ASSESSMENT OF THE SOCIOECONOMIC EFFECTS OF THE NAPIER STUNT DISEASE ON SMALL SCALE DAIRY PRODUCTION 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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Recommendation

This work has been submitted with our approval as supervisors.

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To my dad and mum, Dr. and Mrs. Ephraim Amiani, together with my two siblings Ruth and David Amiani.

ABSTRACT

Napier grass stunt disease (NSD) has been a major challenge to sustainable smallholder dairy production in Kenya. A household (HH) survey was conducted using personal interviews to assess the effect of NSD on level of milk production and on milk income at household level in Bungoma District, Western Kenya. Data were collected using structured questionnaires in a cross-sectional survey involving 130 respondents in five selected divisions of the larger Bungoma District. Descriptive statistics were used to assess farmers' opinions on the extent of NSD infestation on farms. Cobb Douglas (CD) two stage least square (2SLS) model was used to determine the effects of NSD and other variables on the yield of milk. A log linear regression was used to determine the effects of NSD and other variables on the household milk income. Descriptive results indicate that there was an average drop from two cows to one cow that could be fed on an acre of Napier. The CD 2SLS results show that the area under Napier had a positive significant effect on the area of Napier grass under the NSD. Furthermore, NSD had a significant negative impact on milk yield ($p<0.05$). Gender, farming experience, and alternative sources of feed were found to have a significant negative influence on milk yield. Prevailing market milk price and number of cattle had a positive influence on milk yield. Napier stunt disease had a significant negative impact on monthly gross margins (GM) per cow ($p<0.05$). The estimates in Kshs were 4325, 4122, 1433, 2689 and 1782 for Kibabii, Sang'alo, Bumula, Malakisi and Webuye, respectively. The GM estimates were also influenced by other household characteristics such as HH size, push pull practice, land under Napier grass, milk output, and milk prices all of which had a positive impact. The study provides useful information about the effects of the NSD on small scale dairy production and on specific socioeconomic parameters that farmers, extensionists, researchers and policy makers can use in designing appropriate interventions towards mitigating the negative effects of NSD on overall dairy productivity.

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LIST OF ACRONYMS, SYMBOLS AND ABBREVIATIONS

FSH	**-**	Fusarium Head Blight
FAO	**-**	Food and Agriculture Organization of the United Nations
GM	-	Gross Margin
ICIPE	-	International Centre of Insect Physiology and Ecology
NSD	**-**	Napier Stunt Disease
OLS	-	Ordinary Least Squares
PPT	-	Push Pull Technology
TOF	**-**	The Organic Farmer
2SLS	-	Two Stage Least Square
VIF	-	Variable Inflation Factor

CHAPTER ONE

GENERAL INTRODUCTION

1.1 BACKGROUND OF THE STUDY

Napier grass *(Pennisetum purpureum)* is a perennial grass grown widely in East Africa as a fodder crop. It is also planted for environmental protection, to stabilize soils, and prevent soil erosion and therefore the soil does not lose its nutrients and the crop also acts as a windbreak (Jones *et al*., 2004). In Kenya, Napier grass has been used in a novel 'push-pull' pest management system to contain the infestation of cereals by stem borers (Khan *et al*., 2001). Push pull is a pest management technology that involves intercropping maize with desmodium (*Desmodium uncinatum* forage legume repellent plant to deter the pest from the main crop (push), and Napier Grass, planted as boarder around this intercrop to attract the repelled stem borer moths (pull) and eliminate striga (Khan *et al*., 2000, 2001).

On many small-scale farms in Western Kenya, inadequate and poor quality feeds are a major constraint to dairy production. Since farms are small, cattle are confined and fed by cut-and-carry, commonly referred to as zero-grazing (Baltenweck *et al*., 1998; Staal *et al*., 1999). One characteristic of these small-scale farmers is the over-reliance on Napier grass as the main basal feed for dairy cattle. Unfortunately, an emerging constraint to the general production of Napier grass is the rapidly spreading Napier stunt disease (NSD). In fact great is the threat that loss of Napier grass feed could lead to the collapse of small holder dairy industry (Orodho, 2005).

