ANALYSIS OF SMALL-SCALE DAIRY FARMERS' PERCEPTIONS OF ALTERNATIVE FODDER GRASSES CONTINGENT ON NAPIER STUNT DISEASE IN BUNGOMA DISTRICT, KENYA

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DECLARATION AND RECOMMENDATION

DECLARATION

I hereby declare that this is my original work and has not been presented in this or any other university for the award of a degree.

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To my family Kap Chepchoge, who taught me the intrinsic worth of learning!

ABSTRACT

Smallholder dairy sector in Western Kenya plays an important role in the livelihoods of many farm households by generating income and employment. Napier grass is the principal source of livestock feed in the region; as well as being an integral grass in the push-pull technology (PPT). Despite this fact, Napier stunt disease (NSD) has become a serious threat to the growth of Napier grass and consequently to the livestock industry. This thesis focused on farmers' perceptions on alternative fodder grasses to Napier grass and sought to provide a better understanding of the alternative grasses available for adoption due to the threat to fodder availability by NSD. The objective of this study was thus to determine the extent of Napier stunt disease infestation in small-scale dairy farming and to find out alternative fodder grasses small scale dairy farmers would prefer if Napier grass is affected by NSD. The study was conducted in Bungoma District (now county), Western province, Kenya. Primary data were collected from 140 small-scale dairy farmers. Descriptive statistics and multinomial logit model were employed to generate the results using STATA and SPSS application software. Results revealed that, Napier grass is the main source of fodder by the majority (98.6%) of the farmers and that the cultivation and expansion of the fodder crop has been severely threatened by NSD. Most (97.9%) of the interviewed farmers recognized and experienced the damage caused by this disease. At least a portion of each respondent's land had been affected ranging from 0.01 acres to 2.0 acres. The reported effects of NSD on dairy enterprise included: reduction in milk production, reduction of breeding stock and increased costs of production. Results further confirmed that, a majority (68.6%) of the respondents showed willingness to replace Napier grass with alternative fodder grasses. The alternatives in order of priority included: Natural grass; signal grass; Giant seteria; Sudan grass; and Molasses grass. Results obtained from multinomial logit model revealed that, some of the farm and farmer characteristics, institutional characteristics, and grass attributes were important determinants of farmers' perceptions on alternative grasses used in smallholder dairy farming. Consequently, it is essential that when screening alternative fodder grasses, emphasis should be placed on attributes that conform to farmers' preferences and that farmers should be involved in evaluation of fodder grasses to find their suitability to the farmers' circumstances. It is also recommended that on farm trials/ demonstrations to test grass attributes suggested as important in decision making on preference of alternative grasses should be validated.

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LIST OF ACRONYMS, SYMBOLS AND ABBREVIATIONS

ASARECA	Association for Strengthening Agricultural Research in Eastern and Central Africa
CMAAE	Collaborative Masters in Agricultural and Applied Economics
DDP	District Development Plan
ICIPE	International Centre of Insect physiology and Ecology
ILRI	International Livestock Research Institute
IPM	Integrated Pest Management
IID	Independently and Identically Distributed
KARI	Kenya Agricultural Research Institute
MLM	Multinomial Logit Model
MOA	Ministry of Agriculture
NSD	Napier Stunt Disease
PPT	Push-Pull Technology
SSA	Sub-Saharan Africa

CHAPTER ONE

GENERAL INTRODUCTION

1.1 Background of the Study

The dairy sub-sector in Kenya as reported in a study by ILRI (2007) is dominated by smallholder farmers, who are estimated to produce an astonishing 80% of all the milk marketed in the country. The study indicated that the smallholders have farms keeping one to two milking animals on a small piece (about 1 hectare) of land. Furthermore, the research reports that even where annual income from crops and other enterprises is greater, farmers value the even distribution of income offered by dairying, the capital asset represented by the animal and manure. The study also concluded that the manure produced by the dairy sub-sector is of critical importance in smallholder production of vegetables, maize and other crops.

According to Ouma *et al*., (2007), it is estimated that Kenya has up to 6.7 million dairy cattle and about 1.8 million households who rely on dairying. Research done by ILRI (2007), shows that the principal source of livestock feed on about half a million of Kenya's smallholder dairy farms is Napier grass, commonly known as elephant grass. It further mentioned that: Napier grass is highly nutritious; grows well even in poor soils; produces seven times more herbage biomass than traditional grasses; it is generally higher yielding than other cut fodders; and is also easier to propagate and manage. These among other factors make Napier grass a favorite of dairy farmers.

Western Kenya is one of the most densely populated areas of sub-Saharan Africa (SSA) with a high level of hunger and extreme poverty levels ranging between 59% and 63%; which exceed the country's national average of 46% (Mariara and Ngethe, 2004). However, the smallholder dairy sector in Western Kenya plays an important role in the livelihoods of many farm households by generating income and employment (Mudavadi *et al*., 2001).

According to Ouma *et al*., (2007), dairy farming in the mixed small-scale farming systems of Western Kenya ranks second to maize and beans in contribution to household incomes and food security. Further on their observation, Napier grass *(Pennisetum purpureum)* is an improved fodder crop, which is especially important in cut-and-carry systems (zero grazing). The Napier grass can produce large quantities of forage; it is a fast growing, deeply rooted, perennial grass growing up to four metres tall that can spread by underground stems to form thick ground cover; and though best suited to high rainfall areas, it is relatively drought-tolerant and can also grow well in drier areas (Orodho, 2006). In Western Kenya, Napier grass takes up as much acreage as that planted with maize, Kenya's staple food crop. In addition, it has been used by farmers in a novel Push-Pull Technology (PPT), an Integrated Pest Management (IPM) system for cereal stemborers control (Khan *et al.,* 2001).

Although in the last decade cultivation of Napier grass has increased in Western Kenya as small-scale dairying has shifted from extensive to zero grazing, the development of smallholder dairy systems in the region has been marked by declining farm sizes, grazing fields and planted area for fodder. On the other hand, the cultivation and expansion of the fodder crop is threatened by Napier grass stunt disease (NSD). The disease causes economic losses in the smallholder dairy industry, thus affecting the source of revenue of the rural poor (Khan *et al.,* 2008). Napier stunt disease, which **is** caused by *phyto-plasma* bacteria and transmitted by leaf hoppers, retards the growth of the plant and curls the leaves progressively turning them yellow and drying them out (Jones *et al.,* 2004).

According to work by Khan *et al.,* (2008), the NSD has a direct impact on the livestock/dairy industry in Western Kenya. The same authors emphasized that NSD has spread quickly and now covers several districts of Western Kenya causing serious economic losses in the smallholder dairy industry. A study by Jones *et al.,* (2004) showed that most of the Napier grass varieties grown in the area are susceptible to the disease which usually becomes visible in re-growth after cutting or grazing. The study established that affected shoots become pale yellow green in color and seriously dwarfed leading up to 100 percent of their Napier crop. Consequently, farmers are forced to de-stock or sell off their entire herd because of lack of feed especially of the high Napier grass prices and also due to the prohibitive management costs to control the disease.

Khan *et al.,* (2001) established that, the major cattle feeds in Western Kenya are natural grass and planted fodder. They indicate that commonly, Napier grass, molasses grass (*Melinus minutiflora*), Sudan grass (*Sorghum /vulgare var. Sudanese*) and signal grass (*Bracharia brizantha)* are alternative grasses which have been recognized to be of economic importance to farmers in Western Kenya. These are used as livestock fodder and some have shown great potential in PPT, an integrated pest management (IPM) strategy that offers effective control of cereal stemborers and *Striga* weed in maize-based cropping systems.

1.2 Statement of the Problem

In Western Kenya, unstable availability and seasonality of livestock feed have been major constraints to small-scale dairy farming. Farmers have been using Napier grass as livestock feed and as an integral grass in push-pull technology despite the presence of Napier stunt disease. However, there are alternative fodder grasses that farmers can use to enhance dairy productivity in the event of loss of Napier grass. The major cattle feeds that are used are natural grass and planted fodder which include: Napier grass; Sudan grass; signal grass; and molasses grass which are nutritious and highly valued fodder either for own use as livestock feed or for sale. Farmers' perceptions of and preferences on various grasses as alternative fodder given the status of Napier stunt disease are unknown.

1.3 Objectives of the Study

The overall objective of this study was to assess small-scale dairy farmers' perceptions of alternative fodder grasses contingent on Napier Stunt Disease in order to inform on the appropriate fodder grass to be promoted among the farmers to improve small-scale dairy industry. The specific objectives were:

1. To determine the extent of Napier stunt disease infestation in small-scale dairy farming.
2. To assess the damage caused by the NSD
3. To assess farmers' perceptions on suitability of alternative fodder grasses in order to establish their preference for dairy grasses.

1.4 Research Questions

To achieve the above objectives, the following research questions guided the study:

1. What is the extent of Napier stunt disease infestation in small-scale dairy farming in Bungoma District?
2. What damage does the NSD cause?

3. What are the farmers' perceptions on suitability of alternative fodder grasses used for small-scale dairy farming in Bungoma District?

1.5 Justification

Napier stunt disease has seriously threatened the viability of the smallholder dairy industry in Western Kenya. This implies that unless control measures are undertaken, NSD will continue to undermine efforts to develop the smallholder dairy industry, putting rural households' economic as well as food security at risk in the region (Jones *et al.,* 2004). The study therefore targets various stakeholders including small scale farmers, practitioners working with farmers, and policy makers in providing information on appropriate grass (es) as alternative to Napier grass due to the serious effects of Napier stunt disease in Western Kenya. Furthermore, the study results facilitates in solving serious problems of food insecurity and nutritional related health risks experienced in the country.

1.6 Definition of Terms

Perception: The process by which individuals interpret and organize sensation to produce a meaningful experience of the alternative chosen (Adesina, 1995). This study considered this definnition.

Napier stunt disease: A disease that is spread by *phyto-plasma* bacteria transmitted by leaf hoppers which retards the growth of the plant and curls the leaves progressively turning them yellow and drying them out (Jones *et al.,* 2004).

Small-scale dairy farming: Economic activity which involves keeping dairy cows with a herd of less than five milking cows on less than 1 ha of land (Henk *et al.,* 2007). This study considered all dairy cows irrespective of the breeds.

Push-Pull technology: Pest management technology developed for control of stemborers and *Striga* weed in maize based farming systems where maize is intercropped with desmodium forage legume as a repellent plant to deter the pest from the main crop (push) and Napier grass is planted as a border crop to attract the repelled pest, thus the pull effect (Khan *et al*., 2001).

Fodder: Feedstuff that is used specifically to feed domesticated livestock and is mostly from plants. It is especially coarsely chopped hay or straw (Henk *et al.*, 2007).

Contingent: Dependent on or conditioned by something else.

1.7 Scope and Limitation

The study was restricted to small-holder dairy farmers practicing push-pull technology and also those who were not practicing the technology but were facing the problem of Napier stunt disease and would prefer other grasses to Napier grass in Bungoma district. The study area was chosen because of the intensive nature of agriculture practised in the region - most farmers practice zero grazing, grasses have economic impact; farmers are aware of indigenous and novel uses of several grasses in the region, and that Napier stunt disease has become a serious threat to the small-scale dairy industry.

1.8 Organization of the Study

Subsequent to chapter one that presents the general introduction, chapter two, presents literature review on the various aspects related to this study. In this chapter, an assortment of selective findings and ideas from different studies on small scale dairy farming, Napier stunt disease, the role of grasses in pest and weed control in the novel push-pull strategy and farmers' perceptions on forage alternatives is highlighted. Chapter two also provides theoretical and conceptual frameworks whereas chapter three presents the methodologies used in answering research questions of the study. Chapter four presents the first part of results covering the first two objectives by detailing some of the factors that explains the extent of Napier stunt disease infestation in small-scale dairy farming. The chapter mainly aims at estimating the damage of Napier stunt disease. In chapter five multinomial logit results on farmers' perceptions on suitability of alternative fodder grasses are presented and discussed. The main purpose of this chapter is to establish farmers' preferences on alternative fodder grasses for their dairy farming. Finally, chapter six incorporates all the previous results and other relevant information into general considerations for alternative fodder grasses as fodder due to the effect of Napier grass by Napier stunt disease.

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CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

Research done at ILRI (2007), confirms that farm animals are an ancient, vital and renewable natural resource. The research further shows that throughout the developing world, livestock is a means for hundreds of millions of people to escape absolute poverty. Furthermore, livestock in developing countries contributes up to 80 percent of agricultural gross domestic product; nearly one billion rural poor people rely on livestock for their livelihoods. Globally, livestock are becoming agriculture's most economically important sub sector, with demand in developing countries for animal foods projected to double over the next 20 years. Likewise the ongoing 'livestock revolution' offers many of the world's poor a pathway out of poverty. They also emphasize that livestock not only provide poor people with food, income, traction and fertilizer but also acts as catalysts that transform subsistence farming into income-generating enterprises, allowing poor households to join the market economy.

Further, the ILRI impact assessment report indicated that by 2006, Kenya had 1.8 million smallholder dairy farms, 39,650 milk hawkers and 6.7 million dairy cattle and the country was producing four billion litres of milk each year. Nearly half the benefits went to producers, with the remainder going to consumers ($8 million), small-scale milk vendors ($4.1 million) and ($5.1 million) input suppliers.

