, banana stems and cereal by-products were used to sustain animals. Feedstuffs were of moderate feed value: DM, 102 - 919 g/kg CP, 52 - 248 g/kg, NDF, 26.44 81.44%, ADF, 9.14 –51.26 and ADL, 3.05 – 10.83. The invitro digestibility ranged from 787 g/kg to 452 g/kg. Farmers experienced challenges in optimal feeding of lactating cows in the dry months, February and July - October. For improved milk yields, even during dry months, farmer’s capacity on alternative forage conservation methods, silaging and baling, need enhancement.

Key-words: Feed value, roughages, silaging, and smallholder-dairy.

INTRODUCTION

Small holder dairy has gained importance as an economic activity among residents of semi arid Mbeere district (Onduru et al., 2002; Karanja 2003; Katiku et al., 2011). There is growing recognition that economic activities such as dairying are having important consequences on people’s livelihoods and on the environment. However, for rural farming households in the Arid and Semi-Arid Lands (ASAL) areas of Mbeere in Eastern Kenya, there is an urgent need to increase farmer’s incomes as a means of reducing poverty. There is growing demand for milk for feeding the increasing Kenyan population. Similarly, there is need of increasing the efficiency of farm operations through reduction in costs of farm operations such as those resulting from feeding of stall managed dairy animals. The analysis of feedstuffs, their mode of utilization and their feed value allows both the farmers and policy makers to make informed decisions about the development of the agricultural sector (ILRI, 2001). This study quantifies the potential feeding value and the sustainability of locally available feed materials used in feeding stall managed dairy cattle in a tropical semi arid dairy farming system. The objective of the study was to determine varieties, mode of preservation, utilization and feed value of locally available feedstuffs in smallholder dairy farms in Mbeere District, Eastern Kenya.

DATA COLLECTION

Initially, single subject interviews of random sample of 33 smallholder dairy cattle farmers from the two divisions, Siakago and Evurore, were conducted. Primary data were collected in a longitudinal study involving 12 farms with 27 heads of stall managed dairy cows in various stages of lactation, 6 from each of the two Divisions for a period of 3 months. The 12 farms were purposively selected from the 33 farms. The selection of participating households was based on the possession of at least one lactating dairy cow, ability to keep records and willingness to participate in the study. Data collected included types of feeds and amounts fed, feeding regime/practices, milk yields and cow’s parameters such as, age, parity, calving interval and stage of lactation.

An individual animal data card was used to record data on breed and parity, lactation length and milk yields, feed types and daily intake and calving interval. To allow for accurate recording of milk yield at the farm, farmers were provided with 1 litre graduated cups (Figure 1). Similarly, farmers were provided with a 50 kg spring balance (Figure 2) for weighing of feeds given to the animals. Subsequent data on type and weight of feed(s) consumed, milk yield, and cases of sicknesses were recorded for a period of 3 months mainly by the individual farmers. However, for purposes of accuracy in data recording, monitoring visits were made to the farms on ad hoc basis whereby records were checked and unclear details were explained by the farmer.

Each of the participating farmers was trained on feed sampling and was provided with feed sample bags for preserving samples of the feeds given to the animals.

MATERIALS AND METHODS

Small holder dairy cattle

The specific tools used to generate information on the types of feedstuffs, their mode of utilization and feed value of locally available feed materials used in feeding stall managed dairy cattle in two divisions, Evurore and Siakago, in the semi-arid area of Mbeere district and the lactation performance of stall managed dairy cattle was a combination of longitudinal studies and single subject interviews of key stall managed dairy cattle keepers in the district.
RESULTS AND DISCUSSION
Potential feed categories for feeding dairy cattle
Dairy cattle farming in Mbeere District were practiced by ordinary farmers, retired officers, civil servants and businesswomen/men whose main purpose was a means of diversification of income for improved livelihoods (Onduru et al., 2002; Katiku et al., 2011). Eighty-seven percent of farmers planted ley pasture for their dairy animals while the rest relied mainly on natural pasture grasses and legumes (Table II). However, crop by-products and commercial concentrate feeds were widely used in all farms.

The potential feed resources in the study area and their nutritive values are shown in Table I. The feeds were grouped into 4 categories: crop by-products, fodder grasses, trees and shrubs, concentrates and natural pastures. The crop by-product feed category, with the widest varieties, formed the feed base for majority of the farmers. The materials were conserved in structure (Table II); roofed barns with open side walls by over 81% of the households. However, the materials were not sufficiently available throughout the year. The planted fodder feed category - *Pennisetum purperium*, *Leucaena leucocephala*, *Morus alba*, *Chloris gayana*, *Glycine spp*, *Calliandra spp*, *Sorghum spp* and *Manihot spp*, had the second wider variety and also relatively cheaper material for feeding; it was however, considerably underutilized, possibly because of low level of knowledge among the farmers.

Majority of the farmers relied on the crop residues for feeding their grade dairy cows for almost year round, but dominantly in the dry month, February and July to October. The materials were of moderate nutritional value as shown in Table I. The fibre content of most of the rough materials was high. There was little evidence of use of modern technology to improve on the quality except on the use of simple chopping techniques. Therefore, there is need to introduce and advocate for modern crop residue utilization and quality improvement strategies, to improve on the performance of the dairy cattle to the main stakeholders, farmers. Additionally, farmers need to be made aware of the importance of mineral salts in the entire process of nutrition.

Methods of Feed processing, conservation and utilization
Farmers in Mbeere formulated rations (Figure 1) for feeding their lactating stall managed dairy cows using materials from the 4 feed categories shown in Table I. Farmers employed simple techniques in processing roughages fed to dairy animals. The technique involved chopping roughages prior to feeding. However, the techniques varied from use of simple implements such as machetes and ordinary chaff cutters to use of motorized chaff cutters (Figures 3a and 3b). Chopping reduced the feed particle size (Figure 3c). Majority of the farmers, 76%, practiced one form of feed processing. This was beneficial to both the farmers and the animals. Processing increased the efficiency of feed utilization by reducing choice and preference and increasing rumen digestion. However, farmers were not using other feed additives such as molasses to improve both the feed value and intake of the fibrous forages.

It was observed that each of the farms made rations based...
on the feed resources available in the farm, which varied between farms. In order to mitigate against the vagrancy of dry weather conditions, when feeds were in short supply, farmers conserved roughages as shown in Figure 4. However, there were variations in the forms of structures used, ranging from open roofed barns to open unroofed structures.

The kind of feeding regime observed in Figure 1 and Table III, indicates that low amounts of forages (<20 kg/cow/day) were provided to lactating dairy cows during the study period. Forage was normally available in abundant quantities in the study area during long and short rainy seasons (Kamau 2004, Onduru et al., 2002) which are March to June and October to December respectively. The rest of the months were dry, a period when farmers relied on either conserved feeds or commercially procured feed resources. The commercial feed stuffs were not easily accessible to most of the resource poor smallholder farmers (Karanja 2003; Katiku et al., 2011). Farmers resorted in using poor quality roughages, mainly from category 4 and 1 of the feed resources to maintain the animals. A small percentage, 30%, of the farmers conserved roughages in bales. However, all the farmers interviewed indicated that the conserved roughages were hardly sufficient for feeding their animals throughout the year. Baling is a simple technology that farmers employ to harvest and preserve forages for use during the periods of scarcity; however it was not widely applied in the study area possibly because of low level of knowledge. Even though silage making was another alternative option that farmers could employ for preserving the succulent green fodder during the periods of plenty, mainly the wet seasons, the technology was not practiced by the households interviewed in the current study.

Poor nutritional status of animals, exhibited by provision of either poor quality or small quantities of forages, was reflected in the productivity performance (Figure 5) of the mostly grade cows, with moderate yields (7 kg/cow/day) being recorded in the period. There is need to develop a sustainable feeding management that incorporate supplementation strategies for enhancing milk yield even during the dry months for both household food security and as well as for income generation (Waithaka et al., 2002).

It was observed that only 30% of the monitored farms used browse from fodder trees. Fodder trees are a knowledge-intensive practice requiring considerable training and facilitation, especially the first time farmers establishing a nursery and at about nine months later, at harvesting (Franzel et al., 2003).

**Cows feeding regimes and corresponding milk yields**

Table III shows the actual amounts of feed fed to the individual cows in the farms. It was observed that farmers did not have a concise method of determining the quantities of feed offered to cows. However, cows were fed on the type and amount of feed that was available irrespective of body weight and milk yield (Waithaka et al., 2002; Ongadi et al., 2007).

The concentrates mainly consisted of the commercial feeds. However, in two of the farms, it was observed that whole maize was milled without any additives and designated as concentrate. The total amount of each feed category consumed by a cow was the sum total of the different quantities offered in a day as estimated with a spring balance. The amount of roughages and concentrates offered varied both between and within farms with a mean daily consumption of 18.6 ± 6.77 (range 7- 38) kg and 2.74 ±1.77 (range2-8) kg respectively. The variations in feeding resulted in a corresponding variation in milk yield.
### TABLE I- DRY MATTER, CRUDE PROTEIN, FIBRE AND IN-VITRO DRY MATTER DIGESTIBILITY OF FEEDSTUFFS IN THE STUDY AREA.

<table>
<thead>
<tr>
<th>Feed name</th>
<th>DM g/kg</th>
<th>CP g/kgDM</th>
<th>IVDMD (g/kg)</th>
<th>NDF (g/kg)</th>
<th>ADF (g/kg)</th>
<th>ADL (g/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1. Crop by-products</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maize -Zea mais -dry stover</td>
<td>841</td>
<td>39</td>
<td>563</td>
<td>78.44</td>
<td>40.59</td>
<td>4.19</td>
</tr>
<tr>
<td>Banana pseudo stems and leaves (Musa spp)</td>
<td>135</td>
<td>45</td>
<td>650</td>
<td>74.69</td>
<td>33.08</td>
<td>7.92</td>
</tr>
<tr>
<td>Young banana sucker (Musa spp)</td>
<td>131</td>
<td>50</td>
<td>650</td>
<td>56.03</td>
<td>41.35</td>
<td>5.94</td>
</tr>
<tr>
<td>Cassava tubers (Manihot spp)</td>
<td>102</td>
<td>29</td>
<td>675</td>
<td>50.03</td>
<td>9.14</td>
<td>3.05</td>
</tr>
<tr>
<td>Sweet potato vines- vines and leaves –(Ipomoea spp)</td>
<td>233</td>
<td>103</td>
<td>750</td>
<td>60.05</td>
<td>36.22</td>
<td>8.84</td>
</tr>
<tr>
<td>Paw paw dry eaves-(papaya spp )</td>
<td>849</td>
<td>41</td>
<td>557</td>
<td>50.05</td>
<td>46.22</td>
<td>9.84</td>
</tr>
<tr>
<td>Mixture of Napier and maize stover (ratio 50:50)</td>
<td>516</td>
<td>71</td>
<td>563</td>
<td>77.79</td>
<td>43.58</td>
<td>6.41</td>
</tr>
<tr>
<td>Market waste -mixture of kales and cabbage leaves and ripe banana peeling</td>
<td>394</td>
<td>117</td>
<td>787</td>
<td>50.88</td>
<td>31.65</td>
<td>7.79</td>
</tr>
<tr>
<td>Mixture of dry maize stover, napier grass and dry bean haulm (ratio 3:2:1)</td>
<td>616</td>
<td>123</td>
<td>585</td>
<td>71.57</td>
<td>46.71</td>
<td>8.29</td>
</tr>
<tr>
<td>Sorghum straw-Sorghum spp</td>
<td>836</td>
<td>65</td>
<td>532</td>
<td>73.84</td>
<td>46.35</td>
<td>5.99</td>
</tr>
<tr>
<td>Butter nuts</td>
<td>160</td>
<td>93</td>
<td>492</td>
<td>26.44</td>
<td>19.24</td>
<td>7.37</td>
</tr>
<tr>
<td><strong>2. Fodder</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Calliandra leaf fodder (fresh)</td>
<td>484</td>
<td>212</td>
<td>582</td>
<td>40.10</td>
<td>24.72</td>
<td>10.83</td>
</tr>
<tr>
<td>Dwarf Leucaena leaf fodder- dried (Leucaena spp)</td>
<td>887</td>
<td>220</td>
<td>452</td>
<td>68.78</td>
<td>51.26</td>
<td>9.91</td>
</tr>
<tr>
<td>Giant Leucaena leaf hay (Leucaena spp)</td>
<td>712</td>
<td>248</td>
<td>500</td>
<td>58.78</td>
<td>46.26</td>
<td>7.91</td>
</tr>
<tr>
<td>Mulberry fodder-fresh (Moris spp)</td>
<td>592</td>
<td>181</td>
<td>590</td>
<td>39.56</td>
<td>25.01</td>
<td>7.30</td>
</tr>
<tr>
<td>Napier grass- fresh material (Pennisetum spp)</td>
<td>325</td>
<td>63</td>
<td>616</td>
<td>67.88</td>
<td>38.58</td>
<td>5.09</td>
</tr>
<tr>
<td>Rhodes grass- fresh hay Chloris spp –</td>
<td>849</td>
<td>88</td>
<td>556</td>
<td>81.44</td>
<td>47.69</td>
<td>7.72</td>
</tr>
<tr>
<td><strong>3. Concentrates</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dairy meal-Commercial concentrate</td>
<td>894</td>
<td>120</td>
<td>749</td>
<td>41.99</td>
<td>12.44</td>
<td>4.39</td>
</tr>
<tr>
<td>Wheat bran</td>
<td>891</td>
<td>134</td>
<td>582</td>
<td>69.67</td>
<td>34.32</td>
<td>9.04</td>
</tr>
<tr>
<td>Home concentrate-milled whole maize only</td>
<td>811</td>
<td>94</td>
<td>758</td>
<td>64.37</td>
<td>28.71</td>
<td>1.37</td>
</tr>
<tr>
<td>Rice bran</td>
<td>919</td>
<td>85</td>
<td>664</td>
<td>72.67</td>
<td>44.32</td>
<td>8.04</td>
</tr>
<tr>
<td>Wheat pollard</td>
<td>863</td>
<td>157</td>
<td>735</td>
<td>37.46</td>
<td>13.96</td>
<td>4.12</td>
</tr>
<tr>
<td><strong>4. Natural pasture</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Natural pasture hay (Rhychelyntron spp)</td>
<td>271</td>
<td>95</td>
<td>571</td>
<td>58.65</td>
<td>25.97</td>
<td>9.52</td>
</tr>
<tr>
<td>Bush legume – leaves and stems (Glycine spp) (fresh)</td>
<td>216</td>
<td>119</td>
<td>568</td>
<td>38.65</td>
<td>26.97</td>
<td>8.52</td>
</tr>
<tr>
<td>Grass weeds hay-Cynodon spp</td>
<td>869</td>
<td>52</td>
<td>587</td>
<td>68.65</td>
<td>38.97</td>
<td>7.52</td>
</tr>
</tbody>
</table>

*Framing the issues, challenges and opportunities in livestock sector in the 21st century*
TABLE II- METHODS OF FEED PRESERVATION, UTILIZATION AND TYPES OF CONSERVATION STRUCTURES PRACTICED BY SMALLHOLDER DAIRY CATTLE HOUSEHOLDS IN EVURORE AND SIAKAGO DIVISIONS OF MBEERE DISTRICT (MARCH–JULY 2007)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Evurore (n=16)</th>
<th>Siakago (n=17)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roofed barns</td>
<td>12</td>
<td>15</td>
</tr>
<tr>
<td>Conserved in bales</td>
<td>3</td>
<td>7</td>
</tr>
<tr>
<td>On farm feed processing</td>
<td>12</td>
<td>13</td>
</tr>
<tr>
<td>Feeding unprocessed feed</td>
<td>2</td>
<td>6</td>
</tr>
<tr>
<td>Planted Fodder - grass</td>
<td>15</td>
<td>13</td>
</tr>
<tr>
<td>Planted fodder- legumes</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>Mechanized feed processing</td>
<td>5</td>
<td>7</td>
</tr>
<tr>
<td>Silage making</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Figure 2: Daily milk yield of smallholder dairy cows in Evurore and Siakago Divisions of Mbeere District (March, 2007)

yield (Table III) by cows both between and within farms. The variations observed in yields for cows on the same farm offered the same feed was possibly explained by the difference in breed, age, stage of lactation and quantities of feed offered.

CONCLUSION

The smallholder dairy cattle keepers in the 2 Divisions, Evurore and Siakago, relied mainly on locally available roughages for feeding grade cows. Even though mechanical processing was employed to reduce the feed particle sizes, the procedure did not yield better results of the much anticipated outcome of improving the lactation...
performance. Farmers could get 6 to 7 kg/cow/day of milk from exotic dairy cattle breeds through provision of medium quality forage in amounts of less than 20 kg/cow/day. In order to realize the full potential of milk production from exotic dairy cattle breeds, even during dry months, February and July – October, farmer’s capacity on alternative forage conservation methods, silage making and forage baling, need enhancement. Therefore, there is need to introduce and advocate for modern crop residue utilization and quality improvement strategies, to improve on the performance of the dairy cattle. Additionally, farmers need to be made aware of the importance of mineral salts in the entire process of nutrition.

ACKNOWLEDGEMENTS
The authors are grateful to the Kenya Agricultural Productivity Program for financial support which allowed conducting of the present study through the Kenya Agricultural Research Institute. We would like also to thank the many farmers with whom we worked with and who shared with us their useful experiences and plight.

REFERENCES

TABLE III-FORMULATED DIETS AND CORRESPONDING MILK YIELD OF DAIRY COWS IN SIAKAGO AND EVUORE DIVISIONS OF MBEERE DISTRICT.

<table>
<thead>
<tr>
<th>Cow No</th>
<th>Farm</th>
<th>Roughage (kgDM/d) as fed</th>
<th>Concentrate (kgDM/d) as fed</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>11</td>
<td>7</td>
<td>2</td>
</tr>
<tr>
<td>2</td>
<td>11</td>
<td>7</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>11</td>
<td>20</td>
<td>2</td>
</tr>
<tr>
<td>4</td>
<td>9</td>
<td>22</td>
<td>2</td>
</tr>
<tr>
<td>5</td>
<td>9</td>
<td>18</td>
<td>2</td>
</tr>
<tr>
<td>6</td>
<td>8</td>
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</tr>
<tr>
<td>7</td>
<td>8</td>
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<tr>
<td>11</td>
<td>7</td>
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</tr>
<tr>
<td>12</td>
<td>7</td>
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</tr>
<tr>
<td>14</td>
<td>1</td>
<td>15</td>
<td>2</td>
</tr>
<tr>
<td>15</td>
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</tr>
<tr>
<td>16</td>
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</tr>
<tr>
<td>17</td>
<td>6</td>
<td>25</td>
<td>4</td>
</tr>
<tr>
<td>18</td>
<td>3</td>
<td>11</td>
<td>2</td>
</tr>
<tr>
<td>19</td>
<td>3</td>
<td>22</td>
<td>2</td>
</tr>
<tr>
<td>20</td>
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<td>21</td>
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</tr>
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<td>23</td>
<td>5</td>
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<td>2</td>
</tr>
<tr>
<td>24</td>
<td>2</td>
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<td>8</td>
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<tr>
<td>25</td>
<td>2</td>
<td>21</td>
<td>5</td>
</tr>
<tr>
<td>26</td>
<td>2</td>
<td>22</td>
<td>5</td>
</tr>
<tr>
<td>27</td>
<td>2</td>
<td>22</td>
<td>8</td>
</tr>
</tbody>
</table>

| mean   | 18.55 | 2.74 |
| SD     | 6.77  | 1.75 |


FEEDING HABITS AND SEASONAL FORAGE PREFERENCE OF SHEEP AND GOATS IN NORTHERN KENYA

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ABSTRACT
To document the feeding habits and identify the most preferred forages selected by sheep and goats a study was conducted in Merille location in northern Kenya. Sixty of each growing sheep and goats were used for feeding observation during two consecutive seasons. The most preferred grazing pastures by the herders in the location were used for the feeding observations. Both sheep and goats diets had a wider selection of forages and bite count in the wet season than dry season. In the dry season, browse formed the primary component of the diet of sheep (72.7%) and goats (87%). Browse bite of sheep (57.9%) and goats (75%) was higher in the dry season than wet season. Dietary overlap of species consumed by both sheep and goats was higher for browses 82.3 and 55.6% in dry and wet seasons, respectively. Ten most preferred forages represented 88.5% and 85% of dry season forage bites in sheep and goats respectively. In the wet season, the ten most preferred forages constituted 76.4% of sheep and 75.9% of goat’s bites. In conclusion, the ten most preferred forages selected by sheep and goats contributed a major proportion of the diet of grazing small ruminants particularly during the dry season and are representative for feed analysis. Among the preferred forages, dwarf shrubs such as Indigofera spinosa can provide small ruminants with browse feed though out the year. In the dry season, interventions are warranted to compensate for low bite count observed in sheep and goats.

Key words: bites, browse, goats, grasses, herbs, sheep

INTRODUCTION
The arid and semi-arid lands, under pastoral and agro-pastoral production system, are the major sheep and goats production areas in Kenya. About 75 and 84% of the national flock/ herd of sheep and goats, respectively are found in these lands (Kartuki and Letitiya, 1998). Though natural forages are the main feed resources for these stock, their availability and diversity is strongly influenced by season and vegetation type (Sanon et al., 2007).

Under extensive system of sheep and goat production, inadequate nutrition is the major constraint limiting small ruminant productivity particularly in the dry season (Njwe, 1992). In open grazing system practised in the arid lands of northern Kenya, sheep and goats co-graze, and share the available dietary forage resources. Mixed pasture provides the best forage classes for mixed-browsing animals (Lusigi et al., 1984). Goodwin et al. (2002) indicated that goats grazing mixed pastures produced greater average daily gain than those on grass-only pastures. This is because botanical composition of the pasture affects ingestive behaviour of goats and sheep (Animut and Goetsch, 2008).

Sheep and goats exhibit species variations in grazing habits, diet selection, dry matter intake and nutritional adequacy. Studies conducted in northern Kenya on small ruminants showed that goats were highly selective feeders. In the wet and dry season, goats consistently selected diets higher in crude protein and low in crude fiber content than sheep and cattle (Abusuwar and Ahmed (2010).

In African savannas goats depend largely on utilization of browse species for their nutrition (Dziba, 2000), whilst sheep prefer to select from the herbaceous and graminoids species, with graminoids constituting the largest proportion of their diet (Liu et al., 2007). Preference of forage by sheep and goats is influenced by season (Omphile et al., 2004). Diet selection is also influenced by body size, rumen anatomy, energy requirements and social structure of the herds/flocks of these animals (Hofmann, 1989).

In northern Kenya, sheep and goats are kept around permanent settlements with degraded pastures. Analysis of the forages would indicate the nutritional level of the grazed pastures. However, in free grazing animals it is difficult to obtain feed samples representative of the diverse forages consumed by animals for feed analysis. The objectives of the study were to assess the feeding habits and identify the most preferred forage species/types consumed by sheep and goats in dry and wet season which constitute the major diet of animals for chemical feed analysis.

MATERIALS AND METHODS
The study was conducted in Merille location of Marsabit South District in northern Kenya. It has an arid climate, with annual precipitation mean of 275mm and air temperatures of about 35°C. The vegetation types found in the area include riverine woodland, bushed dwarf shrub and bushed grassland. The woodland vegetation comprise of mainly Acacia tortilis, Cordia sinensis, Salvadora persica. Acacia and Commiphora communities, Indigofera spinosa, Sericocomopsis hildebrandtii and Barleria acanthoides are the dominant species of the bush dwarf shrub land.

Twelve pastoral herds, six during each of the dry and wet season, were randomly selected from three purposively selected semi-sedentary settlements which utilized different grazing areas. In each herd, ten sheep and ten goats 1-2 years old were randomly selected. The herds composed mainly of the Small East African goats and the Somali black head sheep. Thirty sheep and 30 goats were used in each season for feeding observations.

Three herders most preferred grazing sites were used to conduct the feeding observations. These were Kamotonyi, Lorora and Salt lick pastures. Feeding observations were conducted in two consecutive seasons, one at the peak of wet season (November to December) and the other at the end of the dry season (February to March). Feeding
observations were conducted between 0830-1130 hours for six consecutive days. Each sheep/goat was observed for 10 minutes and complete bites of forage species and the parts consumed were recorded.

The names of the species were identified and for each site and the number of bites of each species was summed up for the study area. The forages were ranked according to the number of bites which reflects the feeding preference. Based on the number of bites ten most preferred forages were identified in each season for each livestock species.

MS Excel (2007) software package was used to generate descriptive statistics and derive percentages of different forage species and bite counts in sheep and goats diets.

RESULTS AND DISCUSSION

The types of forage consumed by both sheep and goats are shown in Table I. During the dry season, sheep and goats consumed 22 species, out of which 73, 18 and 9% were browses, grasses and herbs, respectively for sheep. The corresponding values for goats were 87, 13 and 0%. In the wet season, the number of grasses and herbs in sheep diet increased, but the proportion of browses declined from 73 to 53.1%. In the same season, the goats consumed less of the browses and increased consumption of grasses and herbs. These findings agree with those reported by Omphile et al. (2004) on foraging strategies of sheep and goats in Botswana. The results suggest that sheep and goats have higher use of complex diet in the wet season than dry season.

Browses contribute a high proportion of forage plants in the diet of sheep (73%) and goats (87%), particularly in the dry season. This observation is consistent with the report by Abusurwar et al. (2010) who indicated that use of browse by livestock generally increases as the dry grazing season progresses. Indeed, browse forage species have been observed to be a key component of goat’s diet in the dry seasons when other forages are limiting (Yahaya et al., 2000). In contrast, browse forages in sheep diets were not affected by season. Sheep selected a similar range of about 16 browse plants in the dry season and 17 browse species in the wet seasons.

Herbaceous plants and grasses were important to both sheep and goats in the wet season as they were more available. Precipitation positively influences forbs consumption (Ramirez, 1999). In the wet season sheep selected a range of 9 grass species versus 8 species in goats. There was drastic decline in the grass and herbaceous forage species in the dry season (Table I). The herb layer was less important component of sheep and goats diets in the dry season.

There was high dietary overlap of forages consumed by both sheep and goats (55.6% in the wet season and 82.3% in the dry season) in the browse layer. Sheep and goats also had high dietary overlap in the herb (14.8%) and grass stratum (29.6%) in the wet season. Overlap was higher in dry season on browses and herbaceous layer in the wet season (Table I). The results suggest that dietary overlap was influenced by season, forage category and plant species diversity. The intensity of competition could be high in herb and browse layers in the wet and dry seasons, respectively. High dietary overlap, which was observed in the dry season particularly on browses, could lead to overuse of overlapping forages. The results shows that forage categories selected by sheep and goats had less variation in the dry season than wet season. This shows that sheep and goats diet, albeit the competition between the two was very similar in the dry season compared to wet season.

Selection of different forage categories by both sheep and goats during the wet and dry seasons are shown in Table 2. Consumption of browses by sheep (57.9%) and goats (75%) increased during the dry compared to the wet season (30.6 and 52.4% for sheep and goats respectively). This is an indication that they rely on browses of trees, bushes and dwarf shrubs as main source of feed in the dry season. However, goats had higher preference on browse (52.4%) than sheep (30.6%) in the wet season. In the wet season, goats spent almost equal time selecting grasses and herbs (47.6%) and browse (52.4%), while sheep consistently selected grasses and herbs (69.4%). During both seasons, sheep selected more herbaceous biomass than goats (Table II). This suggests that sheep preferred a mixed diet of grasses and herbs. The results show that sheep and goats bite percentage vary with forage class and seasons. In the dry season, sheep shifted their diet selection from grazing (69.4%) to browsing (57.9%). Goats which were intermediate grazers (47.6%) and browsers (52.4%) in the wet season switched to browsing (75%) in the dry season. Sanon (2007) observed that sheep and goats shift to browsing in the dry season when herbaceous biomass was less available. Across the seasons, dwarf shrubs

| Table I- Number of Forages Consumed by Sheep and Goats during Wet and Dry Seasons in the Study Area |
|-------------------------------------------------|---------------------------------------------------|---------------------------------------------------|
| Dry season                                      | Wet season                                         |                                                     |
| Sheep                                           | Goats                                             | Both S &G                                          |
| No. of spp                                      | 16                                                | 20                                                | 14    |
| %                                               | 72.7                                              | 87                                                | 82.3  |
| Grasses                                         | 4                                                 | 3                                                 | 3     |
| No. of spp                                      | 18.2                                              | 13                                                | 17.7  |
| %                                               | 9.1                                               | 0                                                 | 0     |
| Herbs                                           | 2                                                 | 0                                                 | 0     |
| Total spp.                                      | 22                                                | 23                                                | 17    |
TABLE II- PERCENTAGE FEEDING BITES OF DIFFERENT FORAGE CATEGORIES BY SHEEP AND GOATS IN THE DRY AND WET SEASONS FOR A TOTAL PERIOD OF 300 MINUTES PER SEASON

<table>
<thead>
<tr>
<th>Forage Category</th>
<th>Dry season Sheep</th>
<th>Dry season Goats</th>
<th>Wet season Sheep</th>
<th>Wet season Goats</th>
</tr>
</thead>
<tbody>
<tr>
<td>Browses</td>
<td>57.9%</td>
<td>75.0%</td>
<td>30.6%</td>
<td>52.4%</td>
</tr>
<tr>
<td>Trees and bushes</td>
<td>21.0%</td>
<td>34.1%</td>
<td>0.4%</td>
<td>10.8%</td>
</tr>
<tr>
<td>Shrubs</td>
<td>4.8%</td>
<td>15.3%</td>
<td>2.2%</td>
<td>15.8%</td>
</tr>
<tr>
<td>Dwarf shrubs</td>
<td>32.1%</td>
<td>25.6%</td>
<td>28.0%</td>
<td>25.8%</td>
</tr>
<tr>
<td>Grasses and herbs</td>
<td>42.1%</td>
<td>25.0%</td>
<td>69.4%</td>
<td>47.6%</td>
</tr>
<tr>
<td>Grasses and sedges</td>
<td>36.5%</td>
<td>25.0%</td>
<td>64.1%</td>
<td>43.2%</td>
</tr>
<tr>
<td>Herbs</td>
<td>5.6%</td>
<td>0.0%</td>
<td>5.3%</td>
<td>4.4%</td>
</tr>
</tbody>
</table>

Components of browse and grass were browses 57.9% and 30.6% for sheep and goats, respectively. The increased browse consumption by sheep during the wet season was due to higher availability of browse during the wet season, and thus, it was eaten more than in the dry season. However, goats showed a preference for grasses and herbs in the dry season, consuming 28.0% and 25.8% of their total feeding bites in the wet season. During the wet season, goats consumed 64.1% and 43.2% of their total feeding bites in the wet season.

The feeding habits of sheep and goats demonstrate seasonal variation in diet selection. Sheep shift from browsing in the dry season to grazing in the wet season, whilst goats switch from browsing in the dry season to grazing in the wet season. Small ruminants in the dry season heavily depended on browses that mainly consisted of C. africana, C. sinensis and I. Spinosa. The tree/bush browse was of green and fallen leaf biomass and the dwarf shrubs bite composed of tender twigs and green leaf foliage. The forage components consumed included green/dry leaves, tender twigs, flowers, fruits, leaf litter and barks. Indigofera spinosa, which was highly preferred, had tender twigs, flowers, pods and leaves in wet season but showed defoliation. The tree/bush browse was of green and fallen leaf biomass. The forage components consumed included green/dry leaves, tender twigs, flowers, fruits, leaf litter and barks. Indigofera spinosa, which was highly preferred, had tender twigs, flowers, pods and leaves in the wet season. Generally, leguminous thorny plants have high protein content (Celaya et al., 2007). Animals may select Indigofera spinosa, a leguminous plant as a source of protein.

The wet season supported more grass and herb layer favouring selection by grazing sheep. Small ruminants in the dry season heavily depended on browses that mainly consisted of C. africana, C. sinensis and I. Spinosa. The tree/bush browse was of green and fallen leaf biomass and the dwarf shrubs bite composed of tender twigs and green leaf foliage. The forage components consumed included green/dry leaves, tender twigs, flowers, fruits, leaf litter and barks. Indigofera spinosa, which was highly preferred, had tender twigs, flowers, pods and leaves in wet season but showed defoliation. The tree/bush browse was of green and fallen leaf biomass. The forage components consumed included green/dry leaves, tender twigs, flowers, fruits, leaf litter and barks. Indigofera spinosa, which was highly preferred, had tender twigs, flowers, pods and leaves in the wet season.

However, grass species such Cenchrus pennisetiformis were available during the wet season only. Goats showed less preference for herbs compared to sheep, while M. Macropus sedge was the most preferred by sheep and goats in the wet season. In the dry season, the herb layer consumed by goats consisted mainly of the dead biomass. Generally, leguminous thorny plants have high protein content (Celaya et al., 2007). Animals may select Indigofera spinosa, a leguminous plant as a source of protein. In the wet season animals consumed green grass with flower and seed head and dry grass in the dry season. Dietary selection can thus occur at both the plant level and at a within-plant level (Palo et al., 1992).

The diet of sheep and goats in the dry season comprised of similar forage plants, but differed in the wet season. In the wet season, sheep balanced their diets by maximizing selection from available leguminous forages and grass species. Penning et al. (1997) observed that sheep had high preference for leguminous forages compared to goats; they spent 70% of the time grazing white clover than 50% of the time observed for goats.

CONCLUSION
The feeding habits of sheep and goats demonstrate seasonal variation in diet selection. Sheep shift from grazing in the wet season to browsing in the dry season, whilst goats switch from browsing in the dry season to...
**TABLE III- LIST OF SOME OF THE FORAGES OBSERVED TO BE CONSUMED BY SHEEP, THEIR BITE COUNT IN 300 MINUTES IN THE WET AND DRY SEASONS**

<table>
<thead>
<tr>
<th>Dry season</th>
<th>Bite count</th>
<th>Bite (%)</th>
<th>Wet season</th>
<th>Bite count</th>
<th>Bite (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Browses</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Sericocomopsis hildebrandtii</em></td>
<td>3</td>
<td>9</td>
<td>1.8</td>
<td><em>Indigofera cliffordiana</em></td>
<td>24</td>
</tr>
<tr>
<td><em>Duosperma eremophilum</em></td>
<td>33</td>
<td>6.6</td>
<td><em>Croton hirsutus</em></td>
<td>30</td>
<td>3.1</td>
</tr>
<tr>
<td><em>Commiphora africana</em></td>
<td>40</td>
<td>8.0</td>
<td><em>Indigofera hochstetteri</em></td>
<td>40</td>
<td>4.1</td>
</tr>
<tr>
<td><em>Cordia sinensis</em></td>
<td>42</td>
<td>8.4</td>
<td><em>Indigofera spinosa</em></td>
<td>177</td>
<td>18.1</td>
</tr>
<tr>
<td><em>Indigofera spinosa</em></td>
<td>112</td>
<td>22.4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Sub-total</strong></td>
<td>47.2</td>
<td></td>
<td>27.8</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Grasses and Herbs</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Commicarpus stellatus</em></td>
<td>10</td>
<td>2.0</td>
<td><em>Mariscus macropus</em></td>
<td>16</td>
<td>1.6</td>
</tr>
<tr>
<td><em>Blepharis linariifolia</em></td>
<td>15</td>
<td>3.0</td>
<td><em>Commicarpus stellatus</em></td>
<td>23</td>
<td>2.4</td>
</tr>
<tr>
<td><em>Bracharia leersiodes</em></td>
<td>18</td>
<td>3.6</td>
<td><em>Cenchrus penisetiformis</em></td>
<td>37</td>
<td>3.8</td>
</tr>
<tr>
<td><em>Tetrapogon cenchriformis</em></td>
<td>38</td>
<td>7.6</td>
<td><em>Aristida adscensionis</em></td>
<td>84</td>
<td>8.6</td>
</tr>
<tr>
<td><em>Aristida adscensionis</em></td>
<td>126</td>
<td>25.1</td>
<td><em>Bracharia leersiodes</em></td>
<td>133</td>
<td>13.6</td>
</tr>
<tr>
<td><strong>Sub-total</strong></td>
<td>41.3</td>
<td></td>
<td>48.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Feeding bites</strong></td>
<td>443</td>
<td>88.5</td>
<td>746</td>
<td>76.4</td>
<td></td>
</tr>
<tr>
<td><strong>Total bites</strong></td>
<td>501</td>
<td></td>
<td>977</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1Tree/bush; 2shrub; 3dwarf shrub; 4grass; 5herb; 6sedge; *bite % (expressed as % of total bites for the season)

**TABLE IV-LIST OF SOME OF THE FORAGES OBSERVED TO BE CONSUMED BY GOATS, THEIR BITE COUNT IN 300 MINUTES IN THE WET AND DRY SEASONS**

<table>
<thead>
<tr>
<th>Dry season</th>
<th>Bite count</th>
<th>*Bite (%)</th>
<th>Wet season</th>
<th>Bite count</th>
<th>Bite (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Browses</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Maerua crassifolia</em></td>
<td>10</td>
<td>3.1</td>
<td><em>Commiphora africana</em></td>
<td>10</td>
<td>1.1</td>
</tr>
<tr>
<td><em>Barleria acanthonoides</em></td>
<td>11</td>
<td>3.4</td>
<td><em>Lippia carviodora</em></td>
<td>35</td>
<td>3.7</td>
</tr>
<tr>
<td><em>Combretum aculeatum</em></td>
<td>12</td>
<td>3.8</td>
<td><em>Bauhinia taitenii</em></td>
<td>40</td>
<td>4.2</td>
</tr>
<tr>
<td><em>Acacia tortilis</em></td>
<td>16</td>
<td>5.0</td>
<td><em>Grewia tenax</em></td>
<td>49</td>
<td>5.2</td>
</tr>
<tr>
<td><em>Bauhinia taitenii</em></td>
<td>19</td>
<td>5.9</td>
<td><em>Indigofera hochstetteri</em></td>
<td>63</td>
<td>6.6</td>
</tr>
<tr>
<td><em>Commiphora africana</em></td>
<td>25</td>
<td>7.8</td>
<td><em>Indigofera spinosa</em></td>
<td>144</td>
<td>15.1</td>
</tr>
<tr>
<td><em>Cordia sinensis</em></td>
<td>39</td>
<td>12.2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Indigofera spinosa</em></td>
<td>65</td>
<td>20.3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Sub-total</strong></td>
<td>61.5</td>
<td></td>
<td>35.9</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Grasses and Herbs</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Tetrapogon cenchriformis</em></td>
<td>14</td>
<td>4.4</td>
<td><em>Cenchrus penisetiformis</em></td>
<td>20</td>
<td>2.1</td>
</tr>
<tr>
<td><em>Aristida adscensionis</em></td>
<td>61</td>
<td>19.1</td>
<td><em>Mariscus macropus</em></td>
<td>41</td>
<td>4.3</td>
</tr>
<tr>
<td><strong>Sub-total</strong></td>
<td>23.5</td>
<td></td>
<td>40.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Feeding bites</strong></td>
<td>272</td>
<td>85.0</td>
<td>722</td>
<td>75.9</td>
<td></td>
</tr>
<tr>
<td><strong>Total bites</strong></td>
<td>320</td>
<td></td>
<td>955</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1Tree/bush; 2shrub; 3dwarf shrub; 4grass; 5herb; 6sedge; *bite % (expressed as % of total bites for the season)

Balance grazing and browsing in the wet season. The small ruminants rely more on grasses and browse in wet and dry seasons respectively. The wide diversity of forage plants in the wet season has potential to offer adequate feed to sheep and goats. However, limited species diversity especially in the dry season reduces diet selectivity and bite count of sheep and goats. In conclusion, the ten most preferred forages selected by sheep and goats constitute the major diet composition of small ruminants particularly in the dry season and can be used for nutritional quality analysis. Among the preferred forages, dwarf shrubs such as Indigofera spinosa can provide small ruminants...
with browse feed throughout the year. In the dry season, interventions are warranted to compensate for the low bite count and reduced forage diversity.

ACKNOWLEDGEMENTS
The authors acknowledge Kenya Arid and Semi-arid Lands project (KASAL/KARI) for financial support especially Dr. D. Miano and Dr. M. Younan. We appreciate the pastoral herders and Mr. Hussein Walaga of KARI-Marsabit for local and botanical identification of forage plants.

REFERENCES
SERO-PREVALENCE OF BRUCELLOSIS IN LIVESTOCK IN TRANSMARA AND ISIOLO COUNTIES AND ITS ZOONOTIC IMPORTANCE

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ABSTRACT

Brucellosis is a worldwide zoonosis that is endemic in Africa and is transmitted through ingestion of bacteria in contaminated material and infected breeding bulls. This disease constrains development of the dairy sector in the East African Region where poverty, food insecurity and unemployment rates are common challenges. In Kenya, livestock has the potential to transform the economy but can also be a useful vehicle for transmission of zoonoses which restricts trade. Department of veterinary services reports indicate that brucellosis is the most commonly diagnosed (34.5%) zoonosis. Diagnosis remains a challenge in the existing health facilities. This notwithstanding, there is limited data on brucellosis prevalence, incidence and distribution hence it remains neglected and control policy weak. Vaccination against brucellosis and test and slaughter are effective control options but are not used in Kenya. There is need to control brucellosis in animal products hence improve food security in the country. This study assessed prevalence of brucellosis in pastoral and agro-pastoral communities as well as farmers perceptions of the disease. Results indicated high prevalence of brucellosis hence risk of zoonotic transmission through cow and camel milk. Farmers are knowledgeable on presence, risk factors and clinical signs of the disease. The data will inform appropriate disease control in the country.

INTRODUCTION

The East African region (EAC) is faced with three important challenges namely high poverty levels, high food insecurity and high unemployment rates (UNDP, 2004). The regional development road map is to revitalize key economic sectors among them agriculture as a strategy towards addressing these problems (Lunyasunya et al. 2010). To this end, investments to the agricultural sector are being increased to improve agricultural productivity and positively contribute towards reducing poverty, improving food security and helping create wealth.

The dairy industry of the EAC is one of the largest in Africa, and is an important part of the region’s agricultural economy (Jensen et al., 2010). Kenya has the largest dairy herd in EAC, with an estimated 3.5-3.8 million milking cows (KARI, 2009). The dairy sub-sector in Kenya contributes 14% of the agricultural GDP and 3.5% of total GDP (Wambugu and Stella, 2010). However, the sector is constrained by animal disease among other challenges. Diseases lead to high mortalities, livestock product losses and high expenditures on treatment drugs. Despite the fact that infectious animal diseases occur quite commonly and have serious socio-economic implications, they are poorly controlled because the veterinary service provision has progressively decreased over the last 20 years (McDermott and Arimi, 2002). This is a consequence of the structural adjustments programmes introduced in the early 1990s leading to perpetual budgetary deficits and staff shortages.

Among the infectious animal diseases are zoonoses that constitute an important threat to human health in developing countries (Wastling et al., 1999). Zoonoses are twice as likely to be associated with emerging diseases as non-zoonoses (Taylor et al., 2001). The emergence and re-emergence of zoonoses and their potentially disastrous impact on human health is a growing concern around the globe (Woolhouse and Gowtage-Sequeria, 2005). Zoonotic diseases have both direct and indirect effects on livestock health and production (Smits and Cutler, 2004). Indirect effects occur as a result of the risk of human disease, the economic impact on livestock producers through barriers to trade, the costs associated with control programmes, the increased cost of marketing produce to ensure it is safe for human consumption and the loss of markets because of decreased consumer confidence (McDermott and Arimi, 2002). In the dairy sub-sector, zoonoses like brucellosis, bovine tuberculosis, Escherichia coli and E. coli 0157:H7 and faecal coli forms among others have been reported to occur (McDermott and Arimi, 2002).

Although tuberculosis complicates the clinical outcomes of immune-compromised persons, its prevalence in Kenya is still very low compared to brucellosis (Koech, 2000; Omore et al., 2005). Brucellosis on the other hand is a fairly common disease particularly in the pastoral areas. Past reports have shown that its prevalence in cattle varies between 10% to 20% in the pastoral areas (Omore et al., 2002). The other zoonoses including E. coli and E. coli 0157:H7 also commonly associated with the dairy sector (Omore et al. 2005) are indicative of the microbial quality of milk. These are reduced through boiling milk before consumption. This no doubt makes brucellosis to be the most important zoonosis afflicting the dairy industry.

Brucellosis is transmitted through ingestion of contaminated material. Common clinical signs are high incidences of abortions, neonatal deaths, repeat A.I, arthritis, swollen joints, retained after-birth and reduced milk off take (Radostits et al. 2000). This leads to enormous economic losses (Oluoch-Kosura et al., 2000) and requires proper control strategies to be put in place for the dairy sector to still remain productive. Test and slaughter of infected animals is employed by industrialist countries to eradicate brucellosis (Radostits et al., 2000) but has limited application in developing countries. Vaccination of cattle using strain s-19 of B. abortus is not used in Kenya (McDermott and Arimi, 2002).

Research problem

The true prevalence and incidence of brucellosis is unknown globally. Reported incidence in endemic-disease areas varies widely, from < 0.01 to > 200 per 100 000 population (Corbel, 1997). According to the World
Health Organization (FAO/WHO, 2006), brucellosis is considered a reemerging infectious disease. An estimated 500,000 new human cases occur annually worldwide (Pappas, et al., 2006). Besides, brucellosis presence has often remained unrecognized through lack of awareness by veterinarians and medical staff, lack of pathognomonic symptoms and absence of accessible laboratory diagnostic facilities (Smits and Cutler, 2004). Thus, there is currently little information available on impact of brucellosis on both human and livestock health and reproduction in Kenya.

In humans, brucellosis clinical syndrome is non-specific as it presents similar clinical manifestations of other infections particularly malaria (Maichomo et al., 1997, 2000; Smits and Cutler, 2004). Most health care institutions lack diagnostic capacity in terms of infrastructure and expertise. There is no hospital surveillance for zoonoses (brucellosis) whose data is lost as pyrexia of unknown origin hence their control remains neglected. Most livestock abortions are unaccounted for due to lack of diagnosis in field veterinary laboratories hence their control is difficult. This study sought to establish the prevalence of brucellosis in livestock, and, evaluate farmers’ perceptions of the disease in the pastoral and agro-pastoral production systems. Generated information will be used for targeted control of brucellosis in order to improve quality of milk availed to consumers.

**Study objectives**
The study was guided by the following objectives: 1. To establish the status of and risk factors for brucellosis in pastoral and agro-pastoral production systems. 2. To disseminate information to stakeholders.

**METHODOLOGY**

*Understanding farmers perceptions of brucellosis*

This was done using a questionnaire survey. A pretested questionnaire was administered to 60 respondents randomly sampled from Transmara County only. Responses were collated and analyzed using descriptive statistics.

**Determining the prevalence of brucellosis**

A cross sectional survey was carried out in Isiolo (Ngare mare, 78, Burat, sharp villages) and Trans Mara (Oloirien and Lolgorian locations) counties in 2011. Multistage random sampling technique was employed in selecting the specific study sites within the two areas. However, purposive sampling was employed in Isiolo county due to high insecurity risk. A list of administrative units (villages) was obtained from the area chiefs to help in the construction of a sampling frame. Participating villages and households (HHs) keeping livestock were then randomly selected from the sampling frame using random computer numbers.

The required number of cattle to be included in the study from each of the two areas will be calculated assuming an estimated brucellosis prevalence of 15% and a desired accuracy level of 5% at the 95% confidence level

\[ n = \frac{Z^2 \cdot p \cdot (1-p)}{L^2} \]

where \( n \) = the number of cattle to be sample from each area; \( Z = Z_{0.05} = 1.96 \) (the value of \( Z \) required for confidence=95%); \( L \) = the precision of the estimate (allowable error or margin of error) equal to \( \frac{1}{2} \) the normal approximation of sample size for the binomial distribution confidence interval. \( L = 0.0025 \) or \( 1/400 \), \( p = 15\% \), the priori brucellosis prevalence estimate. Applying this formula, at least 196 animals were sampled from each area.

Whole blood was collected from the jugular vein of randomly selected animals (cattle, sheep, goat, camel) within identified households and serum prepared. This serum was screened with rose-bengal plate test (RBPT) and further subjected to confirmatory serological tests, that is, complement fixation test (CFT) and Enzyme-linked immunosorbent assay (ELISA) at the veterinary investigation laboratories, Kabete. Descriptive statistics was used to determine prevalence of brucellosis as the proportion of test positive samples (no. positive/total no. sampled) and classified by the different tests used.

**RESULTS AND DISCUSSION**

Farmers perceptions of brucellosis

*Socio-demographic Characteristics of the Respondents*

The respondents were predominantly male (88.6% male) with their ages ranging between 18 and 74 years, modal range was 31-40 years and those above 51 years were 23.3% (Figure 1). Majority of respondents (46.7%) had no formal education while only 10% had completed their secondary education (Figure 2). This implies that any interventions or passing of any messages to this population should be informed by the requirements of an illiterate population. Communication need be in their local language and by visual presentations for maximum impact.

Majority (96.7%) of the respondents were mainly engaged in livestock production with 35% owning between 31-60 heads of cattle, 31.7% owning 0-30 sheep and goats and 20% owning above 120 sheep and goats per individual.

![Figure 1: Age Range of Respondents](image)

**Knowledge about Brucellosis and its symptoms**

Respondents were aware of the existence of zoonoses within the community. Brucellosis was associated with cattle milk and 93.3% of the respondents had heard about the disease before and 91.7% indicated that the
disease is a problem within the community. Further, 90% of respondents thought cattle are mainly affected by the disease. Zoonotic transmission was associated with consumption of raw milk (88.3%) and meat (46.7%). However, being in close proximity to animals was not seen as a brucellosis predisposing factor by all the respondents. The association of brucellosis mainly with the consumption of raw milk would lead to a perception that contact with other body fluids from animals does not predispose people to brucellosis infection. Joint pains, fatigue, back pains, sweats, headache and insomnia are clinical signs associated with human brucellosis (Table I). Symptoms in livestock include abortions, reduced milk yield, coughing, swelling of joints, raised hair coat, fever, swelling of teats, retained placenta, infertility, abnormal scrotal swellings and inapetence (Table II).