While an acre of Napier grass can provide enough fodder to sustain four cows, plots affected by the disease can only support one or two cows, greatly reducing milk yields and incomes of affected dairy farmers (Orodho and Ajanga 2004). Napier grass stunt disease is spreading quickly in Western Kenya causing serious economic losses in the small holder dairy industry (Orodho, 2005). Most of the Napier grass stands are increasingly becoming susceptible to NSD; the symptoms becoming visible in re-growths, after cutting or grazing. Affected shoots become pale yellow green and are seriously dwarfed. Often the whole stool is affected with a complete loss in yield and eventual death. Many small holders have lost up to 100 percent of their Napier grass and are forced to de-stock or sell off their entire herd because of lack of feed (Orodho, 2006).

Laboratory tests have confirmed that Napier stunt disease is caused by a mycoplasma which is a bacteria and the symptoms manifest in the Napier grass by the affected shoots becoming pale yellow green in colour and seriously dwarfed, which means they become tiny and smaller in size and height (News Agriculturalist 2005). Inevitably, urgent action is needed to identify the long lasting solution to this problem of Napier Stunt disease. Certainly a long and sustained programme of research and extension is needed to combat NSD A series of "Going Public" events were held in Western Kenya in July 2005 in an attempt to gain more information about this devastating disease and to learn more about peoples' reactions to it (New Agriculturalist Online, 2005). It was found that most of the farms were affected by the disease, which currently has no cure.

Staal (1999) reported that investment in small holder dairying has increased in recent years at the rate of 1.5% per annum. This increase is partly attributed to the liberalization of the dairy sub-sector and partly to the low prices of cash crops and this has positioned dairy as a competitive enterprise. However, the development of small holder dairy systems in the high potential areas of Kenya has been marked by declining farm sizes, slowness in upgrading the local Zebu cattle to high producing dairy breeds and a heavy reliance on purchased feeds, both concentrates and forages (Staal *et al*., 1998, 1999). The major cattle feeds are natural grass and planted fodder, mainly Napier grass (Orodho, 2005). With the increasing human population, and dwindling land holdings, Napier grass is increasingly becoming available fodder since cattle are fed on cut and carry system, where they do not need to graze (Potter, 1987; Orodho, 1990).

Other feeds, which depend on season and region for availability and which are used in smaller quantities include maize crop residues, compound feeds, milling by-products, sugarcane tops, banana pseudostems, as well as other grasses and weeds (Baltenweck,1998). Where farms are small, cattle are confined and fed by cut-and-carry, commonly referred to as zero-grazing (Baltenweck *et al*., 1998; Staal *et al*., 1999). Nutrient cycling through dairy animals and use of manure are key drivers to dairy adoption and to sustaining smallholdings (Orodho, 2006). The major constraining factors in these intensive dairy systems are: lack of adequate and quality feeds particularly in the dry season, inappropriate animal genotypes and disease challenges on livestock and on Napier grass which is the major livestock feed (Orodho, 2006). Emerging diseases, mainly fungal, viral or mycoplasmal are affecting many Napier grass varieties, consequently raising concerns on the future of small holder dairying as a source of livelihoods to many farmers. It is at times difficult to recognize the Napier stunt disease since it takes a long time for the symptoms to manifest on infected plants. The NSD shows symptoms after about six months to one year from the time of infection (Ssali, 2009).

The Livelihoods of the farmers from Western Kenya

In most of central and western parts of Kenya, high-potential agricultural lands with mixed crop-livestock farming systems are predominant as regards to sole crop farming. It is noteworthy that these areas are characterised by a high human population that is increasingly exerting pressure on the limited natural resources, particularly land (FAO, 2000). This has resulted into farmers practising intensive crop-livestock systems that are viewed as a viable option towards optimizing the use of the limited natural resource. The mixed farming systems are dominated by a combination of dairy cattle, food and cash crops. This is in contrast with the less productive mixed farming systems in marginal areas along the shores of Lake Victoria, in the croplands of East and Southeast of Nairobi and in the coastal hinterland (Manyong *et al.*, 2006). In many of these areas, either rainfall is erratic or soils are less fertile. Here, yields and incomes derived from a mix of livestock and food crops are generally low (FAO, 2000).

Livestock production is an important component in local economies at both the national and farm household level, where cattle constitute the main livestock species kept by farmers. The main source of milk in Kenya is the cow, and the cow's milk constitutes 83.4 % of the total annual milk output (FAO, 2006). In view of its ability to generate significant amount of daily cash income and its contribution to the improvement of the livelihoods of very poor people, dairy production is becoming increasingly important in many developing countries, including Kenya (FAO, 2006).

