AGROFORESTRY TECHNOLOGY UPTAKE AND UTILIZATION BY FARMERS IN KENYA: A CASE STUDY BASED ON FODDER INNOVATIONS DISSEMINATION IN KIPKAREN WARD, MOSOP SUB-COUNTY, NANDI COUNTY

For the Collaborative Research Project under the Ecological Organic Agriculture Initiative

Prepared by: Beatrice Tuei

Phd Candidate, Egerton University

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ABBREVIATIONS

ABS- TCM LTD	Animal Breeders Total Management Limited
AI	Artificial Insemination
AIS	Agriculture Innovation System
ASDSP	Agriculture Sector Development Support Programme
ATC	Agriculture Training Centre
CBOs	Community Based Organizations
DCA	Dairy Commercialization Area
DFBAs	Dairy Farmers Business Associations
EADD	East Africa Dairy Development
HI	Heifer International
ICRAF	International Centre for Research in Agro-forestry
IFAD	International Fund for Agriculture Development
ILRI	International Livestock Research Institute
KAVES	Kenya Agricultural Value Chain Enterprises
KCB	Kenya Commercial Bank
KDB	Kenya Dairy Board
KDFF	Kenya Dairy Farmers Federation
KEPHIS	Kenya Plant Health Inspectorate Service
KENAFF	Kenya National Farmers Federation
KWFT	Kenya Women Finance Trust
MOALF	Ministry of Agriculture Livestock and Fisheries
SHDCP	Smallholder Dairy Commercialization Programme
SSNC	Swedish Society for Nature Conservation
TOTs	Trainers of Trainers
TNS	TechnoServe

PREFACE

The study sought to establish uptake level of fodder based agroforestry technologies that were disseminated in Kipkaren and surrounding locations in Nandi County. The area has benefitted in the past from East Africa Dairy Development (EADD) program, an intermediary organization that provided a platform for enhancing stakeholder collaboration for improved livelihoods of smallholder dairy farmers in East Africa including Kipkaren location in Nandi County within Kenya. The farmers gained knowledge and skills through their involvement in the program implemented in collaboration with a consortium of five organizations; World Agroforestry Centre (formerly ICRAF), Techno Serve (TNS), Heifer International (HI), International Livestock Research Institute (ILRI) and Animal Breeders Total Management Limited (ABS-TCM LTD). The organizations specialized either in research, business development or dairy production or together with other actors contributed to shaping innovations in the area. The actors included government extension and farmer trainers participating in dissemination of fodder and feeds technologies for dairy cows. The project used the volunteer farmer trainer approach to disseminate fodder and feed technologies. The technology disseminated by the highest number of farmer trainers was Napier grass (95 percent) followed by Rhodes grass (80 percent), conservation of crop residues (79 percent), silage making (77 percent), hay making (74 percent) and fodder shrubs (73 percent). The feeds and feeding component of the program led by ICRAF also initiated an institutional innovation by building capacities of new dairy companies also referred to as Dairy Farmers Business Associations (DFBAs) like the Tanykina Dairy Plant Limited Company located in Kipkaren. The famers market their milk through the Tanykina Milk Cooperative Limited in which they are shareholders. The ‘Hub’ model adopted integrated business service provision the core operations of the DFBAs. The services offered included veterinary services, village banking, transport and extension. In addition, Artificial Insemination (AI) and Agro-vet input supplies provided to farmers but on a check off system at the milk cooling plant.

EXECUTIVE SUMMARY

Fodder trees have been promoted among smallholder farmers primarily as supplementary feed that reduces the cost of feeding dairy animals. The perennial fodder trees and shrubs are an option for sustained availability of fodder throughout the year amid the rising population, competition for land with food crops and the climate change challenge. Stakeholders' support was sought in an attempt to holistically address socio-technical constraints that hinder uptake and utilization of agroforestry based technologies by smallholder farmers. This report is based on a study that aimed to 1) assess levels of fodder technologies utilization, 2) identify constraints and opportunities for uptake of fodder agroforestry technologies, and 3) document and analyse stakeholders' roles in dissemination of fodder technologies. The study was conducted in Kipkaren ward, Nandi County, where dairy keeping and maize farming are priority enterprises undertaken in mixed farming system. Focus Group Discussions, key informant interviews and a stakeholder meeting were used to collect data from dairy farmer groups, individual farmers and key stakeholders in fodder technologies dissemination. A total of eight dairy farmer groups and eight key informants from the dairy sector were interviewed followed by a stakeholder meeting. Interview results revealed that both individual farmers and those affiliated to group membership are knowledgeable about indigenous fodder trees used by their animals during the dry season. However, group members are more enlightened about exotic fodder species because of better access to private and public extension services, inputs and credit. The farmers have inadequate knowledge on nutritive value of indigenous trees and require research, training and demonstration on fodder tree utilization and establishment and, benefits and risks associated with agroforestry, in addition to other aspects of dairy production. The stakeholders are cooperative and willing to address the socio-cultural and technical factors identified limiting uptake of fodder agroforestry based technologies. The factors include high cost of inputs, poor access to credit, extension and inputs, limited technical expertise on agroforestry technologies, poor group cohesion and a poor culture of knowledge sharing. The study recommends that farmers' knowledge should be complemented with scientific knowledge to establish the appropriate species and nutritive value of fodder trees befitting the area to guide levels of inclusion and

utilization of the tree forages in animal diets. The study further recommends adoption of integrated extension model encompassing private and public extension workers with lead farmers playing a key role to enhance networking for improved access to inputs and services and, create spaces for continuous knowledge sharing, follow-ups, visioning and realization of increased fodder technologies uptake leading to improved smallholders livelihoods.

1.0 Introduction

The integration of trees and shrubs into farming systems or agroforestry has been promoted as an approach towards agricultural sustainability (FAO, 2008). The practice is traditionally found in mixed farming systems typical of smallholder farms in most developing countries. In such systems farmers realize benefits from environmental functions of trees (ecosystem mimicry, hydrology, protection of crops, animals and soil, biodiversity and aesthetics) and productive functions (timber, firewood, pulp and fodder) as described by Nuberg, George and Reid, (2009). Calliandra-Napier grass hedgerow system, also used as a soil conservation resource can for instance yield large tonnage of biomass to supplement, and in some cases substitute for inputs of protein rations for dairy animals (Angima, Stott, Ongo, O'neill & Weesies, 2002). Experiments conducted in Embu, Kenya, show that 3kg of freshly cut Calliandra can replace 1kg of dairy meal in dairy cows feeding (Wambugu, 2006). It is therefore estimated that if 50 percent of the 625,000 smallholder dairy farmers in Kenya each planted 500 shrubs of *Calliandra calothyrsus* the net benefits per year would reach US$ 81 million (Franzel et al., 2003).

Dairy keeping in Kenya is concentrated in the Central and Rift valley highlands in either a mixed farming systems or dairy production systems. The main constraint faced by farmers is persistent seasonal scarcity of feed and forages because of dependence on rain-fed fodder. Most farmers in north rift valley practice natural grazing but some have adopted planted fodders such as Napier grass, Boma rhodes and maize silage. High cost and unavailability of labour hinders uptake of Napier while high cost of seeds and small land sizes limits establishment of Boma rhodes grass and other leguminous grasses (Lukuyu, 2009). The farmers also utilize low quality crop residues such as bean haulms, maize stovers and straws because these are readily available after a crop harvest. Improving quality and quantity of roughages such as the crop residues and increasing access to both low cost and high quality fodder are viable options of improving feeding in smallholder farms (McDermott et al., 2011). However, scarce extension services reduce smallholders' access to technical knowledge and skills required for production of good quality fodder and feeds. Improving feed production and conservation has been identified as a possibility for increasing dairy productivity because on farm production of feeds minimizes off farm purchases of feed (Moran, 2009).

Despite research findings on benefits of fodder shrubs, grasses and legumes, technology uptake has been slow due to lack of participatory approaches, lack of understanding of the systems, lack of recognition of farmers' perceptions as well as unfavorable policies (Peters et al., 2001). Some research and development efforts have addressed these factors by involving farmers in testing, dissemination, monitoring and evaluating activities (Franzel, 2003). Although conventional research has been successful in the development of various varieties of fodder suited for different regions, it was inadequate in the realization of increased adoption of the technologies. This is because farmers operate in a system where different objectives must be met such that fodder technology may not be prioritized hence fails to be adopted in the farms.

Recent initiatives have evolved from linear technology transfer (transfer of technology from researchers through extension to farmers.) to system-wide oriented and Agriculture Innovation System (AIS) approaches. The System Wide Collaborative Action for Livelihoods and Environment (SCALE) approach by ICRAF and partners facilitated successful *Calliandr*a seed delivery to smallholders for fodder production in Central Kenya (Acharya et al., 2010). The partnership led to the formation of a network of small-scale entrepreneurial seed vendors that increased smallholders' access to seed. Similarly, the AIS approach focus on a combination of technological and social institutional change in a system that is shaped by interactions among stakeholders. The approach attempts to holistically understand the stakeholder interest and roles in the system and the different dimensions of the problem under study (Schut, Klerx, Rodenburg Kayeke, Hinnou & Raboanarielina, 2014). This study adopted the approach to analyze the levels of farmers' awareness, access, affordability and perceived benefits of fodder agroforestry that influence use of the fodder agroforestry technology. The study involved an inquiry into understanding farmers' strategies and needs for fodder technology uptake and, the constraints and opportunities in fodder technology interventions among the stakeholders. The study further sought new ways of knowledge sharing among the stakeholders to enhance sustained utilization of fodder technology.

1.1 The Purpose of the Study

The purpose of the study was to assess the level of uptake and utilization of agroforestry fodder technologies in order to inform strategies of promoting further uptake by many farmers in the Nandi County.

1.2 Objectives of the Study

The study investigated three objectives, namely:

i) Conduct literature review on level of fodder technology uptake, constraints and opportunities and support needed for sustained fodder uptake and participation in fodder and milk markets.

ii) Perform an appreciative inquiry on fodder technologies utilization (farmer innovative strategies, innovation capacity needs and interventions) through focused group discussions and a stakeholder workshop.

iii) Analyze and document stakeholder roles and mechanisms employed in sharing knowledge on fodder technologies

1.3 Significance of the study

The study aimed at assessing uptake and utilization of fodder trees. Agroforestry serves both productive and non-productive functions in the farms. Sustainable agroforestry leads to enhanced soil fertility, controlled soil erosion, provides microclimate in both grazing and crop land (Kitalyi et al., 2011) and overall improvement of the environment. At the local level farmers utilize tree products like firewood, timber and fruit trees and, produce global products such as tea and coffee contributing to resilient food systems profitable to farmers. The use of fodder trees increases incomes of smallholder dairy either from increased volume of milk produced and sold or reduced expenditure by replacing purchase of supplementary dairy feeds. Engaging stakeholders in exploring the constraints and opportunities faced in promotion and utilization of fodder innovations aims at finding sustainable solutions that fit in specific farming contexts. In the end repeatable models will be developed and applied in different contexts to scale adoption of fodder agroforestry and increase benefits to smallholder farmers.

1.4 Limitation of the study

The study was limited to dairy farmers in Kipkaren and surrounding wards supplying milk to Tanykina dairy cooperative located in Kipkaren ward. The smallholder dairy farmers comprise beneficiaries and non-beneficiaries of trainings offered by the cooperative on fodder trees for livestock feeding. The study was limited by respondents' honesty during discussions and interviews. The problem was overcome by holding a stakeholder meeting during which representative dairy farmers and key stakeholders in fodder agroforestry shared experiences and verified the information provided during Focus Group Discussions and key informant interviews.

1.5Assumptions of the study

The researcher assumed that the stakeholders who participated in the discussions were typical of the area and did so openly and truthfully.

1.6 Definition of terms

Action research: According to Stringer (2004), action research is a careful diligent inquiry by an action research team comprising local community and stakeholders for purposes of discovering new facts or revising accepted laws or theories but to acquire information with practical application to the solution of specific problems identified by the team. In this study refers to inquiry constraints and solutions to increased fodder trees uptake by local community and stakeholders in the fodder tree system.

Adoption: Farm-level adoption has been defined as the degree of use of a new technology when the farmer has full information about the new technology and its potential (Feder et al., 1985). In this study adoption referred to uptake of fodder shrub technology in the farm.

Agroforestry: According to FAO (2008), agroforestry is a dynamic ecologically based natural resource management system that through the integration of trees on farms and agricultural landscapes diversifies and sustains production for increased social, economic and environmental benefits for land users at all levels. In the study will refer to the integration of fodder trees in the farm.

Innovations: Innovations as stated by Anandajayasekeram (2011) are new creations social, technical or institutional of economic significance. In this study, innovations referred to new products, processes or organizations aimed at increasing utilization of fodder agroforestry for social and economic gains.