**Risk for Transmission of Brucellosis in livestock and Humans**

Farmers practiced communal grazing and watering of livestock which is also grazed in close proximity with wildlife in the Masai Mara Game Park. This may enhance transmission of diseases from wildlife to domestic animals including brucellosis and other zoonoses. Use of communal

**TABLE I- SYMPTOMS ASSOCIATED WITH BRUCELLOSIS BY RESPONDENTS**

<table>
<thead>
<tr>
<th>Symptom</th>
<th>Frequency</th>
<th>% of respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Joint pains</td>
<td>48</td>
<td>80</td>
</tr>
<tr>
<td>Fatigue</td>
<td>29</td>
<td>48.3</td>
</tr>
<tr>
<td>Headache</td>
<td>21</td>
<td>35</td>
</tr>
<tr>
<td>Back pains</td>
<td>18</td>
<td>30</td>
</tr>
<tr>
<td>Fever</td>
<td>9</td>
<td>15</td>
</tr>
<tr>
<td>Sweating</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>Lack of sleep at night</td>
<td>2</td>
<td>3.3</td>
</tr>
<tr>
<td>Don’t know</td>
<td>6</td>
<td>10</td>
</tr>
</tbody>
</table>

N/B. The frequency and percentage totals do not add up to 60 and 100% respectively because the factors above were independent responses
bulls (43.3%), rams (41.7%) and bucks (43.3%) were practiced and is known to contribute to spread of venereal diseases like brucellosis. Consumption of raw or semi-cooked body parts (81.7%) and blood (76.7%), unboiled milk (80%) and contact of infected body fluids with broken skin enhances transmission of infection. Other observations made regarding transmission of brucellosis include: Gender bias where males are associated with consuming raw body parts and females with milking, occupational hazard for butchers, sharing of residence between human and livestock and assisting animals during parturition and handling animal skins/hides without protective clothing (91.7%).

Status of brucellosis based on serological tests
Four hundred and seventy five (475) assorted serum samples (cattle, sheep and goats) from Transmara and 275 camel samples from Isiolo were collected (Table III) and analyzed using serological tests (RBPT, CFT and competitive ELISA) (Table IV).

The ovine species did not show presence of brucellosis antibodies based on either of the 3 serological tests. Caprine had dismal exposure level of 1% based on C-ELISA which is a great improvement from earlier reports (Omore et al., 2002). The low prevalence is good news to the public since Brucella melitensis in goats is largely attributed to the zoonotic transmission to humans. Bovine species reported a high prevalence of 16.2%. Given that pastoralists in Transmara rely heavily on bovine milk implies high likelihood of transmission to humans and can restrict cow milk trade in the area. The same case applies to camel milk where a prevalence rate of 17% was reported. The results show superiority (high sensitivity, good specificity) of C-ELISA as a screening test compared to RBPT and CFT. From this survey, it is evident that brucellosis is present and circulating in goats, cattle and camels in pastoralist areas and will hence sustain the infection unless controlled effectively. This information is useful given the many

<table>
<thead>
<tr>
<th>TABLE II- POSSIBLE POINTERS TO BRUCELLOSIS INFECTION IN ANIMALS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Observed Attribute (Past 1 year)</td>
</tr>
<tr>
<td>Abortion</td>
</tr>
<tr>
<td>Cattle</td>
</tr>
<tr>
<td>Sheep</td>
</tr>
<tr>
<td>Goats</td>
</tr>
<tr>
<td>Abnormal scrotal swelling</td>
</tr>
<tr>
<td>Cattle</td>
</tr>
<tr>
<td>Sheep</td>
</tr>
<tr>
<td>Goats</td>
</tr>
<tr>
<td>Retained placenta</td>
</tr>
<tr>
<td>Repeated breeding</td>
</tr>
<tr>
<td>Infertility</td>
</tr>
</tbody>
</table>

TABLE III- DESCRIPTION OF ANIMALS TESTED

<table>
<thead>
<tr>
<th>County</th>
<th>Species</th>
<th>Sample size</th>
<th>Sex</th>
<th>Adults</th>
<th>Weaners</th>
<th>Yearling</th>
<th>Heifer</th>
<th>Calf/kid</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transmara</td>
<td>Ovine</td>
<td>161</td>
<td>F (135)</td>
<td>103</td>
<td>4</td>
<td>28</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>M (26)</td>
<td></td>
<td>11</td>
<td>1</td>
<td>14</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Bovine</td>
<td>197</td>
<td>F (147)</td>
<td>106</td>
<td>4</td>
<td>-</td>
<td>35</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>M (51)</td>
<td></td>
<td>35</td>
<td>12</td>
<td>2</td>
<td>-</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Caprine</td>
<td>117</td>
<td>F (81)</td>
<td>54</td>
<td>2</td>
<td>17</td>
<td>-</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td></td>
<td>M (31)</td>
<td></td>
<td>10</td>
<td>-</td>
<td>11</td>
<td>-</td>
<td>10</td>
</tr>
<tr>
<td>Isiolo</td>
<td>Camels</td>
<td>275</td>
<td>F (275)</td>
<td>275</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

F – Female, M – Male

TABLE IV- RESULTS OF SEROLOGICAL TESTS

<table>
<thead>
<tr>
<th>Species</th>
<th>No of samples</th>
<th>Tests conducted</th>
<th>Disease prevalence</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>RBPT CFT C-ELISA</td>
<td></td>
</tr>
<tr>
<td>Ovine</td>
<td>161</td>
<td>0 0 0</td>
<td>0 0 0</td>
</tr>
<tr>
<td>Bovine</td>
<td>197</td>
<td>0 0 32</td>
<td>16.2%</td>
</tr>
<tr>
<td>Caprine</td>
<td>117</td>
<td>0 0 1/117</td>
<td>1%</td>
</tr>
<tr>
<td>Camel</td>
<td>275</td>
<td>13/250 13/250 11/65</td>
<td>17%</td>
</tr>
<tr>
<td>Total</td>
<td>750</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

RBPT – Rose Bengal Plate Test, CFT – Complement Fixation Test, C-ELISA – Competitive ELISA
complaints regarding flu-like conditions inflicting humans and low awareness among the health personnel on their diagnosis reported earlier (Maichomo et al., 1997) which is critical for their cure. The fact that human cases have been reported in Transmara strongly suggests that brucellosis warrants inclusion as a differential diagnosis in patients presenting with flu-like symptoms. However, this study also suggests use of sensitive and specific tests to control unnecessary cases due to false positives associated with RBPT which is an agglutination test. This is also useful information regarding a “One Health” approach to Address Emerging Zoonoses as well as disease control in humans and their livestock.

CONCLUSION

- That a focus of brucellosis exists in Transmara, cattle having a higher prevalence than goats. There is high risk of zoonotic transmission through cow milk. Results do not mean absence of infection in sheep.
- Camels have high prevalence of brucellosis
- Community responses
  (i). Demonstrated knowledge of brucellosis existence, risk factors and clinical signs but some missed facts on transmission by body fluids other than milk through broken skin. This requires farmer education.
  (ii). They understand brucellosis is an occupational hazard and the gender bias
  (iii). Symptoms are non-specific in humans generally referred to as “flu-like” conditions which is ambiguous regarding proper diagnosis for treatment

RECOMMENDATION

There is need for community follow-up to ascertain true burden of brucellosis in humans using gold standard tests i) C-ELISA and ii) bacterial isolation. To control or minimize brucellosis circulation, adequate control measures need to be adopted perhaps such as active screening and culling of infected cases. This has minimal economic impact to both farmers and government compared to test and slaughter with a compensation package as practiced in the developing world.

ACKNOWLEDGEMENT

This work was funded by KAPAP and KASAL. Farmers in Transmara and Isiolo counties cooperated in data collection (questionnaire and serum).

REFERENCES

“Framing the issues, challenges and opportunities in livestock sector in the 21st century”


“Framing the issues, challenges and opportunities in livestock sector in the 21st century”
ABSTRACT

Despite the important contribution of camel milk to food security for pastoralists in Kenya, little is known about the postharvest handling, preservation and processing practices. In this study, postharvest handling, preservation and processing practices for camel milk by pastoralists in Isiolo, Kenya were assessed through cross-sectional survey and focus group discussions. A total of 167 camel milk producer households, 50 primary and 50 secondary milk traders were interviewed. Survey findings showed that milking was predominantly handled by herds-boys (45.0%) or male household heads (23.8%) and occasionally by spouses (16.6%), sons (13.9%) and daughters (0.7%). The main types of containers used by both producers and traders to handle milk were plastic jerricans (recycled cooking oil containers), because they were cheap, light and better suited for transport in vehicles. Milk processing was the preserve of women, with fresh camel milk and spontaneously fermented camel milk (suusa) being the main products. Fresh milk was preserved by smoking of milk containers and boiling. Smoking was the predominant practice, and was for extending the shelf life and also imparting a distinct smoky flavour to milk. The milk containers were fumigated with smoke from burned wood of specific tree species such as Olea africana, Acacia nilotica, Balanities aegyptica and Combretum spp. Boiling was practised by primary milk traders at collection points to preserve milk during times when transport to the market was unavailable. Milk spoilage at the primary collection point in Kulamawe was aggravated by lack of cooling facilities. At the secondary collection point in Isiolo town, milk was refrigerated overnight before onward transmission to Nairobi. The mean quantity of traded milk by traders was 83.2±3.8 litres. The main problems experienced by milk traders in Isiolo included milk spoilage (43.0% of respondents), delayed payments—after one or two days (19.9%), loss of money due to informal courier (12.2%), low prices of fermented milk (10.9%), milk rejection by customers in Nairobi because of spoilage (7.1%), inadequate supply during dry season (3.5%), loss of milk due to bursting of containers (2.1%) and milk not being supplied by producers due to insecurity (1.3%). In-depth understanding of the postharvest handling, preservation and processing practices would help to devise appropriate strategies that would increase the quantity and improve the quality of marketed camel milk. Interventions to enhance postharvest handling, preservation and processing practices for camel milk should include the improvement of infrastructure such as milk transport, collection, cooling and processing facilities of suitable capacity. Such interventions should also include strategies to enhance the literacy level of the producers and traders, as this would enable them to better utilise effectively and efficiently whatever resources existed in their area.

Key words: Camel milk, postharvest, handling, Kenya

INTRODUCTION

The camel (Camelus dromedarius) plays an important role as a primary source of subsistence in the Arid and Semi Arid Lands (ASALs) of Kenya. It lives in areas that are not suitable for crop production and where other livestock species hardly thrive. Due to its outstanding performance in the ASALs of northern Kenya where browse and water are limited, pastoralists rely mainly on camels for their livelihood. In these areas, camels are mainly kept for milk production and produce milk for a longer period of time even during the dry season when milk from cattle is scarce (Kaufman, 1998). The annual camel milk production in Kenya is estimated at 338.3 million litres, valued at USD 107.1 million, and this represents 12% of the national milk production (Musinga et al., 2008). During prolonged droughts, camel milk may contribute up to 50% of total nutrient intake of some pastoralists groups (Farah, 1996; Kaufman, 1998). These essential roles of camel milk emphasise its importance for food security to the pastoral people.

Surplus milk is sometimes sold in urban centres and the derived cash contributes to the total household cash income, which is used to purchase cereals, oil, sugar, drugs and other household requirements. Despite the important contribution of camel milk to ASAL inhabitants, little is known about the postharvest handling, preservation and processing methods for camel milk in Kenya in general and in Isiolo in particular. This study, therefore, aimed at identifying the existing postharvest handling, preservation and processing practices along the camel milk chain in Isiolo District, Northern Kenya. Understanding of these practices will help to design appropriate strategies to enhance the contribution of camel milk to food security for ASAL inhabitants, especially the poorer households.

METHODOLOGY

Study area

The study was carried out in August-September, 2009, along the Kulamawe-Isiolo camel milk chain in Isiolo district, which is situated north of the Equator at coordinates

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Tel: +254-069-210-2220. Mobile: 0710629683; 0738-986220; Fax: +254-069-210-2220. 2Department of Food Science, Nutrition and Technology, University of Nairobi, P.O. Box 29053 (00625), Nairobi, Kenya. Tel. +254-020-631277. 3Framing the issues, challenges and opportunities in livestock sector in the 21st century”

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ABSTRACT

Despite the important contribution of camel milk to food security for pastoralists in Kenya, little is known about the postharvest handling, preservation and processing practices. In this study, postharvest handling, preservation and processing practices for camel milk by pastoralists in Isiolo, Kenya were assessed through cross-sectional survey and focus group discussions. A total of 167 camel milk producer households, 50 primary and 50 secondary milk traders were interviewed. Survey findings showed that milking was predominantly handled by herds-boys (45.0%) or male household heads (23.8%) and occasionally by spouses (16.6%), sons (13.9%) and daughters (0.7%). The main types of containers used by both producers and traders to handle milk were plastic jerricans (recycled cooking oil containers), because they were cheap, light and better suited for transport in vehicles. Milk processing was the preserve of women, with fresh camel milk and spontaneously fermented camel milk (suusa) being the main products. Fresh milk was preserved by smoking of milk containers and boiling. Smoking was the predominant practice, and was for extending the shelf life and also imparting a distinct smoky flavour to milk. The milk containers were fumigated with smoke from burned wood of specific tree species such as Olea africana, Acacia nilotica, Balanities aegyptica and Combretum spp. Boiling was practised by primary milk traders at collection points to preserve milk during times when transport to the market was unavailable. Milk spoilage at the primary collection point in Kulamawe was aggravated by lack of cooling facilities. At the secondary collection point in Isiolo town, milk was refrigerated overnight before onward transmission to Nairobi. The mean quantity of traded milk by traders was 83.2±3.8 litres. The main problems experienced by milk traders in Isiolo included milk spoilage (43.0% of respondents), delayed payments—after one or two days (19.9%), loss of money due to informal courier (12.2%), low prices of fermented milk (10.9%), milk rejection by customers in Nairobi because of spoilage (7.1%), inadequate supply during dry season (3.5%), loss of milk due to bursting of containers (2.1%) and milk not being supplied by producers due to insecurity (1.3%). In-depth understanding of the postharvest handling, preservation and processing practices would help to devise appropriate strategies that would increase the quantity and improve the quality of marketed camel milk. Interventions to enhance postharvest handling, preservation and processing practices for camel milk should include the improvement of infrastructure such as milk transport, collection, cooling and processing facilities of suitable capacity. Such interventions should also include strategies to enhance the literacy level of the producers and traders, as this would enable them to better utilise effectively and efficiently whatever resources existed in their area.

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INTRODUCTION

The camel (Camelus dromedarius) plays an important role as a primary source of subsistence in the Arid and Semi Arid Lands (ASALs) of Kenya. It lives in areas that are not suitable for crop production and where other livestock species hardly thrive. Due to its outstanding performance in the ASALs of northern Kenya where browse and water are limited, pastoralists rely mainly on camels for their livelihood. In these areas, camels are mainly kept for milk production and produce milk for a longer period of time even during the dry season when milk from cattle is scarce (Kaufman, 1998). The annual camel milk production in Kenya is estimated at 338.3 million litres, valued at USD 107.1 million, and this represents 12% of the national milk production (Musinga et al., 2008). During prolonged droughts, camel milk may contribute up to 50% of total nutrient intake of some pastoralists groups (Farah, 1996; Kaufman, 1998). These essential roles of camel milk emphasise its importance for food security to the pastoral people.

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METHODOLOGY

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The study was carried out in August-September, 2009, along the Kulamawe-Isiolo camel milk chain in Isiolo district, which is situated north of the Equator at coordinates
N00.35° and E037.58° and an altitude of between 1730 to 1890 m above sea level. Kulamawe is an important camel milk production cluster which supplies milk to Isiolo town, but its potential is underutilised due to remoteness and lack of supportive facilities. The area is characterised by unreliable and erratic rainfall with precipitation ranging from 237 to 698 mm per annum, high ambient temperatures (>25°C), sparsely distributed vegetation dominated by Cactus and Acacia species, and bushy woodlands. Camels are the most abundant livestock species in this area, with camel milk marketing being an important income earning opportunity for the pastoral households.

**Data collection**

Data were collected through cross-sectional survey and focus group discussions (FGDs). The sampling unit consisted of camel milk producers and milk traders in Kulamawe and milk traders in Isiolo. At the camel milk producers’ level, the sampling frame consisted of a list of camel keeping households obtained from the local administrative personnel. To identify survey households, a two-stage sampling procedure was used. During the first sampling stage, Kulamawe was divided into five zones (Bulla) representing the settlement patterns in the area. In the second stage, systematic random sampling was used to select the survey households in each Bulla. The main paths in the Bulla were used as transects. Starting from one end of the path, every fifth household on alternate sides of the path was visited and the household head, their spouses or the person responsible for making decisions on food purchases, or those directly involved in milk marketing interviewed using a structured questionnaire. A total of 167 camel milk producer households were interviewed. Focus group discussions were conducted on camel milk producers to augment data from the questionnaires. Individuals selected for the FGDs were those knowledgeable on the subject under study so as to have maximum information, and were selected with the assistance of key informants (community leaders).

Milk traders were categorised as primary (those in Kulamawe) and secondary (those in Isiolo town). Primary traders received milk from producers in Kulamawe and sold it to secondary traders in Isiolo, who further sold it to consumers in Nairobi. Milk traders were few and, therefore, all were interviewed. A total of 50 primary and 50 secondary milk traders in Kulamawe and Isiolo, respectively, were interviewed. Personal observations were made to fill the gap that might not have been captured during the survey, particularly to describe some of the routine dairy activities practiced by producers and traders.

**Statistical analysis**

Descriptive statistics (frequencies, means and percentages) were used to describe population characteristics of camel milk producers-continuous and categorical variables being reported as mean±standard errors and percent, respectively. Comparison of socioeconomic characteristics of camel milk producers to postharvest handling, preservation and processing practices was done using analysis of variance (ANOVA) and chi-square test for continuous and categorical variables, respectively. Significance level was accepted at p≤0.05. All analyses were done in SPSS Version 17.0 (SPSS, 2008). Qualitative data from FGDs were analysed using systematic content analysis, by transforming them into thematic components and writing into descriptive prose (Knodel, 1993).

**RESULTS AND DISCUSSIONS**

**Socio-economic characteristics of producers**

The characteristics of camel milk producer households are summarised in Table I.

Most (51%) of the respondents were women (spouses) while the rest were male household heads (49%). All the respondents were Muslims, with 97% being of Boran and 3% of Somali ethnic origin. Generally, the socio-economic status and the education level of the respondents were low. The ability to read and write would enable the producers to better utilise effectively and efficiently whatever resources exist in their area. Livestock keeping was the main economic activity, a finding that agrees with those from earlier studies which show that pastoralism is the main livelihood strategy in the ASALs of Kenya (Kaufmann, 1998; Musinga et al., 2008).

Ownership of livestock as the main economic activity significantly influenced (p=0.016) postharvest handling, preservation and processing methods for camel milk (Table II). The amount of camel milk production per day per household was low. However, households processing milk had significantly better education (p=0.002) than those who did not (Table II). The ability to read and write would enable the producers to better utilise effectively and efficiently whatever resources existed in their area.

**Home production of camel milk**

The average amount of milk a camel produced per milking was 2.0±0.1 litres. All the interviewed producers milked their camels twice a day (morning and evening), which is similar to the milking frequency practiced in many parts of the country (Kaufmann, 1998). Camel milking was predominantly handled by men. This observation is similar to camel milking in many parts of Kenya whereby milking is predominantly handled by men, with the exception of the Turkana where milking is entirely performed by women (Kaufmann, 1998). Because of the height of the udder, the milking process was done in a standing position with one knee raised to support the milking container-plastic container or traditional container called damela (curved from tree trunks) or gorfa (woven from grass). The milker stands on one leg, balances the milking container in his bent other leg and uses both hands for milking. Sometimes both udder halves are milked at the same time by two herdsmen. Camels were milked by hand, with the calf allowed to suckle for a short time prior to milking.
to stimulate milk letdown. Hygiene of milking was poor (hand milking, no udder cleaning). The reality, however, is that consumers in the region are beginning to appreciate the importance of clean milk and are even willing to pay more for higher quality milk than what is typically found in their market place, and this will compel the producers to produce and sell higher quality milk (Wayua et al., 2009).

Traditional preservation methods

The primary dairy products were fresh milk and traditionally fermented milk (suusa). The main preservation methods for fresh milk included fumigation of milk containers and boiling of milk.

Fumigation of milk containers

The main types of containers used by both producers and traders to handle milk were plastic jerricans (recycled cooking oil containers, of capacity 3 to 20 litres). These were used because they were cheap, light weight and better suited for transport in vehicles. The milk containers were fumigated with smoke from burned wood of specific tree species such as Olea africana, Acacia nilotica, Balanities aegyptica and Combretum spp. This indigenous milk preservation technology is locally referred to as qorasum. The milk containers were fumigated by inverting them over smoking chips until the smoke died out (about 5 to 10 minutes). The residual charcoal pieces were brushed out with special twigs, followed by rinsing with water. Fresh camel milk to be stored was then put inside. According to the pastoralists, if properly fumigated, fresh camel milk could stay for 24 hours at ambient temperatures, depending on the qorasum tree species used to fumigate the milk containers. Smoking of milk containers was part of a woman’s daily duty, and was done regardless of whether or not the containers were in use so as to maintain them in good condition. Smoking took place before early morning milking (06.00-07.00 hours) and again before the evening milk was put in them (17.00-18.00 hours). Fumigation is a common traditional practice carried out by pastoralists in northern Kenya (Kaufman, 1998; Wayua et al., 2009). According to the local understanding, smoking of milk containers imparts special taste and flavour to the milk, and disinfects the containers, thus reducing the loads of microorganisms, thereby extending the shelf life of milk. This corroborates with the results of an earlier study in which greater numbers and a faster development of aerobic mesophilic microorganisms occurred in milk kept in non-smoked as compared to smoked containers (Ashenafi, 1996). This practice, however, negatively affects the market because majority of potential consumers of camel milk, especially those from non-pastoral background, do not prefer the smoky flavour in camel milk. To reach a wider market, the traders need to meet the requirements of both market segments-by providing smoked and non-smoked milk according to customer preferences.

Traditional preparation of suusa

Suusa was made by putting raw camel milk in a clean and
fumigated container, wrapping the container with a piece of cloth and keeping it in a warm place (ambient temperature of 24–30°C) for about 12-24 hours to allow spontaneous fermentation. Suusa has a thin consistency compared with yoghurt, and because it is made by spontaneous fermentation, it varies in taste. Similar products from camel milk were reported in other pastoral systems of Africa (Abdelg-Rahman *et al.*, 2009; Seifu, 2007; Nori, 2010). The quality of suusa can, however, be improved using selected starter cultures, resulting in fermented milk with uniform taste and longer shelf life (Abdelg-Rahman *et al.*, 2009).

Whereas milking was predominantly done by men, postharvest handling was the preserve of women (spouses, 99.1%) and rarely by male household heads (0.9%). This has commonly been reported elsewhere in African pastoral systems (Seifu, 2007; Nori, 2010). Both producers and traders used mainly plastic jerricans of cheap quality (recycled cooking oil containers) to handle milk. The obvious advantages of plastic containers (cheap, light weight, better suited for transport in vehicles) coupled with the small volumes of traditional containers led to the increasing use of these containers in the camel milk trade. However, the plastic containers are difficult to clean, wear out frequently, and harbour bacteria which cause milk spoilage. To improve the situation, milk traders should use aluminium containers which are easy to clean and which are specifically designed for milk handling.

All the traders and producers sold raw milk, even though they sometimes boiled the milk to preserve it especially during times when transport was unavailable. In Somalia, where milk was boiled at collection points prior to transportation, it was observed that substantial volume of milk that would otherwise get spoiled was marketed daily in a hostile environment (Nori, 2010). Using firewood to boil milk, however, places intense pressure on woody resources on the already fragile environment (McPeak, 2003). Therefore, renewable energy technologies such as solar energy should be explored for their suitability for milk processing in the ASALs.

All the interviewed households reported that they used camel milk when it was raw, which agrees with an earlier finding that camel milk was predominantly consumed raw in most camel rearing societies (Farah, 1996). Consumption of raw camel milk is, however, of major public health concern. Recent studies from Kenya indicated that higher levels of total bacterial count (Younan, 2004), Salmonella (Matofari *et al.*, 2007) and Streptococcus (Younan *et al.*, 2005) were detected in raw camel milk, which suggests the potential health hazard associated with consumption of raw camel milk. Consumption of pasteurised camel milk should be encouraged since heat treatment destroys these microorganisms without affecting the nutritional value of camel milk, which is an advantage in relation to the commercial production of camel milk (Wemery *et al.*, 2003).

**Kulamawe-Isiolo milk chain**

The Kulamawe-Isiolo milk marketing chain is summarised in Fig. 1.

Morning milking generally occurred between 06.00 to 08.00 hours at the villages (manyattas). After milking and collection, the milk was transported for a duration of about 2.0±0.7 hours (about 10 kilometres) by donkey or women on their backs to the Kulamawe milk collection point. The maximum quantity of milk transported per trip was 20 litres. The producers then sold the milk to primary milk traders at Kulamawe shopping centre. The milk was then transferred from the producer containers to the traders’ containers—both containers were plastic jerricans of capacity 3 to 20 litres. The traders’ containers were properly labelled with the name of the trader (or unique marks of strings tied), which enabled their corresponding clients in Isiolo town to identify the containers.

This system was highly dependent and built upon trust, as there was no written agreement. The process of milk collection and change of containers took approximately 2.5 hours in the open sunshine and was a possible source of milk contamination in the marketing chain. As a result, marketed milk was typically exposed to high temperatures for prolonged periods of time, increasing the risk of spoilage. At the primary collection point, milk was subjected to simple quality tests based on colour, taste, and texture. During bulking, milk from different containers was mixed, further increasing the risk of spoilage due to

<table>
<thead>
<tr>
<th>TABLE II- PEARSON CHI-SQUARE CORRELATION RESULTS BETWEEN CATEGORICAL SOCIOECONOMIC VARIABLES AND POSTHARVEST HANDLING, PRESERVATION AND PROCESSING PRACTICES BY PRODUCER HOUSEHOLDS IN KULAMAWE</th>
<th>Gender</th>
<th>Education</th>
<th>Primary</th>
<th>Marital status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Categorical socioeconomic variables</td>
<td>level</td>
<td>economic</td>
<td>activity</td>
<td>Marital status</td>
</tr>
<tr>
<td>Households processing camel milk</td>
<td>0.186</td>
<td>0.002**</td>
<td>0.088</td>
<td>0.139</td>
</tr>
<tr>
<td>Methods used to process camel milk products</td>
<td>0.951</td>
<td>0.014*</td>
<td>0.000***</td>
<td>0.265</td>
</tr>
<tr>
<td>Camel milk products processed and quantities processed</td>
<td>0.295</td>
<td>0.951</td>
<td>0.990</td>
<td>0.982</td>
</tr>
<tr>
<td>Persons processing the camel milk products</td>
<td>0.295</td>
<td>0.272</td>
<td>0.990</td>
<td>0.000***</td>
</tr>
<tr>
<td>Persons making decisions on camel milk products to process</td>
<td>0.000***</td>
<td>0.758</td>
<td>0.016*</td>
<td>0.000***</td>
</tr>
</tbody>
</table>

* , **, *** means significant at p≤0.05, p≤0.01 and p≤0.001, respectively.
increased microbial contamination from the various milk batches.

Transportation to Isiolo was by an old lorry which was the only means of transport along the Kulamawe-Isiolo route. This lorry made a one way trip each day and was, therefore, only able to transport milk every other day—one day to Isiolo with milk, the next day back. To make its trip to Isiolo (a distance of 82 km on rough terrain) by 16.00–17.00 hours, the lorry departed Kulamawe by 11.00 hours and, therefore, milk had to be delivered by this time from the interior manyattas where the camels were reared. The average time between milking and arrival at secondary market in Isiolo was about 7.5 hours. The average ambient temperatures were 24°C in the early morning at the manyattas, 28°C at the Kulamawe collection point and 30°C at Isiolo town by late afternoon.

Vehicular transport was inefficient and there was no opportunity for refrigeration due to lack of grid electricity. Besides, only milk produced each other day was able to access the Isiolo market. Because the lorry was the only means of transport in this route, milk was transported along with all else that needed to be taken to Isiolo—passengers, livestock, charcoal, etc, which is a public health concern. Milk spoilage was inevitable when the vehicle was not in operation. To minimise milk spoilage during such times, milk traders at the Kulamawe collection point boiled milk using firewood to preserve it for sale the following day.

Once the milk reached Isiolo, it was weighed and assessed for quality in several ways that included colour, taste, texture, use of boiling, dipped matches, and looking for milk layering or separation. Boiled milk of higher quality would yield foam, for example, and would not have a burned residue at the bottom of the cooking pot, whereas a match dipped in watered-down milk would not light. Lower-quality milk would often layer into water, milk, and solids. Fermentation was checked by dipping a wooden cooking spoon to see if the fermentation process had begun. Milk from evening milking was separated from morning milk. Fresh milk was also packed separately from fermented milk—most of it in 20 litre jerricans. Once milk was weighed and graded, records were taken (supplier, volume, grade) and, for some traders, money paid on the spot. Most of the traders, however, paid their suppliers with a one-two day lag after they received payment from their agents in Nairobi (the tertiary market). The milk was then frozen overnight before onward transmission to Nairobi by buses the following day.

The main problems experienced by traders in Isiolo town included milk spoilage, delayed payments (after one or two days), loss of money due to informal courier, low prices of fermented milk and milk rejection by their customers in Nairobi (Figure 2).

Milk spoilage was the major problem and was caused by loss of power in the fridges, pooling of milk from different farmers, mixing of evening and morning milk, long distances between manyatta and town, exposure to high ambient temperatures during transport, use of dirty containers, and inefficient fumigation of milk containers. Loss of milk was due to bursting of milk containers and

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**Figure. 1.** Flow chart for the Kulamawe-Isiolo camel milk marketing chain
theft during transport. Whilst refrigeration was not an option for primary milk sellers in Kulamawe due to lack of connectivity to grid electricity, it was practiced by secondary milk traders in Isiolo. An elaborate business for cold storage had, therefore, emerged in Isiolo town.

Transportation to Nairobi had two segments. The first involved transferring the milk packed in 20 litre jerricans from the cooling hubs to Nairobi bound buses. This was done by casual labourers (usually men) using wheelbarrows, each ferrying two to five jerricans per trip. Transportation to Nairobi was by buses departing between 06.00–07.00 hours each morning and getting to Nairobi by around 11.00 hours.

**Milk traders in Isiolo town**

Whereas all the primary milk traders in Kulamawe operated individually, most (94%) of the traders in Isiolo town operated individually and only 6% operated in groups. The traders who belonged to groups, however, sold their milk on individual basis and only joined into groups to benefit from economies of scale, such as acquiring skills on milk handling and business management and reduced costs of cooling milk due to group freezers. All the traders traded in raw camel milk, the quantities varying from 40 to 160 litres. Traders operating in groups had higher quantity of milk traded per day (103.3±8.8 litres) than those trading individually (81.9±4.0 litres).

**CONCLUSION AND RECOMMENDATIONS**

This study has shown that the camel milk chain in Isiolo District, Kenya is characterised by poor milk handling infrastructure, including poor roads and lack of cooling facilities. Milk spoilage was a major problem. Camel milk is marketed raw under unhygienic conditions with minimal value addition and, therefore, risks of milk spoilage are high. Most of the milk is consumed raw, exposing a major public health concern, hence the need for processing to enhance safety and quality.

Therefore, the primary intervention strategy should be to address milk spoilage at the producing villages and the collection points, especially when transport is unavailable. Provision of appropriate and affordable cooling facilities at milk collection points should be explored. To minimise environmental degradation, renewable energy technologies such as solar energy should be explored for their suitability for heating milk in the ASALs. At secondary milk collection points, there is need for processing and value addition to diversify products to respond to consumer demands. Producers and traders could be mobilised and linked to creditors in order to acquire credit to invest in milk processing. These efforts should be coupled by continuous training of all actors in the marketing chain on hygienic milk handling.

**ACKNOWLEDGEMENTS**

This study was funded by the Kenya Arid and Semi Arid Lands Research Programme (KASAL). Sincere gratitude goes to the pastoral households and milk traders in Kulamawe and Isiolo for their participation.

**REFERENCES**


ABSTRACT

Dairying is an important industry within the livestock sector, with its products (fresh milk, yoghurt, mala, ice-cream, cheese, UHT, powder milk, butter and ghee) contributing 30% of livestock GDP. Policies targeting transformation of subsistence to commercial smallholder dairy production have been formulated. However, information on appropriateness of existing policies in Semi-Arid Kenya is scanty. Thus, a study was conducted to evaluate policy constraints, institutional challenges and incentives for private and public Research and Development (R&D) agencies and stakeholders along the dairy value chain that limit policy adoption levels. Rapid policy identification was conducted within the period November – December 2012, where national policy documents were reviewed. The study revealed the existence of policies targeting development of each stage within the dairy value chain. There is need for further research to establish the extent of awareness of national policies by stakeholders and partners in the dairy industry at local level (Machakos and Makueni Counties).

INTRODUCTION

The livestock sub-sector plays an important role, contributing to rural livelihoods, employment and poverty reduction. In Kenya, it contributes about 12% of the Gross Domestic Product (GDP), while accounting for about 40% of agricultural GDP (Kevevapi, 2013). Livestock provide a means of increasing production of needed nutrients, and are a source of cash income for the purchase of other foods (Staal et al., 1997). They provide milk, meat, manure, draught power, skins and hides, with financial benefits including provision of credit, acting as insurance and as a means of sharing risk (Behnke and Muthami, 2011). Dairying is an important industry within the livestock sector; with its products (fresh milk, yoghurt, mala, ice-cream, cheese, UHT, powder milk, butter and ghee) contributing 30% of livestock GDP and more than 22% of livestock gross marketed products (FAO 2011).

In an attempt to address these constraints, policies targeting development of the dairy value chain have been formulated to catalyze growth of the industry. A policy is simply defined as a plan of action, designed to achieve certain goals, and may adopt a number of mechanisms to reach explicit goals, including technical, regulatory, financial, administrative, managerial and political (Wilcox and Hirschfield, 2007). Despite formulation of numerous policies, challenges within the value chain remain unabated. An initiative focusing on transforming subsistence to commercial smallholder dairy farming in Semi-Arid Kenya (Machakos and Makueni Counties) seeks to address constraints along the dairy value chain. However, information on appropriateness of existing policies remains scanty. Failure to explore the appropriateness of policies that influence production, processing, transportation, marketing and consumption along the dairy value chain would result in less productive efforts. This study therefore intended to evaluate policy constraints, institutional challenges and incentives for private and public R&D agencies and stakeholders along the dairy value chain that limits adoption level. This paper discusses the findings of the policy identification phase of the study.

MATERIALS AND METHODS

Secondary information was used to map the dairy value chain, in identifying different stages within which policies have been formulated. The proposed process of policy evaluation was as shown in Figure 1. A rapid policy identification was conducted within the period November – December 2012, where the following national policy documents were reviewed: Kenya Vision 2030 (GoK, 2007), Draft Sessional Paper on Dairy Industry Development (MoLFD, 2007), National Livestock Policy (MoLD, 2008), Agricultural Sector Development Strategy 2010 – 2020 (GoK, 2010), KARI Strategic Plan 2009 – 2014 (KARI, 2009), Kenya National Dairy Master Plan (GoK, 2010), Ministry of Livestock National Strategic Plan 2008 – 2012 (MoLD, 2010). Proposed interventions targeting transformation of the dairy industry along the dairy value chain were identified.

RESULTS AND DISCUSSION

The dairy value chain comprises of pre-production, production, transportation, processing, distribution and retail as shown in Table 1.

Actors within the pre-production stage include research institutions that generate technologies targeting production and marketing, and input supply services (feeds and equipment). Within the production stage, actors include small scale and large scale producers with the support of extension service providers (public and private), animal health and artificial insemination service providers, artificial insemination services), in-kind...
### TABLE I

#### Value chain stage

<table>
<thead>
<tr>
<th>Value chain stage</th>
<th>Pre-production</th>
<th>Production</th>
<th>Transport</th>
<th>Processing</th>
<th>Chilling and bulking</th>
<th>Retail</th>
<th>Transport / distribution (wholesale)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Players</strong></td>
<td>R&amp;D agencies (technology &amp; dissemination)</td>
<td>Input suppliers</td>
<td>Financial service providers</td>
<td>Extension service providers</td>
<td>Large no. of individuals using bikes, foot and vehicles</td>
<td>Mobile: A number of traders selling milk door to door</td>
<td>Informal: A number of brokers and hawkers</td>
</tr>
<tr>
<td><strong>Integration</strong></td>
<td>Done by public and private research organizations, extension agencies, and equipment traders</td>
<td>Done by processors</td>
<td>Done by either producers or processors</td>
<td>Done by extension service providers</td>
<td>Done by producers or processors</td>
<td>Fixed: Kiosks, stores, supermarkets</td>
<td>Formal: A number of agents and distributors</td>
</tr>
<tr>
<td><strong>Financial service providers</strong></td>
<td>Done by R&amp;D agencies, extension agencies, and equipment traders</td>
<td>Done by processors</td>
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<td>Fixed: Kiosks, stores, supermarkets</td>
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</tr>
</tbody>
</table>

#### Stakeholder consultations on policy constraints

**Pretest and refine draft policy briefs**

**Develop policy briefs and advocacy messages**

**Sensitize decision makers about reviewed policies**

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**Figure 1:** Proposed methodology for policy evaluation along the dairy value chain

**Source:** Adapted from Technoserve (2008) and Kanuga (2009)
“Framing the issues, challenges and opportunities in livestock sector in the 21st century”

<table>
<thead>
<tr>
<th>Value chain stage</th>
<th>Aspect</th>
<th>Proposed policy interventions</th>
</tr>
</thead>
</table>
| Pre-production    | Breeding | • Promote farmer, private and cooperative-based AI provision  
|                   |        | • Harmonize and consolidate functions of animal breeding institutions  
|                   |        | • Proper animal husbandry practices targeting development of young breeding stock.  
| Production | Animal health | • Delivery, management and funding of veterinary services and disease control.  
| Feeds and fodder |        | • Allow para-veterinary workers to treat animals and veterinarians to dispense veterinary medicines.  
| Marketing | Extension services | • Limit government activities in dairy extension to coordination and regulatory aspects to encourage public-private sector investment in extension and advisory services.  
| Research |        | • Promote formation of a national body charged with livestock research which will give priority research on dairy marketing, product development, milk packaging and dairy standards.  
| Milk collection |        | • Explore through research methods (other than cooling) of preserving unprocessed bulk milk  
| Milk cooling |        | • Speed up the rural electrification programme and explore the viability of alternative sources of energy, such as solar, wind, mini hydro plants and organic fuels for use in milk cooling.  
| Milk processing and packaging |        | • Allow dairy cooperatives and private sector operators to benefit from tax allowances on new investments, including the recently introduced initiative on zero rating taxes on inputs used in liquid milk processing with regard to value added tax.  
| Quality control and assurance |        | • Introduce measures to ensure quality testing and assurance systems that conform to national and international standards. Such measures will include provision of incentives for milk testing equipment procurement and installation, stakeholder sensitisation on the importance of safe use  

TABLE II- PROPOSED POLICIES ALONG THE DAIRY VALUE CHAIN
TABLE II- PROPOSED POLICIES ALONG THE DAIRY VALUE CHAIN

<table>
<thead>
<tr>
<th>Value chain stage</th>
<th>Aspect</th>
<th>Proposed policy interventions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Marketing</td>
<td>Quality control and assurance</td>
<td>Antibiotics and other veterinary drugs at farm level, training on milk testing and operation of testing equipment, and strict enforcement of quality standards both for raw milk and dairy products.</td>
</tr>
<tr>
<td>Dairy cooperatives</td>
<td>• Implementation and enforcement of the new management tenets embodied in the amended Co-operative Societies Act of 2004</td>
<td>Encourage partnerships between cooperatives and other private sector players, especially processors.</td>
</tr>
<tr>
<td></td>
<td>• Encouragement to form and support partnerships with other informal traders</td>
<td>Promote the formation of cooperative structures among farmers</td>
</tr>
<tr>
<td></td>
<td>• Promotion of bulk purchases of farm inputs by co-operatives to minimize costs and improve competitiveness</td>
<td>Formulate ways of protecting producers and producer organizations from the effects of collapsed firms.</td>
</tr>
<tr>
<td></td>
<td>• Facilitate transformation of informal milk trade through:</td>
<td>Strengthen enforcement and adherence of quality standards for domestic and imported dairy products</td>
</tr>
<tr>
<td></td>
<td>• Development and adoption of low cost and appropriate technologies for small scale dairy investors</td>
<td>Enhance level of participation in the development and setting of world dairy standards.</td>
</tr>
<tr>
<td></td>
<td>• Investment in and support for training programmes on safe milk handling</td>
<td>Endeavour to classify dairy output as a special product under the WTO to take account of its significant contribution to food security and poverty alleviation.</td>
</tr>
<tr>
<td></td>
<td>• Working with dairy industry stakeholders to improve the standards of milk processing</td>
<td>Encourage processors to offer premium prices during dry seasons.</td>
</tr>
<tr>
<td></td>
<td>• Institute public education campaigns on the demerits of consuming improperly handled and unprocessed whole milk</td>
<td>Promote processing of affordable long-life milk products.</td>
</tr>
<tr>
<td></td>
<td>• Facilitating compliance to standards by the informal milk traders through provision of incentives for improved milk handling and establishment of a supportive milk dealer certification system.</td>
<td>Ensure inclusion of dairy products in the food basket of a National Strategic Food Reserve fund proposing replacement of the current Strategic Grain Reserve fund limited to grains.</td>
</tr>
<tr>
<td>Imports and exports</td>
<td>Strengthen enforcement and adherence of quality standards for domestic and imported dairy products</td>
<td>Increased awareness of the nutritional and health benefits of milk consumption</td>
</tr>
<tr>
<td>Market stabilization and milk strategic reserves</td>
<td>Encourage processors to offer premium prices during dry seasons.</td>
<td>Encourage agricultural colleges and universities to provide updated formal and on-the-job training, through restructuring and granting them semi-autonomous status to enable commercialization of training services.</td>
</tr>
<tr>
<td></td>
<td>• Promote processing of affordable long-life milk products</td>
<td>Encourage stakeholders to contribute to capacity building by setting up training institutions.</td>
</tr>
<tr>
<td></td>
<td>• Ensure inclusion of dairy products in the food basket of a National Strategic Food Reserve fund proposing replacement of the current Strategic Grain Reserve fund limited to grains.</td>
<td>Implement the government ICT and the e-government policy.</td>
</tr>
<tr>
<td>Consumption</td>
<td>Increased awareness of the nutritional and health benefits of milk consumption</td>
<td>Promote strong linkages between universities and research institutions.</td>
</tr>
<tr>
<td>Human Resource Development</td>
<td>Encourage agricultural colleges and universities to provide updated formal and on-the-job training, through restructuring and granting them semi-autonomous status to enable commercialization of training services.</td>
<td>Set up a national dairy information center at Kenya Dairy Board that will be equipped with a databank facility to collect, analyze and disseminate information on the dairy industry.</td>
</tr>
<tr>
<td>Dairy information</td>
<td>Implement the government ICT and the e-government policy.</td>
<td>As shown in Table II.</td>
</tr>
</tbody>
</table>

The study revealed the existence of numerous policy interventions targeting constraints in all value chain stages. Implementation of the proposed policy interventions has a potential in transforming the dairy value chain. If implemented successfully, proposed policy interventions at different stages is likely to give desirable results.

**Pre-production stage**

Implementation of proposed interventions at the pre-production stage would adequately tackle the inadequacy in accessing breeding services thus leading to genetic improvement of dairy cattle leading to increased production potential at farm level.

**Production stage**

At the production stage, implementation of interventions targeting improvement of feed quality and quantity would enhance productivity thus increasing producers’ income.
through lower production costs as well as increased milk off-take. Interventions targeting extension and advisory services would result in enhanced adoption of cost-effective innovations with higher production. Improved access to animal health services is likely to lead to healthier animals as a result of timely treatment and preventive measures thus reducing production costs.

**Marketing stage**

Implementation of proposed interventions which include collective action is likely to lead to reduction in production costs as a result of bulk acquisition of inputs, higher bargaining power thus increased incomes and facilitate bulking of milk for transportation thus reducing per head transaction costs. In addition, collective action is a cost-effective delivery pathway (Brigtwell et al., 2001) for research and development agencies. Innovative technologies in milk handling and processing would lead to higher profit margins for processors and traders and also reduce post-production losses for producers. Interventions geared towards transformation of the informal milk trade are likely to lead to improved access to high quality milk and milk products by consumers at affordable prices. Promotion of responsible business practices is likely to improve the competitiveness of producers, processors and traders.

Efforts in adopting proposed policy interventions by stakeholders and development partners will result in significant development of the dairy value chain.

**CONCLUSION AND RECOMMENDATIONS**

The study revealed the participation of numerous stakeholders, public and private partners implementing activities aimed at enhancing production and marketing. The study further revealed the existence of policies targeting development of the dairy industry, with proposed interventions to address constraints in all value chain stages. To this end, there is need for further research to establish the extent of awareness of national policies by stakeholders and partners in the dairy industry at local level (Machakos and Makueni Counties), level of incorporation of proposed intervention policies in programmes and project implementation, constraints and challenges limiting implementation.

**ACKNOWLEDGEMENT**

The authors acknowledge the financial support of this work by the Association for Strengthening Agricultural Research in East and Central Africa (ASARECA), KARI Director and the Centre Directors (KARI Katumani & Muguga North) for logistical support.

**REFERENCES**


HONEY VALUE CHAIN ANALYSIS IN KIBWEZI DISTRICT, KENYA

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ABSTRACT
This study was conducted in Kibwezi a district, Makueni county to analyze honey value chain in order to identify the types of chain governance, upgrading strategies, determine profitability of the chain actors and its associated constraints and opportunities in honey production and marketing systems and suggest possible intervention measures for the identified problems. The value chain analysis approach was used as an analytical and conceptual framework to guide data collection process and result analysis. Households’ survey questionnaire and focus group discussion checklists were the main tools used to gather primary data from the households and honey value chain actors. At household level, data were collected from 60 beekeepers in six catchment areas within the district. The result of the study showed that, over 90% of the hives owned by the beekeepers were traditional with an average of 15 traditional hives per sample households. The average productivity of the traditional hive in the study area was 10.5kg/hive. In the study area beekeeping is predominantly practiced by and defined as a men’s occupation. The average income earned by sample households from beekeeping was Ksh 3,850 where 50% of the households earned income within the range of Ksh 2,501 - 4,500. During the study period, four different types of governance structures (market based, balanced network, direct network and hierarchy) were identified between different actors involved in honey value chain mainly based on an informal agreements which allowed the actors at higher levels of the chain to exercise some kind of power in setting the requirements and standards that other actors need to fulfill. Process and product upgrading were the main type of upgrading strategies identified in honey value chain. The major constraints which were identified at local level are lack of institutional supports, absence or very limited training services, lack and high costs of modern beekeeping equipments, lack of access to reliable and rewarding markets, colony absconding due to poor hive management and low financial capacity of the beekeepers. Some of the possible recommendations for future intervention measures include encouraging and facilitating establishment of producers’ organization, provision of practical oriented training and credit services, encouraging use of transitional and modern hives, establishing honey collection centers and diversification of hive products.

Key words: honey value chain, household, constraints, beekeeping, upgrading strategies

INTRODUCTION
Kenya is among the Low Income Countries (LICs) with the lowest human development index in the world. In the year 2011, Kenya was ranked 143rd out of 187 countries, (UNDP, 2011). Vision 2030 is Kenya’s long term development blue print which aims at greater and more sustainable growth of the economy in a more equitable environment and thus transform Kenya into a middle income country (GoK, 2007). The livestock sub-sector, which is one of the six priority sectors in vision 2030 of which bees are part, contributes about 10% of Kenya’s GDP. Beekeeping alone contributes about 1.89% of this amount (Muya, 2004). Honey and other hive products have been desired for centuries due to their nutritional and medicinal value (Paterson, 2006), it has immense benefits in terms of provision of pollinators, which enhance crop yield and is essential for sustaining biodiversity (Bradbear, 2002). It is also feasible in marginal conditions and a suitable activity where people need to restore their livelihoods or create new opportunities. In fact nowadays it is widely considered as one of the poverty-alleviation strategies both by the Kenyan government, Non Governmental Organizations (NGOs) and other actors supporting rural development in Kenya. Despite the fact that beekeeping is practiced by thousands of farmers in Kenya and its huge potential for building sustainable livelihoods in rural areas (MoLD, 2010), the apiculture sub sector is constrained due to lack of necessary financial, technological and extension support (MoLD, 2009). Honey production and marketing is still very much traditional. The beekeepers are extremely dependent on the use of low productive traditional hives. This scenario has forced beekeepers to sell their honey through an exploitive chain of agents which consequently has kept farm-gate honey price at very low levels while consumer prices are higher (SNV-Kenya, 2004). Thus, the challenge for policy makers and development partners aiming to support pro-poor economic development is how to create beekeeping value chains which ensure higher income for beekeepers in a sustainable manner.