The dairy sub-component has proved to be practically vital, especially in the smallholder sector where milk is an important source of protein to young children and supplementary income to often cash-starved farm households (Ssali, 2009). The dairy cow is biologically an efficient animal in converting unpalatable roughages to milk. As a ruminant, she can obtain as much as 70% of her total feed intake from non-human food sources such as forages and non-protein nitrogen (Walshe *et al*., 1991). This places the dairy cow in a strong competitive position compared to other livestock as a major supplier of high quality human food now and in the future.

Dairy industry makes use of resources, which include; land, labour, capital and management and offers an opportunity for profit to those concerned with the production, processing, and distribution of milk and dairy products (Walshe *et al.,* 1991; Berry, 2005). Further to this, and due to the large numbers of current and potential producers, the smallholder dairy industry has the greatest potential for increasing national dairy productivity (Ssali, 2009). It is for these reasons that dairying in the developing countries is considered to be an important instrument of social and economic change, and is identified with rural development (Kurien, 1987; Ssali, 2009.)

For farmers who don't have large acreages of pasture, it has been recommended that they can plant an acre of Napier grass which can produce enough fodder to feed one livestock unit, that is, two to three dairy animals per acre of Napier grass (Ssali, 2009). While a healthy acre of Napier grass should provide enough feed to sustain one productive cow for about six months, plots affected by the disease may support the animal for less than three months, greatly reducing milk yields and family income (Ssali, 2009).

1.2 STATEMENT OF THE PROBLEM

Western Kenya is one of the most densely populated regions in the country with a total population of 4,334,282 inhabitants within an area of 8,361 km^2 (Kenya Population Census 2009). The livelihoods of a majority of the population in this region are derived from mixed farming, where farmers plant crops and rear livestock. It is noteworthy that in these mixed farming systems, natural grazing is no longer an adequate alternative to livestock feeding because of lack of land for open grazing. In these mixed systems, Napier grass is increasingly becoming a dependable fodder particularly where zero-grazing is practiced because it has a soft stem that is easy to cut, the roots are deep fairly drought resistant, it also has tender young leaves and the stems are very palatable and finally it grows very fast. Napier grass is also an integral component in this strategy where Desmodium and maize are grown together in a spatial arrangement (push pull strategy/technology) to combat the stem borers with significant economic gains to the farmer. To increase livestock and crop productivity, the push-pull technology or strategy has continued to be promoted by ICIPE and partners for adoption by small-scale farmers. However, since the emergence of the NSD, the effect it has had on the dairy production of the small holder farmers has not been studied and quantified to hasten measures to bring it under control. This is the basis of this study and it will thus provide insights on the effects the disease has had on farmers' incomes and yield from milk, key ingredients for better household welfare, provide basis for recommendations on what can be put in place to the relevant stakeholders for mitigating the effects of the disease.

1.3 OBJECTIVES

1.3.1 General Objective

The purpose of this study was to assess the socioeconomic effects of Napier stunt disease on small holder dairy production in Bungoma district in order to appraise the effects of the disease on livelihoods and heighten efforts to control the disease.

1.3.2 Specific Objectives

1. To determine farmers' opinions on the extent of NSD infestation on farms.
2. To determine the effects of the Napier stunt disease while controlling for socioeconomic factors on milk production by small holder farmers.
3. To determine the effects of the Napier stunt disease on milk income of the small holder farmers.

1.4 HYPOTHESES

1. The Napier stunt disease has no significant effect on milk production by small holder farmers.
2. The Napier stunt disease has no significant effect on the incomes of the small holder farmers.

1.5 JUSTIFICATION

Given the dependence of small farmers on dairy farming as a source of livelihood, the current threat by the Napier stunt disease (NSD) is an issue of concern. It is therefore important to understand how farmers are affected by the NSD and how they are able to deal with the effects of the disease towards dairy production and their livelihoods in general. Therefore, this research study is timely towards understanding the socioeconomic impact of the NSD on the livelihood of the small holder farmers in

Bungoma District. Moreover, little has been documented on the economic importance of the NSD in intensive mixed crop-livestock systems.