Participatory research: According to Gonsalves et al. (2005) participatory research is a pool of concepts, practices, norms and attitudes that enable people to enhance their knowledge for sustainable agriculture and natural resource management. In this study participatory research referred to use of focus group discussions and key informant interviews for participatory assessment of constraints and opportunities to gather knowledge for sustainable uptake and utilization of fodder trees.

Smallholder farmer: These are producers who cultivate not more than two hectares using limited technology (FAO, 2010). In this study, a smallholder was considered a farmer cultivating less than ten acres of land.

Stakeholders: Are defined as all actors who have an interest in production and consumption of agricultural products (Sun, 2007). In this study will refer to those who have an interest in production and utilization of fodder trees.

2.0 Literature review

This section presents a review of relevant literature in relation to the study to reveal gaps in agroforestry technology uptake. The section is organized in three topics namely: i) Promotion of agroforestry technologies for improved livestock productivity, ii) Opportunities and constraints of tree forage based technologies, and iii) levels of fodder technology uptake.

2.1 Livestock and livestock products marketing

Livestock development can be a major catalyst to agriculture-led economic development through the sale of livestock and livestock products and employment creation through production, processing and marketing of animal products. Availability of quality feeds is however, a major impediment in most countries in sub-Saharan Africa despite the region possessing large feed resources (Winrock International 1992; Dawson et al., 2014). Feed shortages are catastrophic in

the drought seasons resulting in low milk yields and general poor performance or even death of livestock.

Novel livestock feeding technologies are therefore much needed as demand for livestock products such as beef, milk and hides continue to expand due to increased household income, urbanization, climate change and human population (Delgado et al., 2008). Per capita meat consumption in the developing world was projected to increase from 25 kg to 35 kg from 1997 to 2020, compared to an increase of 75 kg to 84 kg in the industrial world (World Bank, 2001). Hence, increased livestock demand and production in the developing countries is therefore expected to occur at the entry of the livestock industrialization era (Delgado et al., 2008). Feed shortages often attributed to droughts result in low milk yields and poor performance or even death of livestock (Dawson et al., 2014).

2.2 Promotion of agroforestry technologies for improved livestock productivity

Expanding human population in the high potential areas has contributed to a reduction on the available land for grazing while the competitive land use between crops and livestock exerts considerable pressure against utilization of arable land for planting fodders and pastures. In this situation, a number of approaches have been suggested in order to incorporate fodder shrubs and trees without competing with crops.

According to Topark-Ngarm, (1990) four ways in which fodder shrubs and trees can be incorporated are:

i. **Planting a living fence around the household**

Fodder shrubs such as *Leucaena leucocephala*, *Pithecellobium dulca, Gliricidia sepium, Sesbania grandiflora* and *Artocarpus heterophylus* can be grown as living fences which provide not only human food and fuelwood but also animal feed. Experience from Thailand, shows that the fence can be established by direct seeding or transplanted seedlings at close spacing and be ready for use in 6–8 months. *Gliricidia sepium* has been extensively used in Indonesia and the Philippines and is easily established by sticking the stem or branch cuttings into the ground.

ii. **Vegetation on uncropped lands**

In many of even the most intensively cropped areas of the region there are pockets of land which cannot be used for cropping. These may be in the form of farm boundaries, paddy bunds or forest margins which could be used to grow some shrubs and trees. These areas could be planted with fodder shrubs and trees to augment protein needs of livestock and integrated with plantation agriculture.

iii. **Hedgerows in alley cropping**

A specific concept in incorporating fodder shrubs and trees into farming systems producing annual crops has been developed by the International Institute of Tropical Agriculture (IITA). Shrubs and fodder trees are grown as hedgerows in cropped land. These serve as windbreaks or heat breaks and provide green manure fertilizer for the crops. During the productive period, the cut material from the hedgerow species often provides fodder in excess of the amount needed from green manure for animals. Shade trees such as *Gliricidia sp*, used in cocoa plantations, can be treated the same way when they are routinely pruned to prevent over-shading.

iv. **Component species in inter-cropping**

In this system, shrubs or fodder trees are grown in alternate rows or rows adjacent to food crops. Trees are pruned once or twice for fodder or to reduce competition and shading during the growing period of the crops. Species used in this system are limited to fast growing ones and those tolerant to frequent cuttings. Examples of these include small shrub legumes like *Stylosanthes scabra*, *Stylosanthes viscosa*, *Cajanus cajan* and *Desmanthus virgatus*.

2.3 Opportunities and constraints of tree forage based technologies

At least 300 species of trees and shrubs have been documented as being useful for livestock fodder even though few species have been studied and really utilized (FAO, 1991). Available knowledge nonetheless suggests that tree fodder have positive effects on livestock nutrition and productivity such as growth, meat quality and milk yields (Sekatuba et al., 2004). Tree fodder can also establish on farms easily and do not require extensive agronomic inputs. Some of the fodder shrubs like *Calliandra* and *Leuceana* require little land as they are usually grown in hedges along field boundaries or along the contours (Franzel et al., 2014).

In extensive drylands of Africa, it is estimated that ligneous materials contribute up to 90% of rangeland production and account for 40-50% of the total available feed These figures illustrate need for better knowledge on sustainable use of the existing resources against the background of environmental degradation (Thomas & Sumberg, 1995; Abdalla et.al, 2014).).

Compared to tropical grasses such as the elephant grass, Napier grass, Rhodes grass widely used as basal feeds, most tree shrubs are richer in protein and minerals in the dry season (Gerritis, 1999; Shayo et al., 2004). Crude protein, calcium and phosphorus for majority of the shrubs are higher (less than 20 percent CP) than the minimum (13 to16 percent) required for the maintenance of a lactating dairy cow (NRC, 2001). The quick maturing elephant grass deteriorates rapidly on nutritive quality (leaving less than 7 percent crude protein) during the dry season. Fodder trees can therefore serve as protein banks to improve the quality of feed resources and provide energy to keep rumen microbes active, thereby increasing the ability of livestock to digest fibre and make use of dry season pastures (Leng, 1997; Camero & Franco 2001). In addition, some have medicinal value for example in treating worms, diarrhoea, eye disease, and other uses such as to ease calves, delivery and to preserve milk. Most of the leguminous shrubs further recycle nitrogen into the soil.

Even though high protein content is not the only factor which makes a good fodder plant, the digestibility which varies with animal type is of great importance. Leaves and fruits of ligneous species have much higher levels of digestible protein (DCP) than other fodder sources. For example, in Senegal the level is 180-200g DCP per kg DM in browse compared to 100 to 130 for groundnuts leaves and 50 to 70 for leaves and fruits of various herbaceous species (Guerin et al., 1986).

Fodder trees can therefore help farmers adapt to and mitigate climate change effects (Dawson et al., 2014). For adaptation, they are deep-rooted, resistant to drought and they maintain high protein levels during the dry season, when high-quality feed is scarce (Wambugu et al., 2011). For mitigation, they improve livestock productivity, which helps reduce methane emissions per unit of output by substituting for commercially manufactured concentrates (Franzel et al., 2014). Strategies that can ensure a diversity of fodder tree species are available to enrich livestock diets

and provide strategic feed reserves in the event that highly dependent species succumb to a climatic, entomologic or pathogenic attack could be useful (Dawson et al., 2014). In sum, trees and shrubs fodder have several positives (Ivory, 1989; Roothaert, 1997: Wambugu, 2006) such as:

- Uses to treat livestock and human diseases
- They fill feed gap during periods of droughts/shortages
- They improve livestock health and increase milk yield
- They are palatable
- Some have fast regrowth after harvesting
- They require minimal management
- They have multiple uses e.g. timber, fuel wood, stakes
- Many are resistant to pests and diseases
- Cultivation of fodder trees on farms can help reduce the need to collect fodder from forests or graze livestock in forests, thus contributing to overall forest health.

Selection of suitable fodder species matched to sites however requires a consideration of the plant agronomic features in relation to the desirable objectives and the soil and climatic factors. For instance, *Leuceana* grows well in alkaline, calcareous, clayey soil and performs poorly on acid soils which are saturated with aluminium and manganese (Wong & Davendra, 1983 Kodiago et al., 2014). Multiplication of trees through seed may be challenging due their slow growth and weed competition on establishment and therefore raising seedlings through a nursery is necessary. For range farming, direct seeding in strips or rows is advisable. Obtaining sufficient seed for species like Gliricidia may be a problem and vegetative propagation may work better.

One agronomic practice, which affects fodder yield, is tree plant density. The higher the tree density the higher the total plant yield but individual tree yield decreases. Also higher tree densities reduce weed competition. There is great variation in optimum plant density ranging from 1-15 trees per m^2 for optimum yield. Ivory (1990), reported that under cut and carry systems, highest leaf and wood yield of leuceana, gliricidia, sesbania and calliandra were recorded at 4 trees per m^2 but this was dependent upon good rainfall. In less humid environment, a lower yield is expected. Other factors that affect yields of trees and fodder shrubs are the

cutting intensity and frequency. Longer cutting intervals and less intensive cutting generally increase plant biomass. In the case of leuceana, a high forage yield was obtained at a cutting height maintained at 75cm and 100cm and at a frequency of 60-90 days compared to yields obtained at one month (Solaimalai et al., 2005).

Calliandra yields 1.5 kg dry matter per tree per year on farms in central Kenya, grown in hedges pruned at 0.6m to 1m height, five times per year (Paterson et al., 1998). In Zimbabwe, where many farmers plant in pure stands, calliandra yields range from 2.5 to 5.6 tons per ha per year and *A. angustissima, L. leucocephala* and *Gliricidia sepium* produce more than 3 tons per ha per year when cut a single time at the end of the wet season (Hove et al., 2003). One kilogram of dried calliandra (24percent crude protein and digestibility of 60 percent when fed fresh) has about the same amount of digestible protein as one-kilogram dairy meal (16 percent crude protein and 80percent digestibility) (Roothert et al., 2003; Wambugu, 2006)). A farmer needs about 500 calliandra trees to feed a dairy cow throughout the year at a rate of 2 kg dry matter per day. Under farmers' management, milk production increased by 0.6-0.75 kg milk kg^{-1} dried calliandra. In Tanzania, *L. leucocephala* leaf meal is widely used as an ingredient of one of the country's major mineral supplements (Mekoya et al., 2008). Analyses on the use of leaf meal in mineral blocks for sheep in Nigeria have been conducted but use at the farm level is not reported (Franzel et al., 2007). For most of the fodder trees and shrubs identified in dry tropical Africa, knowledge of browse production and chemical composition is still lacking. Overcoming this constraint would ascertain the value of the fodder and ensure maximization of the use of this fodder by livestock (Boufennara 2012; FAO, 1991).

There are, however, two important gaps regarding the management of indigenous fodder trees in the East Africa region. First, farmers need to enhance the diversity of tree species used. This will serve to both enrich livestock diets and act as strategic feed reserves in the event that highly dependent species succumb to a climatic, entomologic or pathogenic attack (Franzel et al., 2014; Roothaert, 1997). This was seen in the case of the psyllid attack on *Leucaena leucocephala* and a die-back disease for *Calliandra calothyrsus* that considerably reduced biomass yields in Uganda. Secondly, there is a need to assess the potential of the many indigenous fodder species that are used by farmers to feed their livestock. Successful production of these species requires that the

species possess the following characteristics: high nutritive value, high palatability, persistence and compatibility with other crops (Roothaert et al., 1997). Key challenges limiting enhancement of fodder tree benefits for farmers as outlined by Franzel et al. (2014) include:

- Species diversification. There is a lack of species appropriate for different agro-ecological zones, particularly high altitude (>2000 m) and semi-arid zones.
- Lack of functioning seed supply systems to facilitate adoption.
- Weak extension support yet fodder trees production is a knowledge-intensive practice requiring acquisition of new skills such as on nursery establishment, tree pruning and seed collection. Promoting innovative approaches such as farmer to farmer extension can help promote widespread adoption (Wambugu et al., 2011) and, also because fodder trees require little land, labor or capital.

2.4 Level of fodder technology uptake

Trees and shrubs and other plant associations play an important role in cattle feeding systems. About 205 000 farmers were estimated to be planting agroforestry fodder shrubs in East Africa (Kenya, Uganda, Rwanda and northern Tanzania) in 2006, based on a review of household surveys and reports from organizations promoting fodder trees (Place et al., 2009). Even though it's difficult to estimate the numbers of farmers planting fodder trees the numbers are likely to have increased, because a vibrant private seed market has emerged in Kenya (Franzel et al 2014; Wambugu et al., 2011; Acharya et al., 2010). About 40–50% of the planters were women, indicating the appropriateness of the practice to their needs and that many of the organizations promoting the practice targeted women (Kiptot and Franzel, 2011).