This study uses a value chain analysis approach to demonstrate how small-scale beekeepers in the study area can effectively be linked to markets by improving their honey production and marketing system. Value chain describes the full range of value-adding activities required to bring a product from its conception to the final consumer (Kaplinsky, 2000). Value chain analysis is increasingly being used because of its focus on identifying opportunities and key constraints within the chain, and its potential to identify market-based solutions that promote competitiveness (Donald, 2009). According to Ponte (2002), though value chain analysis was initially applied to manufacturing and service sectors, it is also being widely applied to agricultural commodities. The focus in
this study is on local honey value chain which provides an understanding of the actual scenario on the ground which ultimately will provide strategies for the inclusion of small-scale farmers into the chain that could help to increase production and income in rural areas.

**MATERIALS AND METHODS**

**The study area**

The study was carried out in Kibwezi district which is a semi-arid area located approximately 200kms South East of Kenya’s capital Nairobi. Kibwezi District was carved from Makueni District in 2007 and is one of the districts that form Eastern Province. The district borders Kajiado District to the West, Taita District to the South, Mutomo District to the East and Nzaui District and Makueni District to the North. The District covers an area of 3954.6 Km² and lies between the latitudes 2° 6’ S˚ and 3° S˚ and longitude 37°36’ E and 38°30’ E, respectively. It is inhabited by Akamba community who are mainly agro-pastoralists. The area is typical semi arid land characterized by low erratic and unreliable rainfall. The average annual rainfall, evaporation and temperatures are 600 mm, 200 mm and 23˚ respectively. Due to its proximate position along the equator, the area experiences a bimodal pattern of rainfall with long rains from March to May and short rains from November to December. The short rains are more reliable intime than long rains and are therefore more important. Although the livelihoods of the people in the area are diverse, the income generating activities are livestock keeping and crop farming besides beekeeping. Homestead/ backyard and forest beekeeping is the dominant type of honey production in the district. However, the other hive types (frame) are also in use though the number is insignificant as compared to the traditional hives. In 2009, the total number of traditional and frame hives in the district was 23,288 (GoK 2010) and projected to increase overtime.

**Data sources and collection methods**

Though value chain analyses are highly qualitative, this study uses a cross-sectional (qualitative and quantitative) research design. The data collection process consisted of two main phases. The first phase was qualitative interviews (Focus Group Discussion) with key informants selected from private businesses, governmental and non-governmental organizations working with honey value chain. In-depth interviews were conducted with honey and beeswax processors (Kibwezi Women Group refinery) wholesalers, supermarket managers, private dealers, NGO representatives, government institutions representatives from Ministry of livestock, local honey collectors and traders and honey retailers at the district level. The interviewees for the interviews/focus group discussion were purposely selected based on their experience and knowledge in beekeeping. The second phase of the data collection process was mainly household survey using pre-tested questionnaire. The household survey questionnaire included questions related to households’ socio-economic characteristics (sex, age, family size, and educational level), experiences in beekeeping, honey production and marketing systems, number and type of hives owned, amount of honey produced from the different hives types, honey production costs, harvesting frequency and time, honey prices, beekeeping management practices and access to extension services such as training and rural credit services. In total 60 questionnaires were administered. This work was conducted in between 2010/2011.

Finally, Statistical Package for Social Sciences (SPSS) version 11 and spreadsheet were used for the analysis of quantitative data collected from the households. The qualitative information from key informant interviews and focus group discussions were transcribed, coded and analyzed using qualitative assessment method.

**RESULTS AND DISCUSSION**

**Socio-economic characteristics of the beekeepers**

Beekeeping activity in study area is predominantly men’s activity mainly for two reasons. Firstly, sitting of hives high on trees creates difficulty for women to climb trees it is also a taboo for women to climb tree in the community. The beekeepers in the study area tend to have very low level of education (Table I). While 66.6% had received primary education and below, only 33.4% had attained beyond secondary education.

The survey also shows that around 80% of the sampled beekeepers totally depend on the use of traditional hive. The main reasons mentioned by the beekeepers for low adoption of frame hives were: high costs of frame hives and its accessories (90%), lack of training on how to operate the frame hive (75%), shortage of frame hives in the area (18%), and lack of awareness about the relative advantage of frame hives (62%). About 80% of the sample respondents have never participated in any beekeeping training and the remaining 20% have only got one time training.

**Beekeeping management practices**

The beekeeping management practices are mainly traditional though the management level differs from one beekeeper to the other. Around 42% of the sampled beekeepers mentioned that they visit their traditional hives at least once a month, whereas 33% and 15% visit their hives towards rainy season and at harvest respectively. The majority of the beekeepers hang traditional hives just before the onset of rains with the expectation of abundance of bee forages flowering season within the homestead or in the forest far away from their residential areas depending on the availability of land. Only few farmers mentioned they visit once in a while during the initial stages to check whether the hive has been occupied by the bee colony or not. Due to lack of follow up, about 20-40% of the hives hanged on tress are not usually occupied by bee colonies reason being the invasion by ants and other pests and poor
Figure 1: Location of the study area

TABLE 1 - SUMMARY CHARACTERISTICS OF THE RESPONDENTS IN THE STUDY AREA

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Variables</th>
<th>Frequency</th>
<th>Respondents, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td>Male</td>
<td>38</td>
<td>63.3</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>22</td>
<td>36.7</td>
</tr>
<tr>
<td>Age of respondent, (years)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>18 – 30</td>
<td>6</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>31-50</td>
<td>21</td>
<td>35</td>
</tr>
<tr>
<td></td>
<td>&gt;50</td>
<td>33</td>
<td>55</td>
</tr>
<tr>
<td>Level of education</td>
<td>Informal</td>
<td>14</td>
<td>23.3</td>
</tr>
<tr>
<td></td>
<td>Primary</td>
<td>26</td>
<td>43.3</td>
</tr>
<tr>
<td></td>
<td>Secondary</td>
<td>15</td>
<td>25.0</td>
</tr>
<tr>
<td></td>
<td>Tertiary</td>
<td>5</td>
<td>8.4</td>
</tr>
<tr>
<td>Land holding (ac)</td>
<td>&lt; 5</td>
<td>7</td>
<td>11.7</td>
</tr>
<tr>
<td></td>
<td>6 – 10</td>
<td>22</td>
<td>36.7</td>
</tr>
<tr>
<td></td>
<td>11 – 15</td>
<td>17</td>
<td>28.3</td>
</tr>
<tr>
<td></td>
<td>&gt; 15</td>
<td>14</td>
<td>23.3</td>
</tr>
<tr>
<td>Land tenure</td>
<td>Individual</td>
<td>54</td>
<td>90</td>
</tr>
<tr>
<td></td>
<td>Communal</td>
<td>6</td>
<td>10</td>
</tr>
<tr>
<td>Experience (years)</td>
<td>&lt; 5</td>
<td>17</td>
<td>28.3</td>
</tr>
<tr>
<td></td>
<td>6 – 10</td>
<td>13</td>
<td>21.7</td>
</tr>
<tr>
<td></td>
<td>11 – 15</td>
<td>5</td>
<td>8.3</td>
</tr>
<tr>
<td></td>
<td>&gt; 15</td>
<td>25</td>
<td>41.7</td>
</tr>
</tbody>
</table>

management.

Honey bee production systems
Honeybee production systems in the study area were predominantly traditional. The common traditional beekeeping activities practiced in the study area included: log shaping, wrapping hives, smoking hives and putting hives on trees and tree trunks, feeding and watering honeybees, checking ripening of honey and harvesting. Even though there were availability of modern beehives in the area e.g. langstroth, it was not possible for majority to buy because it was considered expensive. Few of them
had also received training on beekeeping. Based on the periodicity of the pollen and nectar flow, two honey harvesting periods were reported in a year. The major honey flow season is April – May, while minor honey flow is from Dec- Jan. All respondents (100%) in the study area did not have any type of modern beekeeping harvesting equipments and this was said to be a great impediment during harvesting. Honey is the major hive product but some beekeepers also consider beeswax and bee brood as the minor bee products. The change in the farming systems has become a threat to the beekeeping activities in the study area. Over (90%) of all the beekeepers responded that there had been decline in bee population overtime and this was attributed to increase in irrigated agriculture coupled with intensive application of insecticides thus affecting bee population.

Based on the information of the respondents, on average the number of colonies in different hives/household were 14.80±8.61 and 3.53±2.49 for traditional and langstroth beehives respectively and also honey yield /production/ household/yr were 80.55kg and 90.18kg for traditional and langstroth beehives respectively. In this study, accurately determining honey production was found to be a difficult exercise, as most of beekeepers were unable to quantify correctly the quantities harvested in kilogram or any other weighing scale. Nevertheless, based on beekeepers estimate, the number of kilograms taken per hive per harvesting ranged from 7 kg up to 25 kg and 8kg up to 30 kg of crude honey for traditional and langstroth beehives respectively (Table II).

<table>
<thead>
<tr>
<th>No.</th>
<th>Type of hive</th>
<th>unit</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Traditional</td>
<td>Kg</td>
<td>5</td>
<td>25</td>
<td>7.20±0.23a</td>
</tr>
<tr>
<td>3</td>
<td>Langstroth</td>
<td>Kg</td>
<td>8.25</td>
<td>30</td>
<td>23.37±0.73b</td>
</tr>
</tbody>
</table>

Means in a column having different superscript are statistically different at P<0.05

These results are indicators of the existence of room for increasing performances of these beehives through good management practices coupled with favorable beekeeping environment. Statistically there was highly significant deference (p=0.05) between the two types of hives in terms of yield per hive per year.

Marketing of hive products

Majority (97%) of respondents sell their honey while the rest (3%) produce honey only for home consumption. About 40% and 5% of beekeepers sell their honey to middle men and local herbalists/brewers respectively. The price of honey in the area varied from Ksh 100-Ksh 200/kg. Almost all farmers have at least a market centre where to sale their honey. The price of honey is subject to fluctuation with highest price in the dry season and lowest during honey harvesting period. In general marketing of honey in the area is promising. Honey in the study area is used as food, drink, medicine and for cultural rituals or ceremony. The annual gross income of respondents from the sale of honey in the study area ranged from KES 500 to KES 8,200. As shown in (Table III), the maximum proportion (50%) of sampled respondents earned an annual gross income of between KES 2,501 to 4,500 and about 28.3% of sampled households obtained KES 500 to 2,500. On the other hand, very few respondents (6.70%) obtained annual income of above KES 6,501. Likewise, the mean annul gross income per household during the survey period was about KES 3,850.20 (Table III).

Key constraints affecting beekeeping

Farmers mentioned different constraints affecting beekeepers in the district, 10 key challenges/constraints were generated. These constraints were ranked (Table IV) according to what the farmers perceived were the most important factors affecting beekeeping development.

Honey value chain and key chain actors

According to Kaplinski and Morris (2003) value chain describes the full range of activities which are required to bring a product or service from conception, through the different phases of production (involving a combination of physical transformation and the input of various producer services), delivery to final consumers and final disposal after use. The primary effort was made to identify the key chain actors, the marketing channels originating from the study area and the relationships among the actors. Figure 2 presents an initial honey value chain map showing main actors and different marketing channels in Kibwezi District. Based on the initial mapping of the chain, researchers, beekeepers, honey collectors and traders, honey processors and exporters, and retailers/supermarkets were identified as the key actors in the honey value chain. The honey value chain in Kibwezi district begins with individual small-scale beekeepers. African Beekeepers limited and Heifer international (NGO) were the only suppliers of a limited amount of frame beekeeping technologies for beekeepers. In the study area, honey is entirely produced by small individual farmers predominantly using traditional hives. Kibwezi Women Group honey refinery (KWGR) was the only well established processing unit in the district with a capacity to process upto one tone of honey/day.

Honey collectors and traders (intermediaries) make up the second link within the honey value chain. The major share of honey marketed goes through the intermediate buyers (honey collectors and traders). These intermediate buyers act as a link between small-scale beekeepers and the actors in the upper ladder of the chain (Local brewers,
honey processors (KWGR), retailers and supermarkets). The intermediaries have different categories based on their financial capacity to buy large volume of honey. The small and medium size intermediaries collect small quantities of honey from households and small markets in the locality and sell to merchants who transport the large volume of honey to other big cities e.g Nairobi and Mombasa.

These larger intermediaries have an established network of information with the small and medium intermediaries about the price and volume traded and therefore, they have the power to set the price leaving small-scale beekeepers and small honey collectors little room for price negotiation. The wholesalers, processors (Packers) and supermarkets are the main actors at the national level.

TABLE III- DISTRIBUTION OF SAMPLE FARMERS BY ANNUAL TOTAL GROSS INCOME EARNED FROM THE SALE OF HONEY

<table>
<thead>
<tr>
<th>Income Category</th>
<th>Kisingo</th>
<th>Kiboko</th>
<th>Nyayo</th>
<th>Machinery</th>
<th>Ivungoni</th>
<th>Nthongoni</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n=10</td>
<td>n=10</td>
<td>n=10</td>
<td>n=10</td>
<td>n=10</td>
<td>n=10</td>
<td>n=60</td>
</tr>
<tr>
<td>Mean income (KES)</td>
<td>3,850.20</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

n= Refers number of respondents

Fully processed the honey using modern technologies and packaged in labeled containers of different sizes, preferably in half and one kilogram for local markets (supermarkets, food groceries and big hotels). It is important to note that there are many middle men involved before the honey finally reaches the retailers, processors or consumers in major towns and cities in Kenya which keeps the honey price paid by the consumer very high as compared to the price received by the small-scale beekeepers.

The third marketing channel is the shortest channel in the area where beekeepers sell their honey to final consumer, local brewers and herbalists.

TABLE IV- PAIR-WISE RANKING OF CHALLENGES/CONSTRAINTS AFFECTING BEEKEEPERS IN KIBWEZI DISTRICT

<table>
<thead>
<tr>
<th>No</th>
<th>Constraints</th>
<th>BF</th>
<th>WS</th>
<th>PD</th>
<th>AC</th>
<th>MH</th>
<th>BS</th>
<th>EQ</th>
<th>MK</th>
<th>CP</th>
<th>DF</th>
<th>Total</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Shortage of bee forage (BF)</td>
<td>WS</td>
<td>BF</td>
<td>BF</td>
<td>BF</td>
<td>BF</td>
<td>BF</td>
<td>BF</td>
<td>BF</td>
<td>BF</td>
<td>BF</td>
<td>8</td>
<td>2</td>
</tr>
<tr>
<td>2</td>
<td>Water shortage (WS)</td>
<td>WS</td>
<td>WS</td>
<td>WS</td>
<td>WS</td>
<td>WS</td>
<td>WS</td>
<td>WS</td>
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<td>WS</td>
<td>WS</td>
<td>9</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>Pests &amp; diseases (PD)</td>
<td>PD</td>
<td>PD</td>
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<td>PD</td>
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<td>3</td>
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<tr>
<td>4</td>
<td>Agro chemicals poisoning (AC)</td>
<td>AC</td>
<td>AC</td>
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<td>AC</td>
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<td>6</td>
<td>4</td>
</tr>
<tr>
<td>5</td>
<td>Lack of modern hives (MH)</td>
<td>MH</td>
<td>MH</td>
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<td>MH</td>
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<td>MH</td>
<td>MH</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>6</td>
<td>Lack of beekeeping skills (BS)</td>
<td>BS</td>
<td>BS</td>
<td>BS</td>
<td>BS</td>
<td>BS</td>
<td>BS</td>
<td>BS</td>
<td>BS</td>
<td>BS</td>
<td>BS</td>
<td>4</td>
<td>6</td>
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<tr>
<td>7</td>
<td>Shortage of equipments (EQ)</td>
<td>EQ</td>
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<td>EQ</td>
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<td>EQ</td>
<td>EQ</td>
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<td>EQ</td>
<td>EQ</td>
<td>3</td>
<td>7</td>
</tr>
<tr>
<td>8</td>
<td>Lack of market (MK)</td>
<td>CP</td>
<td>MK</td>
<td>CP</td>
<td>CP</td>
<td>CP</td>
<td>CP</td>
<td>CP</td>
<td>CP</td>
<td>CP</td>
<td>CP</td>
<td>2</td>
<td>8</td>
</tr>
<tr>
<td>9</td>
<td>Lack of capital (CP)</td>
<td>DF</td>
<td>DF</td>
<td>DF</td>
<td>DF</td>
<td>DF</td>
<td>DF</td>
<td>DF</td>
<td>DF</td>
<td>DF</td>
<td>DF</td>
<td>1</td>
<td>9</td>
</tr>
<tr>
<td>10</td>
<td>Deforestation (DF)</td>
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<td>1</td>
<td>10</td>
</tr>
</tbody>
</table>

Within the domestic honey value chain, a given actor trades with more than one actor through different marketing channels which necessitate the simultaneous existence of more than one type of chain governance among different actors. This study revealed that the domestic honey value

Types of honey value chain governance

According to Schmitz (2004), the success of value chain intervention strategies are basically determined by the type of value chain governance, in which the chain is characterized by either many suppliers and many customers, repeated transactions, limited information flow and absence of technical assistance or balanced network is indicated by suppliers having many customers, intense information flow in both directions, balanced negotiation power, and the actors have complementary competence without having control over each other.
chain is governed by a combination of market-based, unbalanced- and uncoordinated network governance structures (Figure2). Small-scale beekeepers were in a market-based relationship with the brokers, retailers and even consumers who buy honey from the local open markets. In this case, most of the relationships between honey sellers and buyers are informal and tend to have minimal amount of formal cooperation among the participants. The entire transaction process is determined by the market itself and none of the actors control or influence the honey price. The same scenario was also observed in within the marketing channel that involves honey collectors, retailers and supermarkets there is no substantial information flow in both directions regarding the transaction such as honey quality and quantity, delivery frequency and honey price. The balanced network governance structure is more clearly observed between processors (KWGR) and retailers and other players who consume honey. The processors having being certified by Kenya Bureau of Standards (KeBS) have an obligation of supplying quality products to its clients. This is attributed to the directed network governance structure in which KWGR purchase honey from beekeepers and small honey collectors in Kibwezi District. Both the small honey collectors and beekeepers have to deliver honey to the processing plant in Kibwezi town on its own specifications, pricing structure and other requirements. All the agreements are informal but the small-scale beekeepers and honey collectors have to comply with the specification to sell their honey to processing plant. This governance structure is considered the most important in improving honey production and marketing systems in the district.

**Road map: The need for honey production and marketing system upgrading**

Small-scale beekeepers must improve their honey production systems in order to enter the rapidly growing domestic and export honey markets and to obtain substantial benefit from beekeeping. Traditional beekeeping has over the years has been criticized for low honey yield per hive, degraded honey quality, inconvenience for management, and risks of losing lives during tree climbing to hang the hives. The household survey data shows that langstroth hives have upto 30% higher yield on average than traditional hive. The quality of honey from traditional hive is also low because of contamination with debris and other foreign materials, during harvesting, from which the hive is constructed. Due to this reason, the honey from traditional hive is not procured by large processing companies. Hive management difficulties in traditional beekeeping is another reason for the need of upgrading the production system. In the study area, once they hang the hives on trees, it is difficult to inspect the hives for pest and disease control and colony management. According to the information from the District Livestock production Officer, generally around 50 to 70% of the hives hanged on the trees are occupied by bees. Traditional beekeeping is also criticized for distraction of bee colonies during harvesting. In most cases, the beekeepers use a lot of smoke and flames during harvesting and ultimately killing a lot of bees. Beekeepers also endanger their lives with traditional beekeeping. Beekeepers use rope to climb the tree during hive hanging and harvesting period, and in some cases detachment of rope or branch of tree on which...
the rope is tied, lead to the loss of beekeepers life and/or physical disabilities.

The need to involve more women in beekeeping activity also requires shift from traditional beekeeping to modern beekeeping. Although beekeeping can be practiced both by men and women, the difficulties with climbing trees mentioned above together with the local community taboo that prohibit women from tree climbing have prevented women from being involved in beekeeping. Honey marketing in the study area also needs improvement. Most of the marketing agents aim at maximizing their own profit at the expenses of small-scale beekeepers. Owing to lack of market information, beekeepers rely on the information from middlemen collecting honey from the villages and local markets. Because of lack of appropriate honey storage facilities and the need for immediate cash, around 70% the beekeepers sell their honey immediately after harvesting while around 30% store it for one to two months before selling. During harvesting time, the honey collectors and traders and particularly middlemen pay very low price to the keepers because of the over supply of honey to the market in honey production areas. After two or three months the honey price will go up by around 30 to 50% on the same market. This shows the existence of high marketing inefficiencies. For all the reasons, there is a great need to change the current dominant traditional beekeeping system to transitional and or modern beekeeping systems.

**DISCUSSION**

One principle of the value chain analysis is to identify the intervention points where minimal amounts of change generate big effect somewhere else in the chain (Purnomo, et al., 2009). This study was concerned with assessing and investigating the means of enhancing the productivity of small-scale beekeepers in particular and the economic performance of the beekeeping sub-sector in Kibwezi district. The discussion here mainly focuses on the main issues that needs attention in order to improve honey production and marketing in the study area. The challenge at honey production level is to promote wider adoption of frame hives, while making them accessible to the beekeepers in the area. This continues to be a challenge in the foreseeable future in the area. The overlapping financial, technological and institutional constraints that are currently faced by the beekeepers need urgent attention of actors from private, government and NGOs as the existing problems cannot be solved by government or private actors alone. The mentality of beekeepers needs to be changed from considering beekeeping as a leisure time activity to more market-oriented honey production. In the mean time, work needs to be done to effectively link beekeepers with rewarding honey markets. This can be achieved through formation of producers’ organization. As mentioned earlier in the previous sections absence of producers/bkeepers organizations and linkages force the beekeepers to sell their product through exploitative chains of agents. Organizing beekeepers in to producers’ organization can be used as a starting point for improving/upgrading other production and marketing processes. This will also allow beekeepers to pool resources and achieve economies of scale and in the long run help the producers to gain higher prices for their output through increased bargaining power. Furthermore, producer organization can help the individual member to get access to specific supports such as credit facilities, training services and improved beekeeping technologies which would be difficult to access as an individual.

The other approach for upgrading could be the coordination with actors at the higher level of the value chain such as honey processing and exporting companies and supermarkets. Closer vertical relations among the actors can bring constancy and dependability to input and output, reducing vulnerability and encouraging participants to invest in improvements in quality and marketing system. For buyers, stable and suitable relationships with suppliers will help them to address the problem of inconsistency in production and delivery of quality products. This will also assists in technology transfer to the beekeepers regarding the product standards and other requirements which requires compliance.

**CONCLUSION AND RECOMMENDATION**

The District is endowed with abundant bee forage due to its forest cover besides permanent streams such as Kiboko, Kibwezi and the Athi rivers. The hive population currently stands at of 23,288 (GoK 2010) this clearly points out the huge potential in the district. Currently, the beekeepers are price takers, they do not have power to set prices in the current marketing system that is being dominated by middlemen who take the advantage of market information imperfections resulting in the opportunistic behavior that suppress honey farm-gate prices in the study area. The prices paid to the beekeepers are insensitive to output quality differences and providing little incentives for beekeepers to improve their honey quality. Among the other things, poor beekeeping skills, absence of well coordinated and rewarding marketing channels has hindered the adoption of modern beekeeping technologies in the area. Adoption of modern hives and beekeeping accessories will greatly help the beekeepers to earn more income nearly three times higher than what they are getting from traditional hive. In order to increase honey production and beekeepers incomes, there is an enormous need for organizational and institutional improvements. Beekeepers need to be encouraged and supported to organize themselves into a producers’ organization or cooperative in order to overcome some of the technological, financial and marketing constraints. Improvements in market institutions are required to enhance chain coordination, allow the realization of the potential economies of scale, increase marketing efficiencies, and to reduce transaction costs and marketing risks. Moreover, building farmers’ capacity through practical oriented training on the use of improved hives and beekeeping accessories is essential to increase...
the adoption rate of beekeeping technologies and changing farmers’ mind towards business orientation.

ACKNOWLEDGEMENT
The authors are most grateful to Director KARI for the support, also the participating farmers for their willingness to take part in the interviews on particularly complex topics in beekeeping. Lastly but of equal magnitude is to thank Government of Kenya and World Bank for funding this work through Kenya Agricultural Productivity and Agribusiness Project (KAPAP)

REFERENCES
OPPORTUNITIES IN ADOPTION OF COMMERCIAL FISH FARMING AS A NEW ENTERPRISE FOR SMALL SCALE FARMERS IN KISII COUNTY, KENYA

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ABSTRACT
The paper focuses on the opportunities which are present in the livestock sector in terms of new enterprises and which are not exploited by the farmers in the study area. It analyses the socioeconomics behind adoption of fish farming as an enterprise- describing the adopters’ characteristics and explaining the factors that influence the adoption process. Most of the analyzed factors are important and significantly influence the decision to adopt fish farming enterprise, with land size only having a negative relationship. The enterprise is also found to be a profitable venture when the financial analysis is done.

Key words: adoption, fish farming, household, small scale farmer, socioeconomic factors

INTRODUCTION
Fish is ranked the fifth most important agricultural commodity and accounts for 7.5% of total world food production with about 1 billion people in developing countries depending on fish products as the primary source of animal protein (FAO, 2006). Nevertheless, aquaculture production is dominated by Asian countries, contributing 85% of total output, with China alone accounting for about 70% of this output. In 2004, Sub-Saharan Africa contributed only 1.6% (93500 tonnes) of the total fish production (LVFO, 2008).

The fisheries sub-sector provides employment and income to over 500,000 Kenyans, who are engaged in fish production and related enterprises (Nzungi, 2003). The main fish species presently farmed in Kenya are the African Catfish (Clarias gariepinus), Nile tilapia (Oreochromis niloticus), Common carp (Cyprinus carpio) and Tilapia zillii. Current data shows that the value of fish farmed in Kenya grew from 1047 MT valued at Ksh. 55,627,000 in 2006 to 4897 MT in 2009 with a value of Ksh.971,120,000 (KNBS, 2010). About 30% of the fish was exported. There are estimated to be 22,000 fish ponds in Kenya currently and approximately 5,000 fish farmers (LVFO, 2008). Though Kenya has a potential fish farming area of over 1.14 million hectares that if fully exploited could increase production to 11 million metric tons per annum and fetch Ksh.750 billion, farmers have not come out fully to maximize the opportunities in this sector. Latest developments in the sector indicate that the government rolled out Ksh.1.12 billion to support fish farming activities in the country and constructed 200 fish ponds in 140 constituencies with the aim of reducing poverty (GoK, 2012).

Despite the potential in fish farming, farmers in high potential agricultural zones in Kenya still majorly depend of food crop farming. These farmers are faced with ever increasing land fragmentation due to high population and have continuously cultivated available arable land resulting in low productivity. This study looks into viability of fish farming as an alternative enterprise for farmers in such high potential areas and also delves into the socioeconomics characteristics of the farmers.

MATERIALS AND METHODS
Study Area
Kisii County is located to the southeast of Lake Victoria. The total area of the county is 1,317.4km². It lies on a highland equatorial climate thus receives rain almost throughout the year, with two rainy seasons; short season of September to November and long season from February to June. This Rainfall is over 1500mm per annum and temperatures can range from 16 to 27 °C. The area has well drained red clay soils that support a variety of crops including cash crop production (tea and coffee) and subsistence crops (maize, beans, millet and potatoes). This area also has several permanent rivers and streams that drain into Lake Victoria. With a population of 1,152,282 people (48% male and 52% female) and an annual growth rate of 2.75%, most farmers are small scale holders with farm sizes ranging from 0.1 to 1 hectare. The area is also characterized by high population density with over 800 persons per square kilometer. Kisii County is in fact ranked among the top ten most populated counties in the country (census, 2009). Fifty one per cent of the population in this county lives below poverty line and the age dependency ratio is 100:94 (GoK, 2011).

Sampling design and Data collection
Comprehensive information was collected from the study area. Multistage sampling technique was used to sample small scale farmers in this study. The county was first stratified into two strata on a district basis. Gucha South and Kisii central districts were purposively selected because of the presence of significantly high number of fish farmers. From the two districts, farmers were divided into adopters and non-adopters of fish farming. Then using source list divisions with the highest numbers of fish farmers were identified. The fish farmers who had practiced fish farming for more than two years were all purposively selected, in order to increase reliability of data collected and recall. From the same divisions, a random sampling of non-adopters was done. A sample size of 160 was used, that consisted of 80 adopters and 80 non-adopters.
Data Analysis
Chi square test and z-test were used to test whether adopters and non adopters of fish farming had any difference in terms of their characteristics. Chi-square was used to determine whether there was an association between the categorical variables. On the other hand, the Z-test was used because the sample size was greater than 30. Where the P value was less than the conventional 0.05, the null hypothesis was rejected.

General model
The study was based on the maximization of expected utility theory. The traditional consumer theory explains that for a rational consumer to choose between alternatives i and j (the two being discrete choices) the probability of choosing i over j occurs when the utility of i is greater than that of j i.e. $U_i > U_j$. The binary logit model was used to analyze factors affecting the decision to adopt fish farming in Kisii area. In studies where the dependent variable (Yi) is dichotomous in nature, there are different regression models that can be used like the Linear probability model, logit and probit. Linear probability model is criticized for assuming that marginal probability is constant (Greene, 2004). Compared to the probit model, a logit model is preferred due to its simpler mathematical structure. According to Mohammed and Ortmann (2005), the logit model is based on the logistic cumulative distribution function and its results are thus not sensitive to the distribution sample attributes when estimated by maximum likelihood. The logit model provides the advantage of predicting the probability of farmers adopting any technology.

The empirical model was specified as:

$$Y_i = \alpha + \beta_1 GNDR + \beta_2 AGE + \beta_3 SCHYRS + \beta_4 NOEXTIM + \beta_5 LSIZ + \beta_6 AMTCRDT + \beta_7 NOMFGRP + \beta_8 HHSIZ + \beta_9 NOLIVE + \beta_10 COFINC + \beta_11 YRSFARM + \mu$$

With the explanatory variables being: gender, age, education level, years of extension visits, land size, credit borrowed, membership in farmer groups, household size, livestock ownership, amount of farm income and farming experience (years).

To determine profitability, gross margin analysis was done to assess the enterprise’s profitability. The costs the farmer incurred included land clearing, pond construction, purchase of fingerlings, fertilizer costs, harvesting, maintenance and marketing costs. The gross receipts were obtained from sale of market fish.

RESULTS

Background information
The Total acreage owned by farmers in the study area was 412 acres under various farm enterprises and the mean land holding was 2.5 acres with a standard deviation of 1.1 acres. This indicated that producers in this area did not have large land holdings. The average household size was 8.3 people which is higher than the recommended household size in Kenya of 5.1 people (KIHBS, 2006). The mean number of years the respondents had attended school was 9.7 indicating that most of the respondents were literate. The respondents were predominantly male, with only 20 percent being females. The most common age group in this study was 41-50, probably because they were still energetic and recognized the importance of farming. The major source of labor on the farms was family labor. Household labor is associated with family size. High population in this area has provided an abundant and cheap labor for those who hired labor for their farms (40 %).

The government of Kenya has provided the fish farmers support in their production through Economic Stimulus Programme (ESP). Over 50% of the farmers sampled agreed that they had their ponds constructed by the government through the constituency development funds, further, 13% percent received training on fish farming through ESP.

Analysis of adopters and non adopters of fish farming in Kisii
To determine whether there was an association between the dependent variable (adoption of fish farming) and the independent variables, two tests of independence were used. The Chi Square test was used for the categorical variables, while the z-test was used for the discrete variables.

As shown in Table I above, only the variables gender and credit borrowed were significant. In the gender variable, since $p<0.001$, it was concluded that adoption of fish farming was associated with gender of the farmer with more males adopting the enterprise than females. According to the above results, more fish farmers accessed credit than the non-fish farmers. The variable showing the amount of credit borrowed was significant at one percent level. Among the variables mentioned age, education level, years of experience in farming and frequency of extension visits were significant at 1% level as shown in Table II above. The adopters were younger people, who were more likely to take to new enterprises from which they expected higher returns. The non adopters on the other hand were older farmers, who did not take risks of new enterprises. The adopters had attained higher levels of education, enabling them to understand the complexities of new technologies. The adopters also had more visits to/ from extension services providers than the non adopters. These adopters were more willing to seek extension services especially for the new enterprise. The results of the chi- square and the z-test showed that there was strong evidence to reject the null hypothesis, that there exists no difference between characteristics of adopters and non adopters of fish farming.

Decision to adopt fish farming
Differences in the socioeconomic characteristics of adopter and non adopters of fish farming raise questions regarding which factors influence the farmers’ propensity to adopt fish farming. Thus to further analyze the specific factors that determined adoption of fish farming, binary logit was
TABLE I - CATEGORICAL VARIABLES TESTED FOR INDEPENDENCE USING CHI SQUARE TEST

<table>
<thead>
<tr>
<th>Variable</th>
<th>Df</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>GNDR</td>
<td>1</td>
<td>0.001**</td>
</tr>
<tr>
<td>MARST</td>
<td>1</td>
<td>0.135</td>
</tr>
<tr>
<td>COFINC</td>
<td>1</td>
<td>0.593</td>
</tr>
<tr>
<td>AMTCDRT</td>
<td>1</td>
<td>0.001**</td>
</tr>
</tbody>
</table>

Source: own survey data **significant at 1 percent

TABLE II - VARIABLES TESTED FOR DIFFERENCE USING Z TEST

<table>
<thead>
<tr>
<th>Variable</th>
<th>z value</th>
<th>Sig(2 tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>AGE</td>
<td>-3.70***</td>
<td>0.001</td>
</tr>
<tr>
<td>SCHYRS</td>
<td>3.50***</td>
<td>0.001</td>
</tr>
<tr>
<td>HHSIZE</td>
<td>-0.04</td>
<td>0.598</td>
</tr>
<tr>
<td>NOMFGRP</td>
<td>2.10</td>
<td>0.082</td>
</tr>
<tr>
<td>LSIZ</td>
<td>3.30</td>
<td>0.346</td>
</tr>
<tr>
<td>YRSFARM</td>
<td>-1.70***</td>
<td>0.001</td>
</tr>
<tr>
<td>NOEXTIM</td>
<td>6.20***</td>
<td>0.001</td>
</tr>
</tbody>
</table>

Source: Own survey data ***significant at 1 percent

According to the regression results, other factors held constant, the odd ratio of 0.47 indicated that the odds of farmers with large land size adopting fish farming were 0.47 times higher than the farmers with smaller land holdings. Thus land size had a negative relationship to adoption of fish farming. The household with smaller acreage of land were more likely to adopt fish farming. This is because of the need to adopt enterprises that are more land intensive in order to increase farm income. The average land size was 2.5 acres, indicating that in this study area, the availability of land was low; consequently, most agricultural farms are small. In a study by Yaron et al., (1992) land size was found to negatively influence adoption of a new technology. A small land area provided an incentive to adopt a technology especially in the case of an input-intensive such as a labor saving or land-saving technology. In fact, the fish farmers had 60m2 as the smallest pond and 400m2 as the largest. In areas with small sized farms, adoption of land saving technologies seems to be the only alternative to increase agricultural production. Further, in the study by Fernandez-Cornejo (1996), farm size did not positively influence adoption.

Frequency of extension visits was found to positively influence the farmers’ decision to adopt fish farming. Extension services have an important role in influencing adoption of new technologies. Farmers contact with extension agents exposes him to availability of information thus is expected to have a positive influence on adoption. The odds ratio of 0.80 in this variable indicate that the odds of a farmer who does not access extension services to adopt fish farming were 0.80 times higher than those of a farmer who accessed extension services at a higher frequency. These results concur with those of Njeri, (2007) and Ashenafi, (2007) that extension services promote agricultural productivity and adoption of new farm technologies. It provides farmers with adequate and appropriate information in order to make better decisions and that helps them to optimize their use of limited resources.
Economic analysis of fish farming

The fish farmers sampled have been practicing fish farming for 3 years and this was an indicator of experience the farmers have had in fish farming. All of the respondents had earthen fish ponds as it was less costly to construct and easy to maintain. Of the fish species reared in the fish ponds, tilapia was found to be the most common with all of the farmers rearing it exclusively.

From the above economic analysis, fish farming was found to be a profitable enterprise. The farmers had positive returns for two subsequent years. A farmer could cover the cost of a loan within the year. Opportunity cost is the benefit the farmer would have obtained had he used the resources for fish farming for alternative investment available elsewhere in the economy. The fish farmers were encouraged to use organic manure for their ponds; this reduced the costs they would incur in purchase of inorganic manure. The farmers also borrowed the harvesting net from the ministry of fisheries development so no cost was incurred.

When comparing profits per acre, fish farming was found to be more profitable than maize crop farming which was the next best enterprise for farmers in the study area.

### CONCLUSION AND RECOMMENDATIONS

From the above study, it is evident that fish farming adoption presents a new opportunity for farmers to diversify their enterprises. Fish farming has the potential to be successfully adopted in the study area. From the household size, it can be concluded that Kisii county is indeed a highly populated area with the farming population lying in the age group of between 40-50 years. The government had played an important role of promoting production of fish through the Economic Stimulus Programme. From this study, it can also be concluded that the farmers practice tilapia mono-culture and all of them used earthen ponds as holding units. A recommendation from this study was that the fish farmers be introduced to poly-culture. It was also important for the fish farmers be introduced to other types of holding units such as liner and concrete. The farmers should integrate fish farming with other farm enterprises in order to cut down costs incurred in running the enterprise.

Fish farming in the study area is practiced almost entirely by males than females. It is important that gender mainstreaming be done in order to reduce this gender disparity in adoption. Gender mainstreaming can be done through sensitization and capacity building during delivery of extension services by government and non-

### TABLE IV- GROSS MARGIN ANALYSIS OF A 100M2 FISH POND (KSHS.)

<table>
<thead>
<tr>
<th>Particulars</th>
<th>Year 1</th>
<th>Year 2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A: CASH RECEIPTS</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sale of tilapia</td>
<td>0</td>
<td>81,000</td>
</tr>
<tr>
<td>Bank loan</td>
<td>50,000</td>
<td></td>
</tr>
<tr>
<td><strong>Sub total</strong></td>
<td>0</td>
<td>81,000</td>
</tr>
<tr>
<td><strong>B: CASH PAYMENTS (FIXED COSTS)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Land Clearing</td>
<td>700</td>
<td>0</td>
</tr>
<tr>
<td>Pond construction</td>
<td>20,000</td>
<td>0</td>
</tr>
<tr>
<td><strong>Sub total</strong></td>
<td>20,700</td>
<td>0</td>
</tr>
<tr>
<td><strong>C: OPERATING COSTS</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fingerlings 270 frys*Ksh3</td>
<td>4,500</td>
<td>2,500</td>
</tr>
<tr>
<td>Feeds and Fertilizers</td>
<td>1,5000</td>
<td>1,5000</td>
</tr>
<tr>
<td>Harvesting cost</td>
<td>400</td>
<td>400</td>
</tr>
<tr>
<td>Miscellaneous (10% of total cost)</td>
<td>4060</td>
<td>1790</td>
</tr>
<tr>
<td><strong>Sub total</strong></td>
<td>23960</td>
<td>19690</td>
</tr>
<tr>
<td>D: TT CASH OUTFLOW B+C</td>
<td>44660</td>
<td>19690</td>
</tr>
<tr>
<td>TOTAL CASH INFLOW A-D</td>
<td>5340</td>
<td>61310</td>
</tr>
<tr>
<td>Loan repayment at 15%p.a interest rate</td>
<td>(57500)</td>
<td></td>
</tr>
<tr>
<td><strong>TOTAL PROFIT</strong></td>
<td>3048=127,000 per acre</td>
<td></td>
</tr>
</tbody>
</table>

Source: Own survey data

1. The fish farmers harvested at 8 months thus in the financial analysis, calculations were based on 1.5 harvests in a year.
2. The farmer harvested 270 tilapia weighing 300 gms and sold at Kshs. 200 each
3. For land clearing, the farmer employed 2 men paying each Kshs. 350
4. The costs of pond construction included fencing the pond, construction and paying laborers
5. The farmer stocked 270 frys each costing Kshs 3 plus transportation costs
6. Fish feeds cost Kshs.1500 per 20kg bag and the farmer used 10 bags of feeds to harvesting
7. Opportunity cost of capital assumed at 20 percent per annum
8. The farmer took a bank loan of Kshs.50,000 as startup capital. The loan is repayable after one year with an interest of 15% per annum
TABLE V- GROSS MARGIN FOR MAIZE CROP (1 ACRE) IN KSHS

<table>
<thead>
<tr>
<th>Item</th>
<th>Quantity</th>
<th>Unit</th>
<th>Price/unit(Kshs)</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Harvested maize</td>
<td>21</td>
<td>Bags</td>
<td>1,800</td>
<td>37,800</td>
</tr>
<tr>
<td>Costs</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hired labor-Ploughing</td>
<td></td>
<td></td>
<td>1,500</td>
<td>1,500</td>
</tr>
<tr>
<td>-Weeding</td>
<td></td>
<td></td>
<td>970</td>
<td>970</td>
</tr>
<tr>
<td>-Planting</td>
<td></td>
<td></td>
<td>1,000</td>
<td>1,000</td>
</tr>
<tr>
<td>Seed</td>
<td>6</td>
<td>Kgs</td>
<td>300</td>
<td>1,800</td>
</tr>
<tr>
<td>Fertilizer- DAP</td>
<td>1.5</td>
<td>Kgs</td>
<td>2,100</td>
<td>3,150</td>
</tr>
<tr>
<td>CAN</td>
<td>1</td>
<td>Kgs</td>
<td>1,700</td>
<td>1,700</td>
</tr>
<tr>
<td>Total cost</td>
<td></td>
<td></td>
<td>(9,820)</td>
<td></td>
</tr>
<tr>
<td>Total profit</td>
<td></td>
<td></td>
<td>27,980</td>
<td></td>
</tr>
</tbody>
</table>

Source: Own survey data

governmental organizations which promote fish farming.

With the mean age of adopters being 43 years, it can be concluded that relatively young people are more likely to adopt new technologies as they are more of risk takers and most likely have the financial capability. A recommendation from this study is that the stakeholders promoting fish farming should open up the opportunities to younger people between the ages of 18 and 35 years. This is because this age group is the most affected by unemployment in the county.

From this study, the households with smaller acreage of land were more likely to adopt fish farming because of the need to adopt enterprises that are more land intensive in order to increase farm income. Though the county faces continuous land fragmentation, this study recommends the implementation of the national land policy so that the continuous land fragmentation does not become uneconomical in future.

From the characterization of adopters and non adopters of fish farming, extension agents may be now able to target their education and training programs towards farmers who are more likely to adopt fish farming and consequently derive benefits from extension programs. The financial analysis shows that fish farming is a profitable enterprise compared to maize crop farming. It is thus recommended that rather than leave marshes and swamps to waste and consequently spread diseases like malaria and bilharzia, such land should be put into good use by investing in fish ponds.

ACKNOWLEDGEMENT

I would like to acknowledge the Ministry of Livestock Development (MoLD), Egerton University and my supervisors Prof. BK Njehia and Dr. P Mshenga

REFERENCES


“Framing the issues, challenges and opportunities in livestock sector in the 21st century”


“Framing the issues, challenges and opportunities in livestock sector in the 21st century”

Climate Change
PASTORALISTS EXCHANGE WITH PASTORALISTS TO ENHANCE MUTUAL LEARNING AND REDUCE VULNERABILITY TO CLIMATE VARIABILITY

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INTRODUCTION

Livestock keeping is the main source of livelihood in arid and semi-arid northern Kenya. The livestock extension service in northern Kenya is provided by government and non-governmental organizations. The extension staff in this area are few and cannot reach to most of livestock keepers in remote and vast areas of northern Kenya. In addition, the college-trained extension officers provide technologies and information that are out-sourced and in most cases fail to solve local challenges. To curb this problem, identifying local innovations and facilitating sharing of innovations is inevitable. This is to meet sustainable and participatory extension method.

Livestock keepers in the arid northern part of Kenya have had to bear the brunt of the effects of environmental and other social-economic challenges over the past decade. For example, the frequency and severity of droughts have all increased. Yet amongst the livestock keepers are innovators who have developed method and techniques to cope with these adverse effects. The innovations need to be shared amongst livestock keepers in similar setting and even with scientists to facilitate enhance livestock keeper’s general ability to cope with the challenges.

Five promising innovations were identified among the livestock keepers in Marsabit and Isiolo Counties, northern Kenya. It was then shared among the livestock keepers using two ways, that is i) Type A; taking the innovator to the group of livestock keepers to share his/her innovations and ii) Type B; Taking group of livestock keepers to the innovator to learn the innovations. Nine innovation exchange session were conducted using type A method and two exchange session were done using Type B method. The extension method where livestock keepers share innovative ideas and learn from each other is deemed as pastoralists exchange with pastoralists (PEP). In this innovation exchange method, the role of extension officers or scientists is to facilitate exchange of ideas among the innovators and livestock keepers.

Objective of PEP

The objective of PEP is to enhance mutual learning among the livestock keepers. PEP promotes sharing of site-specific and locally formulated technologies and innovations. It also provides avenue to identify and document indigenous traditional knowledge. Experience has also shown that the exchange method results to friendship among livestock keepers from different ethnic communities. This can promote peaceful co-existence among livestock keepers from different communities and sharing of pasture and water resources reducing conflicts over grazing resources.

MATERIAL AND METHODS

Materials required to conduct PEP exchange session

- Shade of Acacia tortilis or Hall; this is to provide venue where exchange session is conducted. In pastoral place where there is no hall; shade of Acacia tortilis or any other available tree can be a meeting place. Use of Acacia tortilis as a meeting point is common among the Rendille and Gabra pastoralists of northern Kenya.
- Computer; this is used to display photos of innovation. Use of computer is relevant in Type A exchange method, where livestock keepers are not visiting the site of innovation.
- Table; It is used to keep computers on and also for placing the writing materials.
- Chairs or stones; this is for participants, innovators and facilitators to sit on during the exchange session. It is common to improvise stones as sitting chairs among the pastoralists of northern Kenya.

Practical Instructions

The exchange session is composed of 4 main phases;

1. Identification of innovations
2. Preparation for exchange session
3. Implementation of session
4. Follow-up Phase

Identification of innovations

Identification of innovations is pre-requisite to the actual innovation sharing process. Livestock keepers with innovative ideas to cope with adverse effects or challenges are identified. Key informant is used to identify the innovative livestock keeper. The innovations are captured using unstructured interview or open ended questions. Photos are also used to document the innovation. Snowball method is used to identify more innovative livestock keepers and their innovations are also documented. This phase results to lists of innovations.

Preparation for exchange session

This is conducted prior to the exchange session. The purpose of this phase is to set the scene for conducting the innovation exchange among the livestock keepers. The preparation phase involves;

1. Agreement on innovations to be shared among the livestock keepers; This depends on the need and challenges of the pastoralists. The innovation to be shared should target to solve certain challenges and problems facing the livestock keepers. The facilitators and other stakeholders select the innovations that solve pressing challenges from the lists of innovations. The willing innovators of the identified innovations who were to share their ideas are also identified.
**Steps** | **Activities** | **Person responsible** | **Details**
--- | --- | --- | ---
1 | Preparing the exchange venue | Facilitators | In the morning of exchange session, the meeting place is arranged. The table and chairs or stones improvised for seats are all arranged. 
2 | Arrival of the innovator and participants (Livestock keepers) | Facilitators (scientists or extension officers) | The innovator and the participants arrive at the exchange session in the morning before the start of the session. The list of names of all participants (livestock keepers) is written down. 
3 | Brief discussion with innovator on important guidelines of sharing innovation | Innovator and facilitator | The facilitator discuss with the innovator the important part of session including, problem that motivated him/her to come up with innovation, clear description of the innovation, benefits of innovation. The need to raise interest of participants to take up innovation and to share with other livestock keepers is addressed during this brief meeting. 
4 | Prayer | Elder among the livestock keepers | The participants and innovator who are in most cases share same religious belief conduct local prayer in their local language. 
5 | Introduction of the participants, innovator and the facilitators | Facilitators | The team introduces themselves by saying their names out, their home location and sources of livelihoods. 
6 | Explaining the objectives of the session | Facilitator | The objective of the session and the importance of sharing innovation are presented. 
7 | Presenting the session programme | Facilitator | The session breakdown including presenting innovations, questions/clarification, healthbreak, closing session is explained. 
8 | Sharing the innovation | Innovator | It involves talk on innovation and also showing the relevant pictures of innovation, in case it is Type A method. Presentation also involves visit and observation of the innovation, in case of Type B exchange method. 
9 | Questions and clarifications | Livestock keepers | The livestock keepers are given chance to ask questions on what they have not understood. They also ask questions on what has not been mentioned during presenting innovation but important to them. 
10 | Reactions to questions and clarifications | Innovator | The innovator answers the questions asked by the participants. 
11 | Summarizing the innovation | Innovator | The innovator summarizes the important concept of innovation in few words or drawings. The summery is a “take home message” for the participants. 
12 | Closing session | Facilitator | The facilitator thanks all the participants in the session. The facilitator also urges the livestock keepers to share the innovation with other livestock keepers. 

**ii) Decision on type of Exchange visit to be used:** This is whether innovator visiting livestock keepers (Type A) or group of livestock keepers visiting the innovator (Type B). This depends on kind of innovations. If the innovation is worthy observation to be understood by livestock keepers, type B exchange method is appropriate. However, if the innovation content is mainly theoretical and cannot be shown physically to the livestock keepers, Type A exchange method is appropriate. Additionally, Type B method is more expensive as it involves travel cost of livestock keepers to the site of innovation, unlike Type A, where only innovator is facilitated to move to group of livestock keepers. Therefore, if there is financial limitation Type A exchange method is recommendable.