1.6 DEFINITION OF TERMS

Assessment: Is collating data and information that would enable an objective evaluation/inference of an occurrence (Atherton 2010), in this case Napier Stunt Disease and its effects on production parameters (Napier production and milk yield).

Household: This is defined as an independent male or female producer and his or her dependants who must have lived together for a period of not less than six months (Ellis, 1988). The members are answerable to one person as the head and share the same eating arrangement.

Napier stunt disease: It is a disease in which the shoots of Napier grass become pale yellowish green in color and are dwarfed leading to subsequent death (Orodho *et al.*, 2004). In this study, it is identified by the same symptoms.

Perennial crops: This is a crop that lasts for a very long time or living for more than two years as is the case of the Napier grass which is a fodder.

Push-pull strategy/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 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 (pull) (Khan *et al.*, 2001).

Small holder farmers: Farm holdings of less than ten hectares and fewer than ten dairy animals (Musalia *et al.*, 2007). In this study, a smallholder farmer is defined as one who has less than five acres of land under cultivation.

Socio economic effects: Results that occur in the social and economic wellbeing of an individual or household after a certain activity or event has happened (Peezey *et al.*, 1998). In this study the results of the prevalence of the disease on the economic status of the farmers is explained and illustrated from the analyzed data.

1.7 SCOPE OF THE STUDY

The study was conducted in Bungoma District, in Western Kenya, where there is a high prevalence of the Napier stunt disease. The study targeted small holder farmers who plant Napier grass and practice push pull technology or strategy and also those who do not practice the technology.

1.8 ASSUMPTIONS OF THE STUDY

1. Farmers did not use feed supplements
2. Farmers were able to identify symptoms of NSD
3. Farmers could quantify the damage by NSD, and indicate losses resulting from damage by NSD.

1.9 LIMITATIONS OF THE STUDY

The study was limited to one district due to limited budget, time to conduct the study (or data collection), the Graduate school's requirement that student researchers have to collect data by themselves to gain experience in field research and hence generalizations of the results have been cautiously made. The study was only limited to cross sectional data.

2.0 OUTLINE OF CHAPTERS

General introduction has been presented in Chapter one. Chapter two, presents literature review and the theoretical and conceptual frameworks whereas, chapter three presents the methodology used in conducting the study. Chapter four presents the results and discussion. The final chapter gives the conclusions and recommendations.

CHAPTER TWO

LITERATURE REVIEW

2.1 INTRODUCTION

Napier grass, also called elephant grass, is a native clumping grass of tropical Africa. It is widely used as fodder and also planted for environmental protection in stabilizing soils and acting as windbreaks. In Kenya, it is currently used in a novel *"push-pull"* pest management system for controlling cereal stem borers (Khan *et al*., 2001). The grass was named after Colonel Napier of Bulawayo in Zimbabwe, who early in the last century, urged Rhodesia's (now Zimbabwe) Department of Agriculture to explore the possibility of using it for commercial livestock production (Boonman, 1993). Napier grass used to be promoted in Uganda as fodder. Napier grass is propagated vegetatively from cuttings of three to four nodes in length (Jones *et al*., 2004). Seeds are usually not available and have been reported to have low genetic stability and viability. Mature plants normally reach up to 4m in height and have up to 20 nodes (Henderson and Preston, 1997). However, Boonman (1997) observed that it could grow to a height of 10 m in riverbeds. He also reported having realized a harvest of 29 tonnes/ha dry matter in one cut on a very mature stand in Kitale.

Napier grass is usually planted solely; however, it can also be under sown with other crops such as maize (Wanjala *et al*., 1983) or intercropped with forage legumes (Kusewa *et al*., 1980). When Napier grass and maize are planted at the same time, its yield is increased, without necessarily reducing the maize yields. Experience shows that both Napier grass and maize can be successfully grown on the same plots (Wanjala, 1983). It has also been found that herbaceous legumes can give high yield when intercropped with Napier grass (Orodho, 2006).

In Kenya, Napier grass has been found to be suitable for grazing because the conventionally preferred grasses demonstrate poor persistence under grazing regimes (Sollenberg and Jones, 1989). Also, most dairy farmers in Kenya are small holders with very small plots on which they rear livestock, mostly grazed on Napier grass. In Brazil, Sollenberg and Jones (1989) noted that the Napier grass variety performed well under specific grazing management where farms were well managed with fertilizer and manure, but small holders in Kenya prefer giant Napier grass citing its suitability in cut-and-carry grazing systems.