Many farmers also grow fodder trees to feed their dairy goats with significant impact on milk yields (Kiruiro et al., 1999; Niang et al., 2009). Feeds supplementation with *Mimosa scabrella* in the highlands of Rwanda enabled goats to gain 50 g day $^{-1}$ compared with 31 g day $^{-1}$ for grass alone. Six other tree species also increased body weight (Niang et al., 2009). Ewes supplemented with *Sesbania sesban* in Ethiopia showed a 13% increase in milk production over ewes supplemented with concentrates (Mekoya et al., 2008). Many experiments have showed the effectiveness of fodder trees in increasing the productivity of sheep and goats for meat

production. Sheep gained 79–90 g day $^{-1}$ in live weight from being fed calliandra in Kenya (Kiruiro, 1999). Calliandra leaf meal has therefore been reported as a potentially valuable substitute for soybean meal in compound feeds for goats raised for meat production (Ebong et al., 2009).

The contributions of *G. sepium* and *Pterocarpus spp* to sheep growth and on the time they save farmers from the drudgery of fodder collection have been evaluated using on-farm trials in Segou, Mali (Hamer et al., 2007). Fodder shrubs were found to be profitable only under conditions where alternative options were expensive. In Ethiopia, *Sesbania sesban* is the most important planted fodder tree and is generally grown in home gardens (Hess et al., 2006) while in East and Central Mashonaland Provinces of Zimbabwe, farmers plant *Leucaena leucocephala, Acacia angustissima, Leucaena diversifolia* and *Leucaena pallida i*n pure stands while others intercrop them with food crops or other fodder crops (Hove et al., 2003; Mapiye et al., 2006).

Much less is known about farmer-managed natural regeneration of fodder trees and how these trees are managed once mature (Franzel et al., 2014). In an area of eastern Kenya ranging from sub-humid to semi-arid, researchers identified 160 such species that farmers used for fodder. Farmers most preferred species were *Triumfetta tomentosa, Aspilia mossambicensis* and *Melia volkensii*. Among the 15 that farmers ranked highest in importance, only one, *Commiphora zimmmermanii*, was planted and its main use appeared to be as live fence while most were scattered in crop land (Franzel et al., 2014).

Adoption of fodder bank and legume technology in West Africa has been addressed by various authors such as Tarawali and von Kaufmann (1987) and Ajileye et al (1994). According to Mohamed-Saleem and von Kaufmann (1995), the total number of fodder banks in the region in 1990 was 530. Between 1987 and 1991, a total of 637 fodder banks were established under farmer-managed supervised loans of the World Bank Second Livestock Development Project (Ajileye et al., 1994). Singh et al. (2003) and Sanginga et al. (2003) noted a rapid uptake of improved dual-purpose cowpea among farmers in northern Nigeria. Kristjanson et al. (2002) projected the technology to reach millions of smallholder farmers in the dry savannas of West Africa with internal rates of return on research investment of 50–103%. The data implied that

fodder bank concept was acceptable as one option to solving the problems of livestock nutrition and soil conservation. Latter studies showed that successful dissemination of fodder legumes involves building partnerships with a range of stakeholders; understanding small-holder systems and targeting appropriately; assisting local communities to mobilise resources; and ensuring the effective participation of farmer groups [Franzel et al., (2003) ; Peters and Lascano (2003)]
In South East Asia the use of fodder shrubs has been widely practised in Java where population pressure on land makes it imperative that every available feed resource is utilized. Fodder shrubs and trees are traditionally used as protein supplement for basal feed consisting of rice straw (Rankuti et al., 1990; Davedra, 2010). In Bali, Leuceana and Sesbania grandiflora are fed to cattle at a rate as high as 15-20kg/head/day (FAO 1991). In the Philippines, Leucaena have traditionally been used in ruminant systems as a source of feed, fuel and is useful for reforestation and erosion control, shade and as fertiliser in agroforestry systems (Trung, 1990; Wambugu, 2006). A number of productivity-enhancing technological options for animal production are gaining wider and more intensive application in many parts of Asia and elsewhere.

One such example is the three-stratum forage system (TSFS) in Indonesia (Devendra, 2010). The three strata forage system (TSFS) adapted for the dryer environments (600–900 mm annual rainfall and 4–8 months dry season) of Bali and Indonesia, integrates cash cropping and ruminant production (mainly cattle and goats) in a sustainable crop-animal system. This system enhances efficient use of natural resources, especially for small farms. The system has potential for application in semi‑arid areas of sub-Saharan Africa (Devendra, 2010). The TSFS integrates planting and harvesting of forages so that a source of feed is available year round. The core area is the centre of the plot where maize, soya bean and cassava are grown for predominantly human consumption while the peripheral area is utilised for fodder crops for animals. The peripheral area consists of three strata:

***Strata 1* – Grasses and legumes for use during the wet season**

Grasses: Buffel (*Cenchrus ciliaris*) and Green Panic (*Panicum maximum*) Legumes: Stylo (*Stylosanthes gracilis*), Centrosema (*Centrosema pubescens*) Caribbean stylo (*Stylosanthes hamata*)

***Strata 2* – Shrub legumes for use during the middle of the dry season**

Shrubs: Gliricidia (*Gliricidia sepium*) and Leucaena (*Leucaena leucocephala*).

***Strata 3* – Fodder trees for producing feeds for the late dry season**

Fodder trees: Ficus (*Ficus poacellie*), Hibiscus (*Hibiscus tilleacius*) and Lannea (*Lannea corromandilica*).

The major highlights of the systems are:

- Increased forage production enabled higher stocking rates (3.2 animal units/ha) and total live weight gains of 375 kg/ha/year in the TSFS compared to 2.1 animal units and 122 kg/ha/year in the non‑TSFS;
- Cattle in the TSFS gained 90% more live weight and reached market weight 13% faster;
- Farmers benefited with a 31% increase in farm income;
- Introduction of forage legumes into the TSFS reduced soil erosion by 57% in TSFS compared to the non‑TSFS, and also increased soil fertility;
- Presence of 200 shrubs and 112 trees logged twice a year produced 1.5 tons/ year of firewood, which met 64% of the farmers' annual firewood requirements;
- Integration of goats, in addition to cattle, into the system, further increased the farmers' incomes.

Overall, though available literature shows extensive utilization of various fodder technologies, the over-dependence on a few tree fodder species such as leuceana, calliandra and gliricidia as good examples of this. Given the diversity of available tree forages there is need to recommend promising species in terms of plant productivity and nutritive value for specific agro-ecological environments and livestock production systems (Dawson et al., 2014). Improved agronomic practices, harvesting and processing aspects also demand great consideration.

3.0 Methodology

The section outlines the research methodology adopted in the study with a focus on research design, target population, sampling procedure, data collection instruments, data procedures and data analysis.

3.1 Research design

The study adopted the participatory research design and relied on primary data sources including Focus Group Discussions and Key Informant interviews. The data collected was qualitative in nature.

3.1 Study location

The study was carried out at Kipkaren ward and surrounding wards of Mosop sub-county, Nandi County in Kenya (Figure 1). Kipkaren is situated about 30km North of Eldoret town and encompasses six sub-locations. Famers in Kipkaren market sell their milk through the Tanykina Milk Cooperative Limited also referred to as a Dairy Farmers Business Association (DFBA) in which they are shareholders. The availability of market for milk coupled with farmer ownership of the plant favours dairy production as a preferred enterprise of choice that is projected to persist as a livelihood strategy for majority of farmers. Since its establishment, the DFBA triggered stakeholder interaction and trust building during service provision (Klerkx et al., 2012), hence provides a good base for forging further cooperation among stakeholders for joint problem solving.

The area has a cool moderately wet climate with an annual precipitation of about 1200 mm of rainfall per year. The long rains start in early March and continue up to end of June, while the short rains usually fall from mid-September to end of November. A dry spell is normally experienced between December and March, but there is no month when the District records virtually no rainfall. The temperatures range between 18^0c to 23^0c making it ideal for dairy farming. Most parts of the county experiences mean temperatures of between 18^0c and 22^0c during the rainy seasons while higher temperatures averaging 23^0c are recorded during the drier months of December and January. The coolest temperatures, as low as 12^0c, are experienced during the cold spell of July and August.

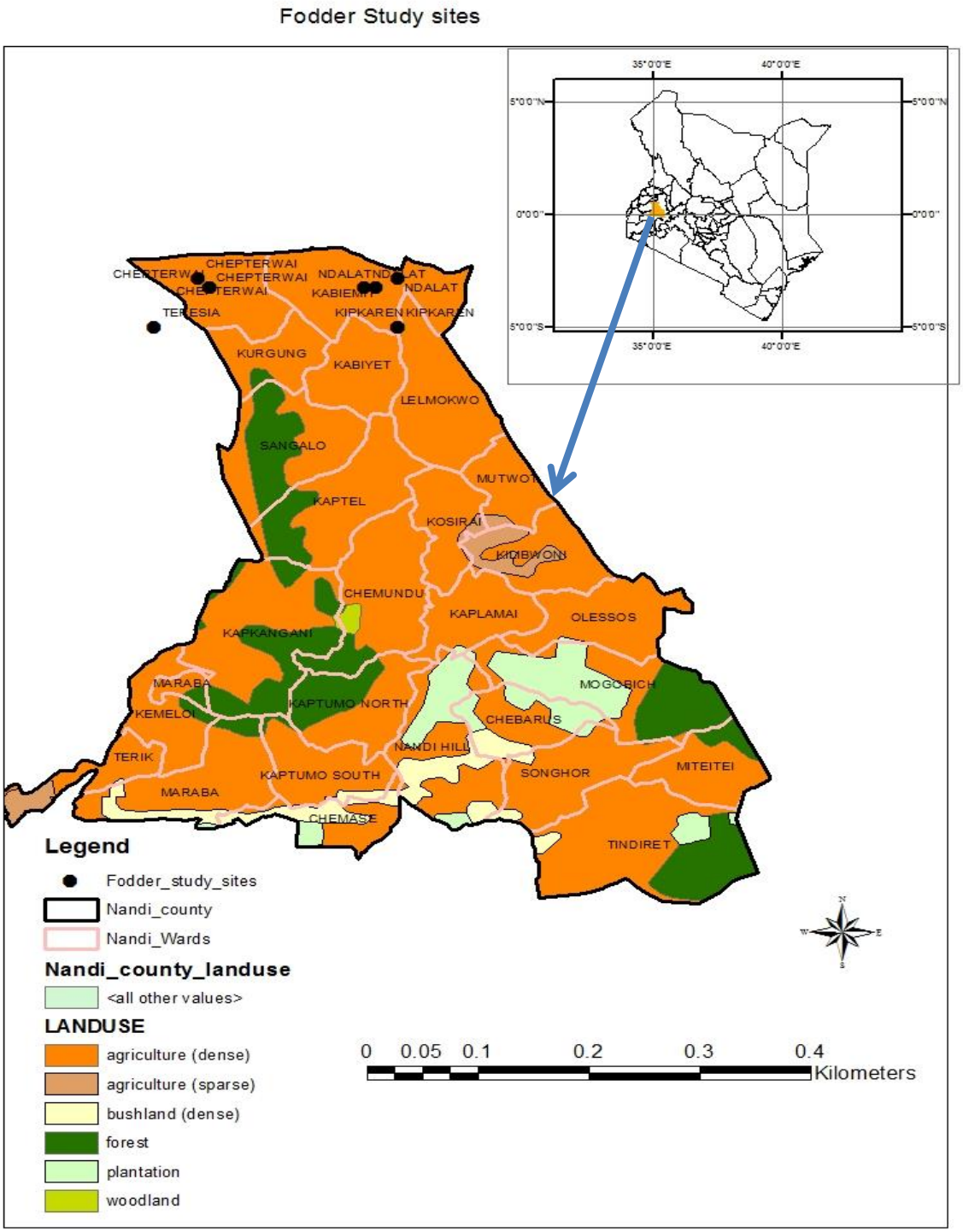

Figure 1: Map of Nandi County showing fodder study sites

3.2 Target population

The target population comprises of all stakeholders, individual farmers and farmers affiliated to dairy farmer groups in the area study.