2.2 Small Scale Dairy Farming

According to Onsongo (2008), Kenya has a relatively well developed dairy industry that spans over 90 years and has undergone various evolutionary stages. During its formative stages the dairy sub-sector was dominated by large-scale farmers. However smallholder dairy farming has increasingly dominated the sub-sector contributing over 80% of total milk production and supporting over one million small-scale farmers in 2007. The dairy cattle industry accounts for about 4 % of GDP, with an estimated cattle population of 3.5 million. The major milk producing provinces are Rift valley, Central and Eastern provinces. Rift valley accounts for about 50% of this production. Kenya Dairy Board estimates 2007 milk production at 3.74 billion litres a minimal increase from 3.59 billion litres the previous year. The increase in production was attributed to favorable weather and relatively stable prices.

Small-scale dairy producers are generally competitive and are likely to endure for some time, particularly where the opportunity costs of family labour and wages remain low. The most compelling evidence towards this is the continued dominance of smallholders in all the countries studied, even where there is steady economic growth. Furthermore, dairy as an enterprise is an option available to landless and socially marginalized groups (ILRI, 2007). According to Khan and Pickett, (2004), smallholder farmers in SSA practice mixed farming, with livestock being an important component. Mixed crop livestock systems predominate, and as human population rises, land becomes an important constraint, necessitating further integration of the two enterprises supported by the small holdings.

In line with the study done at ILRI (2007), the principal source of livestock feed on about half a million of Kenya’s smallholder dairy farms is Napier grass *(Pennisetum purpureum),* commonly known as elephant grass. However the study reported that, Napier is highly nutritious, grows well even in poor soils, and produces seven times more herbage biomass than traditional grasses. This among other factors makes it a favorite of dairy farmers. Scientists from several institutions have been working together to halt the spread of various diseases of elephant grass. They are raising awareness of the diseases, providing information on how best to control them and determining clones of Napier that are genetically resistant to the diseases. This research study seeks to generate more information on how to stop the progress of the spread of Napier stunt disease by assessing farmers’ perceptions of alternative grasses to Napier grass.

2.3 Napier Stunt Disease

Elephant stunt, a new disease of Napier, has been confirmed in over 90% of Napier grass fields in Kenya, most of whose zero-grazing dairy farmers rely on Napier grass for animal feed. It was discovered that the disease is spread by phyto-plasma bacteria transmitted by leaf hoppers. Furthermore, this disease retards the growth of the plant and curls the leaves, progressively turning them yellow and drying them out. However, the disease cuts herbage biomass by more than half, creating a feeding gap that is not only hurting dairy farmers but also compromising the quality and quantity of milk and meat products. In addition, the first sighting of this infection was in Uganda's Masaka District whereby, many fields since then have been wiped out. More so, as most Ugandan dairy farmers have tiny plots of land on which they have room only to practice 'zero-grazing', in which they daily hand cut and carry feed to cows kept in stalls, the country's smallholder dairying could decline drastically (Nielsen, *et al*., 2007; Tiley, 1969 in Orodho, 2006).

According to Ouma *et al.,* (2007), farmers have been reduced to harvesting much larger portions of their Napier fields to get enough grass daily to feed their milk cows. The quality of the herbage is poor and where, as common, farmers fail to get supplementary feeds, milk yields have been reduced by almost half. This feed shortage has led to the price of a bundle of Napier more than doubling in districts badly affected by stunt. Unless controlled, both smut and stunt will continue to undermine efforts to develop East Africa's smallholder dairy industry, putting economic as well as food security at risk in the region.

In Kenya, the Napier stunt disease was first reported in Bungoma district in 1997. Since the year 2000, symptoms have been seen on Napier grass that include foliar yellowing, little leaves, proliferation of tillers and shortening of internodes to the extent that clumps appear severely stunted. Laboratory tests for viruses and root-infecting fungi that might cause these symptoms have been all negative. However, Napier grass stunt is associated with a phyto-plasma belonging to the 16SrXI (*Candidatus* Phytoplasma oryzae) group (Orodho, 2006).

The disease poses a threat to the push-pull multifunctional technology developed for the control of stemborers and *Striga* weed, and soil fertility improvement. Push-pull technology utilizes a strategy in which plant chemicals are deployed to push colonizing insects away from a target crop and aggregate them on Napier grass used as a sacrificial or trap crop so that a selective control agent can be used effectively and economically to reduce the pest population by combining the effects of "push" and "pull" multiplicatively, and providing opportunities for enhanced biological control in sites where the pest becomes concentrated (Khan *et al.,* 2008).

2.4 Push-pull Technology

Push-pull strategy also referred to as a technology was developed by scientists at the International Centre of Insect Physiology and Ecology (ICIPE) in Kenya and Rothamsted Research in the United Kingdom, in collaboration with other research organizations in Eastern

Africa. The strategy combines the knowledge of chemical ecology and agro-biodiversity of the stemborer with *Striga* management (Miller and Cowles, 1990; Khan *et al*., 2001; Cook *et al.*, 2007). Push-pull technology involves intercropping maize with forage legume and planting a grass as a border crop (Cook *et al.*, 2007; Hassanali *et al*., 2008). The cropping strategy uses a combination of molasses grass or desmodium as common repellents to deter the pest from the main crop 'push' and Napier grass or Sudan grass as the common trap plants to attract ('pull') the repelled pest .

The desmodium plant produces volatiles which repel the moths while volatiles produced by the Napier grass attract them (Chamberlain *et al*., 2006). The larvae from oviposition are trapped by a sticky substance produced by the Napier grass which inhibits the larvae's full development to adulthood (Khan and Pickett, 2004). In this technology, desmodium roots produce chemical compounds, some of which initiate *Striga* germination and others inhibit lateral root growth, thereby hindering its parasitic attachment to maize roots. The ensuing suicidal process suppresses *Striga* emergence and effectively reduces the amount of seed bank in the soil (Van den Berg *et al.,* 2006).

2.5 Role of Grasses in Pest Control

Stemborers are the major insect pests of cereals in many areas of Eastern and Southern Africa. They are regarded as major limiting factors of the production of maize, and sorghum (*Soghrum bicolor*). At least four species infest maize in the East African region with yield losses reported to vary from 20-40% depending on agro ecological conditions, crop cultivar, agronomic practices and intensity of infestations (Pickett *et al*., 2001).The two main stemborer species found in the Western part of Kenya are *Busseola fusca* Fuller (*Lepidoptera*, *Noctuidae)* and *Chilo partellus* (*swinhoe lepidoptera: Crambidae*). Stemborer damage causes green yield losses estimated at 10-80% of the potential grain output depending on the pest population, density, and phonological stage of the crop at infestation (Kfir *et al*., 2002).

According to Khan and Pickett, (2004), effective control of stemborers is difficult, largely due to the cryptic and nocturnal habits of the adult moths and protection provided by the host stem for immature pest stages. Moreover the conventionally recommended chemical control strategies are not practical and economical for smallholder farmers, while effectiveness of some of the cultural control methods considered cheaper for resource constrained farmers has yet to be empirically demonstrated (Van den Berg and Nur, 1998).

The push–pull technology described herein involves intercropping maize with a repellent plant such as desmodium and planting an attractive trap plant such as Napier grass as a border crop around their intercrop. On the other hand, during dusk Napier grass produces chemical substances some of which are good attractants for stemborers to lay eggs. Fortunately, Napier grass produces gummy substances which trap the resulting stemborer larvae and only few survive to adulthood thus reducing their population. Whereby gravid stemborer females are repelled from the main crop and are simultaneously attracted to trap crop (Khan *et al.,* 2000, 2001; Cook *et al*., 2007). The technology so far, is effective and indeed the only push –pull strategy in practice by farmers. It also enhances productivity of maize based farming systems through suppression and elimination of *Striga* and also in providing quality fodder for livestock thus increased milk production (Khan *et al.,* 2000, 2001; Cook *et al*., 2007).

2.6 Role of Grasses in Weed Control

According to Vanlauwe *et al*., (2008), plants belonging to genus *Striga* comprise obligate root parasites of cereal crops that inhibit normal host growth via three processes; competition for nutrients, impairment of photosynthesis and a phytotoxic effect within days of attachment to its hosts. In their research, it is estimated that 76% of land planted to maize and sorghum is infested with *Striga* causing up to 100% yield losses, equivalent to annual losses estimated at $40.8 million in Western Kenya.

According to Khan *et al*., (2001), around the Lake Victoria basin, infestation by *Striga* causes 30- 100% loss in maize yield. The study associated *Striga* infestation with increased cropping intensity and declining soil fertility. Furthermore, *Striga* infestation has resulted in the abandoned net of much arable land by farmers in Africa, and the problem is more serious in areas with low soil fertility and rainfall (ibid). Pickett *et al*., (2001), have demonstrated that maize production in the region is also severely constrained by parasitic weeds in the genus *Striga* in which *Striga hermonthica* is by far the most damaging. The study also reported that, *Striga* roots attach to the maize roots from where they draw their moisture and nutrient requirements in the process inhibiting growth of maize plant leading to a reduction in grain yields. In severe cases, the *Striga* strangulation causes death of maize plant. Furthermore, maize yield losses of 30-50% have been reported under typical field infestations by *Striga*.

2.7 Past Research on Forage Alternatives

According to research done by Roothaert *et al.,(*2005), on lessons learnt from participatory evaluation of improved forages with farmer groups in Uganda, one of their objective was to evaluate alternative varieties which would provide high amounts of high quality feed for dairy cows during the critical dry season. Several forage types were evaluated including grasses and legumes and the parameters analyzed included: growth and vigor, germination, pest and disease resistance, plant height, fodder biomass production, maturity, drought resistance, seed production and palatability.

Roothaert *et al.,*(2005), also found that signal grass (*Bracharia brizantha)* has the potential to continue growing during at least part of the dry season, and remains a high leaf: stem ratio unlike Napier grass which normally stays green during the dry season, but stops growing and becomes stemmy. Therefore, replacement of Napier by Bracharia was seen as a way of dealing with a mycoplasma causing the ‘stunt’ syndrome affecting Napier grass in East Africa.

In the same study it was revealed that adoption of forages in East Africa is highly correlated to intensification process and market success of livestock enterprises. Besides, in the case of smallholder dairy systems, many factors contribute to its market success such as adequate artificial insemination (AI) service, veterinary service, input and output systems, and dairy management expertise. The study concluded that when one factor breaks down, the whole system breaks down. Therefore, when improved forages are introduced into a smallholder dairy system, farmers’ perceptions should be taken into consideration and more so, the whole dairy innovation system should be analyzed.

2.8 Farmers' Perceptions in Technology Uptake

According to Adesina and Zinnah (1993), farmers' perception of an agricultural technology is important in influencing adoption decisions. In addition, Boahene *et al*., (1999), found out that technology adoption which is a multidimensional process, is influenced by factors such as; perceived profitability and costs of the technology, its compatibility with production systems, and the clarity with which the new knowledge and information is communicated in a recipient population. Besides the efficacy of a technology, the severity of the existing constraints also conditions the decision to invest in new technologies (Mbaga-Semgalawe and Folmer, 2000; Kalule *et al*., 2006).

As part of continued research on push-pull strategy done by Khan *et al*., (2008), farmers' perceptions of the attributes of the strategy and their influence on adoption of the technology were evaluated and the specific factors that were assessed included the following: perceptions of push-pull technology-practicing farmers on severity of *Striga* and stemborer constraints; primary sources of information about push-pull technology and the reasons for its adoption among the practicing farmers; perceptions of push-pull technology-practicing farmers on any benefits realized from the technology and any labour changes experienced following its adoption on their farms; and perceptions of non-participating farmers attending field days about the technology attributes and motivational aspects for its adoption.

The results from the study showed that the majority of the push-pull technology - practicing farmers rated the technology as significantly superior to the farmers' own practices on all attributes, indicating that they perceived it as an effective technology for the control of stemborers and *Striga*, improved soil fertility and increased maize production. In their study, farmers cited both stemborers and *Striga* as severe maize production constraints in their districts. It was concluded that, given such circumstances, availing an appropriate technology that is affordable and fits well into farmers' farming system is likely to stimulate its uptake. Therefore, farmers' perceptions on the severity of production constraints, such as *Striga* and stemborers, and suitability and effectiveness of any management strategies are a key determining factor on whether farmers adopt or do not adopt such technologies.

Economists investigating consumer demand have accumulated considerable evidence showing that consumers generally have subjective preferences for characteristics of products attributes (Engel and Blakwell, 1982; Steenkamp, 1989). However, when investigating adoption of new agricultural technologies, economists have lagged behind in investigating how users' (the consumer of agricultural technologies) subjective perceptions of technology characteristics affect their adoption decisions. Focusing on the perceptions of farmers towards technologies may provide answers to missing information since they deal with the technologies and they probably perceive technologies differently from researchers and extension agents. Elbasha *et al*., (1999) reviewed the literature and assembled a list of the factors, which have been cited as constraining adoption of forage legumes in West Africa. These included: lack of fencing materials; shortage of labour; inappropriate land tenure; land scarcity; livestock diseases; invasion of grasses and weeds; and damage by fire. Whereas farmers can be reached with new technologies, researchers and extension agents need to learn the farmers' preferences and constraints in order to address effectively problems confronting them.

2.9 Theoretical and Conceptual Framework

2.9.1 Theoretical Framework

Farmers are assumed to make their decisions by choosing the alternative that maximizes their perceived utility (Sadoulet *et al*., 1995)**.** Observations of farmers' preference among different interventions can reveal the farmers' utility ranking of the alternatives. However, in the case where farmers are asked to state their perception for alternative interventions, there is no natural ordering in the alternatives and it is not assumed that there is monotonic relationship between one underlying latent variable and the observed outcomes in ordering the alternatives (Bekele, 2004). In such cases, a common alternative framework to put some structure on the different probabilities is a random utility framework, in which the utility of each alternative is a linear function of observed individual characteristics plus an additive error term (Verbeek, 2000). With appropriate distributional assumptions on the error terms, this approach leads to manageable expressions for probabilities implied by the model.