**iii) Reaching to the innovator and potential participants (Livestock keepers):** The innovator is reached by phone or
by visit to inform him/her task of sharing the innovations. The theme of PEP is explained and the appropriate time for the innovator to travel and share his/her ideas is agreed on. The livestock keepers in similar environment and having same challenges with innovator are visited. With the help of local leaders, 6-8 livestock keepers with which the innovator is to share ideas are selected. The dedicated livestock keepers who are willing to learn and also share the innovations with other pastoralists are selected. The selection of livestock keepers is inbuilt with gender consideration.

The number of livestock keepers to participate in session is 6-8 because smaller groups give opportunity for everyone to participate actively. In addition, the innovator can easily reach to each member and clarify the content of the innovation.

iv) Identifying the meeting Venue; the venue for meeting of innovator and livestock keepers is agreed also with the local leaders. This can be a meeting hall or under the shade of a tree within the location of meeting.

v) Travelling; if it is Type A exchange method, innovator is facilitated to travel to different locations of livestock keepers to share ideas. Innovator moves to different locations of livestock keepers on different scheduled days. If type B, exchange method, livestock keepers are organized and facilitated to travel to innovator location.

Implementation phase

The implementation phase involves actual sharing of innovation among the livestock keepers and innovator. The extension officers or scientists continue with the facilitative role during the implementation work. It involves the following steps;

**Follow-up on the Exchange session**

The follow-up is done to evaluate the impact of the PEP extension method. The livestock keepers who participated in exchange session are interviewed if they understood and remember the innovation and what content of the innovation they remember. Additionally, the diffusion of the innovation among livestock keepers is also captured in follow-up work. There are three main types of follow-up: Immediate follow-up; It is conducted same day of exchange session or a day after the session. The facilitators select 3 - 4 livestock keepers in the session using random sampling method. The interview involves if they understood the innovation, to what extent they can describe the innovation, also interview on if they are will share the innovation and how they are to share the innovation. Late follow-up exercise; this is conducted two months after the exchange session. It captures extent of spreading the innovation. The number of livestock keepers who have learnt the innovation is captured by administering structured questionnaires to the livestock keepers. Continuous follow-up; this involves identifying one literate and willing livestock keepers who participated in the exchange session and mandating him/her to collect data on spread of innovation. A pre-tested data collection sheet is given to the livestock keeper who is to monitor the innovation sharing process. Follow-up activities also give opportunity to capture more innovations from the livestock keepers. The farmers can adopt innovation as it was explained by the innovator or may rectify the innovations to suit his/her conditions. This can result to more innovative ideas.

**CONCLUSION**

It is concluded that, it is possible for the livestock keepers to share innovations that can reduce vulnerability to biophysical and social constraints. During the innovation sharing process, the scientists or extension officers facilitate the exchange process. The pastoralists exchange with pastoralists extension method enhances mutual learning and also provides opportunity for identifying more innovative ideas used by the pastoralists to overcome their challenges. This exchange method is recommended as a sustainable extension method in the vast and remote environment of most pastoral society.
THE CONTRIBUTION OF DAIRY PRODUCTION TO CLIMATE CHANGE MITIGATION AND IMPROVED RURAL LIVELIHOODS THROUGH THE UTILIZATION OF PLASTIC TUBE DIGESTER TECHNOLOGY IN CENTRAL KENYA

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¹Kari-Embu, P.O. BOX 27-60100, Embu

ABSTRACT
Most of the rural communities (over 80%) in the country are highly dependent on wood-fuel, charcoal and paraffin as the main sources of energy for cooking and lighting, with consequences of deforestation and water catchments degradation. Massive carbon dioxide (CO2) production, due to burning of trees, is associated with climate change, a major challenge and discourse world over. Thus, it’s of necessity to seek for promising innovations that contribute to countering these negative climate change processes while improving household livelihoods. Plastic Tube Digester (PTD) Biogas technology was therefore introduced among small-scale dairy farmers to address this issue. The main aim of this study was therefore to assess the socio-economic and environmental impacts of PTD on..., challenges to adoption and suggest way forward. Data was collected using formal survey, group and key informant interviews, and analysed by use of SPSS.

Results indicated that most () households had small dairy herd sizes (an average of three animals) under zero grazing and low level of biogas () awareness (20%). PTD adoption also reduced energy costs and labour requirement, and deforestation in all the households. There were improved ecosystems (63%), improved cooking environment (90%) and increased crop productivity (80%). The main challenge to improved adoption of PTD was inadequate skilled manpower to build farmers’ capacities to adopt and install the PTD technology. Hence a need to build the capacity of local community members to accelerate capacity building, installations and information sharing at the community level for increased PTD adoption.

Key words: Adoption, change, climate, livelihoods, PTD.

INTRODUCTION
Minae and Nyamae (1988) and Kasson et al., (2004) indicated that over 80% of the rural communities in the country are dependent on wood-fuel, charcoal and paraffin as the main sources of energy for cooking and lighting, with over-reliance on the first two, causing negative environmental impacts. This therefore calls for concerted efforts to seek alternative energy technologies/innovations contribute to mitigation against these negative processes. Biogas, which is produced from anaerobic digestion of organic wastes, is considered to be an appropriate renewable energy source, and an innovation that can contribute towards this end. Lekule (1996) indicated that adoption of PTD can reduce dependence on wood-fuel by up to 60%. Hence, the plastic-tube digesters were introduced in Kenya in early - mid 1990s as a low-cost option to the conventional digesters (Karanja and Kiruio, 2003). However, adoption was generally low initially until 2005, when it was re-introduced by the Kenya Agricultural Research Institute’s -Embu. Since then, upscaling has been on going through individual initiatives and some support from outside organisations. The adoption of the technology had increased to over 300 units in Central Kenya by 2007 (Kiruio and Matiri, 2007). (KARI, 2006) showed that one Guernsey animal is able to supply adequate dung for one ten M PTD. In addition, conventional and PTD digester would cost Ksh.70, 000 and Ksh.10, 000 to install (Kiruio and Matiri, 2009).

This study was conducted in 2009 to assess socio-economic and environmental impacts of adopting the PTD technology and the challenges likely to affect adoption and scaling up.

1. To assess the potential of Plastic Tube Digester technology in mitigating against climate change for improved rural livelihoods
2. Identify the main challenges to adoption of plastic tube digester technology
3. Propose way forward for improved adoption of PTD technology

MATERIALS AND METHODS
A sample frame of 300 households that have adopted PTD technology was developed with the assistance of the initial 15 adopters and key informants in the region. This was followed by a purposeful and random sampling to come up with a sample size of 60 households. Data was collected by use of a refined structured questionnaire with the selected 60 households. Data was collected through focused group interviews, secondary data review, participant observation and key informant interviews. Quantitative and qualitative data was analysed by use of SPPS software and qualitative tools respectively. Data was then analysed, report written and shared among the key stakeholders.

RESULTS
Households’ Characteristics
The results showed that farming is the mainstay of most households, with 90% of the households having farming as the main source of income. These Household sizes ranged between three to six members with an average of four members. The level of education was primary (15%), secondary (70%) and post-secondary (15%) respectively. These results are as shown in Table I.

Land and herd sizes
Most household have small land sizes that ranged between one to four acres, with most (65%) having one and half acres and below. Dairy production under zero grazing is dominant with herd size average of three animals per household.

Reasons for PTD Installation and Household Decision Making
Results showed that the decision to install PTD was jointly done, despite men and women having different influencing factors, as shown in Table II
PTD Technology Dissemination Pathways and Level of Biogas Awareness

Main PTD’s dissemination pathways were as shown in Table III. From the results, it was indicated that only 10% of the initial 15 adopters were aware of conventional biogas and none about PTD.

Environmental Impacts of PTDs and Climate Change Mitigation

By use of the environmental and climate change indicators that were identified in participatory process, results indicated that PTD innovations have a high capacity to mitigate against environmental degradation and climate change. The main environmental impact, climate change indicators, and the respondents that indicated possession of environmental and climate change mitigation capacities, are as shown in Table IV.

Socio-Economic Impacts of PTDs at Household Level

Socio-economic indicators that were identified through a participatory process indicated that PTD technology had relatively high socio-economic impacts at the household level. The main socio-economic impact indicators that were identified and respondents that indicated they had impact at the household level are shown in Table V.

Ranking of Socio-Economic and Environmental Impacts of PTD Technology by Gender

So as to capture whether there are any perceived differences on the importance of PTD by gender, men and women conducted pairwise ranking of the PTD’s socio-economic and environmental impacts in Tables IV and V separately. According to the ranking results, men perceived reduced energy costs, reduced deforestation and reduced workload, while women perceived reduced workload, reduced costs and improved cooking environment in that order as the most important impacts due to PTD adoption. This was due to the differences in terms of the importance that each gender attaches to a particular PTD impact. Men are more concerned on cost reduction because they are very influential on how finances/resources are allocated in the household and are the ones who buy fuel-wood and LPG gas when bought. Also, men are the ones who plant the trees that the household uses as firewood and when saved, it becomes an important asset that can be sold when the household is in need of urgent cash. On the other hand women were more concerned on reduced labour requirements because of the time and distance they had to dispense on firewood fetching before PTD’s installation. Manure quality from PTD units was perceived to be superior to the ordinary one by both men and women. Hence, PTD adoption was perceived to improve crop and dairy production due to utilization of quality manures. Both men and women ranked improved crop production to be an important impact due to PTD adoption, compared to its impact on improved dairy production. This can be explained by the fact that despite the fact that the slurry comes from livestock, most of it goes to crop production other than fodder like Napier grass. However, there was a clear perception by both men and women that adoption of PTD reduces deforestation, hence mitigating against climate change. The results of the

### TABLE I- SOCIO-ECONOMIC CHARACTERISTICS OF THE HOUSEHOLD

<table>
<thead>
<tr>
<th>Range in household sizes (persons)</th>
<th>Level of Education</th>
<th>Income Sources</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-3 (10%)</td>
<td>Primary level</td>
<td>Off-farm only</td>
</tr>
<tr>
<td>4-5 (80%)</td>
<td>Secondary level</td>
<td>On-farm only</td>
</tr>
<tr>
<td>Over 6 (8.9%)</td>
<td>Post-secondary</td>
<td>Both off-farm</td>
</tr>
</tbody>
</table>

### TABLE II- REASONS FOR CONSIDERING INSTALLATION OF PTD BY GENDER

<table>
<thead>
<tr>
<th>Reason</th>
<th>Men: N =34</th>
<th>Percent (%)</th>
<th>Women: N =49</th>
<th>Percent (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reduced costs</td>
<td>34</td>
<td>100</td>
<td>29</td>
<td>100</td>
</tr>
<tr>
<td>Reduced tree cutting</td>
<td>26</td>
<td>74</td>
<td>14</td>
<td>29</td>
</tr>
<tr>
<td>Reduced labour</td>
<td>16</td>
<td>47</td>
<td>49</td>
<td>100</td>
</tr>
<tr>
<td>Increased cooking efficiency</td>
<td>12</td>
<td>35</td>
<td>44</td>
<td>90</td>
</tr>
<tr>
<td>Social satisfaction</td>
<td>10</td>
<td>29</td>
<td>21</td>
<td>43</td>
</tr>
</tbody>
</table>

NB: Gender responses were captured through group interviews

### TABLE III- MAIN SOURCES OF INFORMATION ON PTDS

<table>
<thead>
<tr>
<th>Source of information</th>
<th>No. of respondents N = 60</th>
<th>Percent (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>KARI</td>
<td>40</td>
<td>(67%)</td>
</tr>
<tr>
<td>ASK demonstrations*</td>
<td>8</td>
<td>(18%)</td>
</tr>
<tr>
<td>Other farmers</td>
<td>2</td>
<td>(3%)</td>
</tr>
<tr>
<td>Brochures*</td>
<td>6</td>
<td>(9%)</td>
</tr>
<tr>
<td>Radio*</td>
<td>4</td>
<td>(4%)</td>
</tr>
</tbody>
</table>

* Predominantly done by KARI
impact indicators' ranking by men and women were as shown in Table VI.

Costs-Benefit Analysis of PTD Technology Uptake
Plastic tube digester technology is a low-cost investment technology that costs between KES 8,000-12,000 depending on where one is installing and the point of materials’ purchase. It also has a modest lifespan of 2-3 years before replacement of the polythene bag. A summary of costs of PTD installation in the study area is as summarized in table VII.

Cost of Conventional Fuel-wood
An average household in the area of study has 4-6 members, spending around 2 bags of charcoal/month, at times supplementing with paraffin. It can alternatively use 2 ox-carts of firewood/month. A bag of charcoal and ox-cart cost around KES 2000 and KES 1000 respectively.

TABLE IV-ENVIRONMENTAL IMPACTS OF PTD TECHNOLOGY

<table>
<thead>
<tr>
<th>Indicator</th>
<th>No. of Households</th>
<th>N = 60</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reduced deforestation</td>
<td>60</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>Improved cooking environment</td>
<td>54</td>
<td>90</td>
<td></td>
</tr>
<tr>
<td>Reduced respiratory discomforts</td>
<td>38</td>
<td>63</td>
<td></td>
</tr>
<tr>
<td>Improved ecosystems</td>
<td>38</td>
<td>63</td>
<td></td>
</tr>
</tbody>
</table>

These estimations are based on the records from the three organisations and interviews with key informants. However, there are farmers that have installed PTDs through the assistance from other farmers. Hence, the number of PTDs in the region is higher than 600, implying the level of adoption is high. In addition, results indicate that KARI-Embu scientist has installed more PTDs outside the region including Transmara (1), Kitale (6), Nakuru (2), Kiambu (2) and Nyandarua (10) between May 2009 and February 2010, an indication that PTD technology’s demand is spreading outside the region.

Despite this, the results indicate that the technology faces a number of challenges for enhanced adoption. Through group discussions and key informant interviews, the key challenges that were identified included:

1. Inadequate capacities to train and install the required PTDs as the demand
2. Lack of technical information on the associated dung requirement, installation, costs, and expected
3. Lack of information sharing among farmers – it was observed that less than 10% of the farmers neighbouring those that have installed PTD have ever enquired about it from their neighbours.
4. Perceived short lifespan of the digester – three of the first 15 installations lasted for less than two years due to the plastic paper wearing out/getting torn.
5. Perceived high cost of PTD installation – some farmers’ felt that cost of installing is high but without any information to that effect

DISCUSSIONS
The results show that the average land size of most of the adopters is one and half acres with a herd size of three mature animals. Taking this to be a representative sample of the region and the estimated dung requirement per unit PTD, it implies that majority of the farmers in the region...
have the potential to utilise PTD technology. The level of education may influence adoption of PTD since majority of the adopters have at least secondary level of education. This may be due to their ability to grasp issues and being innovative. Although men and women have different reasons to adopt PTD technology, it is clear that their interests are not conflicting but complimentary and hence augmenting adoption of the technology. Consultative decision-making between wife and husband may also be an important factor in improving adoption once the households have the appropriate information relating to PTD and there is available manpower to train and install the technology.

### TABLE VII- SUMMARY OF PTD INSTALLATION COSTS

<table>
<thead>
<tr>
<th>Item</th>
<th>No. of Units</th>
<th>Unit Cost (KES)</th>
<th>Sub-Total cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Polythene Bag (Gauge 1000)</td>
<td>11M</td>
<td>300</td>
<td>3,300</td>
</tr>
<tr>
<td>Hardy pipe (4”)</td>
<td>2M</td>
<td>400</td>
<td>800</td>
</tr>
<tr>
<td>Bio-Jiko</td>
<td>1</td>
<td>1000</td>
<td>1,000</td>
</tr>
<tr>
<td>PVC pipes (4”)</td>
<td>5</td>
<td>200</td>
<td>1,000</td>
</tr>
<tr>
<td>PVC Elbow joints (1/2”)</td>
<td>5</td>
<td>40</td>
<td>200</td>
</tr>
<tr>
<td>PVC T (1/2”)</td>
<td>1</td>
<td>40</td>
<td>40</td>
</tr>
<tr>
<td>Nipple (1/2”)</td>
<td>1</td>
<td>40</td>
<td>40</td>
</tr>
<tr>
<td>PVC Valve socket (1/2”)</td>
<td>1</td>
<td>40</td>
<td>40</td>
</tr>
<tr>
<td>Flexible pipe (1/2”)</td>
<td>1</td>
<td>150</td>
<td>150</td>
</tr>
<tr>
<td>Rubber straps</td>
<td>8</td>
<td>40</td>
<td>320</td>
</tr>
<tr>
<td>Gate valve (1/2”)</td>
<td>1</td>
<td>400</td>
<td>400</td>
</tr>
<tr>
<td>Gum</td>
<td>1</td>
<td>150</td>
<td>150</td>
</tr>
<tr>
<td>Labour cost (skilled)</td>
<td>1</td>
<td>1000</td>
<td>1,000</td>
</tr>
<tr>
<td>Labour cost (unskilled)</td>
<td>1</td>
<td>300</td>
<td>1,000</td>
</tr>
<tr>
<td>Transport costs</td>
<td>1</td>
<td>500</td>
<td>500</td>
</tr>
<tr>
<td><strong>TOTAL COST</strong></td>
<td></td>
<td></td>
<td><strong>9,790</strong></td>
</tr>
</tbody>
</table>

PTD technology has enormous socio-economic and environmental impacts at both household and community levels. This is due to the fact that it reduces energy costs, labour requirement, increases household productivity and reduces deforestation among others. There are also challenges that may impede accelerated adoption of PTD technology with lack of manpower to train and install the PTDs where and when needed.

### CONCLUSION

It is evident that PTD Biogas technology has the potential to highly contribute to socio-economic improvement of the households in the region and beyond. It also has the potential to mitigate against the negative processes of climate change. Reduced energy costs provide the household with resources that could be invested within or off-farm and hence increasing rural livelihoods and food security. Reduced deforestation counters CO2 emissions, hence mitigating against global warming and climate change. In addition, resources saved from energy budget can also be invested in environmental conservation and social infrastructures like education and health, hence contributing to well being of the community and society at large.

There is also need to develop mechanisms that would accelerate adoption of this technology by way of reducing the existing impediments.

### RECOMMENDATIONS

The most impeccable limiting factor to adoption of PTD is lack of manpower for capacity building and installation of the PTDs when required. This is due to the fact that there is over reliance on only one KARI scientist in the region and most other parts of the country for both training and installation. Therefore, there is need to build capacities of other actors (NGOs, extension) as well as some local community members that would be the catalysts in training others, disseminating the appropriate information and providing feedback to the experts. The community also need to become more pro-active and have collective action in training and installation of the technology to accelerate dissemination and adoption. Farmers’ networks could also play an important role to accelerate accessing PTD information to enhance and sustain adoption. Further research need to be done to identify a plastic tube that would have a longer lifespan and hence encourage adoption. Donor support for those who have the expertise to build capacities (scientists, extension and skilled community members) is necessary for them to respond appropriately when needed and impart the required skills to others.

### ACKNOWLEDGEMENT

We wish to acknowledge with a lot of gratitude the financial and logistical support by a team of Norwegian Environmentalists led by Mr. Gunnar Ronning that made the accomplishment of this survey possible. Special thanks go to Mr. E.M. Kiruiro (Co-author) for tireless efforts he has made towards this research.
put in capacity building and upscaling of PTD technology in the community within the region and beyond as well as technical support he offered during the study. We also thank Centre Director, KARI-Embu for logistical support and other facilitations that made accomplishment of this work possible. We also thank all the farmers and other stakeholders (key informants) that spared their precious time to provide us with this information and without their willingness, this work would not have succeeded.

REFERENCES
Pastoral and Agro-pastoral communities entirely rely on livestock and sparingly on crops for their livelihood, although they are highly sensitive to any slight change in climate and its variability. Lack of pasture, shortage of water and outbreak of livestock and human disease is a major consequence of prolonged droughts or floods which are extreme events of climate change. Women agro-pastoralists’ livelihood have not been spared either by the adverse effects of climate change. This study evaluated the impact of climate Change and variability on the socio-economic status of agro-pastoral women in the study area. A cross-sectional survey research design was employed. Simple random sampling was used to draw a sample size of 144 respondents. Descriptive statistics was then used in the survey. Focus Group Discussions were transcribed and information generated assisted in explanation of the survey data. The results show that 60% of respondents appreciated that there were less rain days and 88% reported that its intensity has increased. There were 32% of the respondents that reported an income of less than Kshs. 999 per month. However, 75% have taken charcoal burning as an alternative copying strategy. In addition, 80% ranked donkey, indigenous chicken, goat, cattle and eventually sheep in that order in relation to their vulnerability to adverse effects of climate change and variability. There were 75% of the respondents had their roofs constructed from grass/thatch/cow dung which makes them more vulnerable to roof leaking due to unexpected heavy torrential rainfall than in the past. The stakeholders and development agencies should come up with affirmative action programmes to address this peril.

INTRODUCTION
Globally, climate change and variability are major challenges to sustainable development. The countries in Sub-Saharan Africa (SSA) are heavily dependent on agriculture and lack resources or other necessities to fully deal with the social and economic effects of natural disasters which are associated with climate change and its variability. To be able to adequately address climate change in a sustainable development context, one must begin by carrying out vulnerability and adaptation assessments (Olmos 2001). According to Winograd (2004), in the case of climate change, adaptation is a systems ability to get used to or learn to live with changes in climate, to reduce the potential damage, to capitalize on opportunities and to cope with the consequences.

This study adapted the Winogard’s definitions. Through the study, the assessments of pastoralist women’s socio-economic content to climate change impacts and its preparedness to deal with those impacts was carried out. It was skewed to pastoralist women since they are hardest hit by the adverse effects of climate change due to their socio-economic status in the community. This is because, besides rearing children, women are the main actors in agricultural production and culturally they are responsible for the household food security and therefore climate change extreme products impact on them more.

According to Agarwal (1992 cited in Tipilda and Kristjanson 2008), women and men livestock keepers typically face different livelihood opportunities and constraints in managing livestock as well as in coping with health challenges such as HIV/AIDS, poor access to markets, services and technical information, periodic drought and disease, competing resource uses, policies that favour larger-scale producers or external markets, and weak institutions. In most systems, women provide labour for the various tasks related to livestock but may or may not control the process of decision making, particularly over the disposal of animals and animal products. Likewise, women may be involved in production, but may or may not own the means of production, including Livestock, land, and water.

This study evaluated the impact of climate Change and variability on the socio-economic status of agro-pastoral women in the study area.

MATERIALS AND METHODS

General model
Cross-sectional survey design was used. According to Mutai (2000), this kind of design allows collection of data from individual respondent only once. For this study it involved women farmers. Interview schedules and interview focus group guides (FGDs) were employed in data collection. Personal interviews were conducted in house-to-house visits. In Focus group discussions the investigator tape-recorded interviews (Mack, 2005). Descriptive statistical procedures were employed to generate frequency tables, bar charts and pie charts by use of SPSS, version 17.

The proposed “target population” was the pastoralist community in Narok County. Precisely pastoral women in “women groups”, this study considered them as the “accessible population”. According to Mugenda and Mugenda, (1999), it is often impractical to select a representative sample from the target population because it may be difficult to identify individual members, therefore drawing samples from an “accessible population” is appropriate since it is a more narrowly defined and manageable population. Focus Group discussion of 12 households was also used in the study. This was for enhancing explanations of the survey findings.

RESULTS

Below is age distribution of respondents

Age distribution among the pastoralist women

Majority of the respondents were within the age of 18 to 29 years. According to Maasai culture, marriage is a critical event in one’s life. The community advocates for early marriage and therefore this aspect justifies this age category which came out patently in this study findings.
This aspect of early marriage has an implication to women education profile. The domestic roles and responsibilities of a pastoralist woman are too much. In the past the children used to after the livestock but they now go school since we have realized education is vital and therefore all the responsibilities goes to the mother, this includes waking up very early to fetch water from very far distant, milk the cows and go and herd them in the bush, Jane a young mother of 20 years old said in a focus group discussion.

**Source of income for pastoralist women**
The current study findings revealed that, majority of the women pastoralists’ household derived their earning from the sale of livestock. This is perhaps because pastoralist mainstay is livestock. In this particular community the man who is the husband and the head of the household has ownership of the livestock and is the only one who has authority to sell livestock. This set up denies women in making decision regarding selling of livestock.

Based on this study finding majority of the respondent’s household earn less than ten US dollars per month. This demonstrates that these households are poor.

**Asset ownership among pastoralist women**
Regarding ownership of assets in a household, this study unfolded that majority of the cattle, sheep and land is owned by men while women own the goats and donkeys. This denies the women pastoralist access of disposing cattle for sale. Women could only dispose goat or donkey which is difficult to sell especially so donkeys which assist the woman pastoralist in performing most difficulty domestic duties like collecting water. It also came out patently in the study that, a donkey is popular among women pastoralists.

As a Maasai woman, I normally wake up very early in the morning; I load several cans on my don key to collect water for my family. The day move to collect charcoal with the donkey and sell it to earn a living, Margaret said.

**TABLE I RAINFALL OCCURRENCE, INTENSITY AND INDICATORS OF PROLONGED DROUGHT**

<table>
<thead>
<tr>
<th>Rainfall occurrence and intensity</th>
<th>Frequency</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Rainfall occurrence</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Most frequent</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>More frequent</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Frequent</td>
<td>41</td>
<td>36</td>
</tr>
<tr>
<td>Less frequent</td>
<td>68</td>
<td>60</td>
</tr>
<tr>
<td>Total</td>
<td>114</td>
<td>100</td>
</tr>
<tr>
<td><strong>Rainfall intensity</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Increased</td>
<td>100</td>
<td>88</td>
</tr>
<tr>
<td>Decreased</td>
<td>13</td>
<td>11</td>
</tr>
<tr>
<td>Constant</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>114</td>
<td>100</td>
</tr>
<tr>
<td><strong>Indicators of prolonged drought</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>death of livestock</td>
<td>16</td>
<td>15</td>
</tr>
<tr>
<td>dry up of trees</td>
<td>16</td>
<td>15</td>
</tr>
<tr>
<td>grass dries up</td>
<td>21</td>
<td>18</td>
</tr>
<tr>
<td>lack of water</td>
<td>52</td>
<td>46</td>
</tr>
<tr>
<td>strong winds</td>
<td>9</td>
<td>6</td>
</tr>
<tr>
<td>Total</td>
<td>114</td>
<td>100</td>
</tr>
</tbody>
</table>

Source: Household Survey Data (2011)

The findings showed that, majority of the respondents dwelling houses roofs main construction materials were grass/thatch/cow dung and walls were mud/cow dung while floor were mud/cow dung. This kind of house makes the women pastoralist dwelling houses to be very vulnerable to adverse effects of climate change such as torrential rainfall.

**Pastoralist women’s strategies of coping with climate change**
Based on this study finding, majority of the women pastoralist expressed their perception that, the study area receives less rain days than there before and appreciated that rainfall intensity has increased. They also embraced...
severe shortage of water for the livestock and household use is a key indicator of prolonged drought.

There is insufficient water during drought season, even the borehole dries up so I go to the borehole that hasn’t dried up with two to three buckets or I buy water from “bodaboda” (a commercial bicycle or motor cycle rider) at half US dollar per 20liters can, Violet a 40year old woman pastoralist said a focus group discussion.

The current study findings revealed that, majority of women pastoralists’ households were engaged in charcoal burning and followed by selling the same as coping strategies with the climate change adverse effects. Although, they are making things worse off by cutting trees for the future generation, selling charcoal becomes an easier alternative livelihood since their livestock mainstay is diminished by prolonged drought. From this study it was clear that the climate change adverse effects cuts across all the members of the pastoralist household but women and children are hardest hit.

Women and men are both affected by effects of drought but we women and children suffer most. This is the time that the man feels the pain when the livestock die because livestock is the only source of income so they sweep away the sand and dig for the livestock to get access to water. As for women without milk the food is not complete that, unlike before rains could fall unexpectedly and they are unable to plan than before. “We never used to receive very heavy rainfall, which is experienced within a very short time until our house roofs leaks”, Joyce a 38 year old woman pastoralist said in a focus group discussion. When asked which indicators inform them and make them aware there is a prolonged drought, majority reported that during drought season they is no water hence no milk. Our children and the family as a whole depend on milk. Although we sell some to the market like today (Wednesday) is a market day and also on Saturdays, we are able to buy maize 1-2 “gorogoro”(2-4kgs of maize) said a Mary, a 35year old mother of eight children said.

![Figure 2: Women Agro-Pastoralist Coping Strategies to climate Change adverse Effects. Source: Household Survey Data (2011)](image-url)


TABLE V-CONSTRUCTION MATERIAL FOR RESPONDENTS’ DWELLING HOUSE

<table>
<thead>
<tr>
<th>Material for construction</th>
<th>Roof</th>
<th>Wall</th>
<th>Floor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grass/thatch/cow dung</td>
<td>75</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Corrugated iron sheets</td>
<td>25</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Mud/cow dung</td>
<td>0</td>
<td>90</td>
<td>91</td>
</tr>
<tr>
<td>Cement</td>
<td>0</td>
<td>9</td>
<td>9</td>
</tr>
<tr>
<td>Wood</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

Source: Household Survey Data (2011)

The findings showed that, majority of the women pastoralist expressed to have been collecting water for household use during drought period, two kilometers away from their home.

**CONCLUSION**

Based on the results obtained from this research work age of the women pastoralist came out clearly as a major factor enhancing their vulnerability to climate change adverse effects. Majority got married while very young and culture has insisted they should give birth to as many children as possible. There are more mouths to feed and no food due to prolonged droughts.

Lack of controls of household assets is another drawback to women pastoralist becoming more vulnerable to adverse effects of climate change. They lack the socio-economic endowments to counteract the shock. This is because majority expressed that household assets like cattle are owned by the husbands and are not involved in the sales.

**RECOMMENDATION**

From the study findings, policy recommendations were formulated that can address the hiccups on addressing adverse effects of climate change on women pastoralist in Sub-Saharan Africa.

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*Figure 3*: Distance from Home to the Water Place in Drought Period. Source: Household Survey Data (2011)

*Plate 1*: Young women pastoralist carrying their babies on their backs on 20/10/2011

*Plate 2*: Popular means of transport by women

*Plate 3*: Women Pastoralist household dwelling house vulnerable, Pastoralist in semi-arid in a Kenya 20/10/2011 to roof leaking due to climate change 18/10/2011
Majority (75%) of the household assets are all held under the ownership of the man (husband) who is ever on migration. As such, as a recommendation, although some of these set ups are nurtured by cultural values and norms a policy should be put in place on ownership of household assets such as the cattle, sheep and goats. This should target women pastoralists and children who are left suffering while men have migrated with cattle during prolonged drought.

As a recommendation, NGOs, civil societies, government and development agencies should come with development agenda and implement projects targeting women pastoralist and children who are hit hardest by adverse climate change effects. More emphasis should be placed on the introduction of Indigenous Chicken rearing among the pastoral women and goats as they endure challenges of climate change and variability. Also bring about development growth by involving the pastoralist women in climate change awareness through affirmative action programmes. Sensitize the community on better dwelling houses which are not vulnerable adverse climate change like torrential rainfall.

All stakeholders should ensure that climate change and disaster risk reduction measures are gender responsive, sensitive to indigenous knowledge systems and respect human rights. Pastoralists Women’s right to participate at all levels of decision-making must be guaranteed in climate change policies and programmes.

ACKNOWLEDGEMENT

We wish to acknowledge the Director KARI and the Centre Director for the facilitation. Also we cannot forget to acknowledge Ann and Diana who tirelessly introduced us to the residents and lastly our farmers’ women agro-pastoralists who answered our questions.

REFERENCES


COPING STRATEGY IN FODDER PRODUCTION SHORTAGE BY USE GENETIC AND ENVIRONMENTAL INTERACTION IN SWEET POTATO CULTIVARS IN THE KENYAN HIGHLANDS

J. Kinyua1, G. Muriithi1, and S. Mbuku1
1Kenya Agricultural Research Institute, Lanet, Kenya

ABSTRACT
One of the main challenges that have faced the dairy industry is the shortage of fodder production, both in quality and quantity. As a result, there has been a continuous decline in milk production in various areas in the Kenyan highlands which are the main production areas. One of the crops that can be grown to improve fodder production is the sweet potato. The crop has several advantages among them provision of protein and starch from the vines and roots respectively. However, production of sweet potatoes cultivars which meets both functions is a major challenge in that most of cultivars will either produce vines or storage roots. This problem can be solved by introducing sweet potato cultivars which possess traits that are influenced by genetic and environmental interaction. Six sweet potatoes cultivars namely; Naspot1, 103001, Kemb23, Gweri, Kemb36 and Wagabolige were planted in three agro-ecological locations, Nyeri County (high altitude), in Nandi County (Medium altitude), and in Bomet County (Low altitude) within the highlands of Kenya. Each cultivar was allocated 3 plots at random in two sites per each ecological zone, to make a Complete Randomized Block Design (CRBD). Cultivars were classified into the various classes based on ratio of storage roots (R) over biomass (R+V) [(R/(R+V)]. Gweri, Naspot1 and Wagabolige were universally classified as forage cultivar (0.14 - 0.18), dual purpose (high in storage roots) (0.38 - 0.55) and dual purpose (high in forage) (0.25 - 0.42) respectively. Cultivar 103001 was classified as a root type (0.71 - 0.76) in both Nyeri and Nandi, however in Bomet classification shifted to DP(R) (0.52). In Nyeri cultivars produced little (P>0.05) amount of vines compared to storage roots which was attributed to low rainfall (440 mm). The CP content on day-75 vine was higher (P<0.05) than day-150 for both ratooned and unratooned. The high (P<0.05) day-75 vine CP levels of CP in Naspot1 and 103001 was attributed to the cultivars’ ability in utilization of nitrogen. The variation of the unratooned vine CP content in various cultivars in different locations was due to presence of (GxE).

INTRODUCTION
The dairy industry is important for the livelihoods and food security in Kenya especially in the highlands. Population increase and urbanisation are driving up demand for milk, putting pressure on the sector to continuously increase the production. However, high milk production heavily relies on good and reliable feeding of the cows. One of the major challenges that have faced the dairy industry is the shortage of fodder production in terms of quality and quantity. As a result of this there has been a continuous decline in milk production in various areas in the Kenyan highlands which are the main production areas. One of the crops that can be grown to improve fodder production is the sweet potato. The crop has several advantages among them provision of protein and starch from the vines and roots respectively. Sweet potatoes vines are known to be rich source protein, Li (1974), Purcell et al. (1976) and Dai et al. (2002) reported CP content of which 40% of the total nitrogen is non-protein nitrogen (Purcell et al., 1972; 1976; Dai et al., 2002; Parish, 2003) hence a good source of rumen degradable nitrogen (RDN) in the rumen. Sweet potato vines can therefore be used as a protein supplement as the average CP is about 20% on a dry mass basis (Zhang Dapeng and Li Xiu-Qing, 2003). Crude protein content of sweet potato vines in DM can range from 16 - 29% (Farrell et al., 2000; Hartmink et al., 2000; Dung, 2001; An et al., 2003). Sweet potato tubers are a good source of starch and can be supplemented in cows’ feeds in a combined form with vines or alone to increase energy content of the basal diet of cows for higher milk production. Fetuga and Oluyemi (1976) and Tewe et al., (2003) confirmed the suitability of sweet potato in the nutrition of livestock. However, production of sweet potatoes cultivars which meets both functions is a major challenge in that most of cultivars will either produce vines or storage roots. This problem can be solved by introducing sweet potato cultivars which posses traits that are influenced by genetic and environmental interaction. Some sweet potato cultivars when grown in different ecological zones tend to change their morphological appearance, the same applies when they are grown under different cropping management. This will go a long way in alleviating decline in fodder production and in turn increasing milk production for increased income by the farmer. To some extent the protein content of root crops is influenced by variety, cultivation practice, climate, growing season and location (Woolfe, 1987; FAO, 1991).

MATERIAL AND METHODS
Six sweet potatoes cultivars namely; Naspot1, 103001, Kemb23, Gweri, Kemb36 and Wagabolige were planted in three agro-ecological locations, Nyeri County (High altitude), in Nandi County (Medium altitude), and in Bomet County (Low altitude) within the highlands of Kenya. Each cultivar was allocated 3 plots at random in two sites per each ecological zone, to make a Complete Randomized Block Design (CRBD). The first sampling was done when the vines were 75 days old. During this time half the number of sweet potato plants in each plot were defoliated at 20 cm above the ground using hand clippers. Fresh weight of the vines cut was then taken using a 50 kg weighing scale to estimate the yield. A sample of vines for each cultivar per replicate weighing 0.5 kg was taken using a 5 kg weighing scale and chopped into small pieces of about 3 cm long, then three samples from the three replicates were pooled and a subsample of 0.5 kg taken. The second sampling was done when the vines were 150 days old (end of the crop life cycle). Both the vines and storage roots were harvested separately from the whole of the experimental plot (ratooned and unratooned portion). Ratooned biomass (RB) was a cumulative of yields derived...
from day 75 vine + day 150 ratooned vines + storage root. Unrataloned biomass (URB) was cumulative yield derived by summing up the day 150 unrataloned vines and storage roots yields. To characterize the agro ecological weather conditions of the areas both temperatures and rainfall data for the locations were extracted from the nearest weather station.

Cultivars were classified into the various classes based on ratio of storage roots (R) over biomass (R+V) [R/(R+V)], the four classes being forage (F) = (RV<0.2), two subclasses of dual purpose (i) Dual purpose (high forage) (DP(F)) = (0.2 >RV<0.3) ii) Dual purpose (high root) (DP(R)), 0.3>RV<0.55 and storage roots (R) = (RV>0.55) (table I). This classification took care of the environmental influence on the cultivars unlike Karachi (1990) basis of classifying cultivars into vine, storage root, and multipurpose types based on vine dry-matter differences.

General Liner Model, three way factorial arrangement of SAS (2003) was used to compute analyses of variance (ANOVA) to test for any significant differences using F-test at P <0.05 on DM yield and chemical composition. When F-test was significant, mean separation was done using least significant difference (LSD) procedures (Steel and Torrie, 1980) at probability level of 5%.

RESULTS AND DISCUSSION
Gweri, Naspot1 and Wagabolige were universally classified as forage cultivar, dual purpose (high in storage roots) and dual purpose (high in forage) respectively (Table I). These cultivars therefore do not posses attributes which are useful in adapting to adverse effect of which are brought about by climate change. Which means management and the environmental conditions (E) of the locations had little influence on genetic (G) ability of the cultivars (GxE).

This is in agreement with the findings of Dahniya (1979), Mannan et al., (1992) and Olorunnisomo (2007) who found that there was re-partitioning of dry matter accumulation to favour leaf production at the expense of the storage root in some cultivars. It is also in agreement with FAO (1991) which has documented that leafy growth is increased at the expense of storage root production. Cultivar 103001 was classified as a root type in both Nyeri and Nandi, however in Bomet classification shifted to DP(R) (table I). Kemb36 was classified as DP (F) in both Nyeri and Nandi, however in Bomet it was classified as forage (table I). Kemb23 was classified as DP(R) both Nyeri and Nandi, however in Bomet classification it shifted to DP(F) (table I). This was because there was there was genetic/environment interaction hence the cultivar in adapting the excess amount of rainfall (1072 mm during the growing season April- June), (Table II) that was received in Bomet. Excessive moisture inhibits storage root development in early growth stages storage roots (Wanda, 1988). This is also in agreement with Nguyen and Ogle (2005) reported that excess water in spring affected root production but not the growth and yield of vines.

In Nyeri which received (about 440 mm of rainfall during the growing season), table II, cultivars produced little amount of vines compared to storage roots which can be attributed to low rainfall. Which is as a result of cultivars using G x E for survival mechanism as the amount of rainfall reduced there was more roots formation. Cultivars will concentrate assimilates towards root development as a survival mechanism therefore most of the dual purpose cultivars were classified with a bias towards roots. This is in agreement with Karachi (1990) who found that accessions appear suitable for semi-arid unimodal rainfall, high altitude areas, while other accessions are essentially vine producing types under the same growth conditions.

Crude protein
The CP content on day-75 vine was higher (P<0.05) than day-150 for both ratooned and unratooned (table 3), meaning that management (E) had influence on genetic ability (G) of the cultivars. High level of CP in young plants which declines as the plant matures (Moat and Dryden 1993; Olorunnisomo 2007). The high (P<0.05) day-75 vine CP levels of CP in Naspot1 and 103001 (table 3) can be attributed to the cultivars’ ability in utilization of nitrogen, a phenomena which was largely influenced by summing up the day 150 unrataloned vines and storage root. To characterize the agro ecological weather conditions of the areas both temperatures and rainfall data for the locations were extracted from the nearest weather station.

Cultivars were classified into the various classes based on ratio of storage roots (R) over biomass (R+V) [R/(R+V)], the four classes being forage (F) = (RV<0.2), two subclasses of dual purpose (i) Dual purpose (high forage) (DP(F)) = (0.2 >RV<0.3) ii) Dual purpose (high root) (DP(R)), 0.3>RV<0.55 and storage roots (R) = (RV>0.55) (table I). This classification took care of the environmental influence on the cultivars unlike Karachi (1990) basis of classifying cultivars into vine, storage root, and multipurpose types based on vine dry-matter differences.

General Liner Model, three way factorial arrangement of SAS (2003) was used to compute analyses of variance (ANOVA) to test for any significant differences using F-test at P <0.05 on DM yield and chemical composition. When F-test was significant, mean separation was done using least significant difference (LSD) procedures (Steel and Torrie, 1980) at probability level of 5%.
by the genetic makeup of the two cultivars. There is little genetic variation of protein content of vines among various genotypes (Zhang Dapeng and Li Xiu-Qing, 2003). Gweri, Naspot1 and Wagabolige had high (P<0.05) levels of ratooned vine CP (table III), which means that defoliation (E) of these cultivars at day-75 increased CP content of these cultivars. Several environmental factors have been shown to influence protein content in sweet potatoes (Dominguez, 1992). Olorunnisomo (2007) and Ruiz et al. (1980) reported an increase in crude protein content of sweet potato forage with shorter cutting interval. The variation of the unratooned vine CP content in various cultivars in different locations (table 3) was an indication that there was (GxE). In Bomet, Gweri had the lowest (P>0.05) levels both ratooned and unratooned vine CP (table III) meaning that this attribute in this cultivar was influenced more by excess rainfall than the management. The environmental effects include growing season (Bouwkamp et al., 1985; Lin, 1989), accumulated rainfall (Lin, 1989), and location (Bradbury et al., 1985) have been reported to affect protein content (Zhang Dapeng and Li Xiu-Qing, 2003).

**Metabolizable Energy**

Kieni had sweet potato storage roots with high (P<0.05) levels of ME, while Bomet had the lowest (P>0.05) (Table 4) which was attributed to the amount of rains that was received by the two locations, Kieni having the lowest (P>0.05) hence cultivars with higher (P<0.05) ME.

**CONCLUSION AND RECOMMENDATIONS**

Three sweet potato cultivars; 103001, Kemb36 and Kemb23 were found to adjust well towards adverse effect of climate change and variability hence recommended for the three locations and for higher CP production it was recommended the cultivars to be defoliated at day 75 post planting.

**ACKNOWLEDGEMENTS**

The authors highly appreciate and thank CIP, Egerton University and Director KARI

**REFERENCES**


“Framing the issues, challenges and opportunities in livestock sector in the 21st century”
ECONOMIC VALUES FOR THE DUAL PURPOSE SAHIWAL CATTLE IN PASTORAL PRODUCTION SYSTEMS

E.D. Ilatsia, J.M. Mbuthia, R.N. Pulei, and E. Nyambati

ABSTRACT
Economic values for milk yield, MY, calving interval, CI, sale weights (bulls, SWb, and heifers, SWh), and survival (preweaning survival rate, SR, postweaning survival rate, PSR and cow survival rate, CoSR) traits were estimated for the dual purpose Sahiwal cattle in pastoral production systems. Two systems were considered; extensive system based on grazing on natural pastures only and low input system with some level of supplementation in addition to grazing on natural pastures. Economic values were calculated based on fixed herd-size. Except for milk yield, economic values for all traits were high in low input than in extensive system. The results suggest that genetic improvement of milk yield, weight, fertility and survival traits will positively influence profitability of Sahiwal cattle, especially with some nutrition supplementation.

INTRODUCTION
Sahiwal cattle genetic resources play multiple roles in the livelihoods of pastoral communities. Milk is a staple food and an important component of the daily diet among the pastoralists (Ilatsia et al., 2011a). Compared to other East African Zebus the breed produces relatively high milk. The breed is also favoured because it produces more meat as a result of the relatively big body size. In the face of developing dairy industry with specialized intensive production, the pastoral production systems utilizing dual purpose indigenous cattle genetic resources still remain relevant. This is because they are adapted to the climatic, nutritional and economic constraints affecting them.

Despite the significant contributions of Sahiwal breed to meeting the milk and beef demands in pastoral systems, economic and biological evaluations of the dual-purpose systems are scarce. With the scarcity of formal breeding objectives among the pastoral Sahiwal keepers, the estimation of economic values is necessary to guide the direction of genetic improvement. This is because poorly defined or lack of breeding objectives has the disadvantage of resulting in little or no benefits from breeding efforts, suboptimal selection decisions and eventually low economic returns.

The breeding objective is described by a profit function that takes genetic values as input and produces profit as output. The economic value expresses to what extent improvement of genetic merit of a trait can contribute to an improvement of economic efficiency of animal production systems (Groen, 1988). In this study, biological and economic parameters reflecting the dual purpose Sahiwal breed were used in the bio-economic model developed by Rewe et al., (2006). From the model economic values for production traits (milk and beef), and functional traits (survival rate and calving interval) were determined.

MATERIALS AND METHODS
Model description
Economic values were derived from bio-economic model developed by Rewe et al., (2006) which was modified to suit the dual purpose Sahiwal breed and pastoral system of production. The model is deterministic and static and assumes no variation in characteristics among animals. Most of the input parameters, herd management practices, animal productivity and reproduction characteristics were obtained from field survey (Ilatsia et al., 2011a). The model evaluation is based on per cow per year and therefore the relative herd structure (calves, heifers and bulls) is based on this. Additionally herd dynamics such as calving rate, cow culling rate, and replacement heifers are on per cow per year basis. Seasonal variations in animal performance and prices were not included in the model. The variations in genetic merit between animals were not considered. The model considered herd averages. The production variables applied in the model are presented in table I and the unit prices and costs of the production parameters in table II.

Input costs of the herd were calculated from feed, husbandry, marketing and fixed costs for the different animal categories. Income is from sale of milk and live animals (for slaughter). All male calves and female calves not needed for replacement are fattened up to slaughter weight. The major components of inputs and outputs at different growth stages in the production systems are presented in figure 1. In a dairy system where lactating animals also provide beef, the price per kilogram live weight for the lactating animals disposed depend on dressing percentage and carcass quality, which are influenced by lactation number and stage of lactation (Groen, 1988). Such evaluation systems are lacking in pastoral systems and therefore there was no adjustment for this.

Breeding production and marketing systems
The National Sahiwal Stud (NSS) at KARI Naivasha is the main supplier of Sahiwal genetic resources to farmers, supplemented by ranches and private farms. Dissemination of breeding material is through sale of live animals from NSS and through artificial insemination by the Kenya Animal Genetic Resources (KAGRC) The Sahiwal bulls at KAGRC are bred by NSS. The breeding programme at NSS is supported by an elaborate performance and pedigree recording scheme and artificial insemination that allow for progeny testing scheme. Genetic improvement strategies for the Sahiwal breed in Kenya include both pure breeding and cross breeding (Ilatsia et al., 2011b). Pure breeding programmes are implemented mainly by NSS, some ranches and pastoral herds. At farm level selection decisions are mainly based on physical characteristics and pedigree information (Ilatsia et al., 2011a).

Two production systems were assumed: extensive and low input. In extensive system animals are grazed on natural pastures without supplementation and minimum veterinary intervention. This system assumed that farmers have no other option of utilizing the land or the available forage on the farm and no costs are incurred in forage production. As a result feed costs were set to zero. The level of some input in this system could be lower than for common smallholder production system. Fixed costs were
also set to zero. In low input system animals are grazed on natural pastures with low levels of supplementation and veterinary intervention. The intervention strategies include control of endoparasites through deworming and ectoparasites through spraying/dipping. It was assumed that lactating cows were supplemented with 2.35kg concentrates daily during the lactation period. Mineral licks are also provided.

The dual purpose role of Sahiwal genetic resources guarantees revenue through sale of milk and live animals (Ilatsia et al., 2011a). Milk is mainly fed to calves and used for domestic consumption. Any surplus is sold mainly by women. Surplus milk is sold at local markets, to neighbours, middlemen and other outlets based on volume, while live animals are sold at local livestock markets and butcheries on a willing-buyer-willing-seller basis and prices are determined by visual appraisal of body size/weight (Ilatsia et al., 2011a). Calving interval as a fertility trait affects the calving pattern, lactation milk yield and to an extent culling rate and therefore its inclusion.

In the tropics, the ability of an animal to survive up to a certain predetermined age reflects its ability to adapt to the prevailing conditions (Rewe et al., 2006). Survival traits were included because improved survival rates affect the herd composition, rather than changing the individual animal performance and therefore exert great changes in revenue and costs (e.g. Kahi and Nitter, 2004).

**Derivation of economic values**

Economic values were derived by accounting for unit changes in returns and of costs arising from improvement of a trait also referred to as partial budgeting. This approach is preferred because it enables the user to vary relevant parameters of the model independently. The basic profit equation used was:

\[ P = R - C \]

Where P is the profit, R revenue and C costs.

The revenues per cow per year were calculated as:

\[ R = \sum_{i=1}^{3} R_i \]

and costs were calculated as:

\[ C = \sum_{i=1}^{3} (C_{Fi} + C_{Hi} + C_{Mi}) + fixed\ costs \]

where i is the animal category corresponding to 1 - heifers, 2 - bulls and 3 - cows respectively and F, H and M correspond to feeding, husbandry and marketing costs respectively.