3.3 Sampling procedure

For the group discussion, farmers were purposively sampled from three administrative locations where the active dairy groups are present. The administrative locations are also within the catchment area of the Tanykina milk plant and farmers market their milk to the plant. This approach was based on the assumption that groups have benefitted from training on agroforestry fodder and will provide experiences on uptake and utilization of the technologies. In order to capture the diverse characteristics of dairy farmers in the area, farmers affiliated to farmer groups and individuals not affiliated to any group were sampled for the study. Participants for Focused Group Discussions (FGDs) were drawn from eight existing dairy farmer groups. These groups were located in: 1) Ndalat (**three** FGDs, one with the women group (Kemeliet women group) and another two mixed groups (Canaan and Chepchonge), 2) Kipkaren location (Chepnaria, Taaret gaa and Sokyot all of which are mixed groups) and3) Chepterwai (Teresia AI mixed group). One other FGD was held in Kipkaren with individual farmers selected from the three locations with farmer group presence. A total of **eight** FGDs were conducted for the study. The composition of farmer participants in the FGDs is presented in table 1.

Table 1: No. of Participants in Focus Group Discussion from dairy farmer Group

Name of group	No of male members	No of female Members	Location	Total no. of participants
Caanaan	3	5	Ndalat	8
Sokyot	10	3	Kipkaren	13
Baitich	9	0	Chepterwai	9
Chepnaria youth group	6	3	Kipkaren	9
Taret gaa	4	6	Kipkaren	10
Chepchonge	6	3	Ndalat	9
Kemeliet	0	7	Ndalat	7

Non farmer group	11	2	Ndalat/ Kip Karen	13
Total participants				78

3.4 Data collection procedures

The researcher led the Focus Group Discussions by use of an interview guide (Appendix 1). The interview guide was designed to ensure that all the information gathered was in line with the study objectives. The topics discussed during the FGDs were:

i) Types of fodder technologies adopted and in use; challenges and opportunities in uptake and utilization of the technologies,

ii) Range of stakeholders involved in promoting agroforestry technologies, those missing and how they could be involved in the promotion.

iii) Knowledge shared on fodder agroforestry, extension methods used, farmers' perspective on the effectiveness of the knowledge sharing mechanisms and proposals for improvements of fodder utilization and uptake.

An example of a FGD conducted during the research is shown in Plate 1.

Plate 1: A FGD with members of Chepnaria youth group in Kipkaren

In addition, eight key informant interviews were conducted with the following sectors: private extension at Tanykina (1), public extension at Kipkaren ward office (1), a director at Tanykina milk plant, Nandi County Livestock Production Officer in charge of IFAD (International Fund for Agricultural Development) program, Tanykina plant manager, KAVES (Kenya Agricultural Value Chain Enterprises) field officer and a local proprietor of an agricultural and veterinary store. The researcher used an interview schedule to conduct face-to-face interviews with the key informants. The topics covered included:

i) Roles, mandate and rules of engagements and achievements
ii) Stakeholders' collaboration in promoting tree fodder technologies
iii) Opportunities and challenges in promoting agroforestry among smallholder farmers
iv) Suggestions for improving fodder technology uptake.

Representative farmers from each farmer group that participated in the FGD and the key stakeholders were invited for a stakeholder workshop. The farmer participants were selected based on their performance in fodder technology uptake. Five adopters and non-adopters were invited to the workshop to unravel the fodder tree issues and enrich knowledge sharing sessions. The purpose was to share experiences on fodder agroforestry and clarify facts discussed during the FGD. In the end, the stakeholders were to learn ways of engaging each other and gain insights to improving uptake of fodder technologies disseminated.

3.5 Data analysis

Data on uptake of fodder technologies and stakeholder meeting was analysed by developing themes in line with the study objectives, followed by thick description of text. Stakeholder data were subjected to social network analysis software using the net draw package followed by a power analysis. Further, a Venn diagram on organizations involved in fodder agroforestry showed dairy farmers' view of importance of stakeholder, contacts and cooperation of the organizations.

4.0 Results and discussion

This section presents results for the three categories of research respondents who participated in the study. They include dairy farmers who participated in FGDs, key informants from

organizations promoting tree fodder technologies and stakeholder representatives who participated in a stakeholder meeting. The aim was to compare their responses, reveal differences in order to draw accurate conclusion.

4.1 Focus Group Discussion

The section is organized in three topics; technology uptake and utilization by smallholder farmers, constraints and opportunities of famers in tree fodder uptake and farmers' perspective on stakeholder roles in fodder technology adoption.

4.1.1 Technology uptake and utilization

Both the non-group farmers and the farmer groups interviewed revealed that indigenous trees are utilized as fodder for livestock. Some 13 fodder tree species mentioned were of indigenous origin (Table 2). The farmers also mentioned that the leaves are the common part of some fruit trees fed to dairy cows. Farmers groups indicated that increased livestock feeding on tree leaves occur during the dry months of December to March. Farmers expressed interest in knowledge on the nutritive value of the trees and amount required in feed rations for a more elaborate utilization of the trees. A list of 29 tree species commonly used to feed cattle in some of the wards in Mosop sub-county was recorded (Table 2). Baitich group has different list of trees because Chepterwai location or ward where the group is located is a high altitude area.

Table 2: Fodder Trees and Shrubs Utilized in Mosop sub-county

Scientific name (local name)	Location				Remarks
	Kipkaren	Ndalat	Kabiemit	Chepterwai	
*Combretum molle (Kemeliet)	√	√	√		
*Bridelia micrantha (Chemakandet)	√				
*Prunus africana (Tendwet)	√	√	√	√	Excessive intake causes poisoning
*Vangueria Madagascarensis (Siryat)	√		√	√	
Leuceana	√	√	√	√	Easy to establish

leucocephala (Lukina)					
*Cordia abyssinica				√	
*Polyscias kikuyuensis (Saayet)				√	
*Sparmannia rici (Meswot)				√	
*Dombeya Goetzenii (Silipjet)				√	
*Mimulopsis solmsii (Setiot)				√	
*Albizia gummifera (Seet)				√	
*Ficus sycomorus (Mokokwet)	√			√	
Fig tree (Choruet)				√	
*Dryopteris marginalis (Tilalwet)	√	√	√	√	
Calliandra calothrysus (Calliandra)	√	√	√	√	Good fodder but is attacked by pests
Calliandra sp (Kaibeyot)					
Chamaecyctisus prolifer (Tree Lucerne)		√	√		Drought resistant
*Sesbania sesban (Sesbania)	√	√	√	√	Rarely grown by farmers, found growing in the wild.
Grevillia robusta (Chepkumiat)	√	√	√	√	Exposure to utilization of the tree during tour to Mukurweini
Morus alba Mulberry			√	√	Occur in small numbers about 3-4 trees per member
Tephrosia vogelli			√		Planted in Napier plots to keep off the moles
Psidium guajava (guava)	√	√	√	√	Fruit utilized
Persea americana	√	√	√		Fruit and leaves

(avocado)					utilized
Eryobotrya japonica _(loquart)	√	√	√		Fruit and leaves utilized

*indigenous species

Further, the farmer groups described management requirements for different fodder tree species (Table3). The non-group farmers had no knowledge on management and utilization of the trees especially the exotic species. Tree lucerne seemed unpopular among farmers because of the high levels of management demanded. There is widespread availability and use of a local variety of Calliandra sp (Kaibeyot) and Sesbania sp. Similarly, *Leuceana spp*. is popular because the species is prolific, with fast growth and high biomass production once introduced in any area. The exotic species of *Calliandra calothyrsus* is limited because of challenges in pest control (Table 2).

Table 3: **General Management of Fodder Trees by Farmers**

Common Name /Scientific name	Remarks
Calliandra (*Calliandra calothrysus*)	Established well especially from seedlings. Sometimes requires frequent weeding.
Tree lucerne (*Chamaecyctisus prolifera*)	Demands high management; manuring, and weeding.
Sesbania (*Sesbania sesban*)	Uptake is good because it occurs as an indigenous tree. Grows well especially after pruning
Lukina (*Lueceana sp*)	Establishes very fast and does not require special attention

In conclusion, farmers in groups utilize a variety of fodder trees compared to farmers without group membership. However, both individual farmers and farmers affiliated to groups are almost at the same level of knowledge on use of local indigenous fodder trees.

4.1.2 Challenges and opportunities in tree fodder technology uptake and utilization

A majority of the farmers faced technical challenges hindering uptake of fodder trees while some faced socio-economic and environmental challenges. These challenges were listed as follows:

- Unpredictable weather conditions lead to poor timing of planting.
- Seasonal price fluctuation of milk
- Low income milk sales hinder investment in fodder technologies
- Lack of farmer role models because some who tried failed and there is general fear to test new technologies.
- Lack of appropriate tools for harvesting and processing fodder trees,
- Low technical know-how on fodder management.
- Limited knowledge on utilization of fodder trees. A farmer said, *"We concentrate on growing fodder grasses because the animals require these in large quantities, the fodder trees have less herbage and may not be adequate in feeding the dairy cows."* A typical smallholder fodder plot farm is shown in plate1.
- There is low capacity of extension personnel and hence poor follow up of technologies disseminated
- Inappropriate extension methodologies such as farmer tours that lack follow up hence sustainability
- Fodder tree seeds are not locally available
- Unavailability of fodder tree seeds and seedlings and, when available are expensive.
- Some seeds fail to germinate upon planting.
- Some fodder trees such as Calliandra do not do well in the area. One farmer reported that it was attacked by a pest. They suggested investigations be conducted to establish soil types and varieties appropriate for their area. Research on pests and diseases affecting the fodder trees in the area was desired. Knowledge on pesticides for pest and disease control in the fodder trees was missing.
- Dishonesty in distribution of planting materials in cases where a group or individuals are selected and supported to establish tree nurseries or acquire packet of seeds. Those supported do not sale the seed at the agreed subsidized prices, seedlings are unfairly distributed and some fail to receive the seeds or seedlings.

- Distance to training venues is a hindrance to attendance and subsequently uptake of the technologies promoted.
- The laid back attitude by farmers leads to low fodder utilization. One farmer shared that: '*madam we are culturally pastoralists and not used to planting fodder and feeding livestock. We will take some time before adopting the new technologies"*.
- Excessive intake of fodder trees by animals that stray in the field may cause loss of animals such as sheep and goats. Farmers who may have lost animals are shy to establish the fodder trees. Farmers were of the opinion that fodder trees will thrive if animals are confined in a zero grazing unit. Another farmer warned that the cows will bring down a weak fence in an aggressive search for fodder trees. A farmer uprooted the fodder trees after losing a cow to bloat. Farmers need to be encouraged to properly fence their fields and adequately feed their cows to control access to the fodder fields and minimize risk of bloat.

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Plate 2: A typical smallholder farm in Ndalat with few fodder trees in fodder plot

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There exist opportunities for increased fodder uptake by smallholders in the study area as follows:

- The presence of Tanykina dairies in Kipkaren enhances opportunities for milk marketing and may motivate farmers to increase milk production through agroforestry.
- The community possesses tacit knowledge in agroforestry gathered over the years with experience in dairy farming.
- The climate is ideal for dairy farming and agroforestry trees.

- There have been programs such as EADD conducting trainings and some farmers are aware of importance of fodder agroforestry.

4.1.3 Farmers' perspective of fodder stakeholder's roles

The farmers complained of few stakeholders in the system, even though 11were listed as shown in Table 4. The EADD program spearheaded by ICRAF was lauded for supporting uptake of tree fodder technologies. The program supported extension delivery through the Tanykina dairies. The program further supported various aspects of dairy production such as research, breeding, feeding and business development.

The financial providers such as Juhudi Kilimo played an important role of offering credit facilities to cater for household needs such as school fees and extra money to invest in fodder production. Farmers were however unsatisfied with the terms of loans offered by Kina financial services affiliated to Tanykina dairies. Loan processing takes up to 2 months and the loan disbursed recovered once in a month. Similarly, farmers complained of weekly loan repayment by Morning star and said "*the process is time consuming and one may not be able to benefit from the loan because it is recovered even before you invest".* As a result, some farmers have opted for Juhudi Kilimo facility that has spread loan repayment period over months and process loans in three days.

KAVES (Kenya Agricultural Value Chain Enterprises) and Kenya Seed Company are collaborating in fodder demonstration with only the Baitich group in Chepterwai. Similarly, the IFAD project implemented by MOALF (Ministry of Agriculture Livestock and Fisheries) and county livestock production office has only one Dairy Commercialization Area (DCA) at Kabiemit location hence the lower side of Kipkaren does not benefit. The IFAD project organizes residential trainings for farmers at the Dairy Training Institute at Naivasha, conducts farmer tours of successful farmers, and, supports operationalization of Community Based Organizations (CBO's) and cooling plants. A farmer representative in the program also attends stakeholder meetings where presentations are done on the DCA's progress and policies are discussed such as the public health policy addressing milk hygiene.

A summary of the stakeholders and roles played in fodder agroforestry system are shown in Table 4.