In this study we assumed that farmers, from experiences, know their major agricultural problems and can state their preference among alternative grasses. Underlying this assumption is the fact that the stated preference is based on farmers' implicit cost and benefit expectation from the alternative intervention, given their resource endowment. They are expected to rationally reveal their preference in line with the objective of improving their welfare. This preference can be represented by a utility function and the decision problem can therefore, be modeled as a utility maximization problem.

Suppose that the farmer derives utility from choosing a particular preferred grass, and from his/her own perception. Let choice of a particular grass be represented by *j*, where $j = 1$ if the farmer is willing to choose a particular grass as fodder due to the presence of NSD and $j = 0$ otherwise. The farmer's perception on alternative grass is represented by *w*, and the vector *x* represents factors influencing choice of that grass which include: institutional characteristics, farm and farmer characteristics, and attributes of the grass that gives the farmer confidence to prefer that particular grass. If the farmer prefers a particular grass, his utility is given by $U_1 = U(1, w, x)$ and, if he does not have preference for the grass $U_0 = U(0, w, x)$. As in standard economic theory, farmers would try to choose particular grasses they like most, subject to their attributes.

The basic framework for analysis is provided by the random utility model where consumers are assumed to choose among a range of discrete number of alternatives to maximize their utility. Random utility theory states that a consumer's utility can be decomposed into a systematic and random component of utility (Hwan and Harrison 2004). That is, total utility is the sum of observable and unobservable components,

$$U_{ij}\,(\textit{choice } j \text{ for individual } i) = V_{ij} + \varepsilon_{ij} \text{-----------------------} (1)$$

The utility level U_{ij}, which is individual *i*'s utility from choosing alternative *j*, is determined by the systematic component of utility of V_{ij} and random components ε_{ij}, which is assumed to be independently and identically distributed with type I extreme value (Gumbel) distribution (Greene, 2003). The random component represents the unknown components the consumers' utility function. Consumer *i* chooses alternative *j* if:

$$U_{ij} > U_{ik} \quad \text{for all } k \neq j \text{-----------------------} (2)$$

The probability of individual *i* choosing alternative *j* is equal to the probability that the utility of alternative *j* is greater than the utilities of all other alternatives in the choice set (Greene 2003).

P_{ij}= Pr ($U_{ij} > U_{ik}$) for all k $\neq j$ --- (3)

Extending the argument to multiple choice alternatives, suppose there is a choice between *M* different alternatives indexed by $j = 0 \ldots M$, with the ordering being arbitrary. Assume that the utility that individual i attaches to each alternative is given by U_{ij}, $j = 1, 2 \ldots M$. The farmer will prefer alternative *j* if it can be expected to give him the highest utility (Hwan and Harrison 2004). That is,

U_{ij} = max $\{U_{i0\ldots}\ U_{iM}\}$ -- (4)

The probability that farmer *i* prefers alternative grass *j* from among *M* alternatives is given by:

$P(C_i = \text{j}\ ) = P\left\{\ U_{ij} = \max\ \{U_{i0\ldots}\ U_{iM}\ \}\right\}$-- (5)

where C_i denotes the preference of individual *i*.

Assuming that the error terms in the utility function are independently and identically distributed (IID) two widely used distributions are the normal and logistic that gives the probit and logit model respectively (Haab and McConnell, 2002). In this study we assume that the error term is logistically distributed and use the logit model. This model is more appropriate and makes it possible to study the determination of the factors influencing farmers' perception when the explanatory variables consist of individual specific characteristics and these characteristics are the determinants of the choice.

2.9.2 Conceptual Framework

Farmers' perception about the performance of the technologies significantly affects both the probability and the intensity of having the fodder on the farm. Therefore, it is important that for any new technology to be introduced to the farmers, they should be involved in its evaluation to find its suitability to the farmers' circumstances, especially screening fodder legume varieties to be introduced to farmers. Furthermore, researchers should analyze those factors that farmers themselves consider as important in their decision to adopt the technologies otherwise, when they rely only on literature and extension staff, as has been the habit, researchers may end up considering factors that are irrelevant to the farmers in a particular region (Sinja *et al*., 2004).

The conceptual framework in Figure 1 shows factors that influence farmers' decisions on which alternative grass to choose due to the presence of Napier stunt disease that greatly affects Napier grass in order to improve small-scale dairy industry. The study conceptualizes that, farmers form perceptions favourable to preference of an alternative preferred grass in presence of Napier stunt disease under the influence of several variables which are grouped into farm and farmer characteristics, institutional characteristics and attributes of various grasses. Farm and farmer characteristics include: Age, gender, education level, family size and farm size. Institutional characteristics include: Participation in push-pull technology and access to extension services. While grass attributes include: Cost of grass planting materials, growth rate, disease resistance, dry season tolerance, economy on land, and grass biomass. The above group of variables can influence farmers' perceptions leading to choice of a particular grass (es). On the other hand, farm and farmer characteristics, institutional characteristics and attributes of various grasses can directly influence choice of a particular grass (es). As a result of perceiving to choose a particular preferred grass (es), a farmer can realize direct benefits which include: provision of sufficient livestock fodder either for own use as livestock feed or for sale and increased milk yield thus improving the small-scale dairy industry.

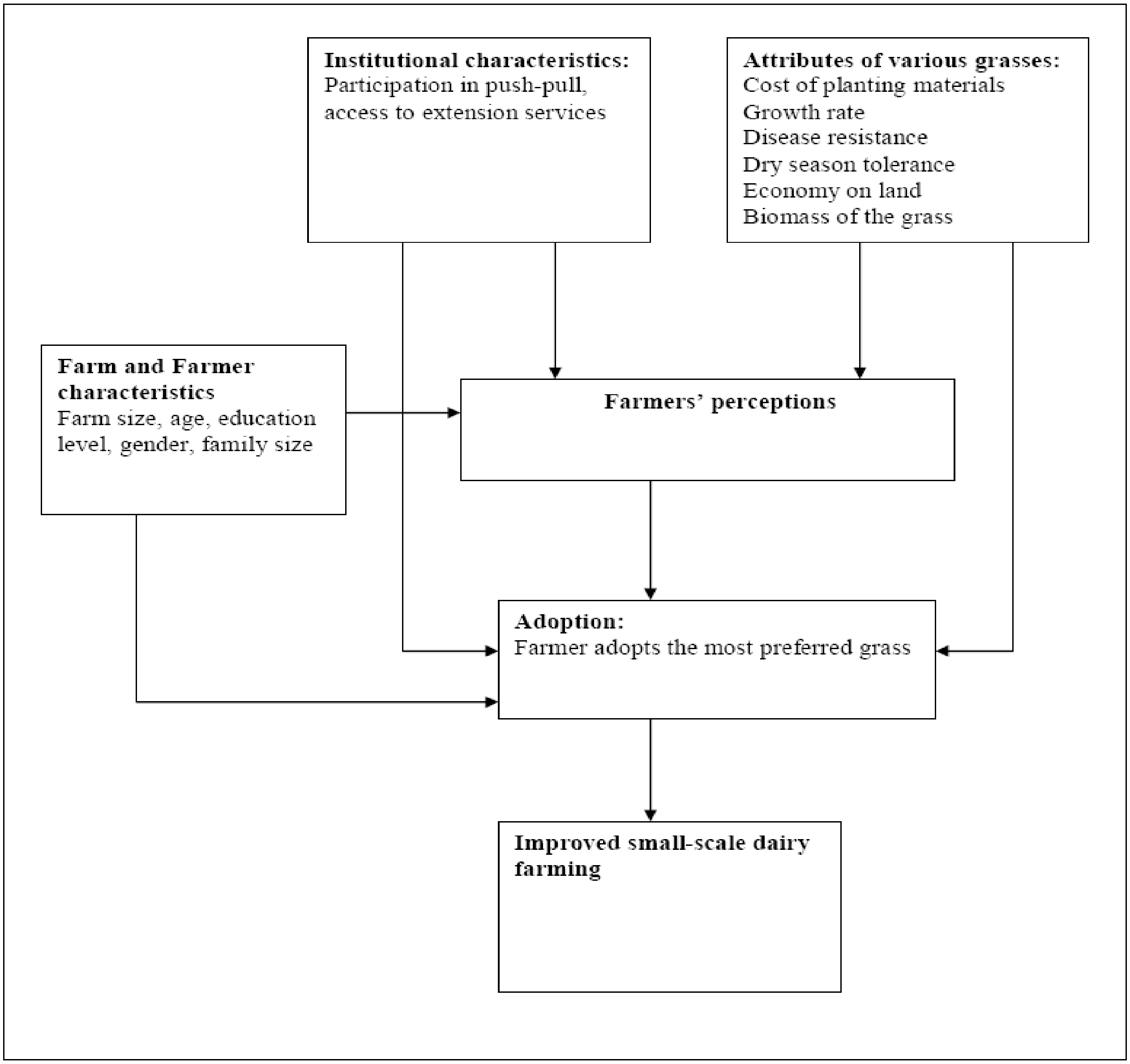

Figure 1: Conceptual framework

Source: Own conceptualization

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CHAPTER THREE

METHODOLOGY

3.1 Study Area

The study was conducted in Bungoma district in Western province, Kenya (see Figure 2). Bungoma ($0^0$25’–$0^0$53’S, $34^0$12’–$35^0$04 E) receives an annual rainfall of 1000–1800mm and lies on an altitude of about 1300–3500 metres above sea level. It lies at the northern tip of western province of Kenya and borders Mt.Elgon district to the Northwest, Trans Nzoia district to the North, Kakamega and Mumias District to the East, Busia District to the West and Teso District to the South west. It covers an area of 2,068.5km^2 (Bungoma District Strategic Plan 2005 – 2010). In this district, maize, cassava, beans, sorghum, and sweet potatoes are the major food crops. In the livestock sector, cattle, sheep, goats and chicken are kept by most of households (KNBS, 2008).

Figure 2: Map of traditional Bungoma District
Source: DDP-Bungoma.

3.2 Sampling design and techniques

Smallholder dairy farmers who were facing the problem of Napier stunt disease, practicing PPT and those who were not practicing the technology and would prefer alternative grasses made the target population of the study. Multistage sampling technique was used where five divisions with high prevalence of the NSD were purposively identified from the district. These divisions include; Bumula, Kibabii, Sangalo, Malakisi and Webuye. All sub-locations in the five divisions were listed and two sub-locations were randomly selected from each division.

Two source lists, one from the push-pull coordinators and another from extension officers from the Ministry of agriculture were used to get the sample of participants and non participants from the sub-locations. Systematic random sampling was employed to obtain a sample of 70 respondents practicing the technology and another 70 respondents who did not practice PPT from the ten sub-locations. This resulted to a sample of 140 respondents for the study.

The required sample size was determined by proportionate to size sampling methodology as per formulation by Kothari, (2004) in the equation below:

$$n = \frac{pqZ^2}{E^2}$$

where;

n = Sample size

Z= confidence level (α=0.05)

p = proportion of the population containing the major interest q = 1-p, and E= allowable error.

Since the proportion of the population is not known, p= 0.5, q= 1-0.5=0.5 and E = 0.083. This results to a sample of approximately 140 respondents.

3.3 Data and Data Analysis

The kind of data collected for the purpose of this study and the different types of analysis used to answer the study’s research questions are explained in the methodology subsections of the subsequent chapters.

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CHAPTER FOUR

EXTENT AND DAMAGE OF NAPIER STUNT DISEASE INFESTATION IN SMALL-SCALE DAIRY FARMING IN BUNGOMA DISTRICT

4.1. Introduction

The high potential agricultural areas of Kenya are very densely populated and holding sizes are very small; free range grazing is no longer feasible and so livestock, especially cattle, have to be fed on crop residues and cultivated fodder complimented with additional concentrates. Many small-scale farmers practice intensive dairy farming where they do stall feeding and/or a combination of stall feeding and grazing. This is because of their small land sizes of usually less than five acres (Bebe *et. al.*, 2002). Napier grass (*Pennisetum purpureum*) has become by far more important than traditional grasses or other cut fodders due to its wide ecological range, high yield potential and ease of propagation and management. This, among other factors, makes it a favorite of dairy farmers. However, there are now serious problems of emerging diseases, both fungal and mycoplasmal, which threaten Napier grass in Eastern Africa and unless resistant cultivars and alternative fodders are found, the smallholder dairy industry will be threatened (Orodho, 2006).

Severe diseases of Napier grass are affecting its continued use and represent a major threat to the smallholder dairy sub-sector. Napier grass head smut; a fungal disease caused by *Ustilago kamerunensis*, is a serious problem in central and eastern Kenya. This fungus has also been reported in Tanzania, Uganda, Rwanda and Congo. The disease results in decreased biomass. Biomass loss caused by smut ranged from 75-90% in Kiambu and 25-90% in Thika, with costs of management and milk loss of 30-75% (Nyanyu 1998).

In Western Kenya and Uganda, the threat comes from Napier grass stunt disease, caused by a phytoplasma which causes severe stunting and yield reduction. The disease is spreading rapidly with high economic costs to farmers. Shortage of feed as a result of the disease has led to a doubling of the price of a bundle of Napier grass in badly affected districts in Uganda. Furthermore, farmers have to sell animals because they do not have enough feed and cannot afford to buy at current prices. With fewer animals, the farmers have less milk so the nutrition of children suffers. Similarly, without surplus milk to sell, income decreases and school fees and other expenses cannot be met (Orodho, 2006).