Economic values were calculated based on fixed herd-size from the equation:

\[ \delta R / \delta t + \delta C / \delta t \]

where \( \delta R \) and \( \delta C \) are the marginal changes in revenue and costs after a 1% increase in the trait of interest and \( \delta t \) is the marginal change in the trait after 1% increase.

**RESULTS**

The sources of revenue in the pastoral systems were milk and beef. Milk was from mature lactating females whereas beef was from bulls, culled heifers and cull-for-age cows. Expenses were incurred in feeds, husbandry, and marketing. The EVs were expressed in KShs. per unit change in each trait and therefore their magnitude is influenced by the unit of measurement chosen e.g. litter, kg or %.

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**TABLE I - PRODUCTION VARIABLES APPLIED IN THE BIO-ECONOMIC MODEL**

<table>
<thead>
<tr>
<th>Production variable</th>
<th>Unit</th>
<th>Production system</th>
<th>Extensive</th>
<th>Low input</th>
</tr>
</thead>
<tbody>
<tr>
<td>Milk yield per cow per lactation (MY)</td>
<td>litres</td>
<td>1370</td>
<td>1663</td>
<td></td>
</tr>
<tr>
<td>Age at first calving (afc)</td>
<td>days</td>
<td>1410</td>
<td>1347</td>
<td></td>
</tr>
<tr>
<td>Calving interval (CI)</td>
<td>days</td>
<td>468</td>
<td>468</td>
<td></td>
</tr>
<tr>
<td>Heifer sale weight (SWh)</td>
<td>kg</td>
<td>339</td>
<td>356</td>
<td></td>
</tr>
<tr>
<td>Bull sale weight (Swb)</td>
<td>kg</td>
<td>370</td>
<td>419</td>
<td></td>
</tr>
<tr>
<td>Mature cow live weight (CoWT)</td>
<td>kg</td>
<td>356</td>
<td>356</td>
<td></td>
</tr>
<tr>
<td>Weaning weight (ww)</td>
<td>kg</td>
<td>48</td>
<td>48</td>
<td></td>
</tr>
<tr>
<td>Dressing percentage (dp)</td>
<td>%</td>
<td>52</td>
<td>52</td>
<td></td>
</tr>
<tr>
<td>Preweaning survival rate (SR)</td>
<td>%</td>
<td>81</td>
<td>81</td>
<td></td>
</tr>
<tr>
<td>Postweaning survival rate (PSR)</td>
<td>%</td>
<td>93</td>
<td>93</td>
<td></td>
</tr>
<tr>
<td>Cow survival rate (CoSR)</td>
<td>%</td>
<td>97</td>
<td>97</td>
<td></td>
</tr>
<tr>
<td>Replacement rate</td>
<td>%</td>
<td>17</td>
<td>17</td>
<td></td>
</tr>
</tbody>
</table>

**TABLE II - UNIT PRICES AND COSTS (IN KSH.) USED FOR CALCULATION OF ECONOMIC VALUES**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Price (KShs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Milk price per litre</td>
<td>30</td>
</tr>
<tr>
<td>Price of beef</td>
<td>300</td>
</tr>
<tr>
<td>Natural pasture cost per kg DM</td>
<td>0.50</td>
</tr>
<tr>
<td>Concentrate cost per kg</td>
<td>30</td>
</tr>
<tr>
<td>Health cost per head per day</td>
<td>200</td>
</tr>
<tr>
<td>Reproduction cost per cow per year</td>
<td>3.50</td>
</tr>
<tr>
<td>Labour cost per head per day</td>
<td>3.50</td>
</tr>
<tr>
<td>Marketing cost per live animal</td>
<td>200</td>
</tr>
</tbody>
</table>
Economic values for traits per unit increase in genetic merit are presented in Table 3. In general EVs were higher in low input than in extensive system. The differences in EVs in the production systems can be attributed to differences in input parameters and consequently animal performances. The results indicate that genetic improvement is likely to yield more benefit with some levels of intervention in management such as feed supplementation and veterinary intervention.

EVs under both systems were positive except for CI indicating that genetic improvement for these traits would have a positive effect on profitability. Genetic improvement of MY in the two systems yield similar EVs despite the low input yielding more profit. This is expected to arise from the extensive system producing more milk at minimal costs. As expected, the EV for calving interval was negative indicating that genetic selection should aim at decreasing the CI to positively influence the overall profit. The genetic merit for sale weights were positive as a result of increase in kg beef from culled animals and fattened bulls despite the increased energy requirements for maintenance and production for the different categories. The differences in EVs between the systems can be attributed to differences in sale weights of slaughter animals. Survival traits gave the highest EVs of all the traits evaluated, being higher in low input than in extensive system.

**DISCUSSION**

Economic values for a number of production and functional traits of Sahiwal breed were computed from a bio-economic model. Relative EVs for different traits in Kenya have been evaluated for dairy (Kahi and Nitter, 2004) and beef cattle (Rewe et al., 2006) defining different breeding objectives. Positive EV for MY in a pasture-based system has been reported by Rewe et al., (2006) who evaluated a beef system where MY was considered an important trait. Differences in EVs for MY are expected in different systems due to differences in price and production levels (Bekman and van Arendonk, 1993). Despite the positive EVs for MY it has been indicated that selection for higher milk yield alone in dairy cattle is generally accompanied by deterioration of functional traits such as health, calving ease, fertility e.g. prolongation of CI (Groen et al., 1997; Veerkamp et al., 2002).

Economic values for sale weights (SWb, SWh and combined SW) were positive. Similarly to Rewe et al., (2006) EVs for SWb was higher than for SWh. This is because more bulls than heifers contributed to beef revenue. The largest proportion of bulls is fattened for slaughter compared to heifers whereby a significant number is retained in the herd as replacements. It is only the culled heifers that contribute to beef revenue. In dairy cattle, improving the body size results in low positive EVs for the trait (Vargas et al., 2002). This is mainly attributed to the low carcass price of dairy animals. Previous studies have reported negative EVs for body weight in dairy cattle (e.g. Groen 1989, Visscher et al., 1994). However these studies assumed a feeding strategy based on nutrient requirements only. In this study the EVs for sale weight are positive despite the increased requirements for maintenance associated with increase in body size. This is because the economic merit of improving body size is not only high beef sale but high milk correlated with it. Selection for milk and beef production would result in a correlated response in body weight of the cows (Bekman and Van Arendonk, 1993). Although the increase in mature $EV_{\text{herd}} = \frac{\delta R - \delta O}{\delta X}$ increased energy requirements for maintenance and production, the economic merit of beef value would increase. Therefore selection strategies for milk and beef production traits should account for body weight.

The negative EVs obtained for CI are desirable. Veerkamp et al., (2002) also obtained negative values whereas Kahi and Nitter (2004) obtained positive EVs for CI. Prolonged CI is an indication of reproductive inefficiency which leads to wastage of breeding opportunities. A shorter CI interval would result in more revenue from increased number of calves per year. The reduced margins are due to reduced...
Because of the nature of the production system where animals are raised under range conditions with minimum husbandry intervention, survival traits become very important. Positive EVs for survival rates have been reported before (Vargas et al., 2002, Kahi and Nitter, 2004, Rewe et al., 2006). The effect of an increase in survival rate is mainly exerted through changes in herd composition rather than change in individual performance (Vargas et al., 2002). The importance of SR and PSR can be linked to adaptability (Kahi and Nitter, 2004) which is critical in conditions characterised by disease challenges, poor nutrition and heat stress. An increase in cow survival rate translates to lower replacement rate and therefore the optimum herd-life increases as cows become more cost effective.

Improvement of genetic merit in traits of economic importance is accompanied by efficiency of resource utilization. For example improvement of genetic merit for milk production per cow will result in a reduction in the number of cows and consequently a reduction in costs of feeding, labour, housing and so on (Groen et al., 1997). This should be the objective in Kenya where land size is diminishing as a result of subdivision for human settlement.

CONCLUSION

This study points the likely direction and magnitude of change for breeding objective traits for a dual purpose cattle breed in pastoral production systems. It implies that genetic improvement on milk yield, sale weight, and survival traits will positively influence profitability more so in a system with nutrition supplementation. However, unlike in dairy systems supplementation with concentrates might not increase in pastoral systems due to the large number of animals involved and the cost of concentrates. Breeding for efficient forage utilization would therefore be more viable given the low cost of its production. The economic values computed here are undiscounted. Discounting in combination with gene flow methodology are required to examine the number of expression of genes over time. It is recommended that cumulative discounted expressions be computed as a further step to determine the relative emphasis of the traits in the breeding goal.

REFERENCES


DEFINING BREEDING OBJECTIVES FOR PIG IMPROVEMENT IN SMALLHOLDER PRODUCTION SYSTEMS IN KENYA: BIO-ECONOMIC MODEL EVALUATION

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ABSTRACT
A deterministic bio-economic model was developed and applied to evaluate biological and economic variables that characterise smallholder pig production systems in Kenya. Two pig production systems were considered namely, semi-intensive (SI) and extensive (EX). The input variables were categorised into biological variables including production and functional traits, nutritional variables, management variables and economic variables. The model factored the various sow physiological systems including gestation, farrowing, lactation, growth and development. The model was developed to evaluate a farrow to finish operation and the results customised to account for a farrow to weaner operation for a comparative analysis. The operations were defined as semi-intensive farrow to finish (SIFF), semi-intensive farrow to weaner (SIFW), extensive farrow to finish (EXFF) and extensive farrow to weaner (EXFW). In SI, the profits were the highest at KSh. 74,268.20 per sow per year for SIFF against KSh. 4,026.12 for SIFW. The corresponding profits for EX were KSh. 925.25 and KSh. 626.73.
The model output implies that pig production is profitable in smallholder production systems in economic terms even without considering the socio-cultural and other intangible roles they play which were not accounted for in the model.

Keywords: Bio-economic model, Kenya, pigs, smallholder, production systems

INTRODUCTION
Pig production play crucial roles in the livelihoods of many smallholder households in the tropics. However, the pig production potential for economic contribution in most developing countries has yet to be realized (Shrestha et al., 2002). This is mainly due to poor nutrition, lack of proper housing resulting in deaths due to cold and predation, lack of and/or inappropriate disease control strategies, minimal genetic control and general lack of formal breeding objectives required in managing the direction of genetic improvement with respect to farmer and market preferences (Wabacha et al., 2004; Lañada et al., 2005; Kagira et al., 2010).

A well defined breeding objective is the first requirement of any genetic improvement programme. Breeding objectives comprise of those traits targeted for improvement in the breeding programme because they influence returns and costs to the producer. In pig production, diverse conditions of environment, management and marketing exist further complicating the process of defining formal breeding objectives. Under such circumstances a general bi-economic model can be used whereby a large number of factors and their complex interactions in the production systems are considered simultaneously (Kahi and Nitter, 2004).

The aim of this study was to develop and evaluate bio-economic profit models for pigs in different smallholder production systems integrating biological traits and economic variables. The bio-economic model was used elsewhere to estimate economic values for production and functional traits in different production systems.

MATERIAL AND METHODS

General model
In this study, a deterministic model was developed and utilized to evaluate the biological and economic aspects of smallholder pig production systems that vary in production potential. These production systems have been categorized into semi-intensive (SI) and extensive systems (EX). The systems differ in pig production intensity, distribution of pig breeds, market access and farm resources availability. Depending on the production operation, farmers rear their pigs until they achieve market weight as either porkers or baconers (farrow to finish), sell surplus weaners (farrow to weaner) or purchase weaners for fattening to market weight (weaner to finish). This study evaluated semi-intensive farrow to finish (SIFF), semi-intensive farrow to weaner (SIFW), extensive farrow to finish (EXFF) and extensive farrow to weaner (EXFW) systems. The model developed in this study focused on the inputs and outputs on each phase of the pigs’ life cycle from piglet through weaning, grower, replacements to breeding stage as presented in figure 1.

The input parameters used in the model are presented in Table I Within the structure, the inputs into each phase, relative number of animals through the cycle and outputs of each phase can be determined. From this information bio-economic profit models were derived and used to estimate the profitability of the herd.

Herd composition and replacement
Various pig categories were identified and classified according to age as piglets (birth to weaning), growers (non-reproducing females and males/castrates from weaning to sale age), breeding sows (reproducing females), and boars (reproducing males). In EX, farrowing rate was assumed to be 75\%. Sows were culled-for-age after three productive years and the boars after two years. Male and female grower pigs fattened for slaughter exited the herd at approximately seven months when they are assumed to have attained a live weight of 75 kg in the SI. In the EX, slaughter pigs attained a live weight of 30 kg at 10 months.

Marketing and prices
Weaner pigs were sold on per animal basis irrespective of the body weight but generally at one and two months of age in EX and SI, respectively. Slaughter pigs were sold on body live weight and marketing costs were assumed to
be uniform for all pig categories. Transport of live animals to the slaughter house, and slaughter and inspection levies were incurred by the farmer as marketing costs. These costs were assumed to be charged to the farmer because traders intrinsically reduce the price of the live animal by the same margin (Kosgey et al., 2003). The unit prices and costs input in the model are presented in table II. The costs were assumed to be uniform for all animals sold for slaughter irrespective of the stage in the life cycle.

Feeding regime
For simplicity the pig rations in SI were assumed to consist of 65% concentrates with the remaining rations consisting of swill and farm-grown feeds. In the EX, pig diets were assumed to consist only 10% commercial concentrates. Piglets were assumed to consume a total of 8.21kg of creep feed and ad libitum suckling from week four to week.

In all systems, the mean energy requirement of the pigs was expressed in terms of metabolizable energy (ME) as provided for by NRC (1998). The amount of energy in feed was expressed in kilo calories (Kcal) of ME per kg of DM. The mean estimate for energy requirement for maintenance, pregnancy and lactation for sows was 106 kcal of ME/kg BW0.75/day. The energy requirement for milk production was established from the growth rate of the suckling pigs in the litter as:

\[ \text{Milk energy} = (6.83 \times \text{PrDG} \times \text{TNB}) - (125 \times \text{TNB}) \]

where PrDG is the pre-weaning daily gain and TNB the total number of piglets born.

The energy requirement for growth was partitioned into energy for protein retention at a mean of 10.6Mcal of ME/kg and energy for fat deposition at 12.5Mcal of ME/kg.

The energy requirement for maintenance for the boar was set at 106 kcal of ME/kg BW0.75 (NRC, 1998).

Biological traits influencing revenue and costs
Biological traits are variables that are partly determined by the genotype of the animals and are considered potential breeding goal traits. The biological traits considered to influence revenues and cost in both systems are presented in Table III.

Bio-economic profit models
The model simulates the productive life of a sow and offspring in a farrow to finish management operation. The input variables were based on the mean phenotypic performance levels of the different classes of pigs. The traits contributing to higher biological and economic efficiency in pigs were divided into production and functional traits.

Profit was derived as the difference between revenue (R) and costs (C);

\[ P = R - C \]

The revenue (R) per pig per year in Kenya shillings (KSh.) was calculated as:

\[ R = R_{\text{weaner}} + R_{\text{growers}} + R_{\text{cull sows}} + R_{\text{cull boars}} \]

Costs (C) were calculated from the equation:

The upper case letters refer to Feeding, Husbandry and Marketing, costs. Fixed costs are those attributable to equipment, machines and farm structures while all other costs are variable costs because they are influenced by the level of herd production.
RESULTS

General model
The model developed simulated the life time performance of pigs in a farrow to finish operation and the results were customised to account for a farrow to weaner operation for purposes of comparing profitability. The outputs of the model developed included revenue, costs and feed intake of different classes of pigs which may be very difficult to collect in field conditions under the different production systems evaluated. The model was executed under the base situation and the simulated outputs checked to determine whether they were reasonable or not.

Feed intake
The piglets’ class in EX did not incur any feed costs since weaning was done at one month where they consume insignificant amounts of feeds. Grower feed costs were the highest of the feed costs in the farrow to finish operations accounting for 76.2% and 72.5% in SI and EX respectively due to the large number of animals involved in this class. The energy requirements for growers, accounting for maintenance, protein retention and fat deposition was 823.44 and 162.16 kcal ME/day immediately after weaning and increased gradually as they gained weight to 2342.95 and 786.89 kcal ME/day at sale age in SI and EX respectively. For the sow class the energy requirements accounting for maintenance and the different physiological status including gestation and lactation was on average 5470.37 and 2390.28 kcal ME/day in SI and EX respectively. This intake assumed a constant sow weight, a gestation period of 115 days and that the sows had reached physiological maturity thus lowering the energy requirement for protein retention and fat deposition.

Revenues, costs and profits
The revenues, costs and profits for the different production systems are presented in Table 4. Generally, revenues and costs were higher in SI than in EX operations. Farrow to finish operations were more profitable than farrow to weaner in all production systems. In SI, the profits were the highest at KSh. 74,268.20 per sow per year for the SIFF against KSh. 4,026.12 per sow per year in SIFW. Comparative profits for EX were KSh. 925.25 in EXFF and KSh. 626.73 in EXFW yielding the lowest profits. The grower pigs contributed the highest gross revenues of all the pig classes in SIFF at KSh. 168,870.89 and KSh. 19,266.46 in EXFF. The farrow to weaner operation disposed all the piglets after weaning and therefore there was no revenue from this category. The revenue from surplus weaners in the farrow to finish operations accrued from the weaners culled and sold to reduce the herd size (approximately 10% of total piglets born).

The overall costs were higher in SI than in EX. Feed costs contributed the major part of the total costs accounting for 67.0%, 50.7%, 60.5%, and 44.5% in the SIFF, SIFW, EXFF and EXFW production operations respectively.

DISCUSSION
The bio-economic models were assumed to be linear and the outcomes were completely determined by the initial input parameters. The model can be modified by adjusting the herd dynamics and management variables and be
TABLE II- UNIT PRICES AND COSTS CONSIDERED IN THE MODEL

<table>
<thead>
<tr>
<th>Production system</th>
<th>Semi-intensive</th>
<th>Extensive</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prices (KSh.)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Price of meat/kg ($P_{meat}$, KSh.)</td>
<td>240</td>
<td>180</td>
</tr>
<tr>
<td>Weaner price (KSh. /head)</td>
<td>2,000</td>
<td>1,000</td>
</tr>
<tr>
<td>Price of concentrate per kg DM ($P_{conc}$)</td>
<td>22</td>
<td>20</td>
</tr>
<tr>
<td>Price of swill per kg ($P_{swi}$)</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Costs (KSh.)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reproduction cost per sow per service</td>
<td>1,500</td>
<td>1,000</td>
</tr>
<tr>
<td>Labour costs per head per day (Clab)</td>
<td>4.00</td>
<td>3.00</td>
</tr>
<tr>
<td>Marketing cost per slaughter pig</td>
<td>500</td>
<td>300</td>
</tr>
<tr>
<td>Veterinary costs per day</td>
<td>3.00</td>
<td>2.00</td>
</tr>
<tr>
<td>Fixed costs per head per year</td>
<td>1,000</td>
<td>100</td>
</tr>
</tbody>
</table>

TABLE III BIOLOGICAL TRAITS INFLUENCING REVENUE AND COSTS

<table>
<thead>
<tr>
<th>Effect on profit</th>
<th>Product or activity</th>
<th>Pig class</th>
<th>Traits $^a$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Revenue</td>
<td>Surplus weaners</td>
<td>Weaners</td>
<td>SoWR, FI, TNB,</td>
</tr>
<tr>
<td></td>
<td>Slaughter pigs</td>
<td>Growers</td>
<td>FI, PrSR, PoSR, PrDG, DP</td>
</tr>
<tr>
<td></td>
<td>Cull-for-age sows</td>
<td>Sows</td>
<td>LW, DP</td>
</tr>
<tr>
<td>Costs</td>
<td>Feeding</td>
<td>Piglets</td>
<td>FEED</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Growers</td>
<td>FEED, LW</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sows</td>
<td>FEED, LW</td>
</tr>
<tr>
<td></td>
<td>Husbandry</td>
<td>Piglets</td>
<td>PrSR, PoSR</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Growers</td>
<td>FI, PrSR, PoSR</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sows</td>
<td>SoSR</td>
</tr>
<tr>
<td></td>
<td>Marketing</td>
<td>Growers</td>
<td>FI, PrSR, PoSR,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Culled pigs</td>
<td>LW, PrSR</td>
</tr>
</tbody>
</table>

$^a$DP, dressing percentage; FEED, feed requirement; FI, farrowing interval; LW, live weight; PoSR, postweaning survival rate; PrSR, preweaning survival rate; TNB, total number born

Revenue, costs and profits
Cash revenue (R) was obtained from the sale of surplus weaners, growers on attaining slaughter weight and pigs culled at different stages. Variable costs are incurred from purchase of feeds, veterinary care, husbandry and marketing costs. The revenue and cash variables vary with the production system, being higher in SI than in EX.

Under similar conditions as in the current study, Lemke et al. (2007) reported high outputs in SI associated with keeping of improved genotypes i.e. Large White and Landrace and/or their crossbreeds. The high benefits are based on high outputs due to high body weights which is further associated with the degree of market orientation as well as optimization of management. The feeding is usually adequate and in most cases balanced. The selected genotypes have short fattening periods due to high average daily gains. In EX, low outputs could be attributed to the small-sized unimproved pigs which result to low meat yield, long fattening periods associated with low average daily weight gains all compounded by the unbalanced feeding and high fibrous diets.

Feed intake
The variable costs arising from feeding were significantly high in the SI mainly due to the stronger use of external inputs including commercial concentrates. To overcome the prohibitive costs of feeds, farmers feed a mixture of the commercial concentrates with local cheap available by-products (Huynh et al., 2007). In this regard, this study evaluated feed costs incorporating swill in the pig diets. The inclusion of high levels of commercial concentrates in SI significantly increased the variable costs. However, this has an advantage of improving the average daily weight gain and therefore pigs attain market weight early. For pigs to attain considerable gains from swill they must consume it in large quantities on as-fed basis than they would consume commercial rations. The inclusion of swill in pig diets should therefore be monitored regularly and be supplemented accordingly.
Annual husbandry costs were higher in SI since pig herds were larger and veterinary interventions were more frequent. In this system, hired labour was mainly utilized and this accounted for a large proportion of husbandry costs. In EX, routine practices such as iron injection, teeth clipping castration are rare and ecto- and endo-parasite control is irregular or lacking. Family labour is mainly utilized and this reduces the overall husbandry costs. Although the profits accrued from some of the production systems seem negligible, it should be understood that farmers keep livestock for other non-cash roles such as insurance and cultural roles. This could explain why farmers in the tropics persist in keeping livestock despite net economic losses as shown for smallholder production systems discussed by Kosgey et al. (2004).

CONCLUSIONS

The bio-economic model developed could be extended with modifications for use in deriving economic values for breeding goal traits for pigs under smallholder production systems in other parts of the tropics. The model output implies that pig production is profitable in smallholder production systems in economic terms even without considering the socio-cultural and other intangible roles they play which were not accounted for in the model. As a result, clear breeding goals to support genetic improvement need to be developed based on the traits of economic importance in the production systems.

REFERENCES


“Framing the issues, challenges and opportunities in livestock sector in the 21st century”


CODON USAGE IN PORCINE GENOME: WHY THE CHOICE OF DIFFERENT CODON USAGE?

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ABSTRACT
The frequencies of usage of different synonymous codons vary both among species and between genes from the same species. The precise mechanism of this selection and its importance has been a subject of intense research in many taxa. Here we determined the codon usage bias in the porcine genome and decipher its relevance to gene ontologies. To investigate the underlying mechanisms of codon bias, we extracted the Coding sequence (CDS) from the swine reference sequence (Ssc10.2) using Biomart. In addition we obtained gene expression data from ongoing RNA-seq experiment. We used in-house built Perl script to derive various genomic traits and codon indices. Analysis was done using R statistical package, correlations and multivariate regressions were performed. We report the existence of codon usage bias suggesting existence of weak translational selection. The codon bias is feebly related to nucleotide composition (GC%, GC3, CDS length) but not to gene expression level. The gene ontology analysis indicates that the highly biased genes are mainly housekeeping genes. These studies can be explored for designing degenerate primers, necessitate selecting appropriate hosts expression systems to manipulate the expression of target genes in vivo or in vitro and improve the accuracy of gene prediction from genomic sequences thus maximizing the effectiveness of genetic manipulations in synthetic biology.

INTRODUCTION
The availability of nearly complete genome sequences from different taxa has enabled tremendous advances in evolutionary biology, providing insight to the actions of natural selection on genomes (Whittle et al., 2012). These biological breakthroughs revealed the importance of studying the degeneracy of genetic code, which enables most amino acids to be coded by more than one so called ‘synonymous’ codon (Wright, 1990). Synonymous codons usage (SCU) bias has been documented both within and between genomes, with huge interspecific and even intragenomic variation (Jia et al., 2009). Several biological factors such as RNA abundance (Kanaya et al., 2001), strand specific mutational bias, replicational, transcriptional and translational selection (Hershberg and Petrov, 2008), secondary structure of proteins, mRNA structure, GC composition (Knight et al., 2001) and environmental factors (Bashak and Ghosh, 2005) have been reported to influence the synonymous codon usage in various organisms. The aforementioned factors led to two hypotheses on the evolution of codon bias; mutation bias and natural selection for translation accuracy and efficiency (Sharp et al., 2005).

Despite reports on codon usage in mammals, there is no such literature in porcine genome. The study of codon usage would shade light to the known disparity in gene expression levels and quantitative trait loci that may be related to genome architectures. In this study we test these hypotheses using genomic traits at our disposal. We report evidence of genomic codon usage bias and its relationship with gene ontologies terms. We further elucidate determinants of genomic Codon Adaptation Index (gCAI) through multivariate regression modeling. The derived gCAI, a proxy of codon usage bias (related to gene expression) is compared to real transcriptome data derived from RNA-seq from brain, placenta and muscle tissues. We report gene expression traits (expression breadth and levels) to be variable and genomic traits causing variability explained.

Objectives
The objectives of the study were i. to determine codon usage bias in pigs genome and identify nucleotide composition factors affecting the codon usage bias
ii. to determine the 5% of genes showing highest and lowest biasness (based on gCAI) and relate them to their ontology terms.
iii. to define gene expression traits variability among brain, placenta and muscle tissues and their relatedness to codon usage bias (gCAI).

MATERIALS AND METHODS
Sequence data
Two different genome sequences were used for analysis. A total of 23,269 coding sequences was extracted from the female Duroc pig breed as the reference genome, (Sus scrofa build 10.2) using BioMart (Ensembl v68). Only 21,550 CDS that were more than 50 amino acids (150 bp) were included for analysis. The short CDS were excluded due to large estimation errors for codon usage which are associated with short sequence length. The majority of the excluded genes were micron RNA which are averagely 22 bp in length (Shi et al., 2007). The gene expression levels data on different tissues (brain, placenta and muscle) was obtained from ongoing RNA-seq experiment.

Codon indices
Relative Synonymous Codon Usage (RSCU)
Relative synonymous codon usage (RSCU) is the proportion of the observed codon divided by its expected frequency at equilibrium. An RSCU value close to 1 indicates lack of bias, RSCU >1 indicates a codon used more frequently than expected, and RSCU < 1 indicates a codon used less frequently than expected (Sharp et al., 2005). RSCU values are largely independent of amino acid composition and are particularly useful in comparing codon usage among genes, or sets of genes that differ in their size and amino acid composition. In this study we developed an in house Perl script to calculate RSCU as;

\[ RSCU = \frac{j}{\sum_j} \]
where $i$ denotes number of synonyms and $j$ denote the codon counts within the synonyms.

Another parameter RSCU’ was calculated as;

$$\text{RSCU'} = \frac{\text{RSCU}}{n}$$

where $n$ is the number of synonymous codons of an amino acid. This parameter measures and compares the usage of all 61 sense codons and is the proportion of use of a codon in all genes.

We finally derived mean RSCU as;

$$\text{RSCU}_{\text{mean}} = \frac{\sum_{i=1}^{L} \text{RSCU}}{N}$$

Where RSCU is the values derived per gene, $N$ is the total number of codon counts per gene. The value of RSCU Mean ranged from one to infinity depending of the biasness of the gene. It is assumed to be a sister index to gCAI that is explained below.

Genomic Codon Adaptation Index (gCAI)

Classical Codon adaptation index (CAI) was first used to measure gene expression. This measure is species dependent and is the empirical measure for gene in studies investigating mutational and selectional components of codon usage (Goetz and Fuglsang, 2005). A CAI value is always between 0 and 1, and a higher value means a stronger codon usage bias and higher expression level and/or translation efficiency. In most research CAI of a coding sequence (CDS) is computed from the two parameters; the codon frequencies of the CDS and the codon frequencies of a set of known highly expressed genes (often referred to as the reference set). This computation leads to CAI which is used as a proxy for gene expression. In this case CAI values are normalized using codon frequencies in highly expressed gene sets. According to Xia (2007), CAI computation involves first derivation of a column of $W$ values;

$$W_{ij} = \frac{F_{ij} \text{ref}}{\text{MAX}_{fi} \text{ref}}$$

where $F_{ij} \text{ref}$ is the frequency of codon $j$ in synonymous codon family $i$, and $\text{MAX}_{fi} \text{ref}$ is the maximum codon frequency in synonymous codon family $i$ from a set of highly expressed genes.

The codon adaptation index for a given gene is then given by;

$$\text{CAI} = \prod_{i=1}^{L} W_{ij}^{1/L}$$

where $L$ is the number of codons from synonymous families in the gene.

In our study genomic codon adaptation index was calculated as the geometric mean RSCU divided by the highest possible geometric mean of RSCU given the same AA sequence.

$$g\text{CAI} = \sqrt[n]{\prod_{i=1}^{m} r_{scu}^{n}}$$

This value (gCAI) is a proxy for codon bias. The CAI values are normalized using codon frequencies at equilibrium, thus there is no assumption of expression bias.

Analysis tools

An in house Perl script was used to derive codon indices, gene length, GC and GC3 (the frequency of G+C at the third position); GC content was also computed using intrinsic sequences) for all the CDS. In addition, we generated a gene codon usage and genome wide usage table. Statistical analysis was conducted using R (V 2.15.0). We used a Sperman’s rank correlation to relate codon indices (gCAI, gRSCU, RSCU_Mean) with different nucleotide composition variables (i.e GC, GC3, CDS length). Multivariate regression model was used to predict the biasness. We extracted the 5% most and least bias genes according to our gCAI index. These were grouped in two categories (low and high bias). We looked for over-representation of gene ontology terms (GO) using a Perl script that compared the GO terms between the two files (selected highest or lowest biased) and all GO terms downloaded from Ensembl genome browser. Statistical significance was computed using a chi square test. In order to correct for multiple testing we used a P values threshold of 0.0001 for GO analysis. The RNA seq data was summarized across tissues. Thereafter, we computed correlation coefficients between gCAI and expression level. Lastly, we studied factors affecting gene expression using multivariate regression.

RESULTS

Codon usage bias analyses

The observed relative synonymous codon usage (RSCU) and its sister index RSCU’ clearly indicate that there is a non-random usage of synonymous codons for individual genes (result not shown). To investigate if the observed biasness, favoring specific codons, were beyond specific genes, we performed an overall genome wise analysis by concatenating all the genes into one large sequence string. The rationale was to exclude factors specific for individual genes. Preference of certain synonymous codons was observed. Figure 1 depicts the overall codon usage of serine AA sequence.

Analysis tools

An in house Perl script was used to derive codon indices, gene length, GC and GC3 (the frequency of G+C at the third position); GC content was also computed using intrinsic sequences) for all the CDS. In addition, we generated a gene codon usage and genome wide usage table. Statistical analysis was conducted using R (V 2.15.0). We used a Sperman’s rank correlation to relate codon indices (gCAI, gRSCU, RSCU_Mean) with different nucleotide composition variables (i.e GC, GC3, CDS length). Multivariate regression model was used to predict the biasness. We extracted the 5% most and least bias genes according to our gCAI index. These were grouped in two categories (low and high bias). We looked for over-representation of gene ontology terms (GO) using a Perl script that compared the GO terms between the two files (selected highest or lowest biased) and all GO terms downloaded from Ensembl genome browser. Statistical significance was computed using a chi square test. In order to correct for multiple testing we used a P values threshold of 0.0001 for GO analysis. The RNA seq data was summarized across tissues. Thereafter, we computed correlation coefficients between gCAI and expression level. Lastly, we studied factors affecting gene expression using multivariate regression.
noting the two indices gCAI and gRSCU only differs in mathematical calculation with former using geometric means while the later using arithmetic mean.

**Codon usage biased and Gene Ontology terms**

We conducted a gene ontology analysis on the 5% most and least bias genes using an in-house Perl script. The significant GO terms covered all the three gene ontology domains of cellular components, biological processes and molecular functions. Notable associated GO terms are, cell surface, plasma membrane, nucleolus, nucleoplasm and nucleus showing anatomical structures. The mentioned cellular components are related to biological processes eg nucleosome assembly and molecular function eg nucleotide binding or nucleic acid binding that interacts selectively and non-covalently with any nucleic acid. The over-representation of ribosome and actin binding for translation and holding cellular matrix (mentioned above), respectively were expected in highly biased genes. The same apply for heme binding for oxygen supply in all body cells.

For the lowly biased genes, there was noted over-representation of GO terms related to immune response. For example, biological processes like defense response, defense to bacteria, virus and negative regulation of inflammatory cytokines. Notably were the over-representations of many GO terms for organs development (liver, lung, skin, skeletal muscle, and thymus) and GO terms related to many negative regulations of some detrimental molecular functions eg low response to Ultra violet light and blood coagulation.

**Determinants of gene expression traits using RNA seq data**

We further tested if expression of a gene could be related to its biasness. To do so, we analyzed RNA-seq data obtained from different tissues (brain, placenta and muscle). For simplicity we used the average expression level of each gene over the three tissues (Park et al, 2012). Our analysis reveals differential expression breadth with some genes not being expressed at all in any tissues while some are expressed in one, two or all the tissues (data not shown). There are varied expression levels of individual genes across tissues as well. The average of expression levels among the tissues reveals that the muscle, placenta and brain had the highest expression levels as shown below.

To investigate if nucleotide composition and Codon Usage Bias (CUB) affect gene expression level, we merged the expression data comprising gene identity, muscle, brain, placenta and average expression levels across tissues with the previous codon usage bias data comprising CDS length, CAI, GC content and GC3. A total of 4882 observations were analyzed. We correlated average gene expression to previously determined gCAI, RSCU_Mean, GC content,
CDS length and GC3. We report weak insignificant correlations between gene expression and gCAI ($r^2 = 0.00015$) and RSCU_M ($r^2 = 0.00012$).

However, there was significant correlation between expression level and GC content ($r^2 = 0.0559$, $p=0.0001$) and CDS Length ($r^2 = 0.1298$, $p<0.001$). Our multivariate regression analysis revealed a variation ($p < 0.001$) in genes expressiveness along the genome. The GC content ($p<0.0001$), GC3 ($p=0.0017$) and CDS length ($p=0.001$) but not gCAI and RSCU_mean were significantly affecting the gene expression levels. This supports our previous finding using correlation. However, the variation explained by these factors was merely 0.4% indicating that other factors are more important.

### DISCUSSION

We hereby present evidence suggesting that the pattern of synonymous codon choices in the Sus scrofa is as a result of a complex equilibrium between different forces, namely the natural selection at the translational level, nucleotide compositional, mutation bias, the length of each gene and other forces.

#### There exists Codon usage bias in the pig genome

We report conclusive evidence for codon usage bias in the pig genome. The CUB is evident in the nonrandom usage of synonymous codons as shown by the RSCU, RSCU’, gRSCU and gCAI. This finding is consistent with other studies involving prokaryotes (Karlin et al., 1997) and eukaryotes (Waldman et al., 2011). The observed preference of some codons could be suggestive of a weak selection force acting on codon pool in the pig genome. The observed CUB is further proved to be influenced significantly by nucleotide composition. However, in contrast to other papers (Rao et al., 2011) we report negative correlation between genomic codon adaptation index (gCAI) or CUB and the CDS length. Two other factors, the GC content or GC3s were consistent with their findings. In humans, the GC content and mutational biases were reported as major factors that influence codon usage (Karlin and Mrazek., 1996). In plants several factors like nucleotide composition of genes, the levels of gene expression and length of the coding sequence contributed to the observed codon usage bias (Sablok et al., 2011).

In B. pseudomallei genome, highly expressed genes had the highest GC content and it tended to use G or C at the third position of the codon (Hershberg and Petrov, 2010). The highly expressed genes in B. pseudomallei also had high GC content positively correlated with CAI value and GC3s. Their result purport that the highly expressed genes tend to use ‘C’ or ‘G’ at synonymous positions compared with lowly expressed genes. In this study our results points to preferred usage of both C or G and A or T at the synonyms sites as shown in table 2, with the C or G ending codons being the majority. However a negative correlation between gCAI and GC content or GC3s is unique. This may be due to the difference in the genome isochore structure, ambiguity (vary with space and time) of the gene expression in mammals, or due to difference in methodology of calculating CAI variants.

### TABLE I- THE CORRELATION BETWEEN THE GENOME COMPOSITION FACTORS AND THE SELECTED CODON INDICES

<table>
<thead>
<tr>
<th>gRSCU</th>
<th>RSCU_ Mean</th>
<th>CAI</th>
<th>GC% Content</th>
<th>CDS Length</th>
<th>GC3</th>
<th>GC3 Ratio</th>
<th>GC3 Counts</th>
<th>CODON counts</th>
</tr>
</thead>
<tbody>
<tr>
<td>RSCU</td>
<td>0.991***</td>
<td>0.725***</td>
<td>0.796***</td>
<td>-0.840***</td>
<td>0.162***</td>
<td>-0.733***</td>
<td>-0.847***</td>
<td></td>
</tr>
<tr>
<td>RSCU_Mean</td>
<td>1</td>
<td>0.705***</td>
<td>0.111***</td>
<td>-0.846***</td>
<td>0.182***</td>
<td>-0.730***</td>
<td>-0.845***</td>
<td></td>
</tr>
<tr>
<td>gCAI</td>
<td>1</td>
<td>-0.355***</td>
<td>-0.773***</td>
<td>-0.321***</td>
<td>-0.823***</td>
<td>-0.777***</td>
<td></td>
<td></td>
</tr>
<tr>
<td>GC% Content</td>
<td>1</td>
<td>0.066***</td>
<td>0.914***</td>
<td>0.367***</td>
<td>0.066***</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CDS Length</td>
<td>1</td>
<td>0.008***</td>
<td>0.931***</td>
<td>0.999***</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GC3 Ratio</td>
<td>1</td>
<td>0.338***</td>
<td>0.008***</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GC3 Counts</td>
<td>1</td>
<td>0.931***</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CODON counts</td>
<td></td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Denotes level of significance

### TABLE II- DESCRIPTIVE STATISTICS OF THE GENE EXPRESSION OF BRAIN, MUSCLE AND PLACENTA TRANSCRIPTOMES

<table>
<thead>
<tr>
<th>Tissue</th>
<th>Number</th>
<th>Mean</th>
<th>Std dev</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brain</td>
<td>71387</td>
<td>29.404</td>
<td>2103.92</td>
<td>358358</td>
</tr>
<tr>
<td>Muscle</td>
<td>71381</td>
<td>206.67</td>
<td>6212.75</td>
<td>819021</td>
</tr>
<tr>
<td>Placenta</td>
<td>71385</td>
<td>179.81</td>
<td>5541.07</td>
<td>780754</td>
</tr>
</tbody>
</table>
longer genes, and long genes should therefore have higher synonymous codon bias. In such genes, by using optimal codons, translation is faster whereby ribosomes move faster along the mRNA and are released quickly to be available to translate other mRNA (Zhao et al., 2007). The use of optimal codons increases the accuracy of translation by reducing translational errors that can occur. The errors include missense in which an incorrect amino acid is incorporated into the growing peptide chain and nonsense in which the peptide synthesis terminates prematurely (Stoletzki and Eyre-Walker, 2007). It is believed that both missense and nonsense errors that produce non- and misfunctional proteins respectively, are costly to the cell because they consume amino acids and energy both in their production and during breakdown (Stoletzki and Eyre-Walker, 2007). Besides, missense errors may have other serious consequences, for example, a missense error in a DNA polymerase may temporarily increase the mutation rate (Ninio, 1991). The phenomenon of rare use of tyrosine codons could be due to its chemical properties, a feature that may be shared with Tryptophan.

Pig genome just like other mammals is found to vary greatly in base composition between different genomic regions (Rao et al., 2011). In vertebrates, such as mammalian and birds, one of the most striking features of their genomes is the difference in G+C contents isolated regions called isochore structures (Costantini and Bernardi, 2008). In pig there exists heterogeneity in G+C content that results in variation in codon usage bias as was revealed elsewhere (Hershberg and Petrov, 2010). Having a relatively high GC content, we expected the pig preferred codons to mirror the genome composition. GC rich organisms tend to have GC rich optimal codons, while AT rich organisms tend to have AT rich optimal codons (Qiu et al., 2011). This observation is manifested in RSCU as most preferred codons end with G or C albeit with some ending with A or T. This phenomenon is dependent on the isochore structure of the pig genome that we confirmed by observed variation in GC content. The data analyzed provide evidence for the mutational bias hypothesis. In our view the codon bias is skewed towards the AT ending codons as was revealed by inverse correlation between gCAI and GC3s. Indeed, AT rich genes were shorter in length and could imply efficient protein translation to minimize energy consumption. We also suspect that other factors besides mutation bias may have contributed to codon usage. Amongst the other factors, we hypothesize that selection for preferred codons is affected by the abundance of tRNA in the cells or the ones that bind those tRNAs with optimal binding strength (Ikemura, 1985, Kanaya et al., 2001). We could not confirm this due to lack of information on tRNA availability. However, this hypothesis has been proven in other organisms like E. coli, B. subtilis and C. cerevisiae. Here cellular tRNAs correlates positively and closely to tRNA gene copy numbers, by extension this suggests that in these species there is correlation between optimal codon use and tRNAs abundance. However such correlation was not found in studies involving D. melanogaster and humans (Kanaya et al., 2001).

The positive correlation observed between GC content, GC3 and gene length explains the computed low codon bias. This is because long genes tend to have more G and C, abundant G or C at the third codons which are negatively related to gCAI. The nucleotide composition factors only play significant but minor roles in shaping the codon usage in the pig genome as revealed in low R2 value and statistical interpretation exhibited in multivariate regression analysis. These statistical inferences are clear indication that the pig genome is so complex and molecular functions are controlled by several factors.

GO terms are associated with codon usage biased
GO terms, such as phosphorylation involved in gene regulation mechanisms were found significantly enriched in highly biased genes. Enriched GO terms are also found to be associated with major functions such as transcription, trans-membrane transport of the transcript from nucleus to cytosol, ribosome manufacture etc. Other major term such as actin binding play a central role in many eukaryotic cells basic metabolism. It compliments cytoskeleton to shape the cells, acts in cell division, motility, contraction, adhesion, phagocytosis, protein sorting, DNA repair and signal transduction (Uribe and Jay, 2009). Many studies have established the presence of actin in the nucleus and cytoplasm and have shown that its functions are as diverse in both cell components. Possible roles for nuclear actin include contribution to the organization of chromatin remodeling complexes, RNA processing, or regulation of DNAse I function (Olave et al., 2002). In addition, actin plays a direct role in transcription by RNA polymerases I, II and III (Percipalle and Visa, 2006). All these functions are important for day to day physiological functions of the cell and may be termed housekeeping. The observed low codon biased in immune genes and olfactory receptors was expected. This could be because these genes are less conserved and need to evolve fast to adapt to ever changing antigenic determinants and artificially created environment for immune and olfactory receptor genes, respectively.

CDS length, GC and GC3 but not gCAI are the determinants of gene expression using RNA seq data
RNA-seq has been used in transcriptome profiling and has altered the view of the extent and complexity of eukaryotic transcriptomes (Wang et al., 2009). Understanding the transcriptosome is essential for interpreting the functional elements of the genome and revealing the molecular constituents of the cells and tissues as well as understanding development and diseases. In this study we ascertained the expression traits and genomic traits determining the level of transcriptomics in the porcine genome. In consistency with other studies (Park et al., 2012), we confirm the differential gene expression levels and breadths among the three sampled tissues. This depicts the complexity and differing expression levels of each transcript under different environments (tissues). The difference in expression traits may show each tissue is under difference genetic programming. The relevancy of such genetic difference and transcriptome variability is a subject of debate. The realization of GC and GC3 as the significant factors affecting gene expression levels is not unique in to study. Park et al (2012) reported the same parameters are major determinants of gene expression in human and mouse RNA-seq data. In this study our analysis show that CDS length, GC and GC3 weakly affects gene expression levels suggesting that other factors may be involved. This conforms to a report published elsewhere considering some
genomic traits as predictors of gene expression (Konu and Li, 2002). The measure of codon usage bias (genomic codon adaptation index) is not significantly affecting gene expression levels in this study. This contradicts the study by Park et al (2012) who reported CAI as a determinant to gene expression level. We speculate the contradictory results could be due to no real correlation between the two and averaging a cross tissues may create too much noise. The noise may be as a result of variation in expression with time and space (development stage and tissue microenvironment). Thus such hypothesis requires a very carefully designed experiment.

**CONCLUSION**

We confirm the existence of codon usage bias in the porcine genome suggesting there is weak selection of preferred codons for translation accuracy. The codon usage bias is influenced subtle by nucleotide composition factors among others. We noted that highly biased genes are mainly housekeeping genes. We did not prove significant correlation between gene expression and codon usage bias indices. The transcriptome analysis showed variation in expression breadth and level among brain, placenta and muscle.

**REFERENCES**


[19] Sablok, G et al., (2011). Bioinformatic analysis of fruit-specific expressed sequence tag libraries of &lt;i&gt; Diospyros kaki &lt;/i&gt; Thunb.: view at the transcriptome at different developmental stages. 3 Biotech, 1, 35-45.


ABSTRACT
Genetic improvement in the last few decades has led to substantial increase in milk yields per cow. Nutrition of the lactating cow affects the milk yield. Proper feeding management of the dairy herd improves the economy of production and provides for a healthier cow. Lactation curves of individual cows were studied at KARI Lanet beef research centre to help identify feeding management problems within the dairy herd. Fixed effects of year and season were considered for available pastures, and analyzed using the General Linear Model. There were differences in seasonal milk yield. The rainy season (April-Aug, and October-December) recorded high milk yields averaging 10L/cow/day, while dry months (January-March) recorded lowest milk yields (5L/cow/day). The lactation curve in this study showed peak yield between 6 and 8 weeks after calving. This curve was successfully used to detect variation in milk yield, poor persistence. The nutritive value of feeds used in this study varied significantly with season, being of high quality during rainy season as opposed to dry season. Therefore this calls for an intervention strategy during dry season and during early lactation to mitigate the impact of negative energy balance. Further research is needed to validate the shape of the lactation.

Key words: feed components, lactation curve, dairy cow, and persistency.

INTRODUCTION
Milk production starts at a relatively high rate immediately after calving and the amount continues to increase steadily. The increase in milk yield in early lactation may be attributed to an increase in the secretion rate per cell which is partially associated with increased nutrients flow through the mammary gland (Dijkstra et al., 1997).

Typical lactation curves of dairy cows show a peak yield between 6-8 weeks after calving, followed by a decrease in milk yield (rate of persistence) until the cow is dried-off or lactation is naturally terminated (Olori et al., 1999). The decline in milk yield after peak production is associated with a die-off of secretory cells as well as hormonal changes among other factors. Milk yield and reproductive efficiency are critical to profitable dairying (Ali, and Schaeffer, 1987). Although genetic improvement in the last two decades has led to substantial increase in milk yield per cow, fertility and reproductive health have declined (Dematawawa and Berger, 1998). A sustainable feeding regime throughout the year and a deliberate feeding intervention strategy during early lactation and during the dry season is important to mitigate the impact of negative energy balance on peak milk production (Roche et al., 2006).

In a pasture-based dairy system, a 365- day calving interval is crucial for optimum profit. Hence, the need to increase milk yield by improving persistency of lactation rather than peak lactation which puts increased stress on the cows at the time when they should be rebreeding (Garcia, and Holmes, 2001). Peak milk yield and persistency can be used to monitor milk production performance of lactating dairy cows. Milk yield from individual cow fluctuates up and down from one milking to the next due to various factors (Wood, 1967; Guo, and Swalve, 1995). Peak yield, persistency and lactation length are the key components of the lactation profile (Beever, et al., 1999). The shape of the lactation curve provides valuable information about the biological and economic efficiency of the animal or herd, and is useful for health monitoring, feed management and planning purposes (Sherchand et al., 1995). A cow’s calving season and nutrition affect the shape of her lactation curve (Tozer and Huffaker, 1999, Roche et al., 2006 and Wilmink, 1987). Lactation curves can be used to diagnose problems and to identify opportunities for increased production (Ferguson, and Boston, 1993). The objective of this study was therefore to use lactation curve to diagnose management problems. This study aimed at the use of the lactation curve to diagnose management problems and to identify opportunities for increased milk production.

MATERIALS AND METHOD
Study site
The study was carried out at KARI Lanet Beef research centre. The research centre lies at 1920 M above sea level; within ecological zone 3 and 4; (quote) with a bimodal rainfall pattern-(April to August (long rains) and October to December-(short rains)) with an annual mean of 800 mm; and a temperature range of 10 0 C to 260 C.