Table 4: Stakeholders in Fodder Innovation System in Kipkaren

Category of farmers	Stakeholders	Roles
Farmer groups	Tanykina	Extension, loans for fertilizer and seeds or seedlings, herbicides and pesticides.
	Juhudi Kilimo	Loans (Agricultural and school fees)
	KAVES	Field days and fodder demonstrations
	Kenya seed	Fodder demonstration
	IFAD collaborating with state department of livestock and county livestock officers	Excursions, training and fodder demos
	Farmers in groups	Extension, guarantors of Juhudi loan
	Private agrovets	Sell fertilizers, seeds,
Non group members	Tanykina- agrovet, kina financial	Milk marketing, extension, loans for fertilizer and seeds and dewormers through their agrovet
	Farmers	Sharing information on fodder trees and providing demonstration sites
	Agrovets	Inputs (fodder trees seeds)
	Banks	Loans
	Morning star	Weekly loans

Tanykina Dairy Limited was identified as a critical stakeholder because of provision to members of various goods and services (Figure 2). However, farmers were unsatisfied with quality of extension services provided by the dairy plant, poorly stocked agricultural and veterinary stores and poor terms of loan. KAVES, Kenya seed and IFAD are important stakeholders but face similar challenges as Tanykina with operations limited to a few areas. Figure 2 shows KAVES and Kenya seed are actively engaged with Baitich group while IFAD engages only Kemeliet and Chepchongi groups although four groups (Sokyot, Taret gaa, Baitich and some non-group farmers) mentioned previous interaction with the program.

Compared to individual farmers, farmers' groups are in contact with more stakeholders and are more aware of the different services available. Figure 2 shows that the non-group farmers are in contact with only morning star, fellow farmer and Tanykina dairies.

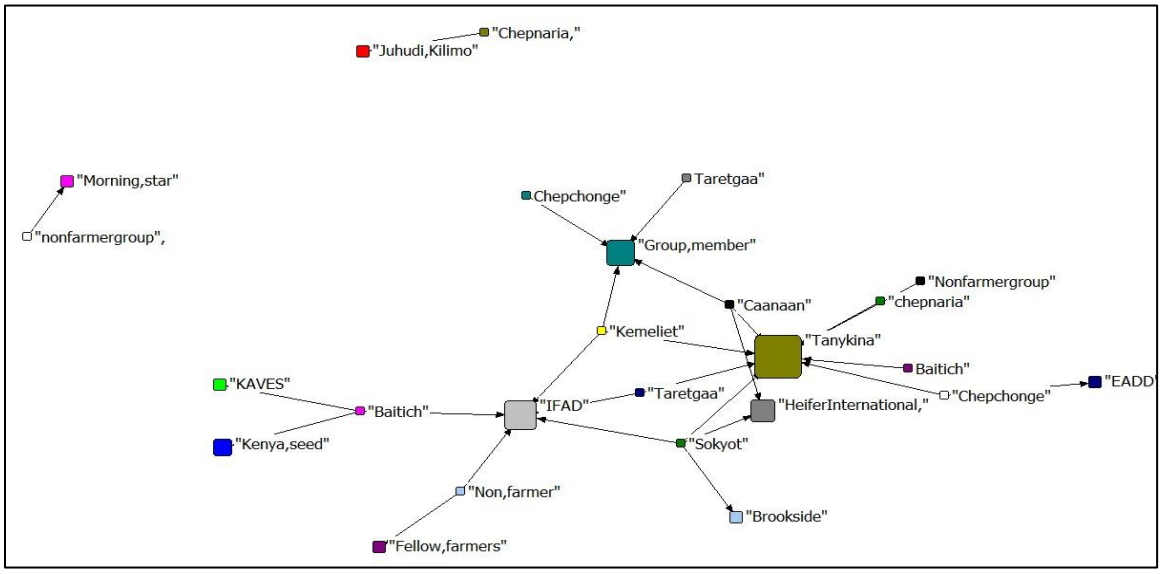

Figure 2: **An analysis of stakeholder relationship with dairy farmer groups and non-farmer groups in Kipkaren**

Required stakeholders

Fodder trees species that establish fast and resistant to pests ensure better and quick returns to investment and are likely to be adopted by the farmers. Research institutions such as Kenya Agricultural and Livestock Research Organization (KALRO) and World Agroforestry (ICRAF) are needed for information provision on suitable species for promotion in the area. Farmers do desire capacity building in all aspects of dairy husbandry and hence suggested that the stakeholders such as processors (Brookside) and agrochemical companies (Norbrook) collaborate in conducting on farm trainings and demonstrations. Some famers expressed desire for A.I services or information on breeding so that they are assured of better incomes from feeding high milk producing cows.

The famers would also like exposure to other financial service providers such as Equity Bank that may be offering extension services and agricultural loans with better terms of loan repayment. Some farmers reported dishonesty among some financial services providers in loan recovery. The farmers desire cooperative societies that will pay better prices for milk supplied hence motivate them to invest in fodder trees for increased milk production. A venn diagram showing farmers interaction with stakeholders and those stakeholders needed in the fodder system is shown in figure 2.

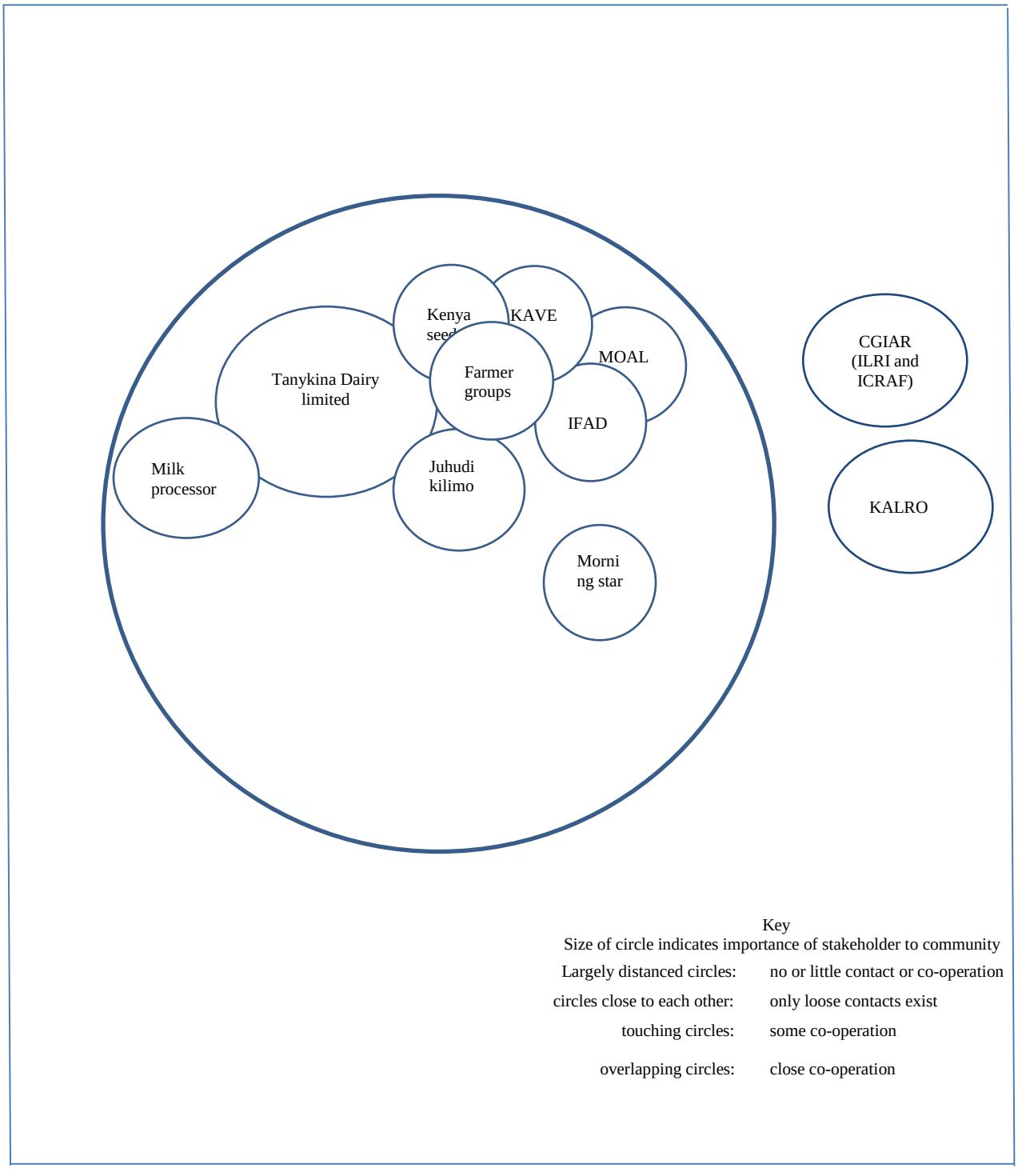

Figure 3: Organizations interacting with smallholder dairy farmers on fodder agroforestry in Kipkaren

Analysis of power dynamics among stakeholders

Power analysis is necessary to understand the dynamism of power among stakeholders in fodder dissemination. Power is thought about negatively as coercion but there are other expressions of power that pave the way for more positive thinking and action (Brouwer, Kormelinck & Vugt, 2012). The power dynamics observed among the fodder stakeholders were **power over (**ability to influence and coerce action of those without power), **power within** (increased individual consciousness, self-dignity and awareness or building self-esteem) and **power with** (increased power from collective action, social mobilization and alliance building).

In the study, Tanykina and Brookside exercised the **power with** each other to plan and conduct trainings at the dairy plant. Similarly, KAVES and Kenya Seed Ltd exercised the power with each other to cooperate with Baitich group in fodder demonstrations.

On the other hand, Brookside possesses **power over** the farmers and conducts trainings at the plant without consideration of their preferred venue, a farmer field. In addition, the processors have power over the plant and the farmers in milk pricing and influence farmers' level of investment in fodder establishment and utilization.

Finally, the farmers' groups have **power within** themselves as organized groups to negotiate for trainings, demonstrations credit provision from stakeholders such as IFAD, Tanykina, MOALF and financiers like Juhudi Kilimo.

The analysis shows that only the processors bear some control over some stakeholders. This explains the desire of most farmers to own cooperatives and processing plants so they can control milk prices with the hope of improving incomes. However, the majority of stakeholders cooperate and hence abilities exist to achieve improved uptake of fodder technologies.

Knowledge sharing on Agroforestry

An expanded extension service is desired with a preference for on-farm training and demonstrations as opposed to non-residential and residential trainings. Non-residential trainings are not favoured because of long distances and time taken to reach to the training venues. Also, few farmers are selected to attend residential trainings while majority feel left out. Farmers who

participated in the residential trainings revealed that many topics were orally presented during the training and often most farmers failed to grasp some concepts. Brochures distributed during trainings would guide farmers when ready for implementation of the technologies.

The farmers suggested that farmer fields can be identified and used as demonstration sites for fodder. Demonstrations offer opportunities to learn every step of fodder establishment and management before implementing on the farms. They also proposed establishment of fodder tree nurseries in order to increase local availability of planting materials. Farmers prefer public extension officers because they work with them for a longer period compared to private extension providers. They wish to have, more of the officers posted to their area to train them on fodder management.

In summary, the study has showed that farmers especially those not associated to any farmer groups have limited access to services such as extension and credit. Farmer groups are advantaged because they are often sought after by service providers such as micro finance institutions (Juhudi Kilimo and Morning Star) and both public and private extension providers. Because of exposure to many stakeholders these farmers have better access to demonstration inputs (fodder seeds or seedlings) and services (credit and extension). However, there is limited capacity of both public and private sector extension hence farmers receive inadequate services. In order to increase technology uptake among both individual farmers and farmer groups enhanced farmer networks are desired. Enhancing networking will assist farmers overcome challenges such as inadequate extension services and poor markets leading to improved technology uptake and incomes from better milk sales.

5.0 Key Informant Report

The key informants drawn from local stakeholders were selected during the FGDs. Farmers provided names of organizations and contacts of the individuals from the organizations whom they collaborate with.

5.1 Stakeholder roles and cooperation

The key informants interviewed were drawn from four organizations namely; KAVES (Kenya Agricultural Value Chain Enterprises Services), KENAFF (Kenya National Farmers Federation), national government, county government and Tanykina Dairy Limited. The organizations are in close contact and cooperate in improving dairy value chain in the county particularly through extension service delivery and commercialization of the fodder enterprise.

KENAFF and KAVES are collaborating in that an officer from KENAFF is the implementing officer for the KAVES project in the county. The two organizations work very closely with Kenya Seed during fodder demonstrations. The KAVES project objectives are to reduce poverty and improve smallholder household. The organization aims at increasing value of dairy enterprise including registration of cows in the farm. The organization also encourages farmers to establish pastures and link them to fodder and milk markets. The focus of the project is to educate farmers on dairy production through trainings, followed by on-farm demonstrations. There are plans to engage certificate or diploma holders in agriculture as trainers of trainers such that there is a trainer in each sub-county for improved extension delivery. KENAFF agenda in the county is to work with other stakeholders in identifying agricultural value chain enterprises and target those that can trigger broad based wealth creation. The value chains developed are subsequently mapped and analyzed in order to develop structured agribusiness investments options and projects.