Napier grass is a predominant fodder crop on most of the farms rearing dairy cattle in the greater Bungoma District. The grass is usually grown in single stands. However, due to limited acreage of land and introduction of the integrated pest management against maize stem borer, the grass is also grown along with maize and Desmodium (Kusewa *et al*., 1980; Wanjala *et al*., 1983; Khan *et al*., 2001). This crop arrangement is a recommended practice, commonly referred to as "*push-pull*" strategy or technology for control of the stem borers. In this arrangement, the Desmodium repels the stem borers while the Napier grass attracts them from the maize-desmodium intercrop. It has clearly been demonstrated that this strategy reduces the stem borer infestation significantly leading to increased maize yields (Khan *et al*., 2001). The poor and stunted growth of Napier grass in this arrangement, due to the NSD, could thus destabilize the effectiveness of this crop as an IPM strategy. Therefore, the role of Napier grass in the mixed-crop livestock systems cannot be over-emphasized.

2.2 USE OF NAPIER GRASS AS FODDER

Inadequate and poor quality feed are major constraints to dairy production on small holders' farms, particularly in dry periods. In some western and eastern regions of Kenya, the prolonged dry season can last up to six months (Jatzold & Schimdt, 1982). During this period cattle are sustained on conserved Napier grass from the high yields produced during the rainy season (Valk, 1990; Thorpe *et al*., 2000).

Attempts have been made by farmers to make hay from Napier grass (Brown & Chavulimu, 1995; Manyuchi *et al*., 1996) but the succulent stem limits the rate of drying and with excess drying the stems may become hard and brittle and less palatable to livestock (Snijders *et al.*, 1992). Research indicates that the alternative is ensiling the surplus since leaving Napier grass to become too mature may compromise the quality (Cunha and Silva, 1997).

In the last decade cultivation of Napier grass has spread rapidly in East Africa, as small-scale farmers shift from extensive to zero grazing because the grass has a soft stem that is easy to cut, the roots are deep fairly drought resistant, it also has tender young leaves and the stems are very palatable and finally it grows very fast (Yokota and Ohshima, 1997).

Unfortunately, the expansion of the fodder crop has been associated with emerging diseases; to the east of Rift Valley, Napier grass head smut, and to the west, Napier grass stunt, with concomitant reduction in fodder biomass. Thus, while a healthy acre of Napier grass should provide enough feed to sustain four productive cows, plots affected by the disease may support only one or two animals, greatly reducing milk yields and income (Orodho, 2006). These trends have spiraled increases in fodder prices, mostly in parts of eastern Uganda and western Kenya. In these regions, farmers have been forced to buy grass hay to compensate for the declining production (The Organic Farmer, 2005).

Kenya has the most developed small holder dairy system in Sub-Sahara Africa with an estimated dairy herd of seven million heads the largest such herd in Africa and more than the rest of the countries in East and Southern Africa combined. Kenya is also the third-largest milk producer in Africa, behind Sudan and Egypt (Kenya Population Census, 2009). Most dairy cattle are crosses of Friesian-Holstein, Ayrshire and other exotic dairy breeds with local Zebu. Dairy is important in the livelihoods of many households in terms of generating income and employment (Lormore, 2005). In western Kenya, small holder dairies [(mainly farm holdings of less than ten hectares and fewer than ten dairy animals (Musalia *et al*., 2007)] are concentrated in the crop – dairy systems of the high potential areas, producing about 60-70% of the milk and contributing over 90% of the market output (Mburu *et al*., 2007). The system is characterized by small crop-livestock farms.

Where farms are small, cattle are confined and fed by cut-and-carry, also referred to as zero-grazing (Baltenweck *et al*., 1998; Staal *et al*., 1999). Nutrient cycling through dairy animals and use of manure are key drivers to dairy production and adoption and to sustaining small holdings (Orodho, 2006). The major constraining factors are: lack of adequate and quality feeds particularly in the dry season, inferior animal genetics and disease challenges on livestock and on Napier grass which is the major livestock feed. Emerging diseases *viz.* Napier stunt disease could lead to the collapse of the small holder dairy industry (Omore *et al*., 2003).