Sampling
One hundred lactations for Friesian cows were used in this study. Milking was done by hand into milk jars and a record for each lactating cow for each day was taken using a weighing balance for the whole lactation period- Pasture samples were analyzed using general linear models of SAS and the means were separated using studentised keul test. The nutritive quality of the pastures. Restricted quantities of 1kg/cow of a supplement, E 1291 grain Sorghum, was fed in communal /shared feeding troughs to groups of cows whenever a deficit in pasture availability was experienced. Samples of pastures and the supplement were analyzed by proximate analysis for dry matter (DM), crude protein (CP), neutral detergent fibre (NDF), Acid detergent fiber (ADF) and Acid detergent lignin (ADL).

Data Collection and analysis
Average daily milk production, lactation lengths, and feed composition data were collected and analyzed using general linear models of SAS and the means were separated using studentised keul test. Majority of cows (80%) were in lactation for 8 months but 20% lactated for 11 months. Average daily milk production 10l/cow/day during wet season whereas it was
5 L/cow/day during dry season. Lactation curve showed a steady rise peaking at 2 months and then an abrupt decline up to the end of lactation (Fig.1). This differed with the earlier findings (Garcia, S.C and Holmes C.W; 2001; Jenkins, T.G; and Ferrel, C.L; 1984). Their herd had an average daily production at 40 L/cow/day. The reason for the difference could be due to different feeds used. They used maize and grass silage whereas in the current study, this study used mixed ley of oats grass (Themeda triandra), Kikuyu grass (Pennisetum clandestenum), Rhodes grass (chloris gayana) and Star grass (Cynodon dactylon). Additives used in the silage making could have affected the chemical composition of the feeds and hence the difference. The most remarkable observation in our study was the irregularity of the milk yield persistency. This could be due to a nutritional deficiency most probably energy and/or protein which have direct influence on milk synthesis.

**CONCLUSION**

Poor persistency of lactation curves observed in this study could be attributed to nutritional factors particularly energy and protein. However the effects of non-nutritional factors such as parity, diseases and heredity were not investigated in this study. Lactation curves can be used as management tool to monitor the nutritional status of lactating dairy cows.

**RECOMMENDATION**

• Feed conservation and dry season feeding regime is recommended to avoid milk yield variations
• Supplementing lactating dairy cows with feed concentrate is recommended.

**FURTHER WORK**

Designed experiment to validate the use of lactation curves as management tool is necessary.

**ACKNOWLEDGEMENT**

The authors would like to thank the centre director KARI Lanet for facilitating the study, the dairy section staff and particularly P.Gachanja and S.Mayavi for assisting in keeping good records. Also many thanks go to the Nutritional Laboratory technicians for the forage analyses.

**REFERENCES**


“Framing the issues, challenges and opportunities in livestock sector in the 21st century”
THE POTENTIAL OF BRACHIARIA HYBRID CV. MULATO 1 AS A FEED RESOURCE IN SMALLHOLDER DAIRY SYSTEMS

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ABSTRACT
The productivity of smallholder crop-livestock production systems in Uganda is threatened by adverse effects of climate change; with severe consequences on livestock feeds, milk yield and household income. A study was conducted in Masaka district of Uganda to promote utilisation of drought tolerant forages as coping mechanisms against climate change shocks, especially in the smallholder dairy production systems. Three drought tolerant forage species were randomly assigned to 24 smallholder farms in a Randomised Complete Block Design: (1) Pennisetum purpureum (Napier grass) and Centrosema pubecens intercrop; (2) Brachiaria Hybrid cv. Mulato 1 and Clitoria ternatea intercrop (Brachiaria) and (3) Napier grass monocrop as a control. One ton/ha/year of composted cattle manure was applied to treatments 1, 2 and 3. Data was collected on fodder yield and analysed using Statistical Analytical Systems (2001) statistical package. Beneficiaries (n=20) of the interventions and non-beneficiaries (n=20) were purposively selected and data collected on household characteristics, land size, feed and household resources, intervention performance and efficiency gains. Comparisons of dairy performance variables between beneficiaries and non-beneficiaries were done using cross tabulations and F tests. Intercropping Napier grass with Centrosema pubecens significantly improved (p<0.05) fodder yield (17,790 +331.2 kg DM/ha) and number of feeding days (207.2+26.9 days) when compared to Napier grass monocrop (10,354+392.6 kg/ha; 94.3+11.3 days, respectively). Introducing 0.5 ha of a mixture of Brachiaria and Clitoria ternatea on farms previously dependent on 0.5 ha of P. purpureum and Centrosema pubecens mixture provided year round feed supply to dairy cattle. Drought tolerant forages increased fodder availability (76%), milk yield (78.7%) and cash incomes (52.4%). In conclusion supplementing Napier grass and forage legume mixture with Brachiaria and forage legume mixtures by 0.5 ha on farm elevate household production levels and lead to economic returns of US$ 676.9 cow/ year.

Key words: drought tolerant forages; forage legumes; intercropping,

INTRODUCTION
Smallholder dairy farming systems dominate in rural Eastern and Central African (ECA) region, employ over 70% of the region’s population and contribute 70-90% of the total meat and milk output in the region (Njauru et. al., 2012). Small-scale dairy production plays a crucial role in food security, human health and overall household livelihoods particularly among climate change prone resource poor households in the region. Zero grazing dairy systems are increasingly promoted owing to progressive grazing land shortages and intensive production dairy requirements. Women are immense contributors to and beneficiaries from smallholder dairy production systems (Njauru et al., 2012), which unfortunately, are progressively being devastated by rapid climate change and its attendant extreme weather conditions. Among the most affected are rural household livestock feeds. The lack of effective adaptation to the adverse effects of climate change is likely to jeopardise the achievement of Millennium Development Goals 1 (eradicating extreme poverty and hunger), 7 (ensuring environmental sustainability) and 3 (promoting gender equality and empowering women).

Napier grass (Pennisetum purpureum) is the major forage in zero-grazing production systems in Masaka district (Kabirizi, 2006). However, the grass is constrained by long droughts, poor agronomic practices, pests and diseases such as Napier stunt disease resulting into a reduction in fodder yield of up to 100% during the dry season. Brachiaria Hybrid cv. Mulato 1 (Brachiaria) has high biomass yield and tolerates long drought and poor soils (CIAT, 2001) and could be used to supplement Napier grass. The commonest and cross-cutting forage legumes include Centrosema pubescens (Centro) and Clitoria ternatea (Clitoria). It is generally recommended, however, that forages are grown in grass-legume mixtures in order not only to ensure calorie-protein balance for livestock, but also harness atmospheric nitrogen (N) for the production systems by the legume component (Kabirizi, 2006; Thomas, 1995). A study was thus designed to develop economically feasible strategies for year-round feed supply to dairy cattle in order to improve year-round feed resource availability, milk yield and household income.

MATERIALS AND METHODS
Description of the study site
Masaka lies between 0° 15’ and 0° 43’ South of the equator and between 31° and 32° East longitude, having an average altitude of 1,150m above sea level. The annual average rainfall is 800-1,000 mm with 100-120 rainy days, in two seasons. Mean temperature ranges between 16°C and 30°C, while relative humidity is 62.1%. The district is typically dependent on crop-livestock systems, with vegetable production as a key income earner.

Effect of integrating drought tolerant forages in smallholder dairy systems on fodder availability
The study targeted dairy zero-grazing farmers with 1-2 cows and having at least 2 ha of land. The treatments involved mixtures of grass species (Brachiaria or Napier) with forage legumes (Clitoria ternatea or Centrosema pubescens) (Figure 1). The forages were established on 24 households using methods described in Kabirizi (2006) and CIAT (2001). The forage banks were compared with
Farmers participated in all stages of project implementation to ensure instantaneous uptake of emerging knowledge and practices.

**Beneficiary assessment of drought tolerant forages**

A beneficiary assessment study was conducted to determine the socio-economic benefits of integrating drought tolerant forages in smallholder crop-livestock systems. Beneficiaries (n=20) of the interventions and non-beneficiaries (n=20) were purposively selected with equal number of women and men. Three data collection approaches namely Systematic Client Consultations based on semi-formal beneficiary assessment case studies, objective data verification by direct observation and Community group discussions were used. Data associated with costs of inputs and returns from milk (including home consumed) were recorded for profitability evaluation using partial budgeting. Data was analysed using Statistical Packages for Social Sciences package (SPSS, 2002).

### RESULTS, DISCUSSION AND CONCLUSION

#### Drought tolerant forages and fodder availability

Intercropping forage legumes with Napier grass increased fodder availability by 50%, crude protein (CP) content by about 16.7% and feeding period (number of days a cow was able to feed on fodder from a given area of land) by about 30% (Table I). Additional fodder obtained from establishing 0.5ha of *Brachiaria* and *Clitoria ternate* mixture on the same farms containing Napier grass and Centro mixture was able to sustain a crossbred dairy cow (470+27kg live weight) throughout the year. Higher total fodder yields and CP content in intercrops (Table I) could be attributed to the presence of forage legumes that improved growth of the grass. The forage legumes acted as a cover crop to control weeds and conserve soil moisture during the dry periods, apart from the possibility of augmenting Nitrogen (N) supplies to the grass component through symbiotic N fixation (Thomas, 1995). This study results revealed that the currently recommended acreage of 0.5 ha of a mixture of Napier grass and forage legumes (Samanya, 1996) cannot sustain an economically producing dairy cow and its calf for a full year. Additional establishment of 0.5 ha of a mixture of Brachiaria and forage legumes is recommended during the dry season when production of Napier grass monocrop is disadvantaged due to drought, poor agronomic practices and diseases such as Napier stunt disease (Kabirizi, 2006).

#### Socio-economic benefits of introduced forages

There were no significant (P>0.05) differences in land size and number of cattle kept between the beneficiaries and non-beneficiaries of the interventions (Table II). Introduction of Brachiaria in smallholder dairy systems depending on Napier grass fodder significantly (p<0.05) improved milk yield and household income by 79.7 and 52.4%, respectively. Area under forage production, quantity of feed offered to the animals and milk yield increased by about 134, 76 and 80%, respectively. Farmers were able to harvest about 56 kg/ cow/day of fresh fodder. In conclusion supplementing the Napier grass and forage legume mixture with *Brachiaria* and forage legume mixtures by 0.5 ha
on farm elevate household production levels and lead to economic returns of US$ 676.9 cow/year (Table II).

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references

Table I - Forage Availability and Feeding Period of Different Forage Banks

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Napier grass and <em>Centro</em>&lt;i&gt;e*&lt;i&gt;a&lt;/i&gt; <em>pubescens</em> mixture</th>
<th><em>Brachiaria</em> and <em>Clitoria</em> <em>ternatea</em> mixture</th>
<th>Napier grass monocrop</th>
<th>SEM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean Dry matter yield (kg/ha)</td>
<td>15,790</td>
<td>12,119</td>
<td>10,354</td>
<td>307</td>
</tr>
<tr>
<td>Feeding period (days) from 0.5 ha</td>
<td>254.6</td>
<td>195.5</td>
<td>167.0</td>
<td>20.9</td>
</tr>
<tr>
<td>Crude protein content (%)</td>
<td>8.4</td>
<td>12.1</td>
<td>7.0</td>
<td>0.14</td>
</tr>
</tbody>
</table>

Table II - Socio-economic Benefits of Introduced Forages

<table>
<thead>
<tr>
<th>Household characteristics</th>
<th>Beneficiaries (n=20)</th>
<th>Non-beneficiaries (n=20)</th>
<th>F-test</th>
<th>IA</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
<td>SD</td>
</tr>
<tr>
<td>Land size (ha)</td>
<td>1.7</td>
<td>1.2</td>
<td>1.6</td>
<td>0.9</td>
</tr>
<tr>
<td>Cattle (number)</td>
<td>1.5</td>
<td>0.5</td>
<td>1.3</td>
<td>0.7</td>
</tr>
<tr>
<td>Fodder area (ha)</td>
<td>1.1</td>
<td>0.3</td>
<td>0.5</td>
<td>0.3</td>
</tr>
<tr>
<td>Feed offered cow/day(fresh)</td>
<td>55.4</td>
<td>12.3</td>
<td>31.4</td>
<td>7.2</td>
</tr>
<tr>
<td>Milk yield (L/day)</td>
<td>10.6</td>
<td>7.2</td>
<td>5.9</td>
<td>3.1</td>
</tr>
<tr>
<td>Revenue (US $) from milk yield cow/year</td>
<td>676.9</td>
<td>48.2</td>
<td>444</td>
<td>64.1</td>
</tr>
</tbody>
</table>

*** = significant at 1%, ** = significant at 5%; NS = not significant SD: Standard deviation; IA: Intervention advantage

"Framing the issues, challenges and opportunities in livestock sector in the 21st century"
NUTRIENT INTAKE, MILK YIELD AND COMPOSITION IN DAIRY GOATS FED ON THREE FORAGE SWEET POTATO CULTIVARS

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ABSTRACT
Globally the goat is an important supplier of milk and meat for processing or family consumption. The requirement is growing primarily due to increase in world population, increased consumer interest in products made from goat milk and demand from people with allergies to cow milk and other gastrointestinal diseases. However, production is limited by high feeds cost and their seasonal distribution. It is, therefore, imperative to evaluate various forages to provide adequate nutrition to dairy goats at economical cost. The objective of the current study was to evaluate three forage sweet potato cultivars on their effects on nutrient intake, milk yield and milk composition in dairy goats. Six lactating dairy goats were fed on cultivars K158, Marooko and Wagabolige for three successive 30-day periods in a 3 x 3 Latin square design. Results of feed intake, milk yield and composition were reported for days 21 to 27 of each period. The DM and OM intake was not affected by the cultivar but CP, NDF, ADF, ADL and ME were affected. The goats on Marooko and Wagabolige ingested similar CP, ADF and ME and. CP ingested on Marooko and Wagabolige was higher than in K158. The cultivars differed in ADL ingested with K158 and Wagabolige recording the lowest and highest ADL respectively. Cultivars influenced digestibility of CP and NDF but did not affect DM, OM and ADF digestibility. Marooko recorded the highest CP digestibility while Wagabolige recorded the highest NDF digestibility. The milk yield and composition were affected by the cultivars. The goats on Marooko and Wagabolige recorded milk with similar butter fat that was lower than in goats fed K158. Goats on K158 and Wagabolige recorded similar quantities of protein, lactose solids-non-fat and freezing point depression that were higher than in Marooko. The goats fed on the three cultivars produced milk that differed in total solids. The three cultivars were ranked in their ability to induce increased milk in descending order as K158, Marooko and Wagabolige respectively and in improving milk quality in goats K158 was ranked highest, followed by Wagabolige and Marooko was third.

INTRODUCTION
Goat milk and its products are alternatives to cow milk. Milk production and composition in goats are affected by many factors including diet, breed and stage of lactation (Sampeleyo et al., 1998; Oprean et al., 2011). The type and amount of feed affects milk fat, lactose, protein, total solids and fatty acids. Intensive grazing and concentrate supplementation has been reported to increased milk fat, lactose, protein and total solids (Sampeleyo et al., 1998; Park et al., 2007; Oprean et al., 2011). Mioc et al., (2008) reported that Saanen goats had a longer lactation and higher daily milk yield compared to Alpine goats. The Alpine goats produced milk containing higher butterfat than Saanen but both breeds produced milk containing similar lactose and protein. Mmbengwa et al., (2008) reported that Boer goats produced more milk than Nguni goats and they differed in milk composition. Garcia-Peniche et al., (2012) showed differences in milk yield and composition among six breeds of dairy goats (Alpine, LaManchas, Nubians, Oberhasli, Toggenburgs and Saanens) with Saanens producing most milk and protein, Nubians with highest butterfat and lowest milk yield, Oberhasli produced lowest fat and protein. Goat milk fat, lactose, protein, total solids and total fatty acids are high at the beginning and the end of lactation and they are lowest in mid-lactation (Mioc et al., 2008; Oprean et al., 2011).

Globally the goat is an important supplier of milk and meat for processing or family consumption. The requirement is growing primarily due to increase in world population (Mioc et al., 2008; Strzalkowska et al., 2009). The other main reason for increased demand for goat milk is increased consumer interest in products made from goat milk. Furthermore increased demand for goat milk has also been reported in people with allergies to cow milk and other gastrointestinal diseases. Additionally, the goats are able to exploit land which cannot be used for other activities (Mmbengwa et al., 2008). However, large scale industrialization of dairy goat sector is limited by low volume and seasonal cyclic milk production (Park et al., 2007; Strzalkowska et al., 2009). Another limitation is the high cost of feeds and their seasonal distribution. It is, therefore, imperative to evaluate various forages to provide adequate nutrition to dairy goats at economical cost.

Forage sweet potato cultivars have been identified as protein rich forages (PRF) thus classifying them in the same category as leguminous forages (Etela et al., 2008). Nutritious and high yielding forage sweet potato cultivars need to be identified and evaluated and the superior cultivars widely popularized among livestock farmers. Selection studies identified some superior cultivars on the basis of their forage characteristics, fast regeneration after harvest, ability to smoother weeds and tolerance to diseases and moisture stress (Ondabu et al., 2007). Hence potential exists in Kenya to utilize forage sweet potato cultivars as a cheap protein source to improve livestock performance either as sole feed or as a protein supplement to poor quality roughages such as crop residues. Unfortunately, new forage cultivars have not been adequately studied in
Eastern Africa (Ondabu et al., 2007; Andrade et al., 2009). These knowledge gaps not withstanding some of these fodder cultivars are already being used by some livestock farmers in the field. There is, therefore, an urgent need to provide objective data on nutrient intake and goat performance when fed on newly identified forage sweet potato cultivars with a view of exploiting the existing potential to utilize these cultivars as livestock feed.

The objective of the current study was therefore to determine the nutrient intake, milk yield and milk composition of dairy goats fed on three superior forage sweet potato cultivars with a view of selecting the best cultivar.

MATERIALS AND METHODS

Study site
The study was conducted at the Kenya Agricultural Research Institute (KARI) at Lanet located in the outskirts of Nakuru town, Nakuru County, Kenya, 160 km North-west of Nairobi. The site is 0° 18’ S, 36° 09’ E and 1920 m above sea level. The area receives bimodal rainfall with the highest amount of 134 and 100 mm received in the long rains of April and August respectively followed by short rains in October and November with about 52 and 51 mm respectively (Jaetzold, 2006). Hence, the area receives on average 800 mm rainfall annually with a relative humidity of 83%. The mean maximum and minimum temperatures are 260C and 100C, respectively. The soils are classified as humic nitosols (Jaetzold, 2006). The study site falls within the classified of agro-ecological (AEZ) IV.

Experimental dairy goats, feeding procedures and experimental design
Six lactating dairy goats (Kenya Dual Purpose Goat, KDPG) at their eighth week of lactation were selected from a large herd for this study. The goats were de-wormed before the start of the experiment and then they were allocated to individual pens at random. They were henceforth fed on the three superior cultivars, in terms of crude protein yielding, for three successive 30-day periods in 3 x 3 Latin square design. The cultivars, K158, Marooko and Wagabolige, were grown and harvested at the optimum maturity of 120 days. These cultivars were harvested daily, chopped to 2.5 cm length and offered at 0900 hr daily to dairy goats in individual troughs. An allowance 15% above the previous day’s intake was offered to cater for unanticipated increased feed intake. Samples from each batch of forage sweet potato cultivar fed were collected between days 21 to 27 of each period and bulked. The refusals from previous day’s feed were weighed and recorded to determine feed intake (Schneider and Flatt, 1975). Water and mineral licks were on offer at all times. The dairy goats were milked twice daily, milk yield recorded and milk composition measured on two successive milkings. Results of feed intake, milk yield and composition was reported for days 21 to 27 of each period.

Chemical analyses and statistical analyses
The samples of the feed offered and refusals were collected, dried at 700C for 24 hours, ground through 1 mm sieve and stored in plastic containers for chemical analysis (AOAC, 1998). Dry matter was determined according to AOAC, (1998) and used to estimate feed intake. The fibre in form of NDF, ADF and ADL of the samples were analysed according to Van Soest et al., (1991). Milk composition was determined using MilkoScan Type 78110, FOSS Analytical A/S, Denmark.

The data obtained on dairy goats’ feed intake, milk yield and composition in the three forage sweet potato cultivars was subjected to analysis of variance for a completely randomized design (CRD) using general linear model (GLM) of SAS (2003). The separation of their respective means was done using least significant difference procedures.

The following statistical model was used:

\[ Y_{ij} = \mu + \tau_i + \epsilon_{ijk} \]

Where \( Y_{ij} \) = Estimated feed intake, milk yield and composition
\( \mu \) = Overall mean feed intake, milk yield and composition
\( \tau \) = Treatment (forage cultivar) effect on feed intake, milk yield and composition
\( \epsilon_{ijk} \) = Residual treatment effect on intake, milk yield and composition

RESULTS

Nutrient composition and nutrient intake
The forage sweet potato cultivar K158 contained the highest DM, OM, NDF, ADF and ME while Marooko and Wagabolige contained the highest CP and ADL respectively (Table: I). The results on nutrient intake are shown in Table: II. The DM, OM and ME intake (g per kg W0.75) by goats was not affected (P>0.01) by the forage sweet potato cultivar but CP, NDF, ADF and ADL were affected (P<0.01). The goats fed on Marooko and Wagabolige ingested similar quantity (P>0.05) of CP and ADF. However, CP ingested by goats fed on Marooko and Wagabolige was higher (P<0.05) than CP intake in K158. The ADF intake by goats fed on K158 was higher than in Marooko and Wagabolige. The NDF intake by goats fed on K158 and Wagabolige was similar (P>0.05) but higher than the NDF intake in Marooko. All the three cultivars differed (P<0.05) in the amount of ADL ingested by goats with K158 and Wagabolige recording the lowest and highest ADL intake respectively.

Nutrient digestibility and digestible nutrient intake
The results on nutrient digestibility are shown in Table: III. Forage sweet potato cultivar influenced (P<0.01) the digestibility of CP and NDF but did not affect (P>0.01) DM, OM and ADF digestibility in goats. The CP and NDF digestibility differed (P<0.05) among cultivars K158, Marooko and Wagabolige. Marooko recorded the highest (P<0.05) CP digestibility and the lowest (P<0.05) NDF
digestibility in the goats. Wagabolige recorded the highest (P<0.05) NDF digestibility and the lowest (P<0.05) CP digestibility.

The digestible DM and OM intake (g per kg W0.75) in goats were not affected (P>0.01) by the forage sweet potato cultivar but the digestible nutrient intake of CP, NDF and ADF were affected (P<0.01) (Table: IV). Goats fed on K158 and Wagabolige ingested similar (P>0.05) quantity of digestible CP and digestible NDF. Goats fed on Marooko recorded the highest (P<0.05) digestible CP intake and the lowest (P<0.05) digestible NDF intake. Marooko and Wagabolige recorded similar (P>0.05) digestible ADF intake that was lower than (P<0.05) in goats fed on K158.

**Milk yield and composition**

The milk yield and composition were affected (P<0.01) by the cultivar of sweet potato (Table: V). The amount of milk recorded in descending order (P<0.05) was in K158, Marooko and Wagabolige respectively. The goats fed on Marooko and Wagabolige recorded milk containing similar amount (P>0.05) of butter fat that was lower than (P<0.05) in goats fed K158. The goats fed on the three cultivars produced milk that differed (P<0.05) in total solids. The goats fed on K158 recorded the highest total solids and those fed on Marooko recorded the lowest.

**DISCUSSION**

**Nutrient composition**

The three sweet potato cultivars were nutritionally high quality forages. They had more than 80g CP per kg DM below which forages are defined as low quality (Leng, 1990) and did not affect microbial activity. The NDF likewise was below 600g per kg DM usually considered as the threshold (Meisser, *et al*; 1991). The low NDF was consistent with the general observation of lower NDF in non-grass forages (Minson, 1990). The three cultivars had adequate fibre, determined as NDF and defined as total cell wall content which is essential for rumination, saliva flow, rumen buffering and health of the rumen wall (Fox *et al*; 1992). Furthermore, the high OM and energy enabled the goats to obtain adequate ME required incorporating ammonia and degradable protein into microbial protein (Preston and Leng, 1987, Muia, 2000).

**Nutrient intake and digestibility**

The similarity in DM and OM intake by goats fed different forage sweet potato cultivars is in accordance with Sampelayo (1998). The goats ingested similar quantity of DM and OM irrespective of the cultivar fed. The goats recorded in Marooko and Wagabolige also were similar (P>0.05) but the freezing point depression in Marooko was lower (P<0.05) than in K158. The goats fed on the three cultivars produced milk that differed (P<0.05) in total solids. The goats fed on K158 recorded the highest total solids and those fed on Marooko recorded the lowest.
fed on Marooko tended to record lower fibre intake, while those on K158 had higher intake. This tendency can be explained by the relatively higher fibre in K158 compared to Marooko (Sampelayo, 1998). The lower CP and ADF intake in K158 may be due to their relatively lower content in this cultivar.

The high nutrient digestibility showed that the three cultivars provided adequate diet to goats. For example, OM digestibility was above 500 to 600 g/kg DM range where most tropical grasses fall (Minson, 1990; Muia, 2000). The OM digestibility compared favourably with 678 to 831 g/kg DM recorded by Snijders et al., (1992) on forage sweet potato cultivars. Likewise, CP and NDF digestibility were higher than 585 to 669 and 585 to 608 g/kg DM respectively obtained by Muia (2000) with sheep fed Napier grass.

The trend in CP digestibility in Marooko and Wagabolige was in agreement with the findings of Minson (1990) who showed that nutrient digestibility rose with increased metabolizable energy. The author also showed that the nutrient digestibility was positively correlated with OM digestibility which in turn was related to the energy available in the forage. The OM digestibility varied with the proportion of cell contents and cell wall. The cell contents are highly digestible while the digestion of cell wall constituents depends on the degree of lignifications, the activity of rumen microbes and the time forage is retained in the rumen (Minson, 1990). The cellular structure and the inherent attributes of NDF and CP of the four sweet potato cultivars were relatively similar (Hagerman et al., 1992). The protein digestability and available energy seemed sufficient for ammonia incorporation into microbial protein (Preston and Leng, 1987).

### TABLE III- NUTRIENT DIGESTIBILITY BY GOATS FED THREE FORAGE SWEET POTATO CULTIVARS

<table>
<thead>
<tr>
<th>Nutrient intake</th>
<th>K158</th>
<th>Marooko</th>
<th>Wagabolige</th>
<th>LSD</th>
<th>SEM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry matter</td>
<td>744.3</td>
<td>742.8</td>
<td>742.5</td>
<td>3.4</td>
<td>0.9</td>
</tr>
<tr>
<td>Organic matter</td>
<td>757.3</td>
<td>756.3</td>
<td>756.0</td>
<td>4.3</td>
<td>1.1</td>
</tr>
<tr>
<td>Crude protein</td>
<td>782.9b</td>
<td>826.1c</td>
<td>750.0a</td>
<td>6.8</td>
<td>1.7</td>
</tr>
<tr>
<td>Neutral detergent fibre</td>
<td>660.9b</td>
<td>627.4a</td>
<td>682.2c</td>
<td>5.8</td>
<td>1.4</td>
</tr>
<tr>
<td>Acid detergent fibre</td>
<td>487.4</td>
<td>487.8</td>
<td>483.2</td>
<td>5.4</td>
<td>1.3</td>
</tr>
</tbody>
</table>

ab: Means within a row with different superscript are different (P<0.05)

### TABLE IV-DIGESTIBLE NUTRIENT INTAKE BY GOATS FED THREE FORAGE SWEET POTATO CULTIVARS

<table>
<thead>
<tr>
<th>Nutrient intake (g / kg W0.75)</th>
<th>K158</th>
<th>Marooko</th>
<th>Wagabolige</th>
<th>LSD</th>
<th>SEM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry matter</td>
<td>86.5</td>
<td>84.3</td>
<td>84.2</td>
<td>2.9</td>
<td>0.7</td>
</tr>
<tr>
<td>Organic matter</td>
<td>75.8</td>
<td>74.9</td>
<td>74.5</td>
<td>2.4</td>
<td>0.6</td>
</tr>
<tr>
<td>Crude protein</td>
<td>13.8a</td>
<td>16.1b</td>
<td>14.2a</td>
<td>0.6</td>
<td>0.2</td>
</tr>
<tr>
<td>Neutral detergent fibre</td>
<td>30.2b</td>
<td>27.4a</td>
<td>30.8b</td>
<td>0.9</td>
<td>0.3</td>
</tr>
<tr>
<td>Acid detergent fibre</td>
<td>16.4b</td>
<td>15.6a</td>
<td>15.6a</td>
<td>0.5</td>
<td>0.1</td>
</tr>
</tbody>
</table>

ab: Means within a row with different superscript are different (P<0.05)

### TABLE V -MILK YIELD AND COMPOSITION BY GOATS FED THREE FORAGE SWEET POTATO CULTIVARS

<table>
<thead>
<tr>
<th>Component</th>
<th>K158</th>
<th>Marooko</th>
<th>Wagabolige</th>
<th>LSD</th>
<th>SEM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Milk yield (g)</td>
<td>680.0c</td>
<td>585.0b</td>
<td>491.7a</td>
<td>8.7</td>
<td>2.2</td>
</tr>
<tr>
<td>Composition (g per kg)</td>
<td>35.7b</td>
<td>26.1a</td>
<td>28.7a</td>
<td>5.4</td>
<td>1.3</td>
</tr>
<tr>
<td>Butter fat</td>
<td>44.7b</td>
<td>35.2a</td>
<td>44.4b</td>
<td>3.0</td>
<td>0.8</td>
</tr>
<tr>
<td>Protein</td>
<td>53.9b</td>
<td>51.1a</td>
<td>53.0b</td>
<td>1.7</td>
<td>0.4</td>
</tr>
<tr>
<td>Lactose</td>
<td>141.2c</td>
<td>107.4a</td>
<td>132.9b</td>
<td>5.7</td>
<td>1.6</td>
</tr>
<tr>
<td>Total solids</td>
<td>108.9b</td>
<td>94.2a</td>
<td>105.6b</td>
<td>4.5</td>
<td>1.2</td>
</tr>
<tr>
<td>Solid non-fat</td>
<td>0.63b</td>
<td>0.60a</td>
<td>0.62ab</td>
<td>0.03</td>
<td>0.01</td>
</tr>
</tbody>
</table>

abc: Means within a row with different superscript are different (P<0.05)
To rank the nutritive value of forages, Norton and Poppi (1995) considered potential digestibility and voluntary intake. The high nutrient digestibility, nutrient and digestible nutrient intake rank the three test forage sweet potato cultivars as highly nutritious forages. These cultivars maintained higher nutrient intake than sheep fed Napier grass, a common fodder in Kenya (Muia, 2000). According to Agricultural Research Council (ARC, 1984), a diet containing metabolizable energy beyond, 9.7 MJ/kg DM and DM intake beyond 90.5 g/W0.75 is classified as a nutritious diet and those below these values are less nutritious diets. Forage sweet potato cultivars K158, Marooko and Wagabolige were therefore categorized as nutritious to goats.

**Milk yield and composition**

Milk yield is determined by the most limiting nutrient in the diet particularly the relationship between energy and protein. Protein is a major limiting nutrient but sweet potato forage contained more than 80g CP per kg DM reported as the threshold (Aregheore, 2003; Lam and Ledin, 2004; Etela et al., 2008). When protein is available in excess to requirements, it is not stored in the body but catabolised to energy. Hence the difference in milk yield by goats may have been due to the difference in ME intake by goats fed on the different forage sweet potato cultivars (Sampelayo, 1998). The goats fed on K158 yielded the highest milk volume as they also ingested relatively the highest ME.

The composition of goat milk is affected by many factors including the diet, breed and the stage of lactation. In ruminants, the pattern of ruminal fermentation that develops depends on the amount and quality of the fibre fraction in the diets. A decrease in fibre in the diet and a decrease in particle size of the fibre all tend to reduce the proportion of acetic acid produced relative to propionate, which is the principal precursor of the fatty acids synthesized in the mammary gland (Sampelayo, et al., 1998). As a result, the fat content of the milk produced tends to be depressed. Hence although the goats fed on K158 and those on Wagabolige ingested similar quantity of both NDF and digestible NDF, their intake of ADF were different causing a difference in butterfat (BF) between them. Consequently as goats fed on Marooko and Wagabolige ingested similar quantity of ADF, they produced milk with similar BF. Furthermore, the energy balance in the goats has been shown to affect BF (Sampelayo, et al., 1998; Strzalkowska et al., 2009; Opren et al., 2011) and in the current study goats fed on Marooko and Wagabolige ingested relatively similar ME that was relatively lower than in K158. This may have enabled goats fed on K158 to produce milk of higher BF than those fed on Marooko and Wagabolige which recorded similar BF.

Dietary characteristics that led to a decreased BF in milk cause an increase in protein content (Sampelayo, et al., 1998). Hence goats fed on Wagabolige increased their milk protein content to match goats fed on K158 although the protein content in milk produced by goats fed on Marooko was lower. Furthermore, Cannas et al., (1998) showed that an increase in dietary protein and a decrease in energy intake increased protein intake and milk protein content in sheep. Additionally, Opren et al., (2011) showed that an increase in the plane of feeding increased protein content in goat milk. These observations are in agreement with the results recorded in the current study.

The lactose content in goat milk is affected by the plane of nutrition (Sampelayo, et al., 1998; Cannas et al., 1998; Opren et al., 2011). Sampelayo, et al., 1998 and Cannas et al., 1998 fed nutritionally adequate diets to goats showing no effect on goat milk lactose content. However, by varying the energy and protein content in the diets they concluded that energy balance was the main cause of lactose variation in goat milk. In the current study goats fed on Marooko ingested relatively lower ME than those fed on K158. This enabled goats fed on K158 to produce milk containing higher lactose compared to those fed on Marooko.

The variations in fat, protein and lactose in goat milk caused by K158, Maroko and Wagabolige have direct effects on total solids and solids non fat content of goat milk (Strzalkowska et al., 2009). Their increase caused higher values in total solids and solids non fat in goat milk (Strzalkowska et al., 2009). Park et al., (2007) reported the freezing point for goat milk to range between -0.540 and -0.570 which was lower than the values recorded in the current study at 0.630, 0.597 and 0.617oC in milk from goats fed on K158, Maroko and Wagabolige respectively. The freezing point values in the current study are in agreement with Strzalkowska et al., (2009) and showed an increased concentration in individual milk components.

**CONCLUSION AND RECOMMENDATIONS**

Marooko had the highest CP, CP digestibility and digestible CP intake in goats. The digestibility of OM, its gross and digestible intake (g/kg W0.75) by goats was not affected by these cultivars. However, the cultivar affected the digestibility of CP and NDF, their gross and digestible intake by goats. The milk yield and milk composition in goats were affected by the cultivars of sweet potato. The goats fed on K158 produced milk containing the highest butter fat and high quantities of protein, lactose, solids-non-fat and freezing point depression. To produce increased amount of milk the three forage sweet potato cultivars were ranked in descending order as K158, Maroko and Wagabolige respectively and to increase milk composition quality in goats K158 was ranked highest, followed by Wagabolige and Maroko was third.

**REFERENCES**


THE EFFECT OF VARIATION OF FEED RESOURCES ON THE PERFORMANCE OF SAHIWAL COWS IN THE NAIVASHA STUD AT NAIVASHA

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ABSTRACT
The effect of fluctuation of feed resources on the performance of Sahiwal cows for the last twenty years was studied. Although the grazing area has remained the same over that period, forage quantity and quality has been inadequate owing to climatic changes. The objective of this study was to determine the effect of variation of feeds on the general performance of Sahiwal. Productivity parameters were used to assess the impact of variation of feed resources on age at first calving, calving interval, fertility and lactation yield. Fertility has been varying greatly, as the average number of services per conception ranged from 1.89 to 4.4 during the period of study. It is recommended that paddock fences be maintained to manage rotational grazing and minimise wastage of pastures. Differences in production and reproduction are attributable to the climatic conditions, management and genetic make-up of animals. As a result, these factors need to be disentangled in a detailed study to ensure proper distribution of resources and informed management decisions.

Key words: Feed resources, calving interval, lactation, fertility, and supplementation.

INTRODUCTION
Sahiwal cattle are a dual-purpose breed introduced in Kenya in 1939 from India and Pakistan. The breed was established at the National Animal Husbandry Research Centre Naivasha as the National Sahiwal Stud in 1963 and has been maintained as a pure breed to supply breeding stock for smallholder mixed farming and pastoral ranching systems. The breed is maintained on natural pastures without supplementation to emulate the pastoral conditions where the breed is mainly utilized. There has been an increase in wildlife population in the last decade posing a great competition for pastures with the livestock. The carrying capacity has not changed yet the stocking rate is being greatly affected. Availability of feed resources supplying nutrients and minerals is important in determining productivity and reproductive performance of livestock. The performance of the herd in this centre has been fluctuating over the period analysed and thus necessitating a study to identify the cause/s of the variations. The objective of the study was to analyze the effect of variation of feed resources on the general performance of Sahiwal.

MATERIALS AND METHODS

Study area
The National Sahiwal Stud utilises 3,600 hectares of the total land area of 4,545 hectares of the National Animal Husbandry Research Centre. It is located to the east of Lake Naivasha in Rift Valley Province at an altitude of 1900 metres above sea level. The area is in a rain shadow zone of Nyandarua escarpments. The rainfall pattern is bimodal with an annual mean of 620 mm. Figure 1 present the rainfall distribution during the study period. The average day and night temperatures are 26o and 8oC, respectively. The relative humidity ranges from 60 and 75%. The soils are volcanic in origin, dark, sodic and deep. The fertility is low although there is humic top layer. The soils are alkaline (pH 7.4) and deficient in trace elements like copper, and thus necessitate mineral supplementation to the livestock. The natural vegetation is predominantly star grass (Cynodon plectostachyus) with scattered tall acacia trees (Acacia xanthophloea). The herbage is composed of natural grasses notably Cynodon species, Pennisetum clandestinum and scanty patches of Panicum maximum and Cenchrus species.

Herd management
The animals are grouped into various categories for ease of management. Each group graze separately in different paddocks. The dry cows are grazed and managed separately in a different farm. Sahiwal cows are inseminated artificially with semen from Sahiwal bulls proven through progeny testing. Heifers are first inseminated when they attain a live weight of 270 kg, while cows are inseminated 70 days after parturition. Pregnant heifers and cows are moved to maternity paddocks 2 months prior to calving down for closer observation. Emphasis is given to disease control and routine vaccinations against Foot and Mouth Disease, Lumpy Skin Disease, Black quarter, Anthrax and any other notifiable disease as necessary. Weekly dipping or spraying of all outdoor animals controls tick-borne diseases. Proper hygiene is maintained to control diseases like mastitis and calf scour.

Data analysis
Twenty year farm records were used to obtain the required data which were analysed. Data collection was obtained from records kept for a period of 20 years. Data for 958 heifers was taken for reproduction and milk production of the Sahiwal herd and analysed. Records on mortalities and sales were also taken into consideration in the study. Data were entered and analysed using Microsoft Excel program (Microsoft Corporation). Descriptive statistics were presented as tables and graphs.

RESULTS

Herd size
The annual average herd size for the milk cows for the
study period is presented in Figure 2.

An analysis of records to determine the effect of non supplementation of Sahiwal heifers on age at first calving showed that the minimum age at first calving was 49.70 months while the maximum age was 82.64 months as presented in figure 3. The average age at first calving was 61 months.

Considering that calving interval is also long, lifetime number of lactations could be on average three, which is quite low. Results indicate that the mean calving interval is 539 (n = 3586) days as presented in Table I.

From Table 1 it can be seen that apart from 1991, which was fairly wet, subsequent years show a decline in fertility. This decline may be attributed to nutritional factors, and compounded by lack of supplementation and mineral licks. This may have caused irregular cycling or failure in cycling and/or conceptions as well. Managerial aspects also may have contributed to the same especially on heat detection and timing of inseminations. Table II shows the total number of inseminations per year and number of services per conception.

From Table II it can be noted that the number of inseminations have continued to increase from 1991 to 2010, 1.89 to 4.4 services per conception. This indicates that fertility has been declining. This can be attributed to variation in feed resources both in quantity and quality. Long Calving Interval lowers milk production significantly. In Figure 4 it can be seen that annual milk yield has fluctuated significantly during the last 20 years. This can be attributed directly to the rainfall patterns as presented in Figure 1.

Total milk yield per year shows that 2002 had the highest annual production of 314,756 kilograms of milk produced, while the year 2009 registered the lowest production at 105,030. This was attributed to the drought of that year. Looking at the average production per cow per lactation day, it shows that the years thought to be better were not actually true for all the years, except 1995 which still remained a better year at 4.10 kilograms per cow per day. 1997, 1998, 1991 and 1992 in that order followed it, (Figure 4).

From Figure 5, it can be noted that milk production per cow showed a steady decline from 1991 to 1994 (3.70 kg to 2.92 kg per cow per day). However, there was an increase in 1995 to 4.10 kg per cow per day. This was attributed to the rain that fell towards the end of the year 1994 thus spilling over to the following year 1995. Production was more or less stable up to 1998 when there occurred, a sharp drop to 2.15 kg per cow per day in the year 2000. This was as a result of the drought that occurred in 1999-2000. The year 2003 registered the highest daily milk yield at 4.2 kilograms per cow. This was comparable to 2002, which recorded 4.1 kilograms per cow. Heifers joining the herd every year are on average 47. This is mainly due the fact that heifers take too long to attain service weight. Calf mortalities were also high over the same period. This has negative effect on replacement stock as well as breeding programmes, as it takes too long to achieve progeny test results.

**DISCUSSION**

The average age at first calving of 53.52 months could be as a result of the pre weaning management. The weaners are left to graze on a low quality pasture with no feed and mineral supplementation thus attaining the recommended weight of first service (270kg) when they are 53.52 months. Age at first calving can be substantially reduced through balanced feeding, improved management and minimum
disease prevalence (Heinrichd et al., 2005). However the long term and cumulative effect can be attained through genetic selection. According to (Bhatti et al., 2007), selection for higher milk yield is likely to have a favourable impact on AFC. Supplementation of concentrates with green fodder has been shown to reduce age and weight at puberty, services per conception and AFC in Sahiwal and buffalo (Bhatti et al., 2007). Additionally, deficiencies of trace minerals, inadequate vitamin intake and energy imbalances have been implicated as contributors to infertility and poor reproductive performance (Lanyasunya et al., 2005). The variations in milk production observed in different periods indicate the level of management and environmental effects. The level of management varies according to the ability of the farm manager, method and intensity of culling (Zafar et al., 2008). The higher milk yield during the year 2002 may be due to good nutrition and other managerial practices during the period. The years 2001 and 2002 registered an increase in rainfall, with the year 2006 having the highest amount of rainfall. This would translate into more pastures and consequently increase in milk yield during the year. Given the low heritability estimates for reproduction and traits, efforts for improvement should focus on management while for milk production should be through genetic selection and (cross) breeding.
TABLE I- CALVING INTERVAL FOR SAHIWAL COWS (MEAN ± Standard Deviation)

<table>
<thead>
<tr>
<th>Year</th>
<th>Number</th>
<th>Mean C.I ± S.D</th>
</tr>
</thead>
<tbody>
<tr>
<td>1991</td>
<td>208</td>
<td>459.69 ± 124.36</td>
</tr>
<tr>
<td>1992</td>
<td>213</td>
<td>500.07 ± 172.04</td>
</tr>
<tr>
<td>1993</td>
<td>188</td>
<td>460.11 ± 126.76</td>
</tr>
<tr>
<td>1994</td>
<td>190</td>
<td>470.43 ± 102.34</td>
</tr>
<tr>
<td>1995</td>
<td>162</td>
<td>531.64 ± 198.22</td>
</tr>
<tr>
<td>1996</td>
<td>187</td>
<td>512.85 ± 143.89</td>
</tr>
<tr>
<td>1997</td>
<td>141</td>
<td>531.19 ± 190.40</td>
</tr>
<tr>
<td>1998</td>
<td>223</td>
<td>535.69 ± 176.44</td>
</tr>
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<td>1999</td>
<td>178</td>
<td>521.21 ± 171.54</td>
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<td>2000</td>
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<td>518.99 ± 176.80</td>
</tr>
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<td>2001</td>
<td>168</td>
<td>539.30 ± 153.90</td>
</tr>
<tr>
<td>2002</td>
<td>193</td>
<td>569.07 ± 187.22</td>
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<td>2003</td>
<td>198</td>
<td>520.04 ± 150.42</td>
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<td>2004</td>
<td>221</td>
<td>551.28 ± 167.48</td>
</tr>
<tr>
<td>2005</td>
<td>257</td>
<td>532.75 ± 225.58</td>
</tr>
<tr>
<td>2006</td>
<td>111</td>
<td>538.15 ± 185.03</td>
</tr>
<tr>
<td>2007</td>
<td>128</td>
<td>621.60 ± 198.47</td>
</tr>
<tr>
<td>2008</td>
<td>189</td>
<td>628.84 ± 232.50</td>
</tr>
<tr>
<td>2009</td>
<td>108</td>
<td>572.71 ± 240.19</td>
</tr>
<tr>
<td>2010</td>
<td>122</td>
<td>664.24 ± 231.62</td>
</tr>
</tbody>
</table>

TABLE II- NUMBER OF INSEMINATIONS PER CONCEPTION

<table>
<thead>
<tr>
<th>Year</th>
<th>Animals served</th>
<th>Total doses</th>
<th>Services/conception</th>
</tr>
</thead>
<tbody>
<tr>
<td>1991</td>
<td>47</td>
<td>89</td>
<td>1.89</td>
</tr>
<tr>
<td>1992</td>
<td>42</td>
<td>84</td>
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<td>1993</td>
<td>78</td>
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<td>1994</td>
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<td>1995</td>
<td>138</td>
<td>296</td>
<td>2.15</td>
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<td>1996</td>
<td>144</td>
<td>348</td>
<td>2.42</td>
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<td>1997</td>
<td>137</td>
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<td>167</td>
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<td>2004</td>
<td>48</td>
<td>149</td>
<td>3.1</td>
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<td>2005</td>
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<td>2006</td>
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<td>235</td>
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<td>2007</td>
<td>82</td>
<td>328</td>
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<tr>
<td>2008</td>
<td>72</td>
<td>255</td>
<td>3.5</td>
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<td>2009</td>
<td>71</td>
<td>284</td>
<td>4</td>
</tr>
<tr>
<td>2010</td>
<td>90</td>
<td>246</td>
<td>2.7</td>
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</tbody>
</table>

CONCLUSION AND RECOMMENDATION

This study points at the variation in reproduction, fertility and milk production arising from variation in feed resource as dictated by rainfall distribution. It is worth noting that the carrying capacity has not changed yet the stocking rate is going down. There is need to have and maintain proper paddocks in order to control grazing. Heifers need to be grazed separately with mature cows/dry cows, at least up to the first insemination. The herd has a potential of performing even better with supplementation of lactating animals in the dry season. However, the economics of supplementation need to be explored. Differences in production and reproduction are attributable to the climatic conditions, management and genetic make-up of animals. As a result these factors need to be disentangled in a detailed study to ensure proper distribution of resources and informed management decisions.

ACKNOWLEDGEMENT

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REFERENCES


THE CAUSES AND RATES OF CULLING IN A FRIESIAN HERD AT NAIVASHA, KENYA

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1 KARI Naivasha, P.O. Box 25- 20117 , Naivasha, Kenya

ABSTRACT
This study investigated the causes and the rates of culling in a Friesian herd aimed at cattle improvement through management. The herd was grazed on natural pastures and supplemented with concentrates and minerals during milking. Machine milking was done twice daily. The Culling rates were below replacement rates which are desirable given the small herd size and the projections of increasing the herd. From the analysis, culling was mainly because of involuntary reasons. Involuntary culling causes economic losses.

INTRODUCTION
Culling is the removal of the unproductive cattle from the herd as they become uneconomical and waste of resources. This is usually accompanied by replacement to maintain or expand the herd. Culling can either be voluntary or involuntary. Voluntary culling is due to low productivity or when cattle are sold to another farm for dairying purpose while involuntary culling is due other factors including illness, injury, infertility or death (Grohn et al., 1998) Voluntary culling usually leads to increased profits while involuntary culling causes economic losses.

It is important to understand culling rates for managing dairy production response and profitability (Hadley et al., 2006). Culling decisions are influenced by animal factors such as cow age, stage of lactation, milk production, health status, disposition and reproductive performance; economic factors such as milk price, price of culled cows, price and availability of replacement heifers and the attitude of the farmer on which cow to cull (Bascom and Young 1998). Culling of a dairy cow necessitates a replacement heifer that has costs associated with it (Lehenbauer and Oltjen, 1998). Culling of sick, non pregnant and low producing dairy cows and replacing them with high quality heifers, increases profits and/ reduces costs. Optimum dairy herd profitability is mainly achieved by optimizing the proportion of involuntary and voluntary culling respectively. The individual farm should establish the reasons for culling and improves the ones arising from management practices.

The objective of this study was therefore to investigate the causes and rates of culling in a Friesian herd reared on-centre to improve performance through management.

MATERIALS AND METHOD

Study site
The study was conducted on the Friesian herd at Kenya Agricultural Research Institute Naivasha. The area is characterized by bimodal rainfall pattern. The dry season months are January to March and July to September. The wet season occurs in April to June and October to December with the total annual rainfall 620 mm. The average maximum and minimum temperature is 26oC and 8oC respectively. The relative humidity varies from 60 to 75%.

Herd management
The Friesian herd was grazed on natural pastures in fields which had paddocks for rotation grazing and water was readily available in troughs in every paddock. The herd was separated into calves, heifers’ dry and lactating herds. Lactating cows were machine milked twice a day, in the morning and evening. Hygiene was maintained at the milking parlour and a strip cup was used before milking to aid in detection and control of mastitis. The milk production per cow was recorded individually. Lactating cows were supplemented with commercial dairy meal rationed according to milk production at the rate for every 1.5 kg of milk above 8 kg the cow was given 1 kg of dairy meal. Additional 30g of well balanced mineral salt were offered at all times. After milking the cows were supplemented with lucern hay before they were taken to the night shed.