The ASDSP (Agriculture Sector Development Program) program is a national program in Nandi county that has prioritized dairy as an important enterprise in the county. The program is working with actors in the dairy value chain including KENAFF, KAVES and Tanykina (through a director of the plant) to grow the enterprise in the county. The goal of the project is to transform agriculture to innovative, commercially oriented enterprises. Similarly, the Smallholder Dairy Commercialization Programme (SHDCP) is a national project focusing on the commercialization of boma rhodes in the target areas also known as Dairy Commercialization Area (DCA). The DCA is managed by DCAC (Dairy commercialization area committee) that oversees the operations of the groups in the area. The program supports dairy groups by granting

loans for hiring land and establishment of fodder. In addition, the program also supports vulnerable group and have supplied dairy goats to some of these groups.

The Sub-County Livestock Production Office is actively involved with the county government and in the extension component of the two national projects (ASDSP and SHDCP). The Sub-County Livestock Production office also works with the provincial administration especially the chiefs and assistant chief in mobilizing farmers to participate in agricultural activities. The office is also in contact with the Kenya Dairy Board (KDB) in matters of milk quality control and regulations. The other key stakeholders are KAVES, KENAFF (concerning matters of management of dairy milk plants and financiers (exposing them to farmers) such as Chasebank, Kenya commercial Bank (KCB), Faulu Kenya, Nandi Hekima, Morning Star, Juhudi Kilimo, Family bank, KWFT (Kenya Women Finance Trust) based in Kabiyet Ward neighbouring Kipkaren. The Sub-County Livestock Production officer noted that availability of cheap credit is important for farmers to invest in feeding dairy cows for improved incomes.

Tanykina extension officer reported that milk processors such as Brookside and Daima are cooperative when called upon to conduct farmer trainings in dairy production. The venue for the processors' trainings is the dairy plant and rarely conducts field demonstrations. Sugar companies such as Butali and West Sugar are promoting sugar cane growing in the area but incorporate dairy production in their trainings. Sugarcane growing is taking root in the area among farmers with larger pieces of land. The Tanykina plant management has in the past engaged graduates from Moi University for an internship program. The students were linked to successful farmers who paid them KES 6 000 per month subsidized by the dairy plant. The student conducted demonstrations and surrounding farmers are allowed to attend. The plant reported that one of the successful farmers linked to the students was able to achieve increased milk production from 10 kgs to 18kgs and another from 28kgs to 68kgs.

Required stakeholders

Financial institutions with better terms on the loans are required. Farmers are constrained by limited period of repayments and loaning conditions. For example, Agricultural Finance Corporation (AFC) requires collaterals such as title deeds to secure loans offered.

Overall, the key informants reported good working relationships with each other. The core mandate of most organizations in public and private sector is extension service provision. Even those with other mandates like the banks and processors have a component of extension delivery.

5.2 Stakeholder perspective to farmer technology uptake and utilization

The stakeholders promote the exotic and indigenous tree species shown in Table 5. None of the stakeholders mentioned utilization of non-conventional trees that farmers utilize during period of drought.

Table 5: Fodder tree species promoted by stakeholders

Common name /Scientific name	Remarks
Calliandra (*Calliandra calothrysus*)	The germination was poor because the pretreatment procedure was not adhered to
Tree lucerne (*Chamaecyctisus prolifera*)	Did not pick up well
Sesbania (*Sesbania sesban*)	Established well and fast growing
Lukina (*Lueceana luceophala*)	Easy to establish

Constraints and opportunities of fodder uptake and utilization

The stakeholders noted that the major challenge in technology uptake is that smallholder farmers do not prioritize fodder establishment in dairy enterprise. Moreover, some of the farmers do not engage in dairy as a business. The Tanykina plant manager noted "*There are two categories of dairy farmers, those doing it as a business and are strategic and willing to adopt the*

technologies. The other category keeps the animals for prestige or as a hobby and their enterprises may not be profitable." In addition, about 70 percent of the farmers feed the animals on natural pastures. The ward livestock extension officer noted, *"Harvesting of fodder trees and fodder grasses using the available tools is laborious and most farmers opt to graze the animals".* The Tanykina plant manager said, *"the company lacks fund to purchase machinery for hire to ease the burden on the farmers in handling and processing fodder."*

An official from KENAFF noted, "*Farmers have no willingness to establish and conserve fodder; they will instead concentrate on growing maize for home consumption and surplus for sale. Very few grow maize for fodder or fodder trees and many animals are left to graze."* The Sub-County Livestock officer observed that majority may not even fence the land to improve on natural pastures.

The other drawback to fodder utilization is that farmers have limited knowledge on the benefits of fodder trees and are not convinced to introduce them to their farms. The farmers are concerned about quantity of fodder produced and less on quality. They are planting and utilizing Napier grass, rhodes grass and some maize fodder and little attention to fodder trees compared to leguminous grasses. Extensive training on usefulness and utilization of trees as a source of protein in the diets of animals is desired. The Tanykina plant manager admitted that if in a good financial position, they would hire more extension staff to adequately cover the catchment area like was the case with the EADD program that engaged 10 extension officers. The private extension agent from Tanykina added, "*We are only two covering the lower side of the catchment area while my colleague is in charge of the upper side. We are overwhelmed with work, we need a different approach to extension since trainings and field days are not working". We have been thinking about clustering farmers into groups and training four groups at ago. There is need to deal with a small group so that we oversee establishment and reduce cases of poor germination so that farmers are encouraged to undertake fodder tree establishment".*

There are concerns about fodder seed accessibility; due to poor access and availability, there is limited use of the inputs. According to SHDCP officer, local availability of fodder tree seed is an issue influencing uptake of fodder technology. Better endowed farmers have not ventured into

production of tree seeds and seedlings. He noted that large scale farmers prioritize growing grasses such as Boma rhodes and lucerne for sale at the expense of fodder trees since land is available. Consequently, local availability of planting materials is low yet smallholder farmers are willing to adopt the technology.

The ward extension officer observed that low frequency of weeding results in reduced vigor of seedlings. As a result, some farmers will think that the fodder trees are not well suited for the area limiting uptake of agroforestry practices. The KAVES field officer noted that fertilizer and manure application is a problem. He said, "*there is need to discuss use of liquid manure and discourage use of solid manure on the farms for planting".*

A private agriculture and veterinary store dealer said, *"Farmers attempt to acquire government subsidized fertilizer but the process takes too long and they end up buying fertilizers from us. We do not stock any fodder tree seeds but have grasses like oats, sunflower and sorghum. During the year there was a shortage of supply of Boma rhodes from Kenya seed".* The chairman of the farmer groups added, "*Calliandra seeds are expensive when bought in large quantities. There is mistrust among the farmers in cases where they purchase large packets of seed as a group. They are suspicious about sharing of the seeds and would prefer that seeds are availed in small packets affordable for purchase by individual farmers".* In order to increase availability of seeds and reduce the cost, the chairman suggested that individual farmer or farmer groups can be trained and supported on establishing tree nurseries. They can in turn sell the seeds to farmers at a subsidized rate.

The processors offer low prices for farmers' milk and in turn are not able to invest in profitable dairy enterprises. The Sub-County Livestock Production Officer said; the production price of milk in Nandi county is KES 21 while the cooling plants pay KES 26, a profit margin of KES 5 is unreasonable and discourages farmers from investing in dairy farming. The sub county officer observed that the cooling plants are not united to confront the issue of low milk prices. There have been attempts to merge the cooling plants in the county and venture into milk processing but the process was scuttled by unknown parties. The ward officer added "*Milk yields are generally low at an average of five litres per animal per day and milk prices are unstable; the*

return from milk production is low, subsequently there is little investment in the enterprise. The situation is worsened by the high cost of conserved feed such as hay"

.

The Sub-County Livestock Production Officer also noted that the farmers have a 'wait and see' attitude and have no knowledge sharing culture that hinders adoption of technologies promoted. She hinted that those who eventually adopt are committed and loyal. The ward officer added, "*no much effort is put to feed dairy cows because the farmers do not undertake dairy as a business. They keep animals for prestige even when the enterprise is not profitable. There is need to commercialize dairy in the area".*

Gender may be influencing level of production in smallholder farms. Firstly, dairy is an enterprise controlled by males in the Nandi community but the women are the implementers. The women may not be motivated to increase production because of unfair share of benefits. In addition, most training is attended by the men who may not pass the knowledge to the women. The sub county livestock officer said, "*There is a farm that registered a drastic increase in milk production. On investigation the woman was left behind in charge of the farm upon transfer of her husband to Mombasa."*

The Ward livestock officers cited some socio-cultural factors hindering adoption of technologies and include cultures such as circumcision and dowry that lead to overstocking. Others are monocropping, decreased soil fertility, HIV/AIDS, water scarcity and reducing land sizes.

Opportunities

The Tanykina dairy plant is willing to support farmers to increase milk production. A director of the company shared that in the company business plan, one of the objectives is to train farmers through the extension department in all aspects that will promote milk production. The director also indicated that collaboration with companies such as Norbrook and Kenya Seed exist for supply of inputs to their agriculture store. In addition, KAVES field officer noted that the ASDSP programme in Nandi County engages stakeholders in the dairy value chain hence

stakeholder collaboration can be enhanced through such a platform. A campaign of fodder trees growing can easily be initiated through such a forum.

5.3 Knowledge sharing on agroforestry technologies

The stakeholders are in agreement that a combination of different modes of knowledge sharing is effective in building capacity of small holder farmers for improved dairy production. The group approach is desired by both the private and public extension providers. The Ward Livestock Production Officer commented, '*I prefer to conduct group trainings in the farmer fields so that on the first days we do the theory and finish with demonstrations'*. The officer also added that successful farmers may be sponsored for exchange visits as TOT's (Trainers of Trainers) and are expected to share the knowledge gained with fellow farmers back at home. However, he noted that there was the tendency of farmers applying the technologies without full consideration of the context in which they operate and sometimes they may not succeed in their farms. The County Dairy Officer in charge of the IFAD project prefers tours and observed that '*farmers in the area are not enthusiastic about learning from fellow farmers but are more responsive and will implement ideas picked from the tour'*. On the other hand, the Sub-County Livestock Production Officer noted that, '*we like to begin with group trainings then demonstrations and finish with field days. By then the farmers are knowledgeable about current technologies and can make choices on the products to utilize among those displayed in the field days or exhibitions'*.

Programmes in extension

The Ward Sub-County officer noted that the EADD program was brief but successful. He said the model used was effective because the program supported the installation of milk cooling plant to enhance marketing of milk. The program also trained extension providers to train farmers. The program supported upcoming farmers to venture into dairy farming. Similarly, the impact of the SHDCP was felt because of the much training and on farm demonstrations that had been organized.

The NALEP (National Agriculture and Livestock Extension Program) was a national extension program in government supported by the Swedish International Development Agency, (SIDA). The program succeeded in training public extension officers in aspects of agriculture development and crosscutting issues such as gender. However, there was a lot of documentation, which left little time for the staff to concentrate on issues raised by farmers. The program deadlines were unrealistic and farmers did not benefit much because officers had too much to do in a short time.

From the key informant interviews, there is a chance for strengthening agroforestry through stakeholder collaboration in Mosop Sub-County. This is because the ASDSP program spearheading the dairy value chain development has mapped out all stakeholders in the value chain. The stakeholders in the county are familiar with each other and their roles since they have been interacting in the ASDSP value chain platform. The greatest challenge is for stakeholders to work out an innovative approach and change mindset of the farmers to undertake dairy as a business. Appropriate ways of sharing technical knowledge and follow-ups on establishment and benefits of agroforestry is desired. Promoting establishment of both local and exotic varieties that are manageable and determining inclusion levels in animal diets encourages adoption. This is because farmers are assured of good results with minimized risks and losses. Smallholders also need sensitization on crosscutting themes such as gender and group cohesion and how these influence uptake of fodder technologies. Addressing these issues will provide a roadmap for farmers to undertake practical steps to overcome poor milk production and milk pricing.

6.0 Stakeholders Assembly Report

The stakeholder workshop was held after the farmer group discussion and the key informant interviews. The objective of the workshop was to enable joint learning through interaction between key stakeholders and representatives of farmer groups. The stakeholders were expected to discuss constraints and opportunities of fodder tree production and utilization. Thereafter they provided suggestions on possible solutions for increasing fodder tree uptake. The workshop also served to verify information provided during the farmer group discussions and interviews.