Though scientists from several institutions have been working together to halt the spread of these diseases. Farmers have shown efforts on how best to control them as some of the coping strategies to stop the spread of the threatening Napier stunt disease. According to research done by Khan *et al*., (2008), farmers gave the following suggestions; uprooting and burning the diseased plants, stopping the application of fresh cow dung on planted Napier, planting diseases resistant Napier grass, application of more fertilizers, and that scientists should carry out research on this disease to determine Napier grass variety that is high yielding and is resistant to the NSD. Other suggestions made included crop rotation, spraying with chemicals, leaving land fallow, planting healthy Napier grass canes and fencing off grazing land.

As part of continued effort to address emerging problems of pests and diseases in the small-scale dairy industry, this study was conducted to make a contribution to the understanding of farmers' perceptions of alternative grasses given the infestation by the Napier stunt disease, in order to inform on the appropriate fodder grass to be promoted among the farmers to improve small-scale dairy industry of which its specific aim in this chapter was to determine the extent of Napier stunt disease infestation in small-scale dairy farming in order to estimate its damage.

4.2. Literature Review

Kenya's dairy industry is the most developed in East Africa. Like other agricultural subsectors, the dairy industry is dominated by smallholder farmers, who account for over 75% of the industry's total output. Additionally, it is one of the largest producers of dairy products in Africa, with an estimated herd of 3.5 million improved dairy animals, 9 million zebus, 12 million goats, and 900,000 camels. Cattle milk account for 88% of the milk produced whereas camels and goats account for the rest, Ministry of Livestock and Fisheries Sessional paper (2006). Most of the dairy farming is done on the Kenyan highland at >1000 m above sea level, due to its favorable agro-ecological conditions for dairy farming (Staal, *et al.*, 1997).

The New Agriculturist Report (2005) indicates that, cultivation of Napier or elephant grass has been common in East Africa, as small-scale dairying has shifted from extensive to zero grazing. However, the expansion of the fodder crop has been confronted with unique disease problems:

head smut to the east of the Rift Valley, and Napier grass stunt (NSD) to the west. In parts of eastern Uganda and western Kenya, market prices for fodder grass have doubled in the last few years as farmers have been forced to buy grass to compensate for declining production.

Napier stunt disease is caused by a phytoplasma (Wambua, 2007). It is a disease of economic importance on Napier grass in Kenya. It has spread throughout western Kenya, causing economic loss in the smallholder dairy industry. All Napier grass varieties are susceptible to the disease which expresses itself after cutting or grazing. Infected shoots become pale yellowish-green in colour and are dwarfed leading to subsequent death loss of up to 100% of their crop. Orodho (2006) reported that many farmers having lost 100% of their Napier crop are being forced to de-stock or sell-off their entire herd because of lack of feed.

The disease is spread in two ways: Over longer distances the primary means of spread is farmers themselves. Napier is vegetatively propagated, so farmers can take either a slice of cane, or split a clump, in order to plant on. If unaware of the dangers, they can inadvertently introduce a diseased plant into their fields. Over shorter distances, such as between plants within a field, the disease is primarily spread by plant hoppers, small insects in the same family as crickets, cicadas and grasshoppers, which feed on the sugar-rich sap in Napier phloem and can, transfer the phytoplasma in their saliva in the process. However, if that plant is cut down they will move to another. Hence in fields where leaves are regularly harvested, as typically occurs with farmers who use Napier for zero-grazing, the rate of insect movements, and therefore of disease spread, is much higher, (New Agriculturist Report, 2005).

Napier stunt was first reported in Bungoma district in Western Kenya in 1997. It has spread quickly and now covers several districts of Western Kenya causing serious economic loss in the smallholder dairy industry including loss of up to 100% of Napier grass. Affected shoots become pale yellow green in colour and seriously dwarfed. Often the whole stool is affected with complete loss in yield and eventual death, Orodho, **(**2006). Furthermore, Mulaa *et al.,* (2004) established in their study that, the affected plants are small, yellow, may have many leaves but they are very thin and the plant eventually dries and dies. As a coping strategy, the authors recommended that farmers should plant grass from healthy fields, should check grass frequently and uproot diseased plants, replant with healthy grass, burn the sick plants, or bury them deeply.

Scientists from several institutions have been working together to halt the spread of Napier stunt disease. They have been raising awareness of the diseases, providing information on how best to control them and determining clones of Napier that are genetically resistant to the diseases. Amongst other research work done, KARI undertook research to identify Napier grass varieties resistant to the disease, whereby two smut-resistant clones of Napier grass; Kakamega 1 and Kakamega 2 from the in trust collection held by ILRI, were identified. However, these varieties are less productive than the best local varieties and not satisfying the demands of local farmers, (Farrel *et al.,* 2002). Furthermore, KARI and the Global Plant Clinic reported on a short "Going Public" campaign in western Kenya to raise awareness of the problem of Napier grass stunt which requires follow up in the form of a sustained and long term program of extension and research to combat this threat to dairy farmers in East Africa. Scientists at the International Centre of Insect Physiology and Entomology (ICIPE) amongst other research work have also made an effort of assessing farmers' perceptions of the NSD in order to investigate their knowledge and experience of the disease and how they were controlling or managing the NSD. Therefore there is still need to determine the extent of Napier stunt disease infestation in small-scale dairy farming in order to estimate its damage which is addressed in this chapter.

4.3. Statistical Analysis.

To achieve the above objective, descriptive analysis was utilized. This entails statistical analysis to determine the mean, percentages, frequencies and likert scale techniques in order to determine the extent of Napier stunt disease in small-scale dairy farming.

4.3.1. Data Collection and Analysis

Prior to the sampling design and techniques discussed in Chapter three, a total of 140 smallholder dairy farmers from five divisions in the traditional Bungoma district; facing the problem of Napier stunt disease, practicing PPT and those not practicing the technology were the target population of the study. Farmers from each of the five divisions who had planted Napier grass on their plots were randomly sampled and interviewed using structured questionnaires developed to capture farmers' knowledge on factors that explain the extent of NSD infestation in order to explain its damage.

The study focused on farmers' knowledge of the NSD and its effects to the dairy industry. Important data collected included, the year the farmers first observed the disease, size of land affected, measures taken to counter the effect of the disease, and whether other preferred grasses in place of Napier grass have been adopted. The respondents were also asked to rate how the NSD had affected their farming enterprise using the Likert type scale on a four point scale with 1= No effect, 2= little effect, 3= Moderate effect, and 4= High effect. Data generated was analyzed using SPSS application software (Version 15.0). The frequencies, percentages, mean and cross tabulations were generated during analysis.

4.4. Results and Discussion

4.4.1 Gender and age of respondents

A total of 140 farmers drawn from Bungoma district were interviewed and 72.9% were male (see Table 1). The mean age of the participants was 49.7 with a range of between 28 and 83 years. Most (46.4%) of the farmers in Malakisi, 42.9% in Webuye, 42.9% in Sangalo, 30% in Kibabii and 42.3% in Bumula division were under the age category of 41-55 years old. The relationship between gender of the interviewed respondents and the divisions was statistically significant ($p<0.05$), whereas there was no significant difference in the age of respondents in the divisions ($p> 0.05$). The results imply that, male respondents were more likely to be interviewed in the divisions as compared to female respondents.

Table 1: Distribution of respondents across Divisions by gender and age (%)

Variable	Malakisi	Webuye	Sangalo	Kibabii	Bumula	Total	Chi-square value
Gender: Male	75	46.4	92.9	86.7	61.5	72.5	20.196***
Age: 25-40	17.9	28.6	14.3	46.7	23.1	26.1	
41-55	46.4	42.9	42.9	30	42.3	40.9	
56-70	28.6	25	39.3	20	26.9	28	11.401
71-85	7.1	3.6	3.6	3.3	7.7	5.1	

Note: *** Statistically significant at 1%

4.4.2 Livestock kept and sources of income

Results in Table 2 show that, farmers in Bungoma district practiced livestock farming of which all of the sampled farmers (100%) kept cattle, 94.3% kept poultry, 49.3% kept goats and 40.7% kept sheep. Furthermore the results indicate that all farmers derived part of their income from livestock while 93.6% of the respondents reported incomes sources from crop sales and 30.7% was from off-farm casual work.

Table 2: Livestock kept and sources of income

Variable	Frequency	Percentage
Livestock kept:		
Cattle	140	100
Sheep	57	40.7
Goats	69	49.3
Poultry	132	94.3
Sources of income:		
Crop sales	131	93.6
Livestock keeping	140	100
Off-farm casual work	43	30.7
Off-farm permanent employment	11	7.9

4.4.3 Farming practices and kind of livestock system

The majority of the farmers from the region (90.7%) practiced mixed farming and the findings also showed that, although zero grazing and open grazing are the kind of livestock system practiced in the region, most farmers (69.7%) practiced both zero and open grazing as shown in Table 3. This is a further indicator that most farmers in the region depend on livestock as their main source of livelihood.

Table 3: Farming practices

Variable	Frequency	Percentage
Type of farm practice:		
Mixed farming	127	90.7
Livestock farming	13	9.3
Kind of livestock system:		
Zero grazing	8	5.7
Open grazing	35	25
Both open and zero grazing	97	69.3

4.4.4 Main source of fodder and use of Napier grass

Findings in Table 4 show that about 98.6% of the farmers grow Napier grass which is the most suitable fodder for small-scale dairy farmers in the region. They further verify that the majority of the farmers interviewed (88.6%), had their own fodder as the main source of feed for their dairy enterprises, 24.3% bought fodder for their livestock and 37.1% obtained feed for their livestock from free grazing fields. The results show the proportionate importance of Napier grass either in feeding livestock for milk production which is represented by 96.4%, soil conservation (72.9%), stemborer control through Push-pull technology (51.4%), or selling for money which was represented by 27.9% of the interviewed farmers. These results suggest that, despite the serious effect of NSD in the region, farmers still value Napier grass as a major source of feed for their dairy enterprise.

Table 4: Distribution, main source of fodder and use of Napier grass

Variable	Frequency	Percentage
Whether farmers grow Napier Grass: (Yes=1)	138	98.6
Main source of livestock feed:		
Own farm fodder	124	88.6
Buy fodder	34	24.3
Free grazing fields	52	37.1
Main use of Napier grass:		
Feeding livestock	135	96.4
Selling for money	39	27.9
Soil conservation	102	72.9
Stemborer control (PPT)	72	51.4

4.4.5 The extent of Napier stunt disease infestation

About 97.9% of the farmers interviewed were aware of the disease and had witnessed it in their own farms. Moreover 78.3% of the farmers acknowledged that the affected grass becomes small in size; their leaves turn yellow in colour and eventually dry off. On measures to be taken to counter the effect of NSD, about 39.3% of them indicated the strategy of uprooting and burying the affected plants, 24.3% recommended uprooting, burning, burying affected plants and replacing with healthy grass, 20.7% advocated uprooting affected plants and 15.7% mentioned that affected plants should be uprooted and animal manure should be applied on entire affected portion of land. This is consistent with Mulaa *et al.,* (2004) who reported that, Napier stunt is a serious disease which if not controlled, farmers may lose over half of their yield of Napier grass. How farmers came to know of the strategies of countering the NSD may be attributed to extension services which is evident from the study results that 60% of the farmers received extension services either on Napier stunt disease awareness or dairy farming practices among others (Table 5).

Table 5: The extent of Napier stunt disease

Variable	Frequency	Percentage
Ever heard of NSD (Yes=1)	137	97.9
Knowledge on NSD:		
Stunted growth (small in size)	4	2.9
Yellowing of leaves	5	3.6
Small, yellow and dries off	108	77.1
Small and yellow in colour	16	11.4
Small and dries off	5	3.6
Whether NSD has affected Napier grass (Yes=1)	137	97.9
How NSD can be controlled:		
Uproot/bury affected plant	55	39.3
Uproot/burn/bury/replant	34	24.3
Uproot	29	20.7
Uproot/apply animal manure	22	15.7
Effect on dairy farming:		
Reduction of milk production	123	87.9
Reduction of stock	11	7.9
Increased cost of production	6	4.3
Access of extension services (Yes=1)	84	60
Adoption of Alternative fodder grasses (Yes=1)	96	68.6

Although the results suggest that most farmers in Bungoma are experiencing negative effects of the disease, none of the farmers had a total loss of Napier grass in their farms. Nevertheless, the disease so far has a negative impact on dairy farming enterprise whereby 87.9% of the respondents pointed out that they had experienced a reduction in milk production, 7.9% had experienced reduction of stock and only 4.3% had experienced an increased cost of production.

Due to the impacts of NSD on Napier grass varieties, the respondents were asked if they had adopted any other alternative grass as fodder in replacement of Napier grass. About 68.6% of the respondents indicated adoption of other alternative grasses (Table 5). However, farmers' preferences on alternative grasses mentioned will be discussed in the next chapter.

Figure 3 presents a profile of the onset of the NSD over a period of years. From the figure it is evident that the symptoms of the disease were first noticed as early as 1998 in Bungoma District though it had not spread and felt much by most farmers in the region. As the effects of the disease spread gradually, its awareness increased with the highest awareness being experienced in 2006 (22.5%). The number of farmers noticing the symptoms of the disease has been growing generally between 0.7-22.5 percent annually. The incidences of NSD declining after the year 2006 towards 2009 may be attributed to coping strategies highlighted by farmers on measures taken to counter the threat of NSD.