Napier grass plays a pivotal role as a livestock feed in small holder dairy production systems in Kenya. The rapid increases in the human population in the high potential areas of Kenya continues to exert pressure on the existing landholdings which presently average 0.9 – 2.0 ha (Gitau *et al*., 2001). In western and central Kenya, over 80% of dairy animals are kept under zero grazing and Napier grass is the main fodder grown by over 70% of the farmers (Staal *et al*., 1998).

With land being a constraint, farmers are tending towards practicing zero grazing and thus integrating Napier grass into the system. It is thus expected that the Napier stunt disease presents a bottleneck to farmers' economic progress. Considering the diversified nature of livelihoods in Kenya, a study by Chianu *et al*., (2008) on the future of dairy industry, concluded that few households diversified into small businesses, employment and in practicing their skills for example, artisan. This diversification is important in enhancing their household income because of high pressure of land and increasing population, but poultry and cattle dominated their livelihoods.

2.3 USE OF NAPIER GRASS IN THE PUSH-PULL STRATEGY

Previously used methods of pest control have been expensive due to use of expensive chemicals, which usually are not within small holders' reach and affordability. The push-pull strategy or technology therefore came in as a less risky, less expensive and a sustainable option for pest control. The strategy involves intercropping maize with a fodder legume, mainly silvery leaf desmodium and planting Napier grass as a trap crop around the crop field. Green leaf volatiles emitted by the desmodium repel the stem borer moths away from maize field (push component), while those released by the Napier grass attract them (pull component) (Khan *et al*., 2000, 2001). Because stem borer moths prefer Napier grass to maize for oviposition (Khan *et al*., 2007; Van den Berg, 2006), the majority of the eggs are laid on the trap crop, leaving the maize protected. Most of the resultant stem borer larvae, however, do not survive on the trap crop due to a range of factors including poor nutrient composition of Napier grass, production of sticky sap that entangles and kills the larvae and abundant natural enemies associated with the Napier grass (Khan and Pickett, 2004). However, the occurrence of the NSD and the concomitant reduction in the biomass of the Napier grass on the affected farms is threatening to affect the potential of push pull technology to address the problems of low soil fertility, striga proliferation, stemborer infestation and lack of sufficient food.

2.4 ADOPTION OF THE PUSH PULL STRATEGY BY THE FARMERS

As part of continued research on push-pull strategy studies by Kusewa *et al*., (1980); Wanjala *et al*., (1983) and Khan *et al*., (2008), assessed 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.

Results of Khan *et al.*, (2008) 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. This study however did not examine the effects of the emerging Napier Stunting disease on the push-pull technology.

2.5 PAST RELATED STUDIES ON NAPIER STUNT DISEASE

A serious Napier grass disease, Napier stunt, which is spreading rapidly in Western Kenya, is causing serious economic losses in the small holder dairy industry (Orodho, 2005). Most of the Napier grass varieties grown in the area appear to be susceptible to the disease; the disease is usually visible in re-growths after cutting or grazing. Affected shoots become pale yellow green and are seriously dwarfed. Often the whole shoot is affected with complete loss in yield and eventual death (Orodho, 2005). Many small holders have lost up to 100% of their Napier crop and are forced to de-stock or sell off their entire herd because of lack of feed. It is envisaged that if urgent action is not taken to identify the exact cause of NSD and to control it, this disease could lead to serious negative impacts on the small holder dairy industry in Eastern Africa (Orodho *et al*; 2004).

The disease was first reported in Bungoma district in 1997. Literature shows that a similar stunt disease had been reported in Uganda and the cause of the disease was suspected to be a virus transmitted by insects (Tiley, 1969).

Some farmers believe that the disease is mechanically spread through harvesting implements, observing that the disease does not spread until after the first cutting (Orodho and Ajanga, 2002). The disease is much more severe and prevalent in poorly managed fields. This has been observed by farmers who have decreased incidences in stands of Napier grass that are well-weeded and sufficiently manured fields. However, weeding and heavy fertilization are only temporary measures of reducing the disease level, more long-lasting solutions have to be sought. This includes the development of resistant Napier varieties to NSD (Orodho *et al*; 2004).