The farmer participants were selected based on their performance in fodder technology uptake. Five adopters and non-adopters were invited to the workshop to unravel the fodder tree issues and enrich knowledge sharing sessions. The invited stakeholders were from the organizations that participated in key informant interviews except a field officer from Equity Agriculture Foundation affiliated to Equity bank. The officer was informed about the meeting by KAVES field officer and intends to start projects in the area. Equity Agriculture Foundation targets the middle income farmers termed a "forgotten" group in agricultural development projects. The objective is to support the farmers in agriculture enterprises of their choice through on farm trainings and markets linkages for the same produce. The medium scale farmers will be selected through the Tanykina Dairy Limited but smallholder farmers will not be barred from any training organized by the foundation.

Some farmers were unaware of different fodder tree species, utilization and benefits of the trees. They admitted having not attended any training on fodder tree establishment. On the other hand, they are aware of indigenous tree species like calliandra grazed on by the animals in the meadows. A majority of the farmers indicated that the fodder trees are palatable and liked by the animals. The problem is that trees are not maintained for fodder, grow tall hence unreachable to the animals unless the farmers harvest the branches for them. Farmers said that many accidents have been reported as a result of consumption of the avocado fruit. Farmers were advised to cut the seed to smaller pieces before feeding the animals to avoid choking.

The adopter farmers complained of frequent weeding associated with raising fodder tree seedlings, unavailability and high cost of seed. The sub county officer informed them about a successful farmer in Kabiyet growing fodder trees in a small piece of land and charging an entry fee of 200 Kenya shillings per individual into his farm. The farmer also sells fodder tree seedlings at 100 Kenya shillings. Farmers indicated that the price of the seedling is high and possible solution is to establish tree nurseries as a group. The officer encouraged farmers to begin small and grow their enterprises like the farmer who ended up hosting Bill and Melinda Gates in his farm to show case his work. The officer encouraged them to form groups to access free trainings offered by public extension agents or private agents like Tanykina.

The farmers were unfamiliar with the sub county livestock production office and mode of operation despite working with some officers from the office. The officer shared her phone contacts and explained that they lack capacity to conduct frequent trainings because they are only three officers responsible for all locations in the sub county. Also, the majority of the stakeholders approaching them for collaboration prefer group trainings because many farmers are reached with extension messages that way. She informed them that individual farm visits are conducted only on request.

The Tanykina extension officer expressed disappointment in low farmer turnout for trainings despite training date reminders in milk delivery receipts and phone messages. The farmers advised that increased attendance may be achieved if trainings and demonstrations are conducted in farmers' fields. The farmers also proposed that lead farmers should be identified and tasked to ensure friends, group members and neighbours attend the trainings. An adopter farmer said, "*Some farmers would want to wait and see if promoted technology picks up with another farmer before trying it in their own farms*. *These farmers are slow in adoption and end up missing out on the technology. They do not benefit from the project and are normally left behind as adopters moved on to other different technologies promoted in newly introduced projects*." He advised that frequent trainings and information sharing on the performance of introduced technologies will assist more farmers to test the new technologies.

Further, the farmers complained of low prices paid by the dairy plant and revealed having sold their milk to milk traders paying 50 Kenya shillings as opposed to 27 KES paid by the dairy. The farmers were warned of errant traders using faulty weighing machines and paying them little for more milk delivered.

The farmers also expressed the need for fodder harvesting machines in particular a mower for harvesting Boma rhodes grass. They were informed that the County Government is in the process of procuring a mower to ease harvesting of the grass. They were also reminded of a processing machine that had been distributed to a group but members were never willing to pay 100 shillings processing fee. The group leader present in the meeting confirmed that the machine was poorly serviced and was not put to use. Another farmer felt they could improve profits if

they owned a milk processing machine, and envisioned a farmer managed cooperative undertaking milk processing. The stakeholders appreciated their vision but explained that the success of a dairy cooperative was pegged on high milk deliveries. In such a situation the cooling and processing plant would run at right capacity and profits would be made through processing. At the end of the meeting, it was agreed that the farmers were well supported by the stakeholders and the issue was one of increasing milk production through fodder and fodder tree production to be able to realize their goal.

In conclusion, the meeting established that stakeholders were willing to forge greater collaboration in fodder tree promotion and other aspects of dairy farming. Farmer attendance in trainings can improve if combined with on farm demonstration. The extension service providers can jointly plan to attend such trainings in order to address various knowledge gaps raised by the farmers, provide and follow up on the interventions. Lead farmers can assist the stakeholders in following up on the interventions for increased uptake of fodder technologies. Stakeholder meetings can be organized periodically to share successes, ideas and update on upcoming projects. Continuous interaction is likely to change mindsets to actualize their vision of running a farmer managed processing plant.

Plate 3: Knowledge sharing session during stakeholder meeting

7.0 Conclusion and Recommendation

The study has established that both non-group farmers and farmers belonging to farmer groups are knowledgeable about indigenous fodder trees and fruit trees used by their animals during the dry season. However, farmer group members are more enlightened of exotic fodder species such as calliandra, leuceana, tree lucern and others. Farmers are knowledgeable on tree parts utilized and some species which are poisonous when excessively consumed. Farmer groups benefit more from trainings from both the private and public extension providers that adopt the group approach to reach out to farmers for trainings. However, both categories of farmers need more training and demonstration on establishment and more so utilization of the fodder trees. The farmers desire a capacity building in all the aspects of dairy husbandry which can be achieved with stakeholder collaboration.

The stakeholders in the study have common understanding of socio-cultural and technical factors influencing uptake and utilization of fodder agroforestry based technologies on the ground. The factors include high cost of inputs, poor access to credit, extension and inputs, poor culture of knowledge sharing and learning, limited of technical knowledge on agroforestry technologies including benefits of agroforestry and ways of minimizing risks encountered because of fodder trees in the farm. Socio-cultural factors such as gender and overstocking are silently influencing fodder technology uptake. However, opportunities exist to improve uptake of fodder agroforestry because of availability of a ready milk market provided by the Tanykina milk plant, the tacit knowledge possessed by farmers and technical knowledge on agroforestry acquired from programs such as EADD. Moreover, the stakeholders are willing to forge greater cooperation to address the constraints faced and improve uptake of fodder technologies.

Recommendations

The pre-existing knowledge on agroforestry possessed by farmers need to be complemented with scientific research to guide better understanding and utilization of the tree fodder in animal diets. This study further recommends an integrated extension model encompassing private and public extension workers incorporating lead farmers to play a key role. The lead farmers will spearhead networking among farmers to overcome challenges such as inadequate extension services, poor

access to seeds and a poor culture of knowledge sharing and learning. Farmers are encouraged to network in groups for better access to good and services (inputs credit and extension) that improve fodder agroforestry uptake and utilization.

Novel approaches of knowledge sharing are desired so that farmers can experience sustained learning for a long period to change their mindsets and increase abilities to take risks. An appropriate model is for the stakeholders to jointly work on changing the mindsets of small groups of farmers by addressing crosscutting issues such as gender and, offering technical supporting for them to succeed in fodder production. In addition, creating continuous spaces for sharing successes would motivate others to learn from the initiatives of the successful group and increase their confidence to test the new agroforestry technologies and actualize their vision of a farmer-managed processing plant. This is expected to improved uptake and utilization of fodder agroforestry technologies for improved livelihoods of smallholder farmers.

Further research

Action research approach is required to allow for cooperation among the key stakeholders and multiple forms of extension system management. Stakeholders would participate jointly in continuous planning, action and research of knowledge sharing and learning for increased uptake of fodder technologies.

REFERENCES

Acharya, K., Booth, E., Wambugu, C., Karanja, E., Arimi, H. and Bender, S. (2010). How can Systems Thinking, Social Capital and Social Network Analysis Help Programmes Achieve Impact at Scale? Results of a Demonstration Project in the Kenyan Dairy Sector. Working Paper No. 116. World Agroforestry Centre: Nairobi.

Ajileye, E.O., Uza, D.V. and Farooqi, M.A. (1994). An assessment of farmers' adoption rate and potential impacts of stylo-based feed production systems. In: de Leeuw P.N., Mohamed-Saleem M.A. and Nyamu A.M. (eds), Stylosanthes *as a Forage and Fallow Crop*. *Proceedings of the Regional Workshop on the Use of* Stylosanthes *in West Africa, held in Kaduna, Nigeria, 26–31 October 1992*. ILCA (International Livestock Centre for Africa), Addis Ababa, Ethiopia. pp. 311–316.

Anigma, S.D., Stott, D.E., O'Neill, M.K., Ong, C.K. and Weesies, G.A. (2002). Use of calliandra–Napier grass contour hedges to control erosion in central Kenya. *Journal of Agriculture Ecosysytem and Environment (9)1:15-23.*

Dawson. I., Carsan. S., Franzel. S., Kindt, R., van Breugel, P., Graudal, L., Lillesø. J.P., Orwa, C. and Jamnadass, R. (2014). Agroforestry, fodder production and climate change adaptation and mitigation in East Africa: issues and options, ICRAF Working Paper No. 178. Nairobi.

Devendra, C. (2010). *Small farms in Asia: Revitalising agricultural production, food security and rural prosperity*. Academy of Sciences Malaysia, Kuala Lumpur, Malaysia.

Devendra, C. (1990). The use of shrubs and tree fodders by ruminants. In: Devendra, C. (ed.), *Shrubs and tree fodders for farm animals*. Proceedings of a workshop in Denpasar, Indonesia, 24–29 July 1989. IDRC-276e, Ottawa, Ontario, pp.42–60.

Ebong, C., Byenkya S.G. and Ndikumana, J. (2009). Effects of substituting Calliandra leaf meal for soybean meal on intake, digestibility, growth and feed efficiency in goats. *Journal of. Applied Animal Resource, 16:211-216. 31.*

Elbasha, E., Thornton, P.K. and Tarawali G, (undated). An Ex Post Economic Impact Assessment of Planted Forages in West Africa. ILRI Impact Assessment Series 2.

FAO (1991). Expert Consultation on legume trees and other fodder trees as protein sources for livestock. Malaysian Agricultural Research and Development Institute (MARDI), Malaysia 14-18 October 1991.

FAO (2008). Agroforestry Systems. Retrieved from http://fao.org/forestry/

Feder, G., Just, R.E. and Zilberman, D. (1985). Adoption of Agricultural Innovations in Developing Countries: A survey. *Economic Development and Cultural Change* 33: 255-295.

Franzel, S., Carsan, S., Sinja, J. and Wambugu, C. (2014). Fodder trees for improving livestock productivity and smallholder livelihoods in East Africa; Current Opinion. *Environmental Sustainability, 6:98-103.*

Franzel, S., Wambugu, C. and Tuwei, P. (2003). The adoption and dissemination of fodder shrubs in Central Kenya, Agnen Network Paper No. 131. ODI, London.

Franzel, S., Wambugu, C., Nanok, T., Kavana, P., Njau, T., Aithal, A., Muriuki, J. and Kitalyi, A. (2007). The Production and Marketing of Leaf Meal from Fodder Shrubs in Tanga, Tanzania. A Pro-Poor Enterprise for Improving Livestock Productivity. Working Paper No. 50. World Agroforestry Centre: Nairobi.

Gerrits, A. (1998). Indigenous knowledge on fodder trees and shrubs: farmers' knowledge of indigenous fodder tree species in the Kigezi highlands, Uganda ICRAF, 1998. ICRAF AFRENA Report No. 128. 38 pp.

Gonsalves, J., T. Becker, A. Braun, D. Campilan, H. De Chavez, E. Fajber, M. Kapiriri, J. Rivaca-Caminade and R. Vernooy (eds). (2005). *Participatory Research and Development for Sustainable Agriculture and Natural Resource Management: A Sourcebook. Volume 1: Understanding Participatory Research and Development. International Potato Center-Users' Perspectives* With Agricultural Research and Development, Laguna, Philippines and International Development Research Centre, Ottawa, Canada.

Hamer, A., Franzel, S. and Mounkoro, B. (2007). Assessing profitability of fodder banks using farmers' criteria in the desert margins of West Africa. *Land Degradation Development*, 18:670-679.

Hess, H.D, Tiemann, T.T., Noto, F., Franzel, S., Lascano, C. and Kreuzer, M. (2006). The effects of cultivation site on forage quality of Calliandra calothyrsus var. Patulul. *Agroforestry System, 68:209-220*

Hove, L., Franzel, S. and Moyo, P.S. (2003). Farmer experiences in the production and utilisation of fodder trees in Zimbabwe: constraints and opportunities for increased adoption. *Tropical Grasslands*, 37:279-283

Ivory, D.A. (1990). Major characteristics, agronomic features and nutritional value of shrubs and tree fodders for farm animals. In: Devendra, C. (ed.), *Shrubs and tree fodders for farm animals*. Proceedings of a workshop in Denpasar, Indonesia, 24–29 July 1989. IDRC-276e, Ottawa, Ontario, 22–38.