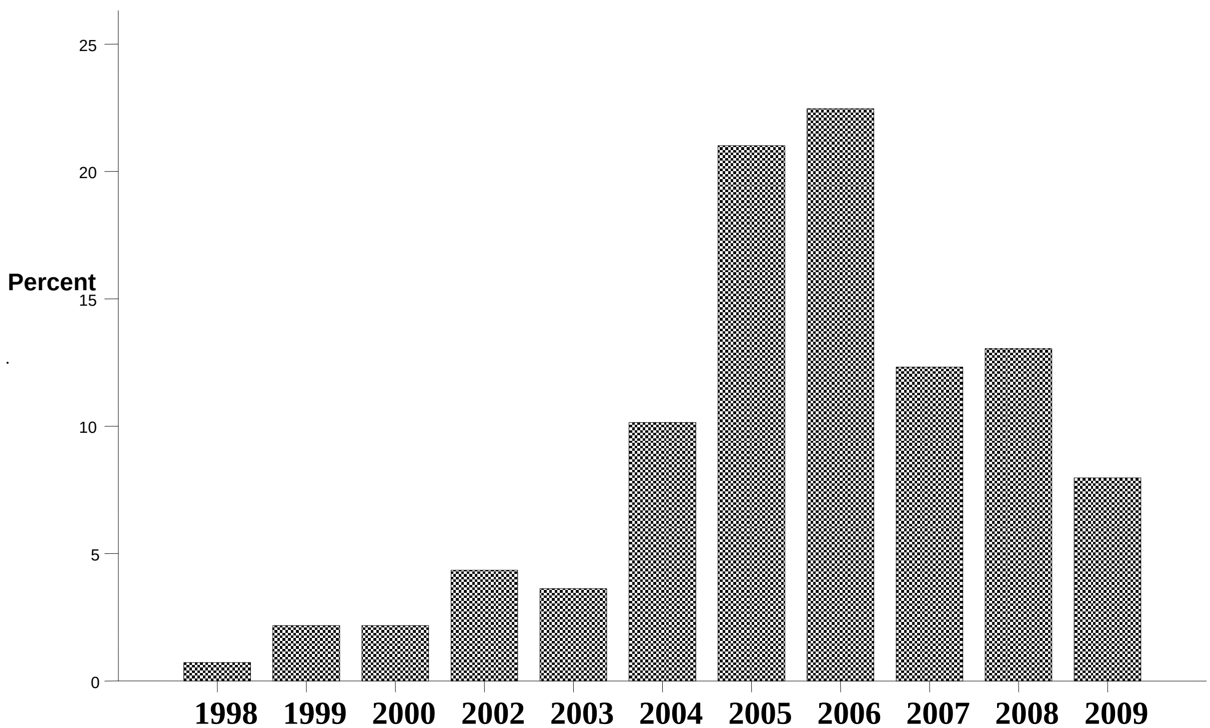

Figure 3: Year when Napier stunt disease was first observed

Furthermore, on being interviewed on the size of land affected by NSD, farmer responses indicated that at least a portion of their land had been affected with minimum size of land affected being 0.01 acres and the maximum being two acres (Table 6). There was no significant difference in the land affected by NSD in the divisions (p>0.05).

Table 6: Size of land in acres affected by NSD (N=140)

Name of the division	Minimum	Maximum	Mean of land in acres
Malakisi	0.01	2.0	0.28
Webuye	0.25	0.50	0.36
Sangalo	0.13	0.33	0.25
Kibabii	0.01	1.0	0.20
Bumula	0.01	0.50	0.25

On how NSD had affected their farming enterprise, results in Figure 4 indicate that a majority (65%) of the farmers in the study area indicated that they had experienced a loss of about 25% of their Napier grass; 33% of the farmers pointed out that they had experienced a loss of about 50% to 75% of their Napier grass and only 2% had not experienced any loss of their Napier at all (Figure 4).

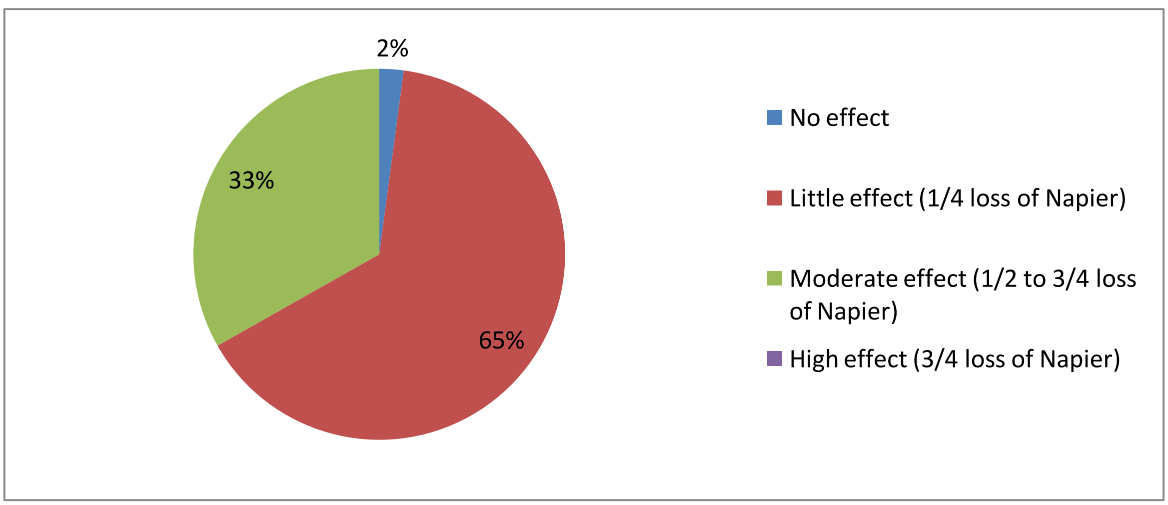

Figure 4: Proportion of Napier grass affected by NSD (Percentage)

4.5 Conclusion

The majority of the small-scale dairy farmers' practice open and zero-grazing, their main source of fodder being Napier grass which was found to be highly susceptible to the stunt disease. The NSD causes small, yellowing of leaves and whole plant dries off. It has spread among small-scale farmers' in the region since it was first noticed in 1998, thus causing economic loss in the smallholder dairy industry and hence affecting the livelihoods of the rural poor. In this study farmers acknowledged the fact that NSD had affected their Napier grass, for instance; in all the five divisions of Malakisi, Webuye, Sangalo, Kibabii and Bumula, farmers mentioned the proportion of the Napier which had the effect of NSD and the proportion loss of Napier grass leading to a reduction in milk production, reduction of stock and an increased cost of production. Moreover, as a NSD control mechanism, the findings obtained from this study show that farmers recommended uprooting, burning, burying affected plants and replacing with healthy grass. They also mentioned that animal manure should be applied on the farms. This suggests that knowledge transfer to farmers about the disease and short-term coping strategies together with extension services are also urgently needed to stem the imminent threat by the NSD to the livestock industry whilst research on long term solutions is conducted.

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CHAPTER FIVE

FARMERS' PERCEPTIONS AND PREFERENCES ON SUITABILITY OF ALTERNATIVE FODDER GRASSES

5.1. Introduction

According to Orodho, (2006), East Africa has many areas suited to dairying, especially in the better-watered zones at medium and high altitudes which are well-adapted for forages, many of which are of local origin. Furthermore, forage quality is looked at in terms of the nutritive value, factors influencing quality and ways of improving it. Further Orodho reported that, smallholder dairying has undergone intensification and changes in management whereby systems are moving from grazing to stall feeding. As a response, smallholder dairy farmers have developed feed management strategies to cope with these changes. Additionally, to enhance and facilitate this transition in management, availability of seed of recommended forages is important as well as the availability of access to adapted seed production technologies and production of seed of recommended cultivars by the formal and informal seed sectors are also essential.

Although disease and parasite challenges can be strong where forages of economic importance are increasingly attacked by diseases and pests, small-scale dairy farmers have over the years depended on Napier grass because of its high herbage yield, ease of establishment and relatively high quality for utilization Mulaa *et al.,* (2004),. Nevertheless, in the recent times Napier grass varieties recommended for on-farm production have increasingly been affected by stunting disease.

As reported by Nandasaba *et al.,* (2005) due to the threat of NSD, there was need to look for alternative high yielding fodder grasses to Napier grass in order to keep and maintain dairy production. Furthermore Nandasaba et al have highlighted that Giant panicum (*Panicum maximum*), Giant seteria (*Seteria splendida*), Guatemala grass (*Tripsacum laxum*), Sudan grass (*Sorghum vulgare sudanense*) among others were identified as fodder grasses that produce high herbage dry matter yields with comparatively high nutritive qualities that could be used as alternatives to Napier grass in stunting disease prone areas. What is not clear is whether the farmers are willing and able to adopt them and under what circumstances.

5.2. Literature Review

Dairy farming is important in and around Kenya's major towns. Smallholder production is constrained by inadequacy and seasonality of feed and its quality, and by low dry matter intake. Stall feeding using crop residues, natural grass – mostly Kikuyu grass (*Pennisetum clandestinum*), star grass (*Cynodon* spp.), Rhodes grass (*Chloris gayana*) and seteria (*Setaria sphacelata*) - is common and increasing. The purchase of fodders such as Napier grass (*Pennisetum purpureum*) or hay, some of which is from the roadside or from farmers who do not have livestock, is common in intensive areas (Staal *et al.*, 1998).

As reported by Orodho (1990), planted fodders on smallholder farms include sweet potato (*Ipomoea batatas*) vines, various kinds of vetch (*Vicia* spp.) and desmodium (*Desmodium uncinatum*, *D.intortum*) or fodder trees such as Calliandra (*Calliandra calothyrsus*) and leucaena (*Leucaena leucocephala).* Farmers also buy grain, concentrates and agro-industrial by-products such as bran, wheat pollard and dairy meal. Nevertheless, Napier grass is the major fodder used by smallholders in Kenya.

According to Orodho's (2006) study, smallholder dairy farmers can increase production by planting improved forage. Further this study reports that, planted fodders play a significant role in smallholder dairy production: they are mostly identified with zero grazing and stall feeding in smallholder dairying. Of all the planted fodders used by smallholders, Napier grass is the most popular; it forms up to 40 percent of the dry matter in the diet of dairy cattle, the rest coming from other cultivated grasses, fodders, crop by-products, crop residues and purchased concentrates (Orodho, 2006). In contrast to the omnipresent Napier grass, other forages, including fodder trees and shrubs and herbaceous legumes have not been widely adopted on most smallholders' farms. A few smallholders plant *Sesbania* spp. or *Calliandra* spp., and herbaceous legumes, such as *Desmodium* spp. This shows that there is always a trade-off, for instance; introducing or cultivating these fodder grasses take up resources that would be used elsewhere. Besides, uptake or adoption of such grasses may be constrained by the kind of objectives that the farmers might wish to optimize.

According to Jones *et al.*, (2004) Napier grass is also attacked by diseases and pests, causing serious economic loss and concern to farmers. Some of the important diseases and pests are;

Snowmould fungal disease, Napier grass head smut and Napier grass stunting disease. Snowmould fungal disease causes a white mould on the leaves and stems. This disease has also been reported to attack Kikuyu grass and Nandi seteria (Van Wijk, 1974). Napier grass head smut is another serious Napier grass disease caused by a fungus *Ustilago kamerunensis*, whereby affected plants develop fungal symptoms that look like flower structures but open up releasing black spores. The stems then become smaller and the total dry matter of the affected crop is drastically reduced and after 2–3 cuttings the entire stool dries (Farrel, 1998). Napier grass stunting disease is further a serious Napier grass disease which has spread in Western Kenya; it was first reported in Bungoma district in 1997. A similar disease had been reported in Uganda and its cause was suspected to be a virus, probably transmitted by insects (Tiley, 1969).

Research done by Muyekho *et al*., (2003) on development and transfer of forage production technologies for smallholder dairying in Western Kenya, utilized a case study approach to evaluate 12 forage species/varieties at two sites in the Trans Nzoia District. Grasses including Rhodes grass (*Chlorisgayana*), Napier grass (*Pennisetum purpureum*), Bana Napier grass, Clone 13 Napier grass, French Cameroon Napier grass, Guatemala grass (*Tripsacum laxum*), Sudan grass (*Sorghum sudanense*), and Nandi Setaria (*Setaria sphacelata*), while forage legumes including Lucerne (*Medicago Sativa*) dolichos (*Lablab purpureus*) Silverleaf desmodium, and mucuna (*Mucuna pururiens*) were evaluated. In general, farmers considered factors that related directly to the animal to be more important than factors related to agronomic characteristics of the forage (tolerance to drought, high forage yield and tolerance to pests and diseases). Furthermore, farmers' preferred Napier grass among the above mentioned forage species.

Sinja *et al*., (2004) did a research on farmers' perception of technology and its impact on adoption using a case study of legume forages in central Kenya highlands. Four most important fodder legume attributes to farmers in their adoption decision were identified as: dry season tolerance; disease resistance; economy on land; and availability of planting materials which were then used in conjoint analysis. An ordered probit model was estimated to assess relative importance of each attribute to the farmer. A Tobit model was also estimated to show the effect of farmers' perception of calliandra and desmodium on probability and intensity of adoption. Results showed that dry season tolerance and economy on land are most important characteristics of fodder legumes to the farmers. It was also found that Calliandra and desmodium were more relevant to the farmers in the area than other fodders.