Statistical analyses
The data on number of cattle disposed and the causes for their disposal from 1998 to 2012 was subjected to quantitative analysis Statistical and the tests for significance were carried out using SAS Statistical software (SAS institute, 2002).

RESULTS AND DISCUSSION
The trends in culling and replacement rates are presented in Figure 1. Generally culling rate has been below replacement rate. This is desirable considering the small herd size (64) on the farm and the projections of increasing the herd. The figure indicated for 2007 is in addition to 27 heifers that were transferred from the herd to another farm Ol Joro orok in Nyandarua as a management strategy but not due to reasons associated to culling.

The reasons for culling and the culling rate are presented in Table 1. Infertility was defined as any cow that failed to conceive for a prolonged period (after 5 inseminations). This category also included cattle that had still births, multiple abortions and other reproductive abnormalities. Cattle disposed of due to foot rot are the category of cows that suffered chronic foot rot and lameness despite
repeated treatments. Cows culled due to mastitis also accounted for those with udder defects. These cows had severe udder inflammation that did not respond to treatment. On the other hand, cows that produced below herd average were also culled. This is production below five litres per day. Although age was factored, there was no specific physiological age set for culling as this was accompanied by other culling reasons. Conformation related to congenital disorders and factors affecting the body score and gait of the cattle.

Average age of cows at culling is 2265±463.26 days or 6.21±1.27 years (Novakovi, 2009). In this study the average age at culling was 8.2±2.7 years with range between 1.6 and 14.7. The correlation between average milk yield and age at culling was 0.67 which was significant at 0.01 (2 tailed test). The analysis showed clearly that cows were mainly culled because of involuntary reasons. Infertility was the major reason for culling while low milk yield ranked the least. However, it was not clear whether cows culled due to infertility had other underlying influences such as problems and timing of heat detection. Breeding in the herd is usually by artificial insemination (AI). Given that cattle were grazed on pastures during the day and placed in a shed during the night could complicate heat detection. Cows that yielded below the set herd average were culled in line with the breeding objectives for dairy cattle at the centre which is improving milk yield under the prevailing production circumstances. The average milk yield for the culled cows was 7.9±3.1kg per day. The proportion of culling due to mastitis/udder was lower than the proportions reported by other surveys done in Iran (Mohammed and Azizzadeh, 2011). Mastitis was ranked low as a contributor to culling maybe because it is usually associated with high yielding cows. In addition, cows were milked by machine thus reducing the risk of contracting mastitis. Moreover, the cows were held in a yard after milking to let the teat canal close to avoid entrance of microorganisms that would cause mastitis before they were taken to their night sheds. The cows could be predisposed to foot rot infection by night shed grazing management and perhaps inadequate maintenance of roads and walkways.

Table II presents two-way cross tabulations for the reasons for culling. There was a strong relationship between culling for low milk yield and all other reasons for culling. This was probably because all factors that contribute to culling directly influence milk yield as they affected the physiological functioning of the cows. Mastitis infection showed the least relation with other culling reasons. It turns out that cows culled due to mastitis had no chance of reaching culling age and were therefore removed earlier. The cross tabulations with mastitis was low probably because the cows were culled due to below herd average for milk yield.

The frequency of culling at different parities is presented in Figure 2. The highest culling rate occurred at the fourth parity and progressively declined with increasing parity. Culling at first and fifth parities was also relatively high. It was observed that there were about 10% of cows culled before the first parity. Menjo et al., (2009) reported that about 25% of dairy cattle born in large scale farms in Kenya

### TABLE I- CAUSES OF CULLING IN FRIESIAN DAIRY COWS

<table>
<thead>
<tr>
<th>Reason for culling</th>
<th>% culled</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infertility</td>
<td>47.9</td>
</tr>
<tr>
<td>Foot rot</td>
<td>25.4</td>
</tr>
<tr>
<td>Age</td>
<td>21.2</td>
</tr>
<tr>
<td>Conformation</td>
<td>16.9</td>
</tr>
<tr>
<td>Mastitis/udder defects</td>
<td>9.9</td>
</tr>
<tr>
<td>Milk yield/</td>
<td>8.5</td>
</tr>
</tbody>
</table>

Figure 1: Culling and replacement rates for a Friesian herd From 1998 to 2012 at Naivasha, Kenya
are culled involuntarily prior to first calving. Cows culled in the first lactation might probably not have expressed their production potential because they are still growing and developing. Moreover, some of the cattle were culled due to conformation before the fourth parity.

Despite the reason for culling, it is important to consider the genetic worth or contribution to herd value such as pedigree information or ranking of the cow in a listing of estimated producing ability (Lehenbauer and Oltjen, 1998). With the advanced computer programmes that support management decisions, farmers can apply them to make informed culling decisions that have important influence on the economic performance of the dairy industry. These computer programmes will supplement the conventional culling method mainly based on decision maker’s perception.

**REFERENCES**


[7] Novaković¹, Ž. Aleksić¹, S. Sretenović¹, Lj Petrović², M. MPantelić¹, V. Ostojić-Andrić¹ D (2009) Longevity of high-yielding cows *Biotechnology in Animal Husbandry* 25 (5-6), p 645-654,

“Framing the issues, challenges and opportunities in livestock sector in the 21st century”
DAIRY TECHNOLOGY ADOPTION AND IMPACT: THE CASE OF SMALLHOLDER DAIRY COMMERCIALIZATION PROGRAMME

M. Kibiego¹, A. Kembe¹, P. Mbondo¹, B. Kimoro¹, W. Olubai¹, L. Mbatia¹, and J. Otieno¹
¹Smallholder Dairy Commercialization Programme (SDCP).

ABSTRACT

Previous studies have shown that the impact of dairy technology adoption, like the prevalence of adoption, vary by location in Kenya. The overall objective of this paper was to evaluate adoption and impact of the dairy technologies promoted by the Smallholder Dairy Commercialization Programme. The specific objectives were to: a) evaluate adoption of dairy technologies by smallholder dairy farmers in the programme regions; b) examine the factors that influence adoption of selected dairy technologies promoted by the programme; and c) evaluate the impacts of adoption of dairy technologies by smallholder dairy farmers. Multi-stage purposive sampling was used to sample 1,074 respondents and structured questionnaires were administered, followed by data analysis using descriptive statistics and regression. Results revealed that investment of SDCP in dairy technologies has shown evidence of adoption and impact. Fodder establishment, use of crop residues, and water harvesting received the highest adoption rates at 96.1%, 87.8% and 62.6% respectively. The district of respondent, level of education, access to credit and the participation in tours have a positive effect on dairy technology adoption. A negative regression coefficient for age of respondent and number of dairy cows owned shows that these variables have an inverse relationship with dairy technology adoption. High impact areas for SDCP include access to good nutrition, technology adoption, market linkages, housing, income, school fees and water access. Increased utilization of farmers’ tours to enhance technology adoption is recommended. It is also noted that greater biogas awareness is needed by smallholders for greater adoption. Evaluation of impact using difference-in-difference method that considers inclusion of respondents who did not participate in the programme, to isolate the contribution of SDCP to impact, needs to be considered in future to enhance the accuracy of impact measurement.

Key words: Dairy, technologies, smallholders, adoption and impact

INTRODUCTION

Various adoption and impact studies have examined the adoption of dairy technologies and their impact on smallholders in Kenya. The adoption-oriented studies have examined the use and diffusion of dairy-related technologies (Metz, 1993, Metz et al., 1995.) and the factors affecting adoption of Napier grass on small farms (Irungu et al., 1998). These impact studies have examined changes in the roles of women in livestock production and marketing (Mugo, 1994, Mullins et al.; 1985, Leegwater et al., 1991, Huss-Ashmore, 1992). Nicholson, et al. (1999) conducted an adoption and impact study of smallholder dairy technology in Coastal area of Kenya. The technologies studied were adoption of grade and crossbred dairy animals, planting of the fodder Napier grass and use of the infection and treatment method of immunisation against East Coast fever. The study revealed that adoption of the technologies may result in substantial increases in household income, can generate employment and may improve the nutritional status of pre-school-age children in the household.

This paper evaluates the adoption and impact of technologies promoted by the Smallholder Dairy Commercialization Programme (SDCP) whose goal is to increase the income of poor rural households, who depend substantially on production and trade of dairy products for their livelihood. It is implemented through a Market Oriented Dairy Enterprise (MODE) approach which involves increasing access to more benefits from the milk and dairy products of smallholder dairy farmers. However, the progression in the MODE levels is slow. Previous studies have shown that the impact of dairy adoption, like the prevalence of adoption itself, vary by location in Kenya (Nicholson, et al., 1999). The adoption and impact of dairy technologies supported by SDCP up to date is not well understood. This paper attempts to address these issues. The overall objective of this paper was to identify and document the level of adoption and impact of the interventions of the smallholder Dairy Commercialization Programme. The specific objectives were to: a) evaluate adoption of dairy technologies by smallholder dairy farmers; b) examine the factors influencing adoption of selected dairy technologies in the programme area; and c) evaluate the impacts of adoption of dairy technologies by smallholder dairy farmers in the SDCP area. A number of factors prevent the smallholder dairy sector from achieving its full potential: poor quality of feeds and feeding regimes; seasonal fluctuations in forage availability; and inadequate access to Artificial Insemination services among others. SDCP has been implemented since 2006 to introduce technologies that provide solutions to these constraints. However, its impact has not been evaluated.

METHODOLOGY

The Study Area

Nine districts and specific areas (Dairy Commercialization Areas –DCAs) within those districts were selected as the Programme area on the basis of Geographical Information System analysis considering, milk production, market access and poverty (see Figure 1). The nine programme districts are; Nakuru, Uasin Gishu, Trans Nzoia, Nandi North, Bomet, Lugari, Bungoma, Kisii Central and Nyamira. A DCA comprises of at least a cluster of 500 – 800 smallholder dairy farmers in a division.
Sampling Procedure
The population of this study is finite and involves all the smallholder dairy farmers in SDCP (see Figure 1). The sampling units used were: district, DCA, and individual smallholder dairy farmers. The sampling frame has the dairy farmers in the programme area. Multi-stage purposive sampling was then used to divide the study area into smaller study units based on the administrative boundaries of the District. The Primary data resulted from a survey of respondents using cluster and purposive sampling. Clusters for this study were 27 DCAs. Purposive sampling was used to identify the respondents at DCA level. Purposive sampling was chosen for use in this study because it makes the study more focused. Given that the population of the study is more than 10,000 dairy farmers, the sample size was calculated using the formula provided by Sekaran, (2006) as indicated below:

\[ n = \frac{z^2 \hat{p} \hat{q}}{\frac{\hat{p}^2}{N}} \]

Where,
\( n \) = the desired sample size (if the target population is greater than 10,000)
\( z \) = the degree of confidence chosen at 95% confidence interval.
\( p \) = the proportion in the target population estimated to have characteristics being measured (smallholder dairy farmers)
\( q \) = the proportion in the target population estimated to having no characteristics being measured (large scale dairy farmers).

\[ n = \frac{1.96^2(0.80)(0.20)}{0.024^2} = 1074 \]

Figure 1: Programme area  Source: IFAD, 2006
Data Collection

The study used primary data that was obtained by administration of structured questionnaires. This study focused on a number of related adoption decisions faced by smallholder farmers in the programme area. Studies of the factors influencing adoption of technologies often focus on household resource endowments, characteristics of the household head, location of the household, information provided for adoption and the characteristics of the technology (Feder et al, 1985).

Data Analysis

Descriptive statistics technique was used as it is of great value in analyzing all qualitative data.

General Model

Econometric models are often used to relate the adoption decision to household and technological characteristics. When the outcome to be modelled is a binary choice (e.g. adopt versus do not adopt a technology) standard linear regression models have short comings that are typically overcome by using Probit or Logit models. Logit and Probit, the two most common techniques for estimation of models with a dichotomous dependent variable, impose the assumption that individuals with a probability of 0.5 of choosing either of two alternatives are most sensitive to changes in independent variables. This assumption is imposed by the estimation technique because both the logistic and normal density functions are symmetric about zero. Long (1997) says that the choice between the Logit and Probit models is largely one of convenience and convention, since the substantive results are generally indistinguishable.

These models relate household and technological characteristics to the probability that a household will adopt a technology. The Probit model is most often derived using the assumption that farm households maximise a utility function that ranks the household’s preferences of available technological choices. The utility function \( U \) depends on attributes of the household and the sources of information about the characteristics of the technologies that the household could adopt. Thus the utility of technology \( t \) for household \( h \) is defined by:

\[
U_{th} = X_{th} \alpha + e_{th}
\]

Where:
- \( U_{th} \) = Utility of technology \( t \) in household \( h \)
- \( X_{th} \) = Vector of variables in \( Z_h \) and \( I_h \)
- \( \alpha \) = Vector of parameters relating the variables \( X \) to household utility
- \( e_{th} \) = Random error term with zero mean and constant variance.

Households are assumed to choose the technology that maximizes their utility. Thus a household will in theory adopt a technology if the utility provided by the new technology exceeds the utility provided by a previously used technology. This implies that adoption occurs when:

\[
U_{th}^{New} > U_{th}^{Old}
\]

If a variable is defined as:

- \( D_{th} = 1 \), if \( U_{th}^{New} > U_{th}^{Old} \) (the new technology is adopted)
- \( 0, \) if \( U_{th}^{New} \leq U_{th}^{Old} \) (the new technology is not adopted)

Then the probability that \( D_h = 1 \) can be expressed as a function of the variables \( X \) as follows:

\[
Pr [D_h = 1] = Pr [U_{th}^{New} > U_{th}^{Old}]
\]

Where

- \( Pr[.] \) = A probability function
- \( F[.] \) = Probit model, giving the probability of adoption as a function of variable \( X \) and parameters \( \beta \).

The variables of the probit model are shown, where adoption of use of silage is considered as a proxy for dairy technology adoption:

\[
Y^* = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta_7 X_7 + \varepsilon
\]

If \( Y^* \geq 0, \ y = 1 \)

If \( Y^* < 0, \ y = 0 \)

\( Y \) = Adoption of use of silage
- \( X_1 \) = district of respondent
- \( X_2 \) = age of respondent
- \( X_3 \) = sex of household head
- \( X_4 \) = level of education
- \( X_5 \) = credit
- \( X_6 \) = study tours
- \( X_7 \) = No of dairy cows

\( \varepsilon \) = Random error term with zero mean and constant variance.

Scope of the study

The study covered the programme area involving nine districts (see Figure 1). Adoption of dairy technologies is considered including its subsequent impact on the programme beneficiaries.

RESULTS

This section gives the adoption of dairy technologies, the factors influencing it and evaluation of impact. Figures 2, 3 and 4 show the adoption rates of selected technologies.

Fodder establishment, use of crop residues, and water harvesting received the highest adoption rates at 96.1%,
87.8% and 62.6% respectively (Figures 2 and 4). These technologies are associated with relatively low costs. Technologies that received moderate adoption were hay making (51.1%), energy saving jikos (53.7%), on-farm milk testing (41.1%), chuff cutter (51.4%), value addition (45.3%) and group milk marketing (57.6%) shown in Figures 2, 3 and 4). These technologies represent a relatively high cost of investment except for the jiko and group marketing. Biogas recorded the lowest adoption rate of 20.6% (see Figure 3) and this could be attributed to its high cost of construction and lack of appreciation of ‘green energy’. Value addition includes preparation of traditional fermented milk products e.g. ‘mursik’, mala and yoghurt.

Several factors are responsible for influencing adoption of technologies as demonstrated in the case of silage use shown in Table I.

Adoption of the use of silage is one of the dairy technologies promoted by SDCP. The districts of respondent, level of education, access to credit and participation in tours have positive effects on adoption of silage use (Table I). A negative coefficient for age of respondent and number of dairy cows owned shows that these variables have an inverse relationship with silage use adoption. As shown in Table I, the standard error of 0.048 compared to the coefficient of sex of household head, is more than double, meaning that the effect of gender on technology adoption is not reliable.
Adoption rates of use of silage

Source: Survey data, 2013

**TABLE I- FACTORS INFLUENCING ADOPTION OF USE OF SILAGE**

<table>
<thead>
<tr>
<th>Variables</th>
<th>Coefficient</th>
<th>Standard error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant)</td>
<td>1.620</td>
<td>.195</td>
</tr>
<tr>
<td>District of respondent</td>
<td>.032</td>
<td>.013</td>
</tr>
<tr>
<td>Age of respondent (Years)</td>
<td>-.004</td>
<td>.002</td>
</tr>
<tr>
<td>Sex of household head</td>
<td>.006</td>
<td>.048</td>
</tr>
<tr>
<td>Education</td>
<td>.017</td>
<td>.029</td>
</tr>
<tr>
<td>Credit</td>
<td>.041</td>
<td>.037</td>
</tr>
<tr>
<td>Participation in study tours</td>
<td>.101</td>
<td>.050</td>
</tr>
<tr>
<td>No. of dairy cows owned</td>
<td>-.040</td>
<td>.011</td>
</tr>
</tbody>
</table>

Source: Survey data, 2013

**TABLE II- THE PERCEPTION OF SMALLHOLDER DAIRY FARMERS ON THE IMPACT OF SDCP (% OF RESPONDENTS)**

<table>
<thead>
<tr>
<th></th>
<th>Improved</th>
<th>Decreased</th>
<th>No change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Food security</td>
<td>98.2</td>
<td>0.9</td>
<td>0.9</td>
</tr>
<tr>
<td>Access to good nutrition</td>
<td>97.9</td>
<td>0.3</td>
<td>1.8</td>
</tr>
<tr>
<td>Technology adoption</td>
<td>94.3</td>
<td>3.1</td>
<td>2.7</td>
</tr>
<tr>
<td>Market linkages</td>
<td>80.8</td>
<td>4.5</td>
<td>14.7</td>
</tr>
<tr>
<td>Collaboration and partnerships</td>
<td>50.6</td>
<td>7.2</td>
<td>42.2</td>
</tr>
<tr>
<td>Housing</td>
<td>75.6</td>
<td>1.5</td>
<td>22.9</td>
</tr>
<tr>
<td>Income</td>
<td>97.3</td>
<td>0.7</td>
<td>2</td>
</tr>
<tr>
<td>School fees</td>
<td>93.9</td>
<td>1.1</td>
<td>5</td>
</tr>
<tr>
<td>Water access</td>
<td>75.1</td>
<td>2.8</td>
<td>22.2</td>
</tr>
<tr>
<td>Electricity connection</td>
<td>36.2</td>
<td>5.9</td>
<td>57.9</td>
</tr>
</tbody>
</table>

Source: Survey data, 2013

The perceived impact of adoption of the technologies is given in Table II.

**DISCUSSION**

This paper considers the adoption of 13 dairy technologies that has been promoted by SDCP and measures the perceived impact on smallholders in Kenya. It appears that low cost technologies like fodder establishment and use of crop residues receive the greatest adoption rates. Batz et al (1999) observed that a strong influence of relative complexity and relative risk of the technologies on adoption is explained by farmer characteristics and farming circumstances of dairy farmers of Meru in Kenya. Technology adopters have been shown to be more educated (Foltz and Lang, 2007). The paper found out a negative relationship between herd size and adoption. This finding seems to agree with Mekonnen et al, (2009) that high levels of technology adoption is associated with better milk yield regardless of the breed of the cattle owned by the farmers. Similarly, like many previous studies, technology adoption is dependent on location of the farms and this could be attributed to access to markets and good infrastructure.

High impact areas for SDCP include food security, access to good nutrition, technology adoption, market linkages, housing, income, school fees and water access. These results are expected in the case of resource poor smallholder dairy producers. That is why electricity connection received 36.2% of the perception of SDCP impact. To identify the specific impact of SDCP on the respondents, then a control sample of similar farmers who did not participate in the
CONCLUSION
Investment of SDCP in dairy technologies has shown evidence of adoption and impact especially for fodder establishment, use of crop residues, and water harvesting. The district of respondent, level of education, access to credit and participation in tours, have positive effects on dairy technology adoption. A negative coefficient for age of respondent and number of dairy cows owned shows that these variables have an inverse relationship with dairy technology adoption. Biogas recorded the lowest adoption rate of 20.6% and this could be attributed to its high cost of construction and lack of appreciation of ‘green energy’.

RECOMMENDATIONS
• Increased utilization of farmers’ tours to enhance technology adoption.
• Further research to identify the reasons for low adoption of biogas technology
• Evaluation of impact using difference-in-difference method that considers inclusion of respondents who did not participate in the programme, to isolate the contribution of SDCP to impact.

ACKNOWLEDGEMENT
We wish to acknowledge the financial support from the International Fund for Agricultural Development (IFAD) and the Government of Kenya. Appreciation is extended to Moses Kembe, the Programme Coordinator, and the APSK for facilitation.

REFERENCES
THE STATUS OF LIVESTOCK TECHNOLOGIES AND SERVICES IN THE SOUTHERN MAASAI RANGELANDS OF KENYA

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ABSTRACT
This study was carried out in the Southern Maasai rangelands of Kenya between November 2010 and June 2011 with the specific objective of assessing the status of livestock technologies and services in Mashuru district, Kajiado County. The overall goal was to develop a strategy for establishing multi institutional linkages for effective delivery of livestock inputs and services in a semi arid pastoralist region. Data was collected using cross sectional survey of 380 households, participatory stakeholder workshops, Focus groups with livestock keepers, and key informant interviews. The findings of this study revealed that livestock production and health services are generally inadequate and inaccessible but only in urban centres. Priority technologies includes: Water, feed resources; vaccines and drugs. Dual purpose breeds for milk and meat production, adaptable to the dry climatic conditions; management skills, market infrastructure and information. Livestock production needs to be strengthened through effective Stakeholder linkages and improved infrastructure. Due to inaccessible livestock inputs and technologies, they prefer the establishment of one-stop-shop centre stocked with priority inputs and technologies they need. The fact that majority of pastoralists (95%) are willing to pay for this services, should attract public -private partnerships to support livestock productivity in rangelands.

Keywords: Livestock technologies; Maasai rangelands; multi-institutional linkages

INTRODUCTION
There is great potential for improvement of livestock productivity in Arid and Semi-Arid Lands (ASALS) in Sub Saharan Africa and Kenya in particular, yet this potential has not been fully realized (Adugna and Aster 2007), mainly due to divergent research, extension and other development approaches, which are largely uncoordinated (Omore et al., 2009) as well as constraints associated with inadequate feed resources, disease control strategies and poor infrastructure (Mgheni et al., 1992). Liberalization era of 1990s in which government reduced provision of free livestock services (Den Haan and Bekure 1991), pastoralists now rely more on drug manufacturers and other service providers for information which is often compartmentalized because it is given by different service providers dealing with different commodities.

The effectiveness of delivery of livestock services in Sub Saharan Africa, including Kenya, has seriously declined over the last two decades following structural adjustment programmes (Tambi et al, 1994). Most of Kenya’s red meat from beef and goats comes from ASALS. However, the country is not self sufficient in meat since about 29% is imported from neighboring countries (AU-IBAR, 2006). Supporting livestock keepers in access to inputs and services has the potential to improve productivity and commercialization in livestock value chain. In view of the challenges faced in delivery of livestock services in ASALS especially by Individual organizations, this study sought to make an assessment of the status of livestock technologies and services in Mashuru district.

MATERIALS AND METHODS
Study area
Mashuru district occupies an area of 2192.6 km2 with a population of 41, 655 persons consisting of 20974 males and 20681 females, grouped into 8810 households with a population density of 17 inhabitants/ km2 (District statistics report, 2010). The occupants of the district are predominantly Maasai pastoralists keeping cattle, goats, and sheep. It is a semi arid region characterized by low rainfall of less than 500 mm per annum and temperatures ranging from 240C to 370C. The low and often unreliable rainfall makes pastoralism the only suitable economic activity in the district.

Sample size, Study variables and data collection methods
All pastoralists in the district (N= 8810) formed the population from which a sample size was determined using the formula by Kothari (2008): n = N/ 1+N (e2), where n is the required sample size, N = estimated study population and e = marginal error set at 5%. Quantitative and qualitative data on livestock technologies, priority diseases, inputs and services were collected through cross sectional survey, stakeholder workshops, focus group discussions, key informant interviews and transect observations. The Quantitative data (Kothari, 2008) was obtained through a cross sectional survey using a structured questionnaire administered to 380 households randomly selected from ten locations in the district. Qualitative data (Kumar, 1993; Mariner, 2000; Kruger, 2002;) was gathered through workshops, ten focus groups - one from each location and interviews with participants purposively selected to provide a deeper understanding of the status of livestock technologies and services.

Data analysis
Descriptive statistics (Kothari, 2008; Mugenda, 2003) was used to analyze data on status of various livestock technologies and services

RESULTS
Livestock species were ranked using pair wise ranking
(Conroy, 2005; LDG, 2003), the pastoralists ranked the livestock kept in order of importance as indicated in table I below:

**Priority diseases**
The Priority diseases to livestock production were identified and ranked by the livestock keepers in ten locations of Mashuru district. This results are listed in the table II. The nearest service provider was the livestock keepers, then agro vets, community animal health workers (CAHW). Public service providers such as the extension and research institutions were the furthest.

**DISCUSSION**
Livestock keeping account for about 99% the economic activity of the 8,810 households. It acts as a current and savings account for purchases such as household needs. Contrary to popular opinion held by outsiders that the Maasai keep livestock for prestige and numbers, this was not mentioned. Cattle are the most important livestock species kept. These results agree with those found by Adugna and Aster (2007) in the Pastoral production system of Southern Ethiopia.

The sahiwal is dominant and is preferred breed, due to

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<thead>
<tr>
<th>TABLE II- IMPORTANT DISEASES TO LIVESTOCK</th>
</tr>
</thead>
<tbody>
<tr>
<td>Livestock species</td>
</tr>
<tr>
<td>-------------------</td>
</tr>
<tr>
<td>Cattle</td>
</tr>
<tr>
<td>Goats</td>
</tr>
<tr>
<td>Sheep</td>
</tr>
<tr>
<td>Chicken</td>
</tr>
</tbody>
</table>

Legend:
FMD: Foot and Mouth disease
ECF: East Coast Fever
CCPP: Contagious caprine pleuropneumonia

**Inputs and services**

<p>| TABLE III - INPUTS AND SERVICES PERCEIVED TO BE IMPORTANT BY LIVESTOCK KEEPERS |
|------------------------------------------|------------------------------------------|</p>
<table>
<thead>
<tr>
<th>Input / service</th>
<th>Frequency</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td>198</td>
<td>52</td>
</tr>
<tr>
<td>Pasture</td>
<td>105</td>
<td>28</td>
</tr>
<tr>
<td>Vaccines and drugs</td>
<td>31</td>
<td>8</td>
</tr>
<tr>
<td>Germplasm: breeding stock, forage species</td>
<td>17</td>
<td>4</td>
</tr>
<tr>
<td>Market information</td>
<td>14</td>
<td>4</td>
</tr>
<tr>
<td>Capacity building</td>
<td>10</td>
<td>3</td>
</tr>
<tr>
<td>Small equipment : spray, pumps etc</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>N=380 100%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**TABLE IV - FACTORS INFLUENCING ACCESS TO INPUTS / SERVICES**

<table>
<thead>
<tr>
<th>Category</th>
<th>Factor</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Institutional</td>
<td>Institutional Long distance to livestock input service providers</td>
<td>1</td>
</tr>
<tr>
<td>Institutional</td>
<td>Inadequate Government livestock service providers</td>
<td>2</td>
</tr>
<tr>
<td>Institutional</td>
<td>Weak institutional linkages</td>
<td>3</td>
</tr>
<tr>
<td>Institutional</td>
<td>Limited facilitation and poor funding of extension staff</td>
<td>5</td>
</tr>
<tr>
<td>Institutional</td>
<td>Lack of feedback from previous projects</td>
<td>10</td>
</tr>
<tr>
<td>Institutional</td>
<td>Government and donor funded project priorities contrast with community interests</td>
<td>8</td>
</tr>
<tr>
<td>Institutional</td>
<td>Inadequate infrastructure –roads, power, water</td>
<td>4</td>
</tr>
<tr>
<td>Technological</td>
<td>Unavailability of cold chain for vaccine portability</td>
<td>6</td>
</tr>
<tr>
<td>Technological</td>
<td>Poor packaging: mismatch between quantity demanded and quantity sold</td>
<td>9</td>
</tr>
<tr>
<td>Economical</td>
<td>High cost of drugs</td>
<td>11</td>
</tr>
<tr>
<td>Environmental</td>
<td>Recurrent drought</td>
<td>7</td>
</tr>
</tbody>
</table>

Proximity of inputs and service providers to livestock keepers
Public
CAHW
SELF
Agro vet
its dual purpose traits of milk and beef production and adaptability to the dry climatic conditions. These results agree with those obtained by Cossins (1985) in the Sahel region, who argued that pastoralists are not attached to unproductive animals as outsiders believe. Rather it is the result of the environment and the multiple objectives for keeping livestock which determines the number of animals a family can keep.

Livestock Priority diseases as perceived by livestock keepers in terms of morbidity, mortality and loss of incomes are mostly trans boundary animal diseases (TADs) caused by interaction of infected and healthy animals during extensive movements, communal watering or newly purchased animals in the herd. TADs have been known to be priority diseases in pastoral areas (Perry et al., 2005). There is little success in control strategies as the public veterinary service appears only when there is an epidemic. These diseases have far reaching economic and social consequences at household, community and national levels and hence control cannot be left to the private sector or pastoralists as a result of reduced state funding. The Integration of livestock keepers in management of these diseases is of utmost importance. Access to drugs and vaccines is a challenge since service providers are found only in large towns. Livestock keepers travel an average of 60 km to the nearest agro vet to buy small equipments and drugs, 140 km to buy vaccines, and 200km to buy breeding stock from the only service provider. Poor road network and lack of electricity are a hindrance to accessibility of inputs.

### TABLE V-BENEFITS ACCRUED FROM PUBLIC VERSUS PRIVATE SECTOR SERVICE PROVIDERS AS PERCEIVED BY LIVESTOCK KEEPERS

<table>
<thead>
<tr>
<th>Merits</th>
<th>Public sector</th>
<th>CAHW</th>
<th>NGO</th>
<th>Agro-vet shops</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cheap</td>
<td>✅✅</td>
<td>✅</td>
<td>X</td>
<td>✅</td>
</tr>
<tr>
<td>Efficient</td>
<td>✅</td>
<td>✅</td>
<td>X x</td>
<td>✅</td>
</tr>
<tr>
<td>Available</td>
<td>✅</td>
<td>✅</td>
<td>X</td>
<td>✅</td>
</tr>
<tr>
<td>Near to livestock keeper</td>
<td>✅</td>
<td>✅</td>
<td>X</td>
<td>✅</td>
</tr>
<tr>
<td>Gives advice</td>
<td>✅</td>
<td>✅</td>
<td>X</td>
<td>✅</td>
</tr>
<tr>
<td>Accessibility</td>
<td>✅</td>
<td>✅</td>
<td>X</td>
<td>✅</td>
</tr>
<tr>
<td>Better known.</td>
<td>✅</td>
<td>✅</td>
<td>X</td>
<td>✅</td>
</tr>
<tr>
<td>Has facilities</td>
<td>✅</td>
<td>✅</td>
<td>X</td>
<td>✅</td>
</tr>
<tr>
<td>Quick to respond</td>
<td>✅</td>
<td>✅</td>
<td>X</td>
<td>✅</td>
</tr>
<tr>
<td>Sub-total points</td>
<td>3</td>
<td>7</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Total points</td>
<td>3</td>
<td>11</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

=Yes  
=Sometimes
X = No

### TABLE VI- PERCEPTIONS OF LIVESTOCK KEEPERS ON PROBLEMS ENCOUNTERED WITH PUBLIC AND PRIVATE SECTOR SERVICE PROVIDERS.

<table>
<thead>
<tr>
<th>Merits</th>
<th>Public sector</th>
<th>CAHW</th>
<th>NGO</th>
<th>Agro-vet shops</th>
</tr>
</thead>
<tbody>
<tr>
<td>No facilities</td>
<td>✅</td>
<td>✅</td>
<td>X</td>
<td>✅</td>
</tr>
<tr>
<td>Expensive</td>
<td>✅</td>
<td>✅</td>
<td>X</td>
<td>✅</td>
</tr>
<tr>
<td>No drugs</td>
<td>✅</td>
<td>✅</td>
<td>X</td>
<td>✅</td>
</tr>
<tr>
<td>No follow up</td>
<td>X</td>
<td>✅</td>
<td>X</td>
<td>✅</td>
</tr>
<tr>
<td>Sometimes not available</td>
<td>✅</td>
<td>✅</td>
<td>X</td>
<td>✅</td>
</tr>
<tr>
<td>No tools</td>
<td>✅</td>
<td>✅</td>
<td>X</td>
<td>✅</td>
</tr>
<tr>
<td>Component</td>
<td>✅</td>
<td>✅</td>
<td>X</td>
<td>✅</td>
</tr>
<tr>
<td>Needs advice from veterinarians</td>
<td>✅</td>
<td>✅</td>
<td>X</td>
<td>✅</td>
</tr>
<tr>
<td>Gives no appropriate advice</td>
<td>✅</td>
<td>✅</td>
<td>X</td>
<td>✅</td>
</tr>
<tr>
<td>No transport</td>
<td>✅</td>
<td>✅</td>
<td>X</td>
<td>✅</td>
</tr>
<tr>
<td>Needs Fuel</td>
<td>✅</td>
<td>✅</td>
<td>X</td>
<td>✅</td>
</tr>
<tr>
<td>Sub-total points</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td>Total points</td>
<td>6</td>
<td>16</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

=Yes  
=Sometimes
X = No

"Framing the issues, challenges and opportunities in livestock sector in the 21st century"
This study shows that the Maasai derives more benefits from private sector due to its availability and accessibility. Though the public sector is not visible on the ground, they are perceived to be more competent and have better facilities than private sector. However, Mugunieri et al., (2004) compared productivity of livestock herds among farmers who utilized the services of community-based animal health workers and veterinarians and found that they were not significantly different. Hence there is need for linkages with private sector for efficient and effective delivery of services.

The Factors influencing access to inputs and intervention strategy are predominantly institutional rather than technological. The Priority interventions suggested addressing the problem of inputs and technology availability and accessibility. These interventions were the establishment of a one-stop-shop for inputs, improvement of road and water infrastructures, market facilities, and capacity building of livestock keepers. The majority of livestock keepers (95%) expressed willingness to pay for the inputs centre and capacity building. However they are not willing to pay for improvement of roads and water since they perceive it as a public service, even though it was their second priority intervention.

**CONCLUSION**

The findings of this study indicate that livestock technologies and services in the Southern rangelands of Kenya are inadequate and need to be strengthened through effective extension, stakeholder linkages and improved infrastructure. In view of problems encountered in accessing livestock inputs and technologies, livestock keepers prefer the establishment of one-stop-shop centre stocked with priority inputs and key information pertaining to livestock production, health and markets. The willing to pay for this service should attract public-private partnerships to support livestock productivity in rangelands. There is therefore need to rethink research and extension from the old approach of discipline centered to a new paradigm of problem-solving through a systemic approach. Towards this endeavor is the implementation of impact models for the provision of livestock services that take into account local contexts in many areas especially where service markets have not worked.

**TABLE VII - SUGGESTED INTERVENTIONS TO ADDRESS CONSTRAINTS TO LIVESTOCK TECHNOLOGIES AND SERVICES**

<table>
<thead>
<tr>
<th>Rank</th>
<th>Intervention</th>
<th>Willing to pay for services</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Establish a one-stop-resource centre for inputs</td>
<td>95%</td>
</tr>
<tr>
<td>2</td>
<td>Improve infrastructure especially water and roads</td>
<td>2%</td>
</tr>
<tr>
<td>3</td>
<td>Capacity building of livestock keepers</td>
<td>35%</td>
</tr>
<tr>
<td>4</td>
<td>Improve market facilities and development of livestock mark</td>
<td>20%</td>
</tr>
</tbody>
</table>

**ACKNOWLEDGEMENT**

This study was made possible through the cooperation and collaboration of Livestock keepers, the provincial administration particularly the support from area Chiefs, District livestock production and veterinary staff, livestock traders, market councils and NGOs, particularly the World Vision. Funding for this study was made possible through KARI-KAPAP project.

**REFERENCES**


“Framing the issues, challenges and opportunities in livestock sector in the 21st century”


CROSS BORDER SHARING OF RESOURCES; A CASE STUDY OF THE GABRA AND THE BORANA COMMUNITIES OF NORTHERN KENYA AND SOUTHERN ETHIOPIA.

A. Kagunyu1, S. Mesele2, G. Haile2, M. Shibia1, and L. Belay2
1Kenyan Agricultural Research Institute (Kenya), 2Oromia Agricultural Research Institute (Ethiopia)

ABSTRACT
This study took place in northern Kenya and southern Ethiopia among the Gabra and the Borana, whose major economic activity is livestock production. This was a cross border study conducted by researchers from Kenya and Ethiopia. The study had three objectives namely: to characterize the key natural resources along and across the Kenya /Ethiopian border, to map pastoral migration routes and to characterize cross-border interactions among different pastoral communities, both positive and negative. The study applied various research techniques to collect data, which included; Semi-structured questionnaires, focus group discussions, key informants and direct observation. The GPS was used to map livestock migratory routes and hot spots. Data collected was analyzed using SPSS. Research findings indicated that pastoral communities move across and along the international border primarily in search of forage and water for livestock. It came out clearly that mutual sharing of resources was common between the Gabra and the Borana of Kenya and Ethiopia respectively. The two communities were using range resources inter-changeably for instance the Gabra of Kenya took their camels to Southern Ethiopia in areas which had suitable camel forage. Similarly the Borana of Ethiopia who were predominantly cattle keepers were able to take their cattle to Northern Kenya for instance Forore, Dida Galgallo among other areas. The shared resources included water, pastures, medicinal plants and mineral licks. The study also indicated that cross border conflict between the two communities interrupted their interaction and this on the other hand hindered them from sharing natural resources across the border. Mutual sharing of resources by communities living along and across the border is very important and has played an important role in saving life for livestock as well as livestock producers There is need for the two governments to ensure that peaceful co- existence is maintained between the communities living across the border as insecurity would curtail their movement. This study further revealed that livestock health delivery systems which were existing in the Kenya–Ethiopia border and vice versa was in a very poor state and as a result there was cross-border disease transmission. There is therefore need for the two governments to introduce appropriate livestock health delivery services along and across the border.

INTRODUCTION
Livestock production is the major economic activity in Northern Kenya and Southern Ethiopia. It is a vital resource in promoting development in Arid and Semi Arid Lands (ASAL). According to ILRI/ASERECA (2000) report livestock have the ability to withstand severe fluctuations in weather patterns and environmental shifts. Livestock population includes: Cattle, goats, camels, sheep, and poultry, among others. Despite the important roles played by livestock in Northern Kenya and southern Ethiopia pastoralists and their animals face so many problems, which undermine their livelihood and wealth creation. Some of these problems include droughts, floods, human conflicts, natural disaster such as, diseases, and raids. These problems disrupt the normal activities of pastoral communities, and even getting food. As a result these pastoralists have devised ways of coping with environmental stress which includes livestock mobility. They migrate with their animals to Northern Kenya and Southern Ethiopia in search of pasture. Livestock mobility is the most important strategy that pastoral communities utilize to cope with devastating effects of drought (Behenke, 1997). For instance pastoralists along the Kenyan - Ethiopian border move very long distances across/along the boundaries and borders in search of better pastures for their animals during the drought season.

Pastoralists routine movements along and across/along the border could have both positive and negative effects on both humans and livestock. The Positive ones include exchanging ideas on disease control, resource utilization and livestock management, the negative ones may includes disease transmission, range degradation and tribal conflicts although there is little data in relation to the interactions of the pastoral communities across/along the border. There was little knowledge on the nature of interaction among the Gabra and Borana communities of Northern Kenya and Southern Ethiopia. The shared resources and their locations are not documented, and the seasonal pattern of their mobility. Therefore, this study aimed at trying to understand the nature of interaction which existed between these two communities. This study was guided by the following objectives:
(1) To characterize cross-border interactions between the Gabra community of Northern Kenya and the Borana community of Southern Ethiopia
(2) To identify and map commonly shared pastoral resources along the border
(3) To identify routes and seasons of livestock movement along the border

MATERIALS AND METHODS
Research sites
This study took place in northern Kenya and southern Ethiopia. In the northern Kenyan side, Sololo and Dukana were the research sites. In the Ethiopian side Dire, Miyo...
and Moyale were the research sites. All these research sites lie along and across Ethiopia-Kenyan border. The study area is mainly occupied by many communities which include Borana and Gabra. Other pastoral communities which also occupy the area are Somali, Burji, Turkana in northern Kenya and Gari and Digodi in the southern Ethiopian side. This study focused on the Borana and Gabra of both Kenya and Ethiopian since they were the communities which having well defined interactions across the border.

**Sampling**

The sites were selected due to the nature of the study, which was meant to be a joint cross border project. These two regions lie adjacent to each other along the Kenyan-Ethiopian border. The unit of the study was household heads. It was held that the household heads made important decisions relating to the areas of migration. So it was thought to be the most important focus of attention since all individuals young and old come from the household. Non-probability sampling was used to arrive at the sampling unit. Due to the tension which prevailed during the time of data collection, it was thought to be the only alternative. A total of 200 respondents were interviewed from both Kenya and Ethiopia.

**Data Collection Questionnaires**

Individual interviews were conducted through the administration of a questionnaire to the respondents. Nassiuma (2000) defines a questionnaire as a set of questions designed to extract information relating to a survey. The questionnaire had both structured and unstructured questions. Mugenda and Mugenda (2003) refers to structured questions as those which are accompanied by a list of all possible alternatives from which respondents select the answer that describes their situation. Open-ended questions were used to extend the materials of the closed ended questions and others were used to enable the respondents to give much information as possible. The interview schedule had questions based on the three research objectives. The filled questionnaires were cross checked every day to see to it that responses were correctly entered in each appropriate place on the questionnaire.

**Key informants**

The key informants were among the following: local chiefs, elders, health officers, security officers OCS, OCPD, GSU Corporal and program coordinators such as program coordinator of Arid lands and Livestock production officers (DLPO). The aim was to solicit additional data on local peoples’ perception towards conflict and its management. Informal discussions were held with the key informants and details of the discussion were recorded in the researcher’s field notebook. In the course of the day the information acquired was cross checked, any additional information was noted down. The questions were similar to those, which were in the questionnaire to check whether there was any relationship and again to get more information on same questions.

**Focused Group Discussion**

Focus group discussions using semi-structured interviews were held by the Ethiopian team and Kenyan team. The groups were composed of opinion leaders, elders and adult pastoralists. Two groups were held in every site, men and women separately. The reason for having them separately is because in pastoral communities women shy of from expressing themselves in front of men. Culturally women were not supposed to talk where there were men.

**Use of GPS technology and GIS software**

Mapping the livestock mobility routes and hot spots was done using GPS to collect data and which was interpreted using GIS software.

**Data processing and analysis**

Mugenda and Mugenda (2003) state that data analysis is a process of bringing order, structure and meaning to the mass of information collected. This study collected both qualitative and quantitative data. Qualitative data derived from direct observations, focus group discussions and key informant interviews were presented in discussions and case studies. Quantitative data derived from the household interviews were edited, coded and entered into a computer and the Statistical Package for Social Science (SPSS) software version 11.5 spread sheets was used for the analysis. Multiple response questions were analysed so as to give frequencies and percentages. Tables and bar charts were used to present the findings.

**RESULTS AND DISCUSSIONS**

**Shared resources**

Pastoralists shared different basic resources on both sides of the border. These included pasture, water points and mineral resources. Pasture and water were shared during livestock mobility throughout the year. The study indicated that in Northern Kenya along the border most of the pasture was referred as wet season grazing region. During this season pastoralists from southern Ethiopia travelled long distances in search of pasture. These remotely situated pasture lands were utilized by the Gabra of Northern Kenya and the Borana of Southern Ethiopia. Mobile herds from southern Ethiopia came to northern Kenyan rangelands. The reason for this was that the range vegetation was mainly grass which was suitable for cattle. The Borana migrated towards the same areas to utilize pastures which were not available in the Ethiopian side due to absence of surface water and deep wells especially during the dry spell. On the other hand the Gabra community of Northern Kenya moved with their livestock to southern Ethiopia where they were able to get suitable forage for their camels.

According to the findings of this study pastoralists migrated across and along the border after considering
many factors. These factors included; rainfall conditions, pasture availability and condition, peace in the area, and diseases. They were able to tell if a certain area or region was safe by making use of their indigenous indicators of rain, war, drought and diseases. Their cultural indicators included observation of the pattern of stars, trees and rumen of slaughtered animal. They also consulted fortune tellers (Ayaantuu and Huchuu) who guided them on the routes which were safe.

Figure 2 below shows where shared resources were geographically located in Kenya and Ethiopia as indicated by the respondents. As many as 52% of the respondents indicated that shared resources were located along the border, 26% cited that they were located in Kenya, while 22% indicated that they were found in Ethiopia.

**Seasonal patterns of mobility**

Cross border livestock mobility was a strategy which was applied as a strategy to bail the two communities from the problem of water and forage during the drought period. During this time livestock tended to be concentrated in areas where there were permanent watering points. Figure 3 and 4 below gives a good illustration of the type of movement which was practiced by the Gabra of Northern Kenya and the Borana of Southern Ethiopia.

**Benefits of having interactions and friendship**

According to the responses given the Gabra and Borana communities, used to live together harmoniously sharing common resources. They used to have mutual agreements on how to use the common resources for instance the Borana of Ethiopia would bring their livestock in Kenya in areas such as Dida Galgallo, Huri hills, Forole, North Horr where their cattle would graze. Likewise the Gabra used to take their camels to Ethiopia in area where there are good pastures for camels. Livestock from these two communities never used to die in big numbers whenever there was drought due to these interactions. When the Gabbra and Borana of Ethiopia started fighting, the Kenya/Ethiopia border was closed and they could no longer...
Physical location of shared resources

Figure 2: Graph showing geographical location of shared resources

Figure 3: Map showing patterns of livestock mobility in dry season
have access to the same resources. This led to the Gabra livestock dying in great numbers due to severe drought which struck the country in the year 2005 to 2006.

The findings of this study also revealed the Borana of Ethiopia and the Gabra of Kenya used to have cross border trade in livestock, cereals, fuel and other retail commodities. The border areas are not well endowed with livestock health services so the two communities used to exchange ideas on curative herbs of treating their livestock and other human related diseases. Both Borana and Gabra communities share cultural values in the Gada system. The Gabra from northern Kenya and southern Ethiopia traditionally would travel to the Borana territory to fulfill the procedures of Gada political systems and rituals. In the same manner, the Borana from southern Ethiopia would make their way to the Gabra to fulfill the requirements in the Gada system. Therefore, these communities have deep cultural relationship far deeper than simply sharing resources.

Challenges that affected the cross-border sharing of resources.
This study indicated that as drought occurrence became very frequent; occurring after 3 to 2 years even yearly competition became very high over the natural resources. As rivalry in exploitation increased and resource bases dwindled, conflict between the two communities sometimes become inevitable. Conflict affected the migration patterns of the two communities and their movement was restricted to the safe areas, which were limited. This on the other hand contributed to forage biomass being too low to support livestock especially in the communal grazing areas leading to massive livestock deaths which would be saved if the two communities lived in harmony.

According to the views of focus group discussion conflict not only disrupted livestock migration across the border but also the cross border trade which existed between the Borana of Ethiopia and the Gabra of Northern Kenya. It also brought land degradation since livestock tended to be concentrated in “safe” areas near settlements to reduce the chance of raiding. This contributed to overgrazing that led to the disappearance of valued perennial forages including Cenchrus ciliaris, Chrysopogon plumulosus, Pennisetum mezianum, Echinochloa haploclada, Panicum coloratum, Leptothorium senegalense, Blepharis linariifolia, Aristida adscensionis, and Indigofera cliffordiana. In contrast, the no-man’s land where conflict had eliminated presence of livestock appeared to improve forage condition because it is rested from being grazed.

Cross border livestock mobility was associated with spread of some livestock diseases. The most prevalent disease as
given by the respondents were CBPP, CCPP, tick borne diseases, foot and mouth diseases. This high prevalence was a threat to market access by the pastoralists and they regarded it as limiting factor to effectively respond to marketing opportunities. According to respondents interviewed high incidences of the mentioned trans-border diseases had caused frequent livestock quarantines and continuously interrupted access to terminal markets.

CONCLUSIONS
This study shows that the positive interaction between the cross border communities has been very helpful. The existence of cross border trade in cereals, livestock, and hides and skins has been of great help to these two communities since they are land locked especially Dukana in the Kenya side transport and communication is a big problem. Mutual sharing of resources contributes to survive of livestock during the drought period whenever the two communities are living harmoniously.

The shared resources according to this study included pasture, water and salt minerals. It came out clearly that there was mutual sharing of resources the Gabra community of Northern Kenya took their camel to browse in Southern Ethiopia, similarly the Borana of Southern Ethiopia brought their cattle to Northern Kenya where there was grass for their cattle. This sharing was very helpful as it acted as an indigenous strategy for the communities coping with forage of forage especially during the drought period.

The cross border routes were mapped (see Figure 3 and 4). According to the findings of this study pastoralists migrated across and along the border after considering many factors. These factors included; rainfall conditions, pasture availability and condition, peace in the area, and diseases. They were able to tell if a certain area or region was safe by making use of their indigenous indicators of rain, war, drought and diseases. Their cultural indicators included observation of the pattern of stars, trees and rumen of slaughtered animal. Routes which were not secure were avoided.