Kiptot, E. and Franzel, S. (2011). Gender and Agroforestry in Africa: Are Women Participating? Occasional Paper No. 13. World Agroforestry Centre: Nairobi.

Kiruiro, E.M., Ouma, O. and Arimi, H. (1999). The potential for improving milk production from dual purpose goats by using *Calliandra calothyrsus* on smallholder farms of the coffee/tea land-use system of Embu District. Annual Report. Embu: Agroforestry Research Project, Kenya Agricultural Research Institute, Regional Research Centre.

Kristjanson, P., Tarawali, S., Okike, I., Singh, B.B., Thorton, P.K, Manyong, V., Kruska, L.L. and Hoogenboom, G. (2002). Genetically modified dual purpose cowpea: Assessment of adoption and impact in Dry savannah region of West Africa. ILRI impact assessment, series 9, Nairobi, Kenya.

Mapiye, C., Foti, R., Chikumba, N., Poshiwa, X., Mwale, M., Chivuraise, C. and Mupangwa, J.F. (2006). Constraints to adoption of forage and browse legumes by smallholder dairy farmers in Zimbabwe. *Livestock Research for Rural Development*, 18.

Mekoya, A., Oosting, S.J., Fernandez-Rivera, S. and van der Zijpp AJ (2008) Farmers' perceptions about exotic multipurpose fodder trees and constraints to their adoption. *Agroforestry System*, 73:141-153.

Mohamed-Saleem, M.A. and Suleiman, H. (1986). Nigeria and West Africa fodder banks: dry season feed supplementation for traditionally managed cattle in the sub-humid zone. *World Animal Review* 59:11–17.

Niang, A.I., Ugeziwe, J., Cooper, P., Styger, E., Coe, R. and Gahamanyi, A. (1996). Forage potential of 8 woody species: intake and growth rates for local young goats in the highland region of Rwanda. *Agroforestry System* 34:171-178. 30.

Nuberg, A., George, B. and Reid, R.(Eds).(2009). *Agroforestry for Natural Resource Management.* CSIROPublishing. Collingwood, Victoria, Australia 340 pp.

Paterson, R.T., Karanja, G.M, Roothaert, R., Nyaata, Z. and Kariuki I.W. (1998). A review of tree fodder production and utilization within smallholder agroforestry systems in Kenya. *Agroforestry System* 41:181-199.

Peters, M. & Lascano, C. (2003). Forage technology adoption: linking on-station research with participatory methods. *Tropical Grasslands,* (2003), pp. 179–188.

Place, F., Roothaert, R., Maina, L., Franzel, S., Sinja, J. and, Wanjiku, J. (2009). The impact of fodder shrubs on milk production and income among smallholder dairy farmers in East Africa and the role of research undertaken by the World Agroforestry Centre. Occasional Paper 12. World Agroforestry Centre.

Rangkuti, M, Siregar, ME. and Roesyat, A. (1990). Availability and use of shrubs and tree fodders in Indonesia. In: Devendra, C. (ed.), *Shrubs and tree fodders for farm animals*. Proceedings of a workshop in Denpasar, Indonesia, 24–29 July 1989. IDRC-276e, Ottawa, Ontario, pp. 266–278.

Roothaert, R., Franzel, S. and Muriuki, K. (2003). On-farm evaluation of fodder trees and shrubs preferred by farmers in central Kenya. Experimental Agriculture 39:423-440.

Schut, M., Klerx L., Rodenburg J., Kayeke J., Hinnou, L.C. and Raboanarielina S. (2014). Rapid Appraisal of Agricultural Innovation Systems (RAAIS) Part 1. A diagnostic tool for integrated analysis of complex problems and innovation capacity. Wageningen University

Sekatuba, J., Kugonza, D. Wafula, Wusukwe, W. and Okorio J. (2004). Identification of indigenous tree and shrub fodder species in the Lake Victoria shore region of Uganda. *Uganda Journal of Agricultural Sciences,* vol. 9: 372–378.

Singh, B.B., Ajeighe, H.A., Tarawalia, S.A., Fernandez-Rivera S. and Abubakar, M. (2003). Improving the production and utilization of cowpea as food and fodder. *Field crops research* 84:166-177.

Tarawali, G. and von Kaufmann, R. (1987). *Fodder Banks: Benefits to Ruminant and Crop Production.* Paper presented at the Regional Seminar on Forages and Ruminant Nutrition, held at Ngaoundere, Cameroon, 16–20 November 1987. 15 pp.

Thomas, D. and Sumberg, J.E. (1995). A review of the evaluation and use of tropical forage legumes in Sub-Saharan Africa. *Agriculture, Ecosystems and Environment* 54: 151–163.

Topark-Ngarm, A. (1990). Shrubs and tree fodders in farming systems of Asia. In: Devendra, C. (ed.), *Shrubs and tree fodders for farm animals*. Proceedings of a workshop in Denpasar, Indonesia, 24–29 July 1989. IDRC-276e, Ottawa, Ontario, pp. 12–21.

Trung, L.T. (1990). Availability and use of shrubs and tree fodders in the Philippines. In: Devendra, C. (ed.), *Shrubs and tree fodders for farm animals*. Proceedings of a workshop in Denpasar, Indonesia, 24–29 July 1989. IDRC-276e, Ottawa, Ontario, pp. 279–294.

Vercoe, T.K. (1987). Australian Acacia in development countries. In: Turbull, J.W. (ed.), *Fodder potential of selected Australian tree species*. ACIAR Proceedings No. 16. ACIAR, Canberra, Australia, pp. 95–100.

Von Kaufmann, R. (1986). An introduction to the sub-humid zone of West Africa and the ILCA subhumid zone programme. In: *Livestock systems research in Nigeria's sub-humid zone*. Proceedings of the second ILCA/NAPRI symposium held in Kaduna, Nigeria, 29 Oct. - 2 Nov. 1984. ILCA, Addis Ababa, Ethiopia.

Wambugu, C., Place, F. and Franzel, S. (2011).Research, development and scaling up the adoption of fodder shrub innovations in East Africa. *International Journal of Agriculture Sustainability*, 9:100-109.

Wambugu, C., Franzel, S., Cordero, J. & Stewart J. (2006). *Fodder shrubs for dairy farmers in East Africa: making extension decisions and putting them in practice*. World Agroforestry Centre, Nairobi, Kenya, Oxford Forestry Institute, Oxford, UK. 169 pp.

Winrock International (1992). *Assessment of Animal Agriculture in Sub-Saharan Africa.* Winrock International Institute for Agricultural Development, Morrilton, Arkansas, USA. 125 pp.

APPENDICES

Appendix 1: Interview Guide for Focus Group Discussion

PART A: Group General Information

Name	
No. of members	
Year of Registration	

PART B: Evaluating Agroforestry uptake

1) What trees or shrubs are used as fodder in the area?
2) What parts are used and how is it used?
3) What did not work?
4) What are the constraints experienced?
5) Suggest ways of overcoming these constraints?
6) What opportunities exist?
7) What important lesson learnt from the discussion on Agroforestry?

PART C: Analyzing stakeholders in Agroforestry

1) Who are the stakeholders promoting agroforestry?
2) Which stakeholders work closely with you?
3) Are there organizations that should be involved but absent in the area?
4) How would they get involved?

PART D: Analyzing knowledge sharing mechanisms and learning

1) What types of knowledge on Agroforestry fodder is shared?
2) Who is sharing knowledge and with who?
3) How is the knowledge shared?
4) What is working?

5) What is not working?

Appendix 2: Interview Schedule for Key informant Interview

1) What is the mandate and role of your organization in fodder agroforestry?
2) Who are involved in strengthening fodder agroforestry in the area?
3) What type of linkages exists among the actors and who initiated them?
4) What organizational capacities exist among the actors?
5) Which agroforestry strategies have farmers adopted to deal with fodder scarcity?
6) What challenges do they experience?
7) What opportunities exist for exploitation?
8) What are the critical problems to be dealt with by actors in order to realize optimum results?

9) What are the prominent ways of knowledge sharing in the system?

10) What methods have been successfully employed by your organization? Why and what were the results?

11) What can be done to improve knowledge sharing and learning in the system and what expected outputs or change will be seen?

12) Are there any arrangements in the past that yielded outstanding results in strengthening the fodder agroforestry?

13) What did the processes entail? Identify unique activities of the frameworks attributable to realized change.

Appendix 3: List of Chepnaria Youth Group

S/No	Name	**Sex**
1.	Josiah K. Yego	**M**
2.	Sammy Kering	**F**
3.	Nebson Kogo	**M**
4.	Josphat Bett	**M**
5.	Monica Bett	**M**
6.	Elizabeth Yego	**M**
7.	Prisca Chepchirchir	**F**
8.	Jacob Rotich	**M**

Appendix 4: List of Chepchongi Dairy Farmers

S/no	Name	Sex
1	Benjamin Kipkenei	M
2	John Mello	M
3	Ezekiel Sitere	M
4	Rose Katam	F
5	Alfred Boit	M
6	Prisa Mining	F
7	Prisca Chepkwony	F
8	Conslatina Keino	F
9	Simon Biwott	M
10	Benjamin Kipkenei	M

Appendix 5: List of Sokyot Farmers

No	Name	Sex
1	Joseph K. Bor	M
2	James K. Kosgei	M
3	Hellen J. Arusey	F
4	Ben Serem	M
5	Dorcas J. Lele	F
6	Emily J. Kosgei	F
7	Eunice J. Tarus	F
8	Marcella J. Koskei	F
9	Marcella J. Koskei	F
10	Leah Kogo	F
11	Hillary Rotich	M
12	David Agio	M
13	Job Lez	M
14	Daniel Ngetich	M
15	Elkana Siror	M
16	Richard Kogo	M
17	Julius Serem	M
18	Michael Yego	M

Appendix 6: Kemeliet women's group

S/No	Name	Sex
1.	Emily Lagat	F
2.	Jane Tenai	F
3.	Milcah Samoei	F
4.	Prisilla Bitok	F
5.	Julie Maiyo	F
6.	Lydia Kosgei	F
7.	Rose Lelei	F
8.	Evelyn Tou	F
9.	Hellen Soo	F

Appendix 7: List of Baitich Members

S/No	Name	Sex
1.	Joshua Kemmey	M
2.	Benson Kiprop	M
3.	Johnston Kebenei	M
4.	Isaac Kogo	M
5.	Julius Koech	M
6.	Charles Koech	M
7.	Joseph Chepkwony	M
8.	Stanley Kemey	M
9.	Nicholas Muttai	M

Appendix 8: List of Taret Gaa Sacco

S/No	Name	Sex
1.	Richard Keter	M
2.	Philemon Songok	M
3.	Timon Bwaley	M
4.	Joseph Ngetich	M
5.	Gladys Tuwei	F
6.	Cleophas Tuwei	M
7.	Juliah Bwaley	F
8.	Christine Oroyo	F
9.	Sammy Talam	M
10.	Eliud Keter	M

Appendix 9: Individual farmers or Non-group members

S/no	Name	Location
1.	Wilson Kibet	Ndalat
2	Elisha Kipchirchir	Ndalat
3	Noah kendagor	Tuktuk
4	John mwalemet	Chepkemel
5	Jemeli	Sokyot
6	Arap Saina	Sokyot
7	Aoron Juleget	Kabiemit
8	Ronald Bii	Kabiemit
9	Shadrack Nyelechei	Kabiemit
10	Jepleting	Kaplemur
11	Mengich	Chepkemel
12	Jona Bii	Kabiemit

Appendix 10: Stakeholder Meeting Participants

S/No	Names	Tel No	M/F	Organization
1	Ben Serem	0719899479	M	Farmer
2	Richard Chirchir	0717343890	M	Farmer
3	Gideon Kemey	0723076552	M	Farmer
4	Clady Rono	O721927278	M	Farmer
5	Milcah Samoei		F	Farmer
6	Shadrack Ngellechei	0722458394	M	Farmer
7	Micah Yego	0720980618	M	Farmer
8	Meshack Rop	0702020641	M	Farmer
9	Ruth Jemeli	0725062632	F	Farmer
10	Charles Koech	070020641	M	Farmer
11	Charles Rono	0723511314	M	Equity Foundation
12	David Kamidany	0722692019	M	Farmer
13	Josphat Bett	0721410779	F	Farmer
14	Esther Omayio	0726911625	F	Nandi County Government
15	Sarah Tanui	07106655	F	Student- Moi university
16	Joel Maiyo	07252668	M	Nandi County Government