The objective of this chapter was to assess farmers' perceptions on suitability of alternative fodder grasses in order to establish their preference for dairy grasses. This study contributes to the understanding of farmers' perceptions of alternative grasses in small-scale dairy farming given the infestation by the Napier stunt disease. Farmers were provided with a list of alternative grasses which they were to rank in order of their preferences; the ranks were then subjected to descriptive statistics to determine the order of preference. Multinomial logit analysis was performed to determine the relationship between grass alternatives; molasses, Sudan, natural, giant seteria and signal grass, and the independent variables including; farm and farmer characteristics; land size, gender, age, years spend in schooling, institutional characteristics; availability of extension services, adoption of push-pull technology, and grass attributes; cost of grass planting materials, growth rate, dry season tolerance, grass biomass, economy on land and disease resistance. For a better interpretation of the outcomes, marginal effects were computed by differentiating the coefficients at their mean.

5.3. Data and methods

5.3.1: Multinomial Logit Model (MLM)

According to McFadden (1974), Multinomial logit models are used to model relationships between a polytomous response variable and a set of regressor variables. Generalized logit and conditional logit models are used to model consumer choices. The generalized logit model consists of a combination of several binary logits estimated simultaneously. In studying consumer behavior, an individual is presented with a set of alternatives and asked to choose the most preferred alternative. Both the generalized logit and conditional logit models are used in the analysis of discrete choice data. In a conditional logit model, a choice among alternatives is treated as a function of the characteristics of the alternatives, whereas in a generalized logit model, the choice is a function of the characteristics of the individual making the choice.

In many situations, a mixed model that includes both the characteristics of the alternatives and the individual is needed for investigating farmers' choice. This study will utilize both generalized and conditional logit models which focus on individual farmer as the unit of analysis and the characteristics of the alternative grass attributes, institutional, farm and farmer characteristics as explanatory variables.

The explanatory variables are constant over the alternatives in the choice set (Maddala, 1992). Logistic regression analysis was used to reveal and quantify the relations between the farmer's perception for a particular grass and some chosen explanatory variables. Grass attributes in the study were captured by: cost of planting materials; growth rate; disease resistance; dry season tolerance; economy on land; and biomass of the grass. Farm and farmer characteristics included: Farm size; age; gender; education level and family size. Institutional characteristics included Adoption of PPT and access to extension services.

A more general model may be obtained by combining generalized and conditional logit formulations, so the underlying utilities U_{ij} depend on characteristics of the individuals as well as attributes of the choices, or even variables defined for combinations of individuals and choices (such as an individual's perception of the value of a choice). The general model is usually written as:

$$u_{ij} = x_i b_j + z_{ij} \quad \text{------} \quad (6)$$

where, $\mathbf{x}_i$ represents characteristics of the individuals that are constant across choices, and $\mathbf{z}_{ij}$ represents characteristics that vary across choices (whether they vary by individual or not) Rodriguez, (2000).

Suppose $\boldsymbol{X}_i$ is a vector of explanatory variables, $\boldsymbol{\beta}_j$ is the matrix of parameters to be estimated and $\boldsymbol{Y}$ is the response variable which can be binary or multiple in nature such that ***Prob*** $(Y_i = j)$ is the probability of individual farmer $\boldsymbol{i}$ choosing a particular grass $\boldsymbol{j}$. A general formalization of the MNL according to Schmidt and Strauss (1975) is: The probability that individual farmer i chooses alternative j is;

$$P_r(Y = J) = \frac{e^{\beta_j x_i}}{1 + \sum e^{\beta_k x_i}}, = j = 1,2,\ldots\ldots j \quad \text{------} \quad (7)$$

The log likelihood function is expressed as:

$$P_r(y=0)=\frac{1}{1+\sum e^{\beta_k x_i}}, \text{ -- (8)}$$

The reduced linear form of the MNL model becomes:

$$Y=\beta_0+\sum_{i=1}^{i}\beta_i X_i+\sum_{j=1}^{j}\beta_j X_j+.........+\sum_{k=1}^{k}\beta_k X_k+\varepsilon \text{ -- (9)}$$

where; Y is the log – odds ratio, β_0 is the intercept term, β_i, β_j and β_k are vectors of parameters to be estimated (each of which is different, even though X_j is constant across alternatives), X_i, X_j and X_k are vectors of grass attributes, farm and farmer characteristic variables and institutional characteristics that influence farmers' perception leading to a choice of a particular grass and ε is the error term which is assumed to be independently, normally distributed with zero mean and constant variance.

The estimation model is specified as follows:

$Y_i = \beta_0 + \beta_1$ (FAMSIZE) + β_2 (AGE) + β_3 (GENDER) + β_4 (EDUC) + β_5 (FAMLYSIZE) + β_6 (PPT) + β_7 (EXT) + β_8 (COSTP) + β_9 (GR) + β_{10} (DR) + β_{11} (DST) + β_{12} (ECN) + β_{13} (BM) + ε

where; Y_i is the farmers' perception on choosing/ preferring a particular grass such that; Y = 0 if the farmer does not perceive to choose a particular grass, Y = 1 if a farmer perceives to choose a particular grass. β_0 = constant term and ε = error term. Table 7 summarizes the hypothesized relationships between Y_i and X_k

Table 7: Description of the Variables and Expected Signs

Abbreviation	Variable name	Description	Hypothesized effect
FAMSIZE	Farm size	Acres	+
AGE	Age of the farmer	Years	+
GENDER	If decision maker is male /female(male=1,female=0)	Dummy	+ or-
EDUC	Years of schooling	Years in formal education	+
FAMLYSIZE	Family size	Number of persons	+
PPT	Adoption of PPT	1 if yes, 0 otherwise	+
EXT	Availability of extension services	1 if yes, 0 otherwise	+
COSTP	Cost of grass planting material	3=high 2=moderate 1=low	+ or -
GR	Growth rate of the grass	3=high 2=moderate 1=low	+ or -
DR	Disease resistance	3=high 2=moderate 1=low	+ or -
DST	Dry season tolerance	3=high 2=moderate 1=low	+ or -
ECN	Economy on land	3=high 2=moderate 1=low	+ or -
BM	Biomass of the grass	3=high 2=moderate 1=low	+ or -

In light of what the other researchers have done the choice of important fodder attributes were identified based on their studies. Adesina *et al*., (1993 and 1995) in their studies included attributes whose perception by the farmer is thought by the researchers or extension agent to be important in their decision to adopt the technology. Sinja *et al*., (2004), considered fodder legume attributes suggested by the farmers' themselves through participatory techniques which included; economy on land, dry season tolerance, cost of planting material and disease resistance. In research done by Muyekho *et al*., (2003), criteria for suitable forage species were set and farmers ranked the attributes based on their own local technical knowledge. Amongst the agronomic characteristics, tolerance to drought, high forage yield and tolerance to pests and diseases were considered to be more important than other factors.

In this study grass attributes, cost of grass planting materials, growth rate, disease resistance, dry season tolerance, economy on land and grass biomass were set and each attribute had three levels; high, moderate and low. Other explanatory variables included farmer, farm and institutional factors hypothesized to influence perception whereas dependent variable was alternative fodder grass to be used in the dairy industry due to the presence of NSD. Five alternative fodder grasses were identified and included molasses, Sudan grass, Giant seteria, signal grass and natural grass. Since rankings and ratings all yield bounded discrete indices, the empirical utility function can be estimated via probit or logit (Mackenzie, 1993).

An appropriate framework for analyzing the effect of independent variables on choice, when there are a finite number of choices greater than two, is multinomial logit estimation which has been used widely by agricultural economists. Using multinomial logit, the probability of the i^{th} individual's choice of the j^{th} grass is assumed to follow a logistic distribution Maddala (1983).

Marginal probabilities of choice (that is, the marginal effects) can be calculated from the multinomial logit results employing the following formulation (Greene, 2003):

$$\frac{\delta p_j}{\delta x_i} = p_j\left(\beta_j - \sum_{i-1}^{m} p_i \beta_j\right), j = 1,2..,m \text{ -- (10)}$$

The marginal effects are partial derivatives of probabilities with respect to the vector of characteristics and are needed since parameter estimates do not allow for direct determination of the marginal effects in multinomial logit models (Schupp, 1998).

5.4. Results and Discussion

5.4.1. Descriptive Analysis on Grass Alternatives

In chapter four, it was shown that a majority of the respondents (about 68.6%) had adopted alternative grasses to Napier grass. The first step in the assessment of farmers' perception on suitability of alternative fodder grasses involved determining farmers' perceived ranking of fodder grasses. Perception is a behavioral issue that cannot be observed by the investigator. What is observable is the response received from farmers on the specific questions raised. The assumption is that the reply to the question reflects the perception the individual possesses on the topic of interest.

Table 8 presents a profile of the proportions of respondents that ranked a specific grass alternative according to their preferences. Two alternative fodder grasses: Giant panicum and Boma Rhodes are dropped in the analysis because only a minority (<20%) were able to rank these alternative fodder grasses. Natural grass was best preferred and was ranked first by 66.4% of all the respondents, signal grass was ranked second by 61.4% of the respondents, Giant seteria was ranked third by 60% of the respondents, 55.7% of the respondents ranked Sudan grass fourth and Molasses grass was ranked fifth by 60% of the respondents.

Table 8: Proportion of farmers who ranked alternative fodder grasses in order of their preferences

Grass type/Alternative	Priority of the grass (Rank)	Frequency	Percentage
Natural grass	1st	93	66.4
Signal grass	2nd	86	61.4
Giant seteria	3rd	84	60
Sudan grass	4th	78	55.7
Molasses grass	5th	84	60

The results suggest that farmers were able to rank natural grass as the most preferred grass. This may be due to the fact that natural grass is readily available for grazing purposes and it is less costly to access/get. It does not need establishment, does not warrant conservation; and it is good in soil conservation.

Signal grass was ranked second after natural grass by majority of the farmers may be due to the fact that it increases livestock productivity. According to Muyekho *et al.*, (2004), signal grass is well distributed in Western Kenya among other regions, and has good grazing value, and makes good hay. The authors also established that it controls soil erosion due to its good ground cover; commonly used for thatching, mulching, compost manure making and seed is commercially available. Roothaert (2005) also found that, signal grass has the potential to continue growing during at least part of the dry season and remains a high leaf: stem ratio unlike Napier grass which normally stays green during the dry season, but stops growing and becomes stemmy during the dry season.

Giant seteria was ranked third. This is probably due to the fact that it provides good forage for livestock production when fed to the domestic animals. Muyekho *et al.,* (2004) have shown that giant seteria is common in damp places (this is characteristic of Western Kenya). It is leafy and of good grazing value with potential to improve livestock health and increase productivity. However, they also found that it is among the top 10 grasses that farmers in western Kenya would like to conserve on their farms and it is observed to drain soil moisture rather quickly at the onset of dry season.

Sudan grass and molasses grass were ranked fourth and fifth, respectively. This would be explained by the fact that, farmers had the information of being used as integral grasses in the novel push-pull technology which has been adopted by majority of the farmers in the region. This is consistent with Khan *et al.,* (2002) who established that plants that have been identified as effective in push-pull technology include; Napier grass, Sudan grass, molasses grass, silver leaf desmodium and Greenleaf desmodium. Furthermore, Napier grass and Sudan grass have shown high potential for use as trap plants, whereas molasses grass and silver leaf desmodium repel ovipositing stemborer moths. The study also noted that these plants are of economic importance to farmers in Eastern Africa as it has improved fodder and milk productivity and have shown great potential in stemborer and *Striga* management in farmer participatory on-farm trials. For further assessment of farmers' perceptions on suitability of alternative fodder grasses, survey data were subjected to multinomial logit. The results of this analysis are discussed next.

5.4.2 MNL Model Results: Determinants of Farmers' Perceptions on Alternative grasses

Table 9 shows the multinomial logit results for the relationship between farmers' perceptions on alternatives to Napier grass including: molasses; Sudan grass; Giant seteria; signal grass; and natural grass and the explanatory factors including farmer and farm characteristics, institutional characteristics and grass attributes. Most of the explanatory factors were significant at the 5% and 10% levels. The likelihood ratio chi-square value was 166.99 with 48 degrees of freedom and significant *p* value ($p<0.05$. This implies that the model as a whole was statistically significant - at least one of the predictors' regression coefficients in the model is not equal to zero. The pseudo R square was 0.557 (55.7%) and natural grass was dropped as the base outcome for comparison purposes. Further discussions of the model results by means of marginal effects follow.

Table 9: Multinomial Logit Model estimates for determinants of perceptions on alternative fodder grasses

Variable	Molasses	Sudan	Giant seteria	Signal grass
Gender	-0.888	0.431**	-3.136***	-1.342
	(1834)	(1.343)	(1.112)	(1.325)
Age	-0.074	-0.043	-0.021	-0.095**
	(0.084)	(0.048)	(0.044)	(0.052)
Years of schooling(EDUC)	-0.016	-0.239	0.331**	0.512**
	(0.323)	(0.163)	(0.145)	(0.219)
Land size	0.143	-0.406	-0.057	0.175
	(0.191)	(0.274)	(0.130)	(0.141)
Extension services(EXT)	23.758	1.218	1.224	3.434**
	(18.823)	(1.109)	(1.060)	(1.510)
Push-pull technology(PPT)	1.318	0.119	1.056	-2.385
	(1.888)	(0.963)	(0.898)	(1.543)
Cost of planting materials(COSTP)	-4.745***	-0.794	-4.327***	-6.008***
	(2.223)	(0.895)	(0.970)	(1.341)
Growth rate(GR)	3.551	1.656*	2.295**	3.358***
	(2.321)	(0.977)	(0.885)	(1.161)
Dry season tolerance(DST)	5.526	-1.110	-1.688**	-0.163
	(3.808)	(0.904)	(0.737)	(1.184)
Biomass the grass (BM)	-4.502*	-0.981	-1.194	-1.670
	(2.562)	(1.116)	(0.923)	(1.199)
Economy on land(ECN)	1.574	1.101	-2.084**	1.617
	(1.856)	(1.036)	(1.045)	(1.471)
Disease resistance(DR)	3.423	-0.832	2.429**	4.922***
	(2.397)	(1.083)	(1.053)	(1670)

N=139, Pseudo R-squared =0.557, chi-square = 166.99***, Log likelihood function = -66.361;

Note: values in brackets are standard errors.