Ethnic conflict affected the migration patterns of the two communities. Whenever conflict erupted between the two communities movement is usually restricted to safe areas and this leads to overgrazing leading to range degradation and massive death of livestock. The other problem identified was the spread of trans-boundary livestock diseases due to limited health delivery services across and along the Kenya and Ethiopian border. This on the other hand affects the livestock trade locally and internationally.

Recommendations with policy implications
The positive interaction between the neighboring communities of Ethiopia–Kenya is usually affected by the resource-based conflict. The resource-based conflict led to the closure of the Kenya–Ethiopian border hence affecting any form of interaction between the neighboring communities. This being the case there is need to restore peace so that their trade could go on as it used to be before.

This study revealed that the impact of conflict to the two communities was enormous which includes; loss of grazing lands, loss of livestock, and loss of human life when two communities fight and development projects are destroyed. Therefore, there is need for the communities of the two countries to live harmoniously so as to save their livestock from vagaries which are brought by climate change. There is need for the government of Kenya and Ethiopia, NGOs, CBOs and the county administrators working in the two countries to promote peace.

It came out clearly that some of the plant species along and across the border has been depleted due to overgrazing. There is need for the communities sharing the resources to come up with laws guiding common resource use and the EMCS and the governments to make sure that the laws are followed by the stakeholders.

There is also need to come up with range rehabilitation strategies by using EMC (environmental management committee), CBOs and any other stakeholder to avert land degradation. Seminars on range rehabilitation should be held frequently and reseeding programs to be started in areas where land degradation has taken place. This study also revealed that livestock mobility led to disease transmission among the pastoral herds. The respondents identified the commonly transmitted diseases, which is an indication that their livestock health delivery systems were poor. There is need for the Kenya and Ethiopia governments to train the pastoral communities on how to identify common diseases and to treat them. There is also need for the governments to improve health delivery systems in these areas, as this will also help in marketing of livestock and their products. The governments of the two countries need to improve the essential livestock health delivery systems.

REFERENCES


STATUS OF FODDER CONSERVATION AMONG SMALLHOLDER DAIRY FARMERS IN COASTAL KENYA

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ABSTRACT
Farmers in coastal Kenya depend on forages to feed livestock. Forage production is rain fed, and therefore feeds are scarce and of poor quality during the dry season. As a result of poor feeding, dairy cattle suffer severe nutritional stresses resulting in decreased productivity; most importantly low milk production. Fodder conservation is an option for providing high quality feed during the dry season. Situational analysis was conducted to establish the status of fodder conservation in Kwale and Kilifi Counties of coastal Kenya to identify the opportunities and constraining factors in fodder conservation among smallholder dairy farmers. A structured questionnaire was used to collect information from 181 smallholder dairy farmers. The study found that 46.6% of the farmers conserved forage mostly maize stover, leucaena and hay from natural pastures. Silage conservation on the other hand was least practised despite 24.6% of the farmers having been trained on it. Reasons were given for the farmers’ inability to conserve hay and silage, which included inadequate skills, high cost and inadequate materials to conserve. The study recommends inter alia, the use of conservation training approaches for farmers with low education level and use of low inputs for silage conservation and promotion of improved fodder grasses.

INTRODUCTION
High quality level forages are essential for increased dairy and milk productivity. However, productivity is constrained by seasonality of feed quantity and quality which causes glut in wet season and deficiency in dry season. This can be evened out with feed conservation during excess for use in the deficit period (MoLD 2010). In coastal Kenya, dairy production is important, with annual milk production averaging 90 million litres and a dairy herd of 97,393 animals (PDLD 2010). The farmers in coastal Kenya depend on forages to feed livestock. Forage production is rain fed, and therefore feeds are scarce and of poor quality during the dry season. As a result of poor feeding, dairy cattle suffer severe nutritional stresses resulting in decreased productivity; most importantly low milk production. Fodder conservation is an option for providing high quality feed during the dry season. Situational analysis was conducted to establish the status of fodder conservation in Kwale and Kilifi Counties of coastal Kenya to identify the opportunities and constraining factors in fodder conservation among smallholder dairy farmers.

MATERIALS AND METHODS
The study covered smallholder dairy farmers in coastal lowland Kenya. Both purposive and multistage random sampling techniques were used to select the study sample. Kwale and Kilifi Counties were purposefully selected to represent coastal lowland Kenya and South and North coast respectively. The counties were selected because they have the highest number of dairy animals and the highest milk production potential in coastal Kenya. Kilifi County has 58812 dairy animals while Kwale County has 3851 (PDLD 2011). Rainfall in coastal Kenya decreases from south to north and hence the need to sample both areas.

Two divisions were selected from Kwale and Kilifi District while one division was selected in Malindi. From the selected divisions, a list of the dairy farmers was developed with the assistance of the Divisional livestock extension officers. This comprised the sampling frame from which the farmers were selected randomly for interviewing in the study.

A structured questionnaire was used to collect information through face to face interviews of the selected farmers. The IBM SPSS STATISTICS 20 software was used for data analysis. Quantitative data was analyzed using descriptive statistics and cross tabulations were done to establish associations between some of the variables. The study was carried out during the month of April 2012. This is the transition period from the dry season (January to March) to the wet season of April - July.

RESULTS AND DISCUSSION

Farmers’ demographic characteristics
The study sample consisted of 181 smallholder dairy farmers 62.4% of whom were female. The mean household size was 7.7 persons. The main occupation was farming for 66% of the respondents, while others were engaged in various forms of off farm employment (Annex 1). The respondents had varied experience in dairy farming. The mean number of years for which the respondents had kept dairy animals was 9.3 years with a range of 1 – 30 years. About a quarter of the respondents had 10 years experience, while 73.3% had 10 years experience and below.

Age
The mean age of dairy farmers in the study area was 45.1 years ranging from 16 - 86 years. When distributed by age groups, there were almost equal proportions of the youth (18-35 years) and the elderly above 55 years (26.5% and 22.7% respectively). The retirement in Kenya is 55-65. The nearly balanced proportion shows that the youth can replace the aging adults. This is in line with the government policy to encourage youth participation in agriculture to enhance employment and rural – urban
manner. There was a significantly high proportion (at \( \alpha = 0.05 \)) of farmers in the active and productive working age of 36-55 years which shows that this group is willing to invest in dairy farming. This age category has more resources and provides a potential window for promotion of capital intensive technologies.

**Education level**

Education level is positively correlated to adoption of dairy technologies (Makokha 2005). Within the study site, 40.9% of the respondents had primary school level of education while 19.9% had no formal education. Whereas primary education may just be adequate for adoption of technology, lower primary level may be inadequate. The 19.9% proportion of the population having no formal education may be a challenge to technology adoption and a recipe to reduced dairy productivity in coastal Kenya.

**Dairy management**

**Number of dairy animals**

The total number of dairy cattle inclusive of bulls, heifers and calves per farmer was 3.5 animals (SD 2.4), ranging from 1 – 16 cattle. The mode was 2.0 cattle. Farmers with four animals or less were 78.5%. There were no differences across Districts. This agrees with Thorpe et al (2000) who observed that generally smallholder farmers had 1-2 dairy cows comprising 50% of the herd, the other half consisting of female calves and heifers.

**Dairy management system**

The main dairy management systems used by dairy farmers in the study area were zero grazing (55.6%), and others that included semi zero grazing, free ranging, tethering and their combinations (Table I). There were no significant differences in the grazing system applied during the rain and dry seasons. Over 91.7% of the farmers reported using the same management system for both dry and rainy seasons.

**Forage conservation**

Forage conservation is a critical strategy for dairy farmers to ensure year long availability of feed for their livestock. There are two main seasons affecting feed availability in Kwa and Kilifi Counties. These are the dry season which falls between November and March when feed is scarce. The critical period is January - March when feed is most scarce. The other season is the rainy season of April – June when feed is in plenty.

The Ministry of Livestock Development and KARI have been promoting fodder conservation to leverage farmers against feed scarcity during the dry season. The study found that 37% of the farmers conserved forage (Table II). Hay from natural pasture was the main forage conserved. This was expected since natural pasture was in abundant supply during the rainy season hence the surplus could be easily conserved. Other forms of conserved fodder were leucaena and maize stover. There is an opportunity for the farmers to increase production and improve the quality of the conserved fodder through planting improved grasses (eg Rhodes grass).

**Dry forage conservation**

Hay was mainly conserved from natural pastures. Natural pasture was readily available during the rainy season hence surplus can easily be conserved. Apart from natural pastures, hay was also made from a combination of natural pastures and leucaena. Although the main reason for fodder conservation was to get dry season feed, for almost half of the farmers (48.9%) (Table III), there were other factors that enhanced or impeded hay conservation. Farmers considered the cost of conservation to be important as well as the ease of conservation. These are critical considerations especially because the whole exercise is mostly done manually. The small number of animals that the farmers keep with an average of four; and the expected milk production could also be a factor contributing to low conservation efforts.

The main constraints to forage conservation in general were lack of skills and knowledge on conservation (74%), inadequate materials to conserve and the high cost of labour and materials used in conservation. Silage making

Silage best retains the original feed nutrients, hence should be most important to increase dairy productivity.

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**TABLE I - GRAZING SYSTEMS PRACTICED SMALLHOLDER DAIRY FARMERS IN KWALE AND KILIFI COUNTIES (N=180)**

<table>
<thead>
<tr>
<th>Grazing system</th>
<th>Frequency</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zero grazing</td>
<td>100</td>
<td>(55.6)</td>
</tr>
<tr>
<td>Semi-zero</td>
<td>29</td>
<td>(16.0)</td>
</tr>
<tr>
<td>Tethering</td>
<td>19</td>
<td>(10.6)</td>
</tr>
<tr>
<td>Free range</td>
<td>12</td>
<td>(6.6)</td>
</tr>
<tr>
<td>Zero grazing + tethering</td>
<td>8</td>
<td>(4.4)</td>
</tr>
<tr>
<td>Tethering + free range</td>
<td>6</td>
<td>(3.3)</td>
</tr>
<tr>
<td>Zero grazing + free range</td>
<td>4</td>
<td>(2.2)</td>
</tr>
<tr>
<td>Tethering + semi-zero</td>
<td>2</td>
<td>(1.1)</td>
</tr>
<tr>
<td>Total</td>
<td>180</td>
<td>(100)</td>
</tr>
</tbody>
</table>
However all respondents in the study area except one in Kwale District did not make silage. The main reasons for not making silage were lack of skills and knowledge (63%), insufficient materials (13.7%) and high expense (10.1%) (Table IV). The estimated cost of ensiling one ton of silage is KES 3500 – 4200 at current (2013) labour and materials costs. Major costs are labour requirements for harvesting, chopping and compacting, digging of the silage pit, polythene sheets and maize bran.

<table>
<thead>
<tr>
<th>Forage conserved</th>
<th>Frequency</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hay</td>
<td>42</td>
<td>27.3</td>
</tr>
<tr>
<td>Silage</td>
<td>1</td>
<td>0.6</td>
</tr>
<tr>
<td>Other</td>
<td>14</td>
<td>9.1</td>
</tr>
<tr>
<td>Total</td>
<td>57</td>
<td>37</td>
</tr>
<tr>
<td>No conservation</td>
<td>97</td>
<td>63</td>
</tr>
<tr>
<td>Total</td>
<td>154</td>
<td>100</td>
</tr>
</tbody>
</table>

*Numbers in parenthesis are percentages

The conventional silage technology recommends ensiling Napier grass with gliciridia forage and maize bran (Mambo et al, undated leaflet). It is therefore possible that the technology was not disseminated as recommended and therefore farmers may have achieved less satisfactory results from the silage they made thus being discouraged from adopting the practice.

Further, farmers were trained to make Napier/molasses silage during the NDDP (late 80s) project in pits where a tractor was provided by the project for compacting. This was not practical and that is why at the coast KARI-Mtwapa developed a technology to replace molasses with maize bran which is readily available on farm since most farmers grow maize and pound before milling into maize flour. Planting Napier grass in gliciridia alleys was promoted during the KARI/ILCA program (early 90s) and that is why gliciridia was added to improve the quality of silage. Later Ali et al showed that silage can be made in polythene tubes to reduce the cost of compacting with a tractor. The two leaflets have been sold to farmers during field days. However, there was no aggressive training on these technologies until 2012 when HPI/KARI trained a few farmer groups in Malindi on ensiling silage in polythene bags. In the proposed training under this EAAPP funded project, farmers will be trained on the same with the aim of reducing the cost of silage making further. Use of recycled polythene bags was proposed but some preliminary trials at the centre show that the bags should be airtight and therefore any perforations should be avoided. Ensiling in small bags allows the farmer to ensile small quantities of silage on a daily basis and hence reducing on the cost of casual labour to ensile in a pit. Lack of farmer training
may explain why the technology has not been taken up by farmers as noted in the situational analysis.

**Motivation to take up the technology**

The project plans to train the youth and any other interested farmers on making silage as a business to sell to other farmers during the dry season. The fact that a farmer can make small quantities at their convenience may be a motivation also. We intend to demonstrate to them that when used during the dry season it can sustain milk production when milk prices are high. A feed experiment which has just been concluded at KARI Mtwapa experiment has shown that.

Farmers who had been trained on silage making were asked why they were not practicing. Their responses were that they did not feel skilled enough to make the silage by themselves (39.3%); lack of materials for silage making (32.1%); high expenses involved (14.3%); high labour requirements (7.2%) and having enough fodder for their animals (7.2%). The project therefore should target to further enhance the skills of those already trained, and also focus on promoting production of the Napier grass and cassava required for silage making.

The mean land size was 6.3 acres, ranging from 0.5 - 62 acres (Table 4). However, the mode was 3.0 acres and 49.4% of the farmers had 3.0 acres or less. Farmers in Malindi District had significantly smaller land sizes at $P<0.05$ than those in Kwale and Kilifi. In Malindi therefore the need for production intensification is higher. While farmers in Malindi may lack the capacity to make silage on farm due to their limited land size, they are likely to provide a market for silage made elsewhere if they must sustain or increase their milk production. About 40.9% of the respondents owned land under free-hold system (Table 1) which is ideal for agricultural investment. However, 47.5% were operating on family land (Annex 2).

**CONCLUSIONS**

Fodder conservation among smallholder dairy farmers in coastal Kenya is low. Only 37% of the farmers conserve forage. Despite the training there is very little silage conservation, due to the high cost and availability of materials and inadequate skills.

**RECOMMENDATIONS**

The following recommendations are proposed as a follow-up towards enhancing the project outputs.

1. Owing to the low education levels of the smallholder dairy farmers in Kwale and Kilifi Counties, dissemination of fodder conservation technology should be packaged in simple format to be understood by farmers of low literacy level. There is also need to reinforce the knowledge and skills of the farmers with previous training.
2. Strategies to enhance availability of materials for making hay and silage should be adopted.
3. The cost of silage making should be minimized through use of low cost inputs.
4. There is need for further research on the economic viability of dairy farming in coastal Kenya. It is also important to explore non-market reasons for keeping dairy animals in order to make recommendations on how to improve the dairy enterprise in the region.

**ACKNOWLEDGEMENTS**

We acknowledge the EAPP for funding this study. Thanks for the support provided by the Director KARI, the enabling environment provided by the Centre Director, KARI – Mtwapa. Also acknowledged are the farmers and all who participated in any form in this study in coastal Kenya.

**REFERENCES**


humid zone.


STAKEHOLDER PARTICIPATION IN AGRICULTURAL EXTENSION: A CASE STUDY OF NALEP II PROGRAMME IN KAKAMEGA DISTRICT OF KENYA

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ABSTRACT

Agricultural extension still remains a key component of agricultural development. In the 19th to 21st century, agricultural extension has undergone numerous evolutions and reforms. However, there appears that no solutions have been found yet on a globally satisfactory strategy to be employed in implementation of agricultural extension. Currently in the 21st century, participation is perceived as one of the key concepts in development and is viewed as a compulsory undertaking in strategies for development worldwide. This is because it is seen as a potential channel through which different stakeholders can influence development ventures. Although for the last two decades participation has taken differing perspectives in development ventures and has been viewed as a disputed concept and approach.

The main objective of the research was to explore the effectiveness of stakeholder participation in NALEP II agricultural extension process. This was by exploring the aims of the Kenya government in promoting farmer participation and analysing the experiences of various stakeholders in an agricultural extension program jointly funded by the Kenya government and the government of Sweden. Case study methodology was used where two methods were employed that included NALEP II program document analysis and in-depth interviews carried in six focus groups and four individual interviews. Findings indicate that the required reforms in the 21st century in agricultural extension were incorporated in well formulated policy papers, accompanying implementation frameworks and field operational procedures. The findings indicate strong interactions between the policy formulation and coordination, and the public extension staffs in Focal Areas due to available activity based budgeting. However, perception of stakeholders in Focal Areas indicated that the anticipated optimal participation was not achieved. This strongly pointed to non-functioning local institutions that were supposed to be the engine for the participatory extension process. The local institution members appeared ignorant of their roles pointing to a possibility of poor constitution of these bodies. This, therefore, calls for further research to: explore the effectiveness of NALEP II extension process on a wider scale using qualitative in-depth methods; evaluate the management capacities of the agricultural extension staff and; possibly evaluate the training curricula of the agricultural education institutions in Kenya.

Key words: Agricultural extension; stakeholders; participation; agricultural extension policies

INTRODUCTION

There is a general agreement that effective extension service is an essential medium for development (Rivera, 1991; Samanta, 1991; van den Ban and Hawkins, 1996; Anderson and Feder 2004). Agricultural extension initially perceived as simply extending research knowledge to farmers to improve on their farm productivity (Baxter 1989; Davis 2009) has since the mid-1980s gone through several reforms and can be perceived to have had a “paradigm shift” to mean an “entire set of organizations that support and facilitate people engaged in agricultural production to solve problems and to obtain information, skills, and technologies to improve their livelihoods and well-being” (Birner et al., 2006). Pretty et al., (2011) notes that an increase in agricultural production in the last half of the 20th century has led to improvements in rural and urban economic growth globally: more so in developing countries where agriculture is and will continue to be the main source of income and food for the people (Rivera 1996). To this end, various international bodies and governments are putting forward efforts to improve agricultural extension to conform to continuous changing needs of farmers (Rivera and Qamar, 2003).

Structural, financial and managerial reforms being advanced include decentralization, bottom-up planning and stakeholder participation (Rivera and Qamar, 2003). This requires that local people should be the principal decision makers in matters that affect them (Smith et al., 2009). Consequently, various participatory approaches have been promoted in pursuit of development (Ghimire et al., 2009).

In the participatory process the stakeholders are allowed to negotiate and ultimately determine both the methods and outcomes of a development venture (Bruges and Smith, 2007). Therefore, the participants are involved in planning (bottom-up planning), implementation (stakeholder participation) and eventually the decision making of the development venture becomes decentralised.

The small scale rural agriculture in Kenya accounts for 75% of the total agricultural output and about 70% of marketed agricultural produce (Government of Kenya, 2007). These characteristics of the agricultural sector have important implications on the structural and institutional organisation of both public and private agricultural extension in terms of approach and content of extension service (Government of Kenya, 2007). In addition, Kenya’s development blueprint inaugurated by the government in 2008 -Vision 2030, identifies agriculture as one of the key sectors to provide the 10 per cent per annual economic growth rate envisioned therein. To realize this growth, it is imperative that the
predominant small scale uneconomical farming must be transformed to economical magnitudes. This has become a major objective of the Agricultural Sector Development Strategy 2010–2020 (ASDS) in Kenya.

Agricultural extension in Kenya has evolved through various stages since colonial and post-independence eras. The approaches employed were characterised with great requirement for finances and human labour. Generally, strategies since independence in early 1960s to 1990s lacked participation in articulating clientele demands. Therefore, Public agriculture extension in Kenya was in 1960s to 1990s perceived as means of conveying agricultural information from research bodies to farmers, who in turn were supposed to implement the innovations (Kiara, 2011). This was largely a top-down approach that was seen as not allowing farmers to make decisions and therefore the innovations were not demanded by farmers and in some instances not applicable to farmers: It was dominated by the public agricultural extension with negligible inclusion of the private sector and was therefore considered lacking in effectiveness (Kiara, 2011).

Motivated by the experiences of a National Soil and Water Conservation Programme that started in 1974, Kenya formulated a new policy NAEP (National Agricultural Extension Policy) to reform agricultural extension and its policy- implementing program NALEP phase I (NALEP I) in 2000. In 2005 Kenya reformulated the extension policy to a sector wide national extension policy NASEP (National Agricultural Sector Extension Policy) where NALEP phase II (NALEP II) spearheaded the policy implementation: The NALEP II was implemented from 2007 to 2011. The National Agriculture and Livestock Extension Program (NALEP-sida), was funded by the governments of Kenya and Sweden (Swedish International Development Cooperation Agency-sida) whose objective was to advance development of agriculture through an extension service that was supposed to have been pluralistic, efficient, effective and demand driven (MOA 2010): A decline in effective public extension having been identified as one among other factors that had hampered agricultural growth in Kenya (Muyanga and Jayne, 2006; Government of Kenya, 2007). An agricultural extension reform required a policy and a nationwide strategy that could be implemented to revitalize the agricultural growth (Rivera and Qamar, 2003).

Work on the overall NALEP II impact assessment has been carried out by both internal and external evaluators (Wambua et al. 2010; Hill 2011; Kiara 2011; NALEP 2012) but little has been assessed on the effectiveness of the delivery of the participatory bottom-up approach in the agricultural extension process in Kenya.

The purpose of the research was to explore the effectiveness of stakeholder participation in NALEP II agricultural extension process. The research focused on extension processes that were carried out in Focal Areas in Kakamega district of Kenya during the implementation of NALEP II program between 2006 and 2011.

The objectives were:
I. To investigate government’s agricultural extension objectives at state, program and district levels in adopting participatory agricultural extension policies.
II. To explore the effectiveness of the agricultural extension as outlined in various documents, and the experiences of the stakeholders who participated in the program.
III. To analyse and explain the participation of stakeholders in the extension process.

The search approach used in the literature review was to trace the development of agricultural extension over time and its importance, agricultural extension approaches, and agricultural extension policies from a broad range of literature materials.

The literature reviews seemed to indicate that effectiveness of extension was as a result of the interrelations of development in agricultural extension, the approaches/ strategies employed and policies that direct the approaches/ strategies. This is depicted in figure 1.

MATERIALS AND METHODS

General Model

Globally, there seem to be three major models that have defined agricultural extension over the years. Initially extension delivery followed a top-down “transfer of technology” model where innovations started from research on top and flowed down to farmers through extension service; this defined agricultural extension globally for much of the 20th century (Mulyavey and Robbins, 2010). However, the linear linkage model came under criticism in the 1980s and public sector extension was extremely attacked globally due to disputes on the ‘technology transfer’ approach by politicians and economists (Rivera, 1996). The main issues were on costs and financing of public extension that came under public scrutiny, political attack and tough competition from the private sector (Rivera, 1991a). Public agricultural extension was therefore reviled for being insufficient, ineffective, inefficient and irrelevant; in addition to being accused of not implementing programs that advanced equity (Rivera, 1991a).

The crisis and further various low governments budgetary crisis of 1990s led to considerable alterations in economic, ideological, and technical aspects of agricultural extension that saw various governments and international organizations develop structural, financial and managerial approaches to revitalize agricultural extension (Rivera, 1991a). In the past few decades agricultural extension has stressed more on the quality of association among actors instead of the mere passage of technical information through hierarchical orders (Jones and Garforth, 1997; Röling and Van De Fliert, 1998).
Consequently, three changes in agricultural perspectives occurred that aimed at mitigating the attacks on agricultural extension and to revitalize the extension system: The first was the agricultural extension ideological perspective: where perceptions on extension have gone above technology transmission to facilitation, above training to learning, and involves aiding farmer groups’ formation, handling market concerns, and networking with other service providers (Davis, 2009). The second was economic perspectives with the realisation that the growing large numbers of farmers could not be sufficiently covered by the publicly supported extension system (Rivera 1991). The third was the technical aspects stemming from the 1990s debates on Agricultural Knowledge and Information Systems- AKIS (Röling, 1994), that drew attention to the significance of broader sources of information and the importance of generating systems that facilitate the creation and diffusion of knowledge (Rivera & Sulaiman, 2009) what Rivera (1991a, p. 5) called “alternative diffusion practices”. AKIS emphasized on importance of enhancing the capabilities of the various systems i.e. research, extension and education and the association in the systems (Rivera and Sulaiman 2009).

Later Agricultural Innovation System (AIS) arose from the idea of innovation being portrayed as an outcome of interactions among stakeholders concerning a natural resource or ecosystem services (Röling and Van De Fliert, 1998). AIS stressed on enhancing capacities of different players in agricultural growth to generate, diffuse and apply knowledge realising that innovation was not only a research-driven process that relied on technology transfer but was perceived to be a process of generating knowledge, accessing knowledge and utilizing it (Rivera and Sulaiman 2009; Rivera 2011). It was recognized that innovations needed in agriculture had a collaborative scope that required alternative approach in interaction, organization and consensus among multiple players (Leeuwis and van den Ban, 2004). Consequently in the new scenario of agricultural innovation, roles for extension agents were seen to comprise of: determination of innovation agenda; mobilizing producers and the rural poor and enhancing their capacities, networking with other stakeholders, promoting forums for information sharing, exploring and learning from emerging strategies; and acting as centres that provide access to knowledge, skills and services from a broad scope of organizations (Sulaiman and Hall 2002, 2004).

Important to the Agricultural Innovation System (AIS) are the interactions of different actors and their insights; the associations (habits, practices, attitudes, and manner of duty performance) that structure how individuals and organizations interact; and learning as a way of developing current arrangements distinct to local conditions (Rivera and Sulaiman 2009; Rivera 2011). It is imperative that the many innovations needed in agriculture have a collaborative scope that require alternative approach in interaction, organization and consensus among multiple players (Leeuwis and van den Ban 2004) and thus the term participation (Rivera and Sulaiman 2009).
In participation there are two elements: one is the extent of interaction of actors in the agricultural extension and two is the depth of the interactions in program knowledge disclosing, discussion, and initiation of actions (Paul 1987). Consequently, there are several practical approaches in the planning and implementations of a program for effective interactions of actors, which include two main stages (Rivera 1996):

1. Planning stage where there is participation in evaluation of needs, target establishments, activity plan, designing performance, and designing appraisals.
2. Implementation stage with participation in monitoring and evaluation of a program.

It is claimed that participation has remained in the development dialogues, may be with the reason that the term participation conveniently accommodates different meanings that include (Chambers 1995, 2002; Feder et al. 2010): Using it as an external label, to make whatever is suggested to appear compliant; describing a co-opting practice, in order to prompt local labour and minimize costs; Using the term to describe a self-mobilizing process that enables local farmers to seize initiatives to alter systems free of external organizations and to acquire self-reliance.

Nevertheless, many nations are diligent on participatory extension systems; although, how the process is carried out is a matter of concern (Davis 2008).

**Qualitative research approaches**

The study used qualitative research approaches with the purpose of understanding the problem, collecting data and analysing the data. The strategy of inquiry employed in this research was Case Study methodology where Document analysis and semi structured interview methods was used in data collection. In data analysis a secondary form of analysis and a thematic content analysis were employed.

The research sites were the new districts of Kakamega Central, East, North and South with an estimated 151,000 households. Due to administrative reasons an initial Kakamega district was later in the course of implementation subdivided to form four districts of Kakamega North, Kakamega South, Kakamega East and Kakamega Central. The four new districts operated independently and each had its own public extension staffs. However, NALEP II continued to operate as one even after the split of the district receiving financial allocations centrally in Kakamega Central that was shared equally in the four districts.

Five focus groups were formed and interviewed. Four consisted of farmers in the four districts (each with 9-11 farmers) and one extension staff focus group of eight agricultural extension staffs, two from each new district. In addition 4 private development agents were also identified.
for individual interviews. Non probability purposeful sampling was used. The stakeholders involved in the implementation of the program in each of the four locations were identified and then purposefully selected to get 12 farmers, two extension staffs and one private development agent from each location (new district).

50 interviewees were involved as follows: Kakamega central (7M, 4F); South (6M,4F); North (8M,2F); East (6M,2F); Extension staff(3M, 4F), Farmer Organization 1M; Commercial bank 1M; NGO 1M; and Provincial administration 1M. Semi structured questions were used in all focus group interviews and individual interviews. Secondary system of analysis was used where data from NALEP II documents were investigated: to compare the objectives of agricultural extension at the state, program and district levels and; to explore the participatory agricultural extension procedures of NALEP II in Focal areas in Kakamega district. In addition, a qualitative thematic content analysis was used to identify themes that emerged from recorded interviews as explained by Robson (2011); the method involved creating probable initial areas of codes prior to field research as explained by Miles and Huberman (1994). The resultant coding framework for data analysis in the study is shown in Figure 4.

RESULTS

The findings of the research are reported below according to the research questions.

Research question 1: “What were the objectives of agricultural extension at the state, program and district levels?” The National Agricultural Sector Extension Policy (NASEP) states that the objective of agricultural extension is to empower the extension clientele by way of sharing information and imparting knowledge, skills and changing of attitudes so that they can efficiently manage their resources for improved socio-economic developments (Government of Kenya 2007).

The objective of NALEP II was to enhance the contribution of agriculture to socio-economic development and poverty alleviation by promoting pluralistic, efficient, effective and demand-driven agricultural extension among farmers and agro-pastoralists (GoK 2010).

At the district level NALEP employed a multi-stakeholder Focal Area (FA) Development approach in the delivery of agricultural extension targeting resource poor farmers and vulnerable groups. At this level NALEP’s ultimate goal was to contribute to socio-economic development and poverty alleviation by promoting the adoption of sustainable technologies for natural resource management.

Figure 4: Resultant coding framework for stakeholder participation in agricultural extension
in agriculture as outlined in the SRA (District NALEP Coordinator 2009).

Similarities in the objectives of agricultural extension at the state, NALEP II program and the work plans at the district agriculture offices show existence of a deep interaction between the policy formulation and implementation plans at the national, program and Kakamega district levels.

**Research question 2:**
“What were the participatory agricultural extension procedures of NALEP II in Focal areas in Kakamega district?”

There were several forms and meanings of participation in NALEP II identified during NALEP II document analysis as shown in table 1 below. Although, the listing does not necessarily reflect the order of farmer empowerment, but instead it is more on the stage of the program development, since one type of participation led to the next as the local communities were expected to evolve into self-sustaining entities.

**Research question 3:** “What were the experiences of the stakeholders in the participatory agricultural extension process?”

A summary of several types and meanings of participation in NALEP II identified during stakeholder interviews is as shown in table 2 below. The listing of participation types in table 2 is a continuation of table 1 above reflecting the order of farmer empowerments.

Table II framework adapted from (Pretty 1994, 1995; Dart et al. 1998; Cornwall 2000; Mikkelsen 2005; Cornwall 2008)

The results of the interviews seems to indicate that the local institutions were viewed as means to realize predetermined objectives which appeared not have been the expected farmer empowerment: this led to the formed institutions tending to continually be dependent on external initiations and facilitators and did not seem to ultimately develop into independent units. This is unlike in table 1 where the formed institutions were supposed to develop into independent and self-sustaining units i.e. self-mobilization with optimal participation.

**Research question 4:** “How did stakeholder participation influence the extension process and its outcomes?”

The interactions between the different stakeholders seemed not to have been well organized and the interactions seemed haphazard. The extension staffs appeared to have managed almost every part of the participatory process, from calling the initial publicity meetings to organizing and facilitating the final action plans. This resulted in non-empowerment of farmers due to: Insufficient knowledge on reasons for involvements in the program. Many of the farmers upon being asked why they involved themselves in NALEP II, all had training as the reason of participation that was greatly publicised during initial public meetings; Insufficient information that included lack of marketing information that led to farmers giving up on some enterprises. There was also lack of transparency and accountability to farmers who complained about lack of information on available NALEP II funds. The private sector, too, seemed not to know their roles in the stakeholder meetings they were invited to and in NALEP II as a whole. This included the trained FADC members, who, despite going through several days of training seemed not to have understood their roles as members of FADCs; Insufficient skills that seemed to stem from the public extension staffs that appeared to have missed opportunities in handing stakeholder meetings and trainings; and Lack of physical and financial productivity resources despite having appropriate institutions was lacking among farmers too, some who gave up on agricultural enterprises initiated by the public extension staffs.

Consequently, it seemed that the strong voice that was required in deciding priorities and the authority to hold public agricultural extension accountable for the quality and effectiveness of the service delivery lacked in the extension process. The usual training procedures somehow assisted the capable farmers, who benefited from the training and increased production, but the resource poor farmers seemed to have been marginalized further and, even those who had increased production encountered marketing problems in some locations.

The low interactions among the stakeholders in Kakamega district affected outcomes in farm productivity—agriculture, that consequently affected the anticipated development in taking farming as a business, for example a banana farmer claimed to have taken farming as a business but on further probing it was discovered that the farmer had only three stools of bananas! Hence the growth in agribusiness remained an issue in the district. Eventually, the expected sustainability in agriculture looked not yet achieved in the NALEP II extension process.

This is greatly supported by the National Impact Assessment of NALEP II carried out at the end of the program that states in one section that “One concern is the low level of interaction between the programme and credit institutions, technology innovation and equipment firms and research organizations. This explains why only about 9% of the households accessed formal credit and only about 30% adopted technologies and innovations (NALEP 2012, p. 38).

**DISCUSSION, CONCLUSIONS AND IMPLICATIONS**

According to figure 1 above drawn from literature reviews, it is implied that the effectiveness of agricultural extension is the interrelations of development in agricultural extension, the approaches/strategies employed and policies that direct the approaches/strategies. However, from the research carried out in Kakamega district of Kenya, it
There were both individual and group targeted in NALEP II in order to serve even the marginalised farmers e.g. resource poor, women, HIV/AIDS affected persons (NALEP-sida 2006).

Empowered farmers in taking charge of project management of extension projects (NALEP-sida 2006; Government of Kenya 2007; NALEP 2009)

Mutual involvement of farmers, public extension and private sector in carrying out agricultural program (NALEP-sida 2006; Government of Kenya 2007)

NALEP promotes formation of stakeholder fora, Focal Area development committees, Common Interest Groups etc. to realise objectives of socio-economic development of farmers (NALEP-sida 2006).

Table I framework adapted from (Pretty 1994, 1995; Dart et al. 1998; Cornwall 2000; Mikkelsen 2005; Cornwall 2008)

seemed that the benefits of the participatory agricultural extension as a result of policy reforms appeared not to have been achieved.

The objectives of agricultural extension at the state, program and district levels appeared to agree. This showed an interaction between the policy formulators and the extension staffs on the ground which was in line with the global requirements of reforms in agricultural extension that would only occur with a relevant agricultural extension policy formulation that required structural, organizational/management and financing changes (Rivera 1996; Rivera and Sulaiman 2009). The specific goals of the NASEP policy (Government of Kenya 2007) was intended to achieve the required reforms. However, this did not seem to result into self-mobilization entities among farmers and other stakeholders. Thus it can be concluded that participation in Kakamega district might have been used as an external label only, to make whatever was suggested in NASEP policy and the operational manual to appear compliant. It strongly appeared that there was dominance of top-down participatory approaches in practice as opposed to the bottom-up participatory approaches in policy documents.

The failures might have been due to: Too many assigned roles and responsibilities among the agricultural extension staffs which was coupled with ineffective local institutions (DivITs and FADCs) such that their roles were played by the public extension staff and; lack of capacity by the public extension staffs to handle the required levels of participation: this was greatly manifested in the almost dormant FADCs and CIGs.

The financial, structural and management reforms required in reforming agricultural extensions as indicated by Rivera (1996) and Rivera & Sulaiman (2009) were clearly provided for in the Kenyan agricultural extension policy. As noted, the key roles of extension agents require highly qualified extension agents that could handle stakeholder identification and mobilizations and create centres of sources of knowledge, skills and services to and by other actors. This therefore requires high levels of professionalism, leadership and management skills at local levels that can enable them to handle these roles in a participatory manner.

<table>
<thead>
<tr>
<th>Type</th>
<th>Distinctiveness of type</th>
<th>Views from documents</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Optimum participation</td>
<td>The participation points to the requirement to direct attention on the various contexts and purposes to enable determination of suitable forms of participation.</td>
<td>There were both individual and group targeted in NALEP II in order to serve even the marginalised farmers e.g. resource poor, women, HIV/AIDS affected persons (NALEP-sida 2006).</td>
</tr>
<tr>
<td>2. Self mobilization</td>
<td>Farmers participate by seizing initiatives to alter systems free of external organizations, but the latter can create enabling policy framework. Farmers retain control on how resources are utilized.</td>
<td>Empowered farmers in taking charge of project management of extension projects (NALEP-sida 2006; Government of Kenya 2007; NALEP 2009).</td>
</tr>
<tr>
<td>3. Interactive participation</td>
<td>Farmers participate by getting engaged in preparation of action plans, monitoring and evaluation. Participation is perceived as totally appropriate. Local institutions may be formed and jointly with partners utilize organized and planned knowledge processes. The local organizations acquire power and farmers take responsibilities of sustaining institutions.</td>
<td>Mutual involvement of farmers, public extension and private sector in carrying out agricultural program (NALEP-sida 2006; Government of Kenya 2007).</td>
</tr>
<tr>
<td>4. Functional participation</td>
<td>Farmers participate by forming local institutions that are externally initiated. The local institutions are seen as means to realize predetermined objectives. The organizations rely initially on external organization but ultimately develop into independent units.</td>
<td>NALEP promotes formation of stakeholder fora, Focal Area development committees, Common Interest Groups etc. to realise objectives of socio-economic development of farmers (NALEP-sida 2006).</td>
</tr>
</tbody>
</table>
levels of program implementations: that could change the lower levels of participation e.g. passive gradually to self-mobilization at high levels of community participation where optimal participation is employed in a program development.

The development of agricultural extension from linear model through AKIS to now the AIS requires, apart from the indicated Government Policy and regulatory framework, empowered public agricultural extension agents that have the capacity to effectively take up their roles and network with other actors for an effective participatory agricultural extension process. This indicates that the evolution in agricultural extensions should be accompanied by evolution in management of extension by the extension providers.

As noted earlier, important to the Agricultural Innovation System (AIS) are the interactions of different actors and their insights; the associations (habits, practices, attitudes, and manner of duty performance) that structure how individuals and organizations interact; and learning as a way of developing current arrangements distinct to local conditions (Rivera and Sulaiman 2009; Rivera 2011); without which the success of an agricultural extension policy may not be achievable.

The study findings seem to suggest that lack of capacity by the field public agricultural extension staffs to handle the required levels of participation might have led to ineffective extension process despite the presence of favourable policies and operational procedures. This, therefore, calls for further research to explore the management capacities of the field agricultural extension staff and possibly the training curricula of the agricultural education institutions in Kenya.
REFERENCES


[26] cRivera, W.M., (1996). ‘Agricultural extension in...


CREATING AN EFFICIENT AND PROFITABLE KENYA HONEY SECTOR VALUE CHAIN THROUGH RESEARCH AND TECHNOLOGY

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ABSTRACT
Research on honey sector is limited, hence improved technologies to enhance honey production; processing and value addition, diversification of bee uses and bee types, marketing and consumption of beehive products are scarce. The sector has low productivity caused by weak bee colonies, low hive occupation due to high absconding rates and mismatch in the floral calendars of forage, use of inappropriate hive types and climate change. Accurate information on current hive products type, their seasonal distribution, regional and national aggregated production and quality are unavailable. The quality standards for hive products have not been adequately popularized. Currently the farmers produce a narrow range of raw hive products and customer demands are on few hive products. Hence there is a felt need to add value through diversification, standardization, patenting and diversifying bee types and products through rearing and promotion of stingless bees. Additional value will occur through diversified uses of bees through pollination of fruits and vegetables in open pollination, green house and enclosure pollination. There is an urgent need to document, evaluate and adapt suitable indigenous knowledge on suitable bee hives and nest types, beehive products diversification, bee forage, control of pests and diseases and climate change mitigation strategies. Kenya’s annual honey potential has not been exploited because of an underdeveloped market caused by low production, fragmented and disorganized beekeepers, poor infrastructure and inadequate national coordination. Other challenges include environmental degradation through deforestation and increased use of herbicides in high potential areas thus reducing beekeeping potential. The overall objectives are to transform beekeeping into a commercially oriented activity for food and nutrition security, increased household income and employment creation while utilizing the natural resources and biodiversity in sustainable way.

INTRODUCTION
Bee-keeping and hive-products have played important social roles in the traditions of mankind (Wilson, 2006; Muli et al., 2007). Honey provides food, medicine and acts as a natural preservative. It is universally accepted as an important ingredient in many medical and food recipes (Krell 1996).

Beekeeping is suited to ASAL areas of Kenya due to abundance of suitable plant species for nectar and pollen production hence ASAL areas produce 80 percent of Kenyan honey (Carroll, 2006; MoLFD, 2010). Furthermore, honey production plays an important economic role due to limited livelihood options available to ASAL communities. Considering that at least 85 percent of Kenya is ASAL, honey production can play major economic roles. Additionally, beekeeping is an opportunity to harvest and add value to a local resource (floral nectar) in order to reduce poverty, generate wealth and create employment subsequently enhancing skills among stakeholders on managing bees and handling hive products (Wilson 2006; MoLFD, 2010).

Problem Statement
Accurately documented information on current hive products type, their seasonal distributional, regional and national aggregated production and quality are unavailable (Gichora, 2003; Baiya and Nyakundi 2007). The quality standards for existing and newly developed hive products have not been adequately popularized and patented (Baiya and Nyakundi 2007; Muli et al., 2007). Currently the farmers produce a narrow range of raw hive products and also customer demand is on a narrow range of hive products (Gichora, 2003; Wilson 2006; Baiya and Nyakundi 2007). Increased value will occur through diversified uses of bees through pollination of fruits and vegetables in open pollination, green house and enclosure pollination (Macharia et al., 2010). There is an urgent need to document, evaluate and adapt suitable indigenous knowledge on suitable bee hives and nest types, beehive products diversification, bee forage plants, control of bee pests and diseases and climate change mitigation strategies (Gichora, 2003; Muli et al., 2007; Macharia et al., 2010). These improvements will have a big impact on the honey sector as 80 percent of beekeepers use traditional systems, sell honey and bee-hive products in crude form which calls for value addition to fetch higher returns, create jobs and induce industrial development (Wilson 2006; Baiya and Nyakundi 2007). Kenya’s over 80,000 tonnes annual honey potential has not been exploited (MoLFD, 2010) because of an underdeveloped market caused by low production, fragmented and disorganized beekeepers, poor infrastructure and inadequate national coordination (Carroll, 2006; Wilson 2006; Baiya and Nyakundi 2007). Other challenges include environmental degradation through deforestation and increased use of herbicides in high potential areas thus reducing beekeeping potential further (Macharia et al., 2010; Muriuki, 2010).
Objectives

Broad Objectives
The overall objectives are to transform bee-keeping into a commercially oriented activity for food and nutrition security, increased household income and employment creation while utilizing the natural resources and biodiversity in sustainable way.

Specific Objectives
• To upscale honey-bee technology transfer among producers, processors and markets through appropriate training of all stakeholders and empower them for more benefits from the honey industry.
• To increase hive occupation through use of suitable hive types, Queen selection, multiplication and rearing, propagation of suitable bee forages while minimizing the effects of bee pests and diseases and conserving the environment.
• To add value of bee products through diversification, standardization and patenting of existing and newly developed bee products and diversify bee types and products through rearing and popularization of stingless bees.
• To diversify uses of bees through pollination of fruits and vegetables in open pollination, greenhouse and enclosure pollination
• To document, evaluate and adapt suitable indigenous knowledge on suitable hives and nest types, beehive products diversification, bee forage, control of bee pests and diseases and climate change mitigation strategies
• To catalogue popular bee forage, their distribution and flowering patterns, their methods of conservation and the effects of climate change.

Summary of themes, their objectives and activities

Theme: 1. Increasing hive occupation in Kenya

Objectives
• To evaluate different bee hive types in at least three eco-zones in terms of bee foraging behaviour, occupation and absconding and migration rates and their causes, amount of honey and beehive products yielded and harvesting ease.
• To upscale technology on Queen rearing, selection, multiplication and farm distribution
• To document suitable bee forage, their distribution and flowering patterns
• To conserve and multiply important bee forages
• To document the effects of climate change on popular bee plants, their distribution and flowering characteristics
• To characterize bee pests and diseases, their prevention and control
• To document, evaluate and adapt suitable indigenous knowledge on suitable bee hive types, beehive products diversification, bee forages, control of bee pests and diseases and climate change mitigation strategies

Activities
• Compare hive types in different eco-zones
• Training artisans on fabrication of suitable hive types
• Raising at least 10 functional Queen rearing, selection and multiplication nuclei
• Establishing floral calendars at least in Ngong, Naivasha, Njoro and Kerio Valley
• Documenting the effects of climate change on important bee forages, their distribution and flowering characteristics
• Conduct hive inspection in apiaries in key honey producing counties to identify key bee pests and diseases and recommend their prevention and control
• Conduct a survey on indigenous knowledge covering bee hive types, range of beehive products, bee forages, control of bee pests and diseases and climate change mitigation strategies, evaluate them for suitability, adapt them on suitability and diversification
• Establishing Model Demonstration Apiaries, Train Trainers on suitable hive types, on-farm Queen rearing, selection and multiplication; popular bee forage plants, their distribution and flowering patterns and their conservation, key bee pests and diseases and their prevention and control

Theme: 2. Value addition of bee products

Objectives
• To analyze, characterize and enumerate available bee products and their demand
• To analyze, characterize and enumerate demand for new bee products
• To train clients on high quality existing and new bee products
• To popularize hive products through media campaign

Activities
• Carrying out market surveys on available bee products, their kind, demand and quality
• Carrying out market surveys on new bee products, their kind, demand and quality
• Training clients on high quality existing and new bee products
• Carrying out media campaign to popularize hive products

Theme: 3. Economics of bee pollination of fruits and vegetables
Objectives

- To evaluate, document and promote use of bees in open pollination
- To evaluate, document and promote use of bees in Green house and enclosure pollination

Activities

- To evaluate, document and popularize use of bees in open pollination
- Assess success of pollination through fruit set and fruit quality
- Characterizing bee forage preference, foraging behavior, life cycles and nesting habits
- Determine the placement, distribution and number of colonies to maximize pollination benefits
- Document the effect of wind, temperature and humidity on effective pollination
- Determine use of hive stands to increase flight and help to insure foraging activity under marginal weather conditions
- Assess optimal hive strength for effective pollination
- Training clients on optimal technology on effective pollination
- To evaluate, document and popularize use of bees in Green house and Enclosure pollination
- Selection of gentle colonies, permitting human activities near their nests
- Selection of more prolific queens to enable colonies to increase rapidly for enhanced pollination
- Determine performance and survival of bees in green houses and enclosures
- Selection of colonies that are relatively free of parasites and predators or can easily be managed to eliminate them
- Training clients on optimal technology for effective pollination
- To identify, characterize and document stingless bees in Kajiado, Naivasha, Mwingi, Makueni and Kakamega
- To study the reproduction cycle of stingless bees, evaluate and recommend various factors that enable increased reproduction and survival
- To enumerate and evaluate the different stingless bee nests types in at least three counties in terms of amount of honey and beehive products yielded
- To establish demonstration apiaries for stingless bee
- To upscale technology on suitable stingless bees and nests types in Kajiado. Naivasha, Mwingi, Makueni and Kakamega
- Developing and evaluating various mechanisms in supplying stingless bees to farmers
- Conduct a survey on indigenous knowledge covering bee nest types, range of nest production management and products types, bee forage plants, control of bee pests and diseases and climate change mitigation strategies, evaluate them for suitability.

The Key Outputs of this Programme will include:

- Increased quantity and quality of hive products, their regular supply and increased incomes through an efficient and profitable honey sector
- Additional employment opportunities through increased hive occupation and Queen Selection, multiplication and rearing operations
- Promotion of suitable bee forages and conservation of the environment.
- Diversified high value hive products with high market demand
- Catalogue of important bee forages, their distribution and flowering patterns, their methods of conservation and effect of climate change.
- Handbook on suitable indigenous knowledge on suitable bee hive types, diverse beehive products, bee forage plants, methods of controlling bee pests and diseases and climate change mitigation strategies
- At least one suitable bee-hive type popularized among honey bee producers in five ecological zones.
- Training materials on bee-keeping industry developed and used to increase knowledge on bee technology through client training.
- A pool of well trained and experienced Trained Trainers
• Knowledgeable stakeholders

Impact of Outputs
• An efficient and profitable honey sector
• Increased income and employment among stakeholders in the honey value chain.
• Quality standards enforced and popularized within the honey sector
• Up-scaled honey-bee technology among producers, processors and marketers in honey value chain
• Knowledgeable stakeholders, readily available learning materials on honey industry and available catalogues and handbooks
• Readily available popular bee forage plants, their distribution suitability and their methods of propagation and conservation.
• Suitably conserved environment enabling sustainable honey industry
• At least one suitable bee-hive type readily available and popular among honey bee producers in at least five ecological zones.

Dissemination of Research Outputs
• Provide videos and documentaries on technologies
• Create databases on technologies
• Stakeholders’ Platforms such as Honey Council of Kenya
• Through radio and television talks and advertisements and print media.
• Distribution of fliers, pamphlets, catalogues and handbooks during field days, workshops, seminars and shows and distributed to many libraries.
• Through stakeholders’ training, workshops and site visits.
• Documentation in various official reports including progress and briefing reports, quarterly and annual reports,
• Presentation during professional events including lunch and dinner talks, seminars, workshops, conferences, magazines and scientific journals.
• Providing training materials to learning institutions including schools, colleges and universities

REFERENCES