*** Significant at 1%, ** 5% and *10%.

The results in Table 10 signify that gender of the interviewed respondents had significant and positive marginal effects (0.277 and 0.011) in choosing natural grass or Sudan grass respectively. They further show that male respondents were more likely to prefer the two grasses due to the effect of Napier stunt disease. On the other hand, being a female respondent increased the likelihood of choosing molasses, giant seteria or signal grass.

Table 10: Marginal effects of determinants of farmers' perceptions on alternative fodder grasses

Variable	Molasses	Sudan	Natural	Giant seteria	Signal grass
Gender	-9.534	0.011**	0.217*	-0.284*	-0.004
Age	-1.180	-0.001	0.002	-0.001	-0.003**
Years of schooling	-7.174	-0004	-0.019	0.014*	0.002*
Land size	2.486	-0.007	0.008	-0.002	0.001
Extension services	0.002	0.019	-0.078	0.045	0.013*
Push-pull technology	2.185	0.001	-0.035	0.044	-0.011
Cost of planting materials	-7.386*	-0.010	0.205**	-0.175**	-0.020**
Growth rate	5.568	0.027*	-0.130*	0.092**	0.011*
Dry season tolerance	9.168	-0.018	0.086*	-0.068*	-0.001
Grass biomass	-7.226*	-0.016	0.070	-0.048	-0.006
Economy on land	2.672	0.021	0.060	-0.086*	0.006
Disease tolerance	5.412	-0.017	-0.010*	0.099**	0.017*

** Significant at 5% and *10%.

Results from this study show that age of respondents had an inverse relationship in choosing molasses, Sudan, giant seteria or signal grass but positively influence the choice of natural grass with a marginal effect of 0.002. This implies that despite the presence of Napier stunt disease in the region, older farmers are less likely to prefer alternative grasses as younger farmers would do. The observed inverse relationship between age and preference of alternative fodder grasses maybe due to the fact that elderly farmers who have been using Napier grass are more risk averse to adopt a technology that they are unfamiliar with and whose expected returns are not assured.

Years spent in schooling was negatively significant in influencing the probability of choosing molasses, Sudan or natural grass and positively significant in choosing giant seteria or signal grass. More years spent in schooling increased the probability of preferring giant seteria or signal grass. The marginal effects of giant seteria and signal grass were 0.014 and 0.002 respectively. The results imply that more educated farmers have access to information on alternative grasses that can be used as fodder due to the threatening effects of Napier stunt disease in the dairy industry. This is possible because farmers who are more educated attend and participate in various agricultural based functions such as field days, farmer field schools and focus group discussions among others.

Total land size owned by the farmers had an inverse relationship in choosing Sudan grass or giant seteria and positively significant in choosing molasses, natural or signal grass. The positive marginal effects for land size signify that those who have more land have an incentive and the potential of planting other alternative fodder grass as a substitute to Napier grass due to the effects of Napier stunt disease which has caused a great loss to the small-scale dairy industry. This corroborates with Wanyoike (2004), who also found similar results that farm size had a significant influence on adoption of Calliandra trees.

The results also show that extension services had a positive significant influence in choosing molasses, Sudan, giant seteria or signal grass but had a negative relationship in choosing natural grass. The positive marginal effects for the extension services signify that, availability of extension services provided to the farmers enables them to get more information on alternative fodder grass establishment and management particularly on how to plant, where to obtain seeds and or planting materials. Therefore with the availability of knowledge or rather information on alternative grasses, farmers are able to express their preference for alternative fodder grasses. On the other hand, negative marginal effect may imply that interviewed farmers have access to extension services but the information may be such that they should not prefer the grass (es) due to associated costs of adopting a new system.

Push-pull technology had a positive relationship in choosing molasses, Sudan or giant seteria and a negative relationship in choosing natural or signal grass. The results indicate that farmers who adopt the push-pull technology are well endowed with information on various integral grasses used in the novel push-pull technology thus are more likely to prefer molasses, Sudan or giant seteria as alternatives to Napier grass. Farmers get involved with trained agricultural personnel through farmer field days, seminars and frequent visits by extension officers therefore, can get access to information on alternative grasses that can be used to substitute Napier grass due to the presence of NSD.

Cost of grass planting materials influenced positively the choice of natural grass and had a negative influence on choosing Molasses, Sudan, giant seteria or signal grass as alternative fodder grasses due to the presence of NSD. This implies that grass alternatives which require seeds as planting materials might be expensive to small-scale farmers who would prefer grasses which are easy to establish through cuttings or root splits. As might be expected, farmers with no off farm income placed greater importance on high cost of planting materials, which may be because they cannot easily access ready cash. This is in accordance with Muyekho *et al*., (2003), who recommended in their research that, small-scale dairy farmers require readily available planting materials in forage establishment which are commercially available and economically viable.

Results further signify that, growth rate had a positive significant influence in choosing molasses, Sudan, giant seteria or signal grass and a negative influence in choosing natural grass (marginal effect of -0.130). This implies that high growth rate during establishment is an indicator for potential for dairy development, which will provide continual availability of pasture to livestock. This corroborates with Wandera *et al*., (1997); Mason *et al*., (1999) who reported that, in western Kenya major constraints to livestock farming systems are inadequate livestock feeds.

Dry season tolerance had a positive influence in choosing either molasses, natural or signal grass and a negative influence in choosing Sudan grass or giant seteria as alternative grasses to be used in place of Napier grass. This implies that farmers' perception that fodder grasses have high dry season tolerance significantly enhanced the probability and intensity of the farmer preferring the fodder on the farm. However farmers would choose grasses which are dry season tolerant in that they would have sufficient feeds for their livestock during dry season and even in presence of drought. This is consistent with Roothaert *et al*. (2005) who established that; Napier is good forage in many aspects, but it needs high soil fertility and continuous rainfall throughout the year. Besides, this is an important attribute to small-scale dairy farmers who rely on mixed farming as their main source of livelihood and require sufficient fodder throughout the year for their dairy industry.

Furthermore, the results show that grass biomass had a negative influence in choosing molasses, Sudan, giant seteria, or signal grass and a positive influence in choosing natural grass. This may be due to the fact that, continued use of Napier grass which is the highest yielding grass in the region despite the presence of NSD, makes the farmers not to prefer any other alternative grass apart from the natural grass which is readily available. Moreover for small-scale dairy farming improvement, farmers would prefer grasses that produce a lot of biomass because the more the biomass produced, the more is available for livestock feeding thus increased milk production with associated increased income.

Economy on land positively influenced the choice of molasses, Sudan, signal or natural grass and negatively influenced the choice of giant seteria with a marginal effect of -0.086. As might be expected, farmers with smaller farms placed more importance on high economy on land. This implies that small-scale farmers would prefer grasses which economize on land which is meant for both livestock production and food crop farming. Besides, Western Kenya is well known as a predominantly high potential agricultural area with a high population density; moreover average farm size has been steadily declining therefore alternative grasses with high economy on land that can satisfy the demands for local farmers are preferred. This corroborates with research done by Farrell (1998), who observed that identification of alternative resistant grasses and more resistant clones of Napier is one of the approaches to address feed shortages. This approach is economical and particularly suitable for Napier grass disease since the farmers threatened by these diseases are resource poor and traditionally grow Napier grass with no or low inputs.

Disease resistance significantly increased the likelihood of choosing molasses, giant seteria or signal grass with marginal effects of 5.412, 0.099 and 0.169 respectively and a negative influence in choosing Sudan or natural grass with marginal effects of -0.017 and -0.099 respectively. This implies that regardless of the fact that Napier grass has been identified as the most suitable fodder for intensive milk production on majority of smallholder farms in the region, in the recent times Napier grass varieties recommended for on-farm production have succumbed to stunting disease which seriously reduces grass yields. This is in accordance with Muyekho *et al*., (2003), who reported that a number of Napier varieties favored by farmers, especially Bana grass which is both high yielding and most preferred by farmers was found to be susceptible to the disease.

The results also suggest that due to the presence of NSD which is affecting the continued use of Napier grass consequently causing a major threat to the smallholder dairy sub-sector, farmers would prefer other alternative grasses. This is a valid observation because adoption of other alternative grasses preferred by farmers will also improve the feed base and related milk production with associated increased income. This concurs with Muyekho *et al.*, (2003) who reported that amongst agronomic factors in addition to high yields, farmers greatly valued tolerance to drought and resistance to local diseases/pests.

5.5. Conclusion

Since farmers' perception about the performance of alternative fodder grasses significantly affects both the probability and the intensity to choose an alternative grass, it is essential that researchers analyze those factors that farmers themselves suggest as important in their decision to prefer and adopt fodder grass alternatives as was addressed by the multinomial logit analysis method in this study.

Due to the effects of Napier stunt disease, recurrent scarcity of grazing materials especially during the dry season and decreasing land size due to the high population pressure, small-scale farmers in the study region value: low cost of grass planting materials; high growth rate; dry season tolerance; high grass biomass; economy on land; and disease resistant fodder grass attributes. Furthermore, attributable to different weights given to different fodder grasses by the farmers, researchers can come up with specific fodders for each region.

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CHAPTER SIX

GENERAL DISCUSSION AND CONCLUSIONS

6.1. Aim of the study

Livestock feed to support dairy sub-sector remains a challenge while low milk yields, high calf mortality and long calving intervals experienced by many small-scale dairy enterprises are predominantly due to insufficient good-quality feed (ASARECA, 2008). The recurrent scarcity of grazing materials especially during the dry season and decreasing land size following high population pressure has led to the recommendation of fodder grasses as the ideal forages for Western Kenya. In addition, their high productivity and quality per unit area makes them appropriate for small-scale farmers because they provide immediate feeding material for the livestock especially in zero grazing systems. Surplus material can be conserved in form of hay or silage for dry season feeding Muyekho *et al.,* (2005). Most forage are multi-purpose plants. Direct effects on crop production include weed suppression, pest and disease reduction (when used in rotation), while indirect effects include their use as green manures, improved fallows, cover crops and live barriers, (Delgado *et al.,* 1999).

In Kenya, more than 0.3 million smallholder dairy producers (53%) rely on Napier grass as a major source of feed. It has been observed that the demand for Napier grass is so high that landless farmer's plant along the highway verges and free land to cut and sell to animal owners (Nyanyu 1998). Despite being a very valuable and highly productive grass for livestock on smallholder farms, Napier grass is also being promoted in the push-pull production system for the control of maize stem borers. However, the cultivation and expansion of the fodder crop is being threatened by various pests and diseases amongst them Napier grass stunt disease (NSD). This disease represents a major menace to the smallholder sub-sector in the region. This study was based on two specific objectives: (1) to determine the extent of Napier stunt disease infestation in small-scale dairy farming in order to estimate its damage and (2) to assess farmers' perceptions on suitability of alternative fodder grasses in order to establish their preference for dairy grasses.

6.2. Study methodology

One hundred and forty (140) respondents in the traditional Bungoma district were selected for this study. Interest was restricted to small-holder dairy farmers practicing push-pull technology and also those who were not practicing the technology but were facing the problem of Napier stunt disease. In conjunction with descriptive statistics on several aspects of the extent of Napier stunt disease in small-scale dairy farming, multinomial logit analysis were executed to assess farmers' perceptions on the alternative grasses in order to establish their preference for dairy farming. Frequencies, percentages, mean and cross tabulations were generated during analysis to capture farmers' knowledge on factors that explain the extent of NSD infestation in order to explain its damage. Descriptive statistics in form of frequencies and percentages were further utilized to determine farmers' perceived ranking of fodder grasses in order of their preferences. The relationship between farmers' perceptions on alternative fodder grasses and the explanatory factors was done using MNL model whereby marginal effect estimates showed influence of a group of variables on the choice of alternative grasses.

6.3. General Discussion of the Results

The study established the extent of Napier stunt disease infestation in small-scale dairy farming by employing several aspects of analysis. From the results it was evident that livestock keeping is a major source of livelihood in the region where majority of the farmers kept; cattle, sheep, goats and poultry and their source of income is mainly from livestock keeping, crop sales, off-farm casual work, and off-farm permanent employment among others. The results also showed that, farmers in the region practiced mixed farming and both open and zero grazing are predominant. This corroborates with Peeler and Omore, (1997) who noted that dairy farming generates more regular household income and jobs than any other enterprise whereby resource poor smallholder dairy farmers produce more than 80% of the marketed milk.

On the main source of fodder, results showed that majority of the farmers grew fodder grasses which they used as the main source of feed for their dairy enterprises. Although some acknowledged that they buy fodder for their livestock, greater part of the small-scale farmers said that they obtained feed for their livestock from free grazing fields. The study also established that, majority of the farmers (98.6%) used Napier grass as the main source of fodder in addition to soil conservation, stem borer control through Push-pull technology, and incomes from selling. This concurs with the research done by Staal *et al.,* (1997), which indicated that Napier and its hybrids is one of the major forages grown and adopted by small-scale farmers.

The NSD is a disease of economic importance on Napier grass in the region. Though most farmers started noticing the emergence of the disease in the year 1998, it is thought that the effects of the disease might have been felt before then. The NSD, causing short internodes, bushy appearance, yellow to purple streaking and a low biomass Nielsen *et al.*, (2007), has spread among small-scale farmers in Kenya, causing economic loss in the smallholder dairy industry and hence affecting the livelihoods of the rural poor. Most farmers recognized the NSD and 97.9% of the farmers interviewed had experienced the damage caused by this disease. For example; they mentioned the effect on dairy enterprise as: reduction in milk production, reduction of stock and increased cost of production.

As a NSD control mechanism, the findings obtained from the study suggest that farmers should use clean plant materials by obtaining planting materials from a reputable source such as Kenya Agricultural Research Institute (KARI), practice field sanitation by removing and burning the affected plants as they are reservoirs of the phytoplasma, and put into practice field management. They also need to use recommended cutting intervals and fertilize the plant well at planting and manure during crop growth. This is consistent with Mulaa *et al.,* (2004), who reported that as recommendations for NSD, farmers should plant grass from healthy fields, check their grass frequently and uproot diseased plants, replant with grass, and burn the sick plants or bury them deeply. They also advised that farmers should plant grass at one meter by one meter for each plant to have room to grow healthy, fertilize Napier grass with one 50 kilo bag of Triple Supper Phosphates at planting and top-dress with 2 bags of Calcium Ammonia Nitrates per acre.

Given the vulnerability of the Napier grass to NSD, the respondents showed the willingness of replacing Napier grass with other alternative fodder grasses. This is enough evidence that, there is urgent need to look for alternative high yielding fodder grasses to Napier grass in order to keep and maintain the dairy industry. Although Farrell (1998) reported that, two-smut resistant clones of Napier grass; Kakamega 1 and Kakamega II, have already been identified in Kenya by KARI, and that French Cameroon was reported to be less severely affected than the more affected Bana.

Other fodder grass alternatives should be introduced to the farmers to enable them increase their ability to manage risks associated with fluctuating feed supply and disease threat. This corroborates with Jamnadass, (1999) who established that, a Napier grass cultivar resistant to one disease may not necessarily be resistant to another disease even if it is of the same genus.

Since perception on alternative grasses clearly showed that farmers preferred; Natural grass, signal grass, Giant seteria, Sudan grass and Molasses grass respectively in that order, it is also important for the farmers to consider grass attributes which include cost of planting materials, growth rate, dry season tolerance, grass biomass, economy on land, and disease resistance along with farm, farmer and institutional characteristics that also significantly affect both the probability and the intensity of having the fodder on the farm. The main prerequisite to obtain efficient forages is however, to choose the appropriate species and cultivars, for which the following basic aptitudes are requested: the adaptability to the local environmental conditions mainly climate and soils; the capability to ensure high yields in palatable materials with acceptable nutritive value; and the maximum efficiency in soil fertility improvement (Sebastien *et al.*, 2008).

6.4. Conclusions and Recommendations

This study has demonstrated that small-scale farmers have great experience and knowledge of Napier stunt disease and alternative forage grasses that may meet their needs. From the findings of farmers’ perceptions, it is evident that, Napier stunt disease has lead to the reduction in milk production, reduction of livestock, and an increased cost of production. Furthermore, some farm and farmer characteristics, institutional characteristics, and grass attributes are important determinants of farmers’ perceptions on alternative grasses to Napier grass used in smallholder dairy farming. It is therefore important that when screening alternative fodder grasses, emphasis should be on focusing on farmers’ desired fodder attributes. That is; farmers should be involved in evaluation of fodder grasses to establish their suitability into farmers’ farming systems.

Given that this study was based on assessing farmers’ perceptions on alternative fodder grasses to Napier grass this study recommends that alternative fodder grasses should be tested on farms to assess their productivity in different agro-ecological zones and under farmer managed regimes. They should also be assessed for their ability to resist or tolerate emerging diseases in different agro-climatic conditions. Equally important, they should be assessed for their integration with the novel push-pull technology given the technology's multiple functions including provision of fodder. Such efforts will also call for further research to quantify the effects of Napier stunt disease on milk production, livestock, and cost of production is recommended.

A policy recommendation emanating from this study calls for relevant line ministries (Agriculture and Livestock) to hasten research work on alternative fodder grasses to assess their potential in enhancing smallholder dairy industry and mitigation of the serious threat by the NSD to the sector. Also investments in farmer training and extension information should be promoted by both the public and private sectors to enable farmers to access appropriate technologies and management practices with potential to boost the smallholder industry.

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APPENDIX 1: QUESTIONNAIRE

TITLE: ANALYSIS OF SMALL-SCALE DAIRY FARMERS' PERCEPTIONS OF ALTERNATIVE FODDER GRASSES CONTINGENT ON NAPIER STUNT DISEASE IN BUNGOMA DISTRICT.

The purpose of this study is purely academic and above all, to contribute to the understanding of farmers' perceptions of alternative fodder grasses in small-scale dairy farming given the infestation by the Napier stunt disease. As a respondent you are kindly requested to participate in answering this questionnaire and you are assured that any information shared will be strictly confidential. The information generated will help small-scale farmers in deciding which grass (es) among alternatives to plant given the threat by the Napier stunt disease and therefore make economically viable decisions.

Section A: General Information

1. Date of interview ____
2. Name of enumerator____
3. District ____
4. Division____
5. Location____
6. Sub location____
7. Village____

Section B. Farmer Characteristics

1. Name of the farmer/household head: ________________________________

2. Gender of the farmer: 1. Male [ ] 2. Female [ ]

3. Age of the farmer: ___________ ***(please enter date of birth, if known):*** [19 _ _]

4. Marital status (***please tick one***)
   1. Married [ ] 2. Single [ ] 3. Widowed [ ] 4. Divorced[ ]

5. How many years have you had in school? _________ (years)

6. Number of Household members (including HH head) living permanently on the compound

Household members	**Number**
Men	
Women	
Children(below 18 years)	

7. What are your household's main sources of income? **(Please tick appropriately)**

   1. Crop sales [ ] 2.Livestock keeping [ ] 3. Off-farm casual work [ ] 4.Off-farm permanent employment [ ] 5.Remittance [ ] 6.Food aid [ ] 7.other (specify) -----------------

Section C. Farming and the extent of Napier stunt disease

8. What is the size of your land? ____________________ (Acres)

9. What is the size of your land under cultivation? ____________(Acres)

10. What kind of farming do you practice? **(Tick appropriately)**

    1. Mixed farming [ ] 2.Livestock farming [ ] 3. Food crop farming [ ] 4. Cash crop farming [ ] 5. Other specify------------------------

11. If you keep livestock, what kind of livestock system do you practice in your farm?

    1. Zero grazing [ ] 2.Open grazing [ ] 3. Both Zero grazing and Open grazing [ ]

12. What kind of livestock do you keep in your farm? (**Tick appropriately**)

    1. Cattle [ ] 2.Sheep [ ] 3.Goats [ ] 4.Poultry [ ] 5.others (specify) -------------------

13. If cattle, please indicate the number of stock that you own

Cattle	***Mature cows***	***Bulls***	***Heifers***	***Calves***
Zebu (local)				
Cross (improved)				
Pure breed				

14. What is the main source of feed for your dairy?

    1. Own farm fodder [ ] 2. Buy fodder [ ] 3.Free grazing fields [ ] 4.Others (***specify***) --------

15. How long have you been practicing dairy farming? ___________________ (years)

16. Do you grow Napier grass in your farm?

1. Yes [ ] 2. No [ ]

17. What is the main use of Napier grass in your farm?

1. Feeding livestock for milk production [ ]
2. Selling for money [ ]
3. Soil conservation [ ]
4. Stemborer control in push pull strategy [ ]
5. Others (***please specify***) ------------------------

18. (a). Have you had any extension services/contact in the last twelve (12) months?

1. Yes [ ] 2. No [ ]

(b). If yes, what topics where covered? (***Tick appropriately***)

1. Napier stunt disease [ ] 2.Dairy farming [ ] 3.Others, specify…………

19. (a). Do you practice push-pull technology?

1. Yes [ ] 2. No [ ]

(b). If yes, when did you start practicing push-pull?______________(Year)

20. What was your initial acreage under push-pull?___________________(Acres)

21. What is your current/present acreage under push-pull? _____________(Acres)

22. Why have you increased **OR** decreased your area under push-pull? (***Please give reasons)***

a. ____

b.____

c.____

d.____

23. Have you ever heard of Napier Stunt Disease?

1. Yes [ ] 2. No [ ]

24. If yes, what do you know about it? (***Please explain*)**

a____

b.____

c.____

d.____

e.____

25. Has Napier stunt disease affected your Napier grass plantation?

1. Yes [ ] 2. No [ ]

26. If yes, when did you first notice/observe the disease in your field? ____________ (years).

27. What size of land has been affected? ______________________ (Acres)

28. What measures have you taken to counter the effect of the Napier stunt disease? ***(Please give reasons)***

a.____

b.____

c.____

d.____

29. How has the Napier stunt disease affected your dairy farming enterprise? (***Tick appropriately***)

1. Reduction in milk production [ ] 2. Reduced stock [ ] 3. Increased cost of production [ ]

4. Others (***please specify***) ----------------------

30. Using a four point likert scale of no effect (1), little effect (2), moderate effect (3), and high effect (4), how has the Napier stunt disease affected your farming enterprise?

1. No effect meaning no loss of fodder [ ]
2. Little effect - meaning loss of about ¼ of the Napier [ ]
3. Moderate effect – meaning about ½ to ¾ of the Napier [ ]
4. High effect - meaning over ¾ of the Napier [ ]

31. With the onset of Napier stunt disease; have you ever considered adopting alternative grasses as fodder?

1. Yes [ ] 2.No [ ].

32. In order of preference and ranking would you please provide a list of the alternative grasses?

Grass type/Alternative	**Rank**
Molasses grass	
Sudan grass	
Signal grass (*Bracharia*)	
Giant seteria	
Giant panicum	
Natural grass	
Others (***please specify***) _________________	

33. On a scale below, with 3=high, 2=moderate and 1=low, how would you rate the following grass attributes on your farm?

Grass alternative ONE

	High	Moderate	low
(a) Cost of planting material	3[ ]	2[ ]	1[ ]
(b) Growth rate	3[ ]	2[ ]	1[ ]
(c) Dry season resistance	3[ ]	2[ ]	1[ ]
(d) Grass biomass	3[ ]	2[ ]	1[ ]
(e) Economy on land	3[ ]	2[ ]	1[ ]
(f) Disease resistance	3[ ]	2[ ]	1[ ]

Grass alternative TWO

	High	Moderate	low
(a) Cost of planting material	3[ ]	2[ ]	1[ ]
(b) Growth rate	3[ ]	2[ ]	1[ ]
(c) Dry season resistance	3[ ]	2[ ]	1[ ]
(d) Grass biomass	3[ ]	2[ ]	1[ ]
(e) Economy on land	3[ ]	2[ ]	1[ ]
(f) Disease resistance	3[ ]	2[ ]	1[ ]

Grass alternative THREE

	High	Moderate	low
(a) Cost of planting material	3[ ]	2[ ]	1[ ]
(b) Growth rate	3[ ]	2[ ]	1[ ]
(c) Dry season resistance	3[ ]	2[ ]	1[ ]
(d) Grass biomass	3[ ]	2[ ]	1[ ]
(e) Economy on land	3[ ]	2[ ]	1[ ]

(f) Disease resistance 3[ ] 2[ ] 1[ ]

Grass alternative FOUR

	High	Moderate	low
(a) Cost of planting material	3[ ]	2[ ]	1[ ]
(b) Growth rate	3[ ]	2[ ]	1[ ]
(c) Dry season resistance	3[ ]	2[ ]	1[ ]
(d) Grass biomass	3[ ]	2[ ]	1[ ]
(e) Economy on land	3[ ]	2[ ]	1[ ]
(f) Disease resistance	3[ ]	2[ ]	1[ ]

Grass alternative FIVE

	High	Moderate	low
(a) Cost of planting material	3[ ]	2[ ]	1[ ]
(b) Growth rate	3[ ]	2[ ]	1[ ]
(c) Dry season resistance	3[ ]	2[ ]	1[ ]
(d) Grass biomass	3[ ]	2[ ]	1[ ]
(e) Economy on land	3[ ]	2[ ]	1[ ]
(f) Disease resistance	3[ ]	2[ ]	1[ ]

Grass alternative SIX

	High	Moderate	low
(a) Cost of planting material	3[ ]	2[ ]	1[ ]
(b) Growth rate	3[ ]	2[ ]	1[ ]
(c) Dry season resistance	3[ ]	2[ ]	1[ ]
(d) Grass biomass	3[ ]	2[ ]	1[ ]
(e) Economy on land	3[ ]	2[ ]	1[ ]

34. When did you start planting the alternative grasses?

Grass	**Year first planted**
Alternative ONE	
Alternative TWO	
Alternative THREE	
Alternative FOUR	
Alternative FIVE	
Alternative SIX	

Thank you for taking your time to provide answers to this questionnaire.