The NSD is a new disease affecting Napier grass that has been least studied. It was not until 2004, when the cause of the NSD was identified (Boa et al; 2005; Mulaa and Ajanga; 2005). The interest in this disease and its effects in Napier grass have gained momentum in the last five years. Recent studies on NSD have mainly focused on bio-physical aspects that include the search for tolerant varieties through adaptation trials on possible resistant varieties (Orodho, unpublished). Additional reports indicate that NSD has been newly recognized and affects Napier production with an incidence of between 30% and 90% as seen on many small holder fields (Mulaa and Ajanga, 2005). By the year 2004, it was estimated that the disease had affected Napier grass across about an area of 23,298km^2, and affecting about two million households comprising of nine million people (30% of the population) in Western Kenya and the Rift Valley provinces (Bungoma District Agricultural Annual report, 2004). This project on search for tolerant varieties through adaptation trials on possible resistant varieties covers the collection, characterization of genetic diversity in Napier grass clones disease diagnosis, and identification of resistant clones. Besides this, there have been initiatives by the Global Plant Clinic to create the awareness of the disease and its possible effects on dairy productivity in endemic areas. Further, studies by Orodho (2006) indicate that unless resistant varieties to NSD are developed, the small holder dairy industry would seriously be affected.

There are potential economic losses that do occur in the case of the emergence of a disease or a pest to the crops or livestock. The economic simulation model in the analysis of the likelihood of the emergence of Soya bean rust in the U.S depicted that growers in the infected areas suffer reduced profits since production is reduced and costs increased (Kuchler *et al*., 1984).

A collaborative study by crop scientists, working with livestock researchers and socio-economists in southern India, has confirmed that plant diseases, which affect grain yield of crops, also affect the quantity and nutritive value of residues for use as cattle fodder. The study, funded by the UK Department for International Development, has shown that farmers earn significantly less when cattle are fed on diseased fodder, because of the poor quantity and quality of the milk produced. Results indicate that improvements in digestibility of only a single percentage unit could result in an increase in the value of milk, of 3-11% (New Agriculturalist online).

However, there has been little effort to determine objectively the effects of Napier Stunt Disease on the small-holder dairy productivity in the affected areas. This study pioneered work on the socioeconomic effects of NSD on small-scale dairy cattle production in selected sites in Bungoma District, Western Kenya.

2.6 THEORETICAL FRAMEWORK

2.6.1 Theoretical framework

Although the Napier stunt disease is a risk to farmers (producers) the producers still make the choice of planting the Napier grass. The producers face two types of risks, production and price risks. Production (or yield) risks are those which arise because of natural causes such as variation in rainfall, weather, pests or diseases (Valdes and Konandres, 1981).

Production theory which is the conversion of inputs to outputs as described in micro economics (Davis, 2004) forms the premise for this study. In a broader definition, production theory entails the different combination of inputs (factors of production) to maximize output (Mansfield, 1994). The factors of production are land, capital, management and labour. .

A general production function is expressed as

$$Y = f\left(X_i\right) \qquad \text{.......1}$$

where X is a vector of inputs (Capital, Labour and Land). The general production function has a set of assumptions. The common assumptions are that resources are scarce relative to their demand, inputs combine in a scalar ratio, production function is assumed to yield maximum output for arbitrary input vector, and that for a unit increase in input output increases by the same ratio.

It is postulated that milk yield will be influenced firstly, by the proportion of the farm area under Napier grass and secondly by the proportion of the area under Napier grass affected by NSD. It is hypothesized that less quantities of Napier from the affected lands will result in lower gross margins from the reduced yield of milk and milk sales. Orodho, (2004) postulated that an acre of clean Napier grass can sustain four dairy cows, but a similar acreage of land affected by the disease can only support generally two dairy cows, thus greatly reducing milk yields and incomes from the sale of milk.

Farmers have been forced to buy Napier grass to compensate for the declining production due to the Napier stunt disease and thus the sale of Napier grass too has an effect on gross margin levels of the farmers (The Organic Farmer, 2005). Some famers do sell Napier grass to those that do not have enough land to plant Napier. The affected Napier grass will not sell and thus lower the incomes.

The push pull technology or strategy has a direct effect on the gross margins. A study in the economics of Push pull by Khan *et al*. (2001) reported a cost benefit ratio of 2.2 in PPT relative to 0.8 from conventional farmers' practices.

The yield of milk is also affected by the farming experience of the farmer. A farmer who has a long experience in managing the farm and even in controlling the spread of the Napier Stunt disease will most likely produce more milk and thus generate more income from milk sales. On the other hand, farming experience may come with advances in age and management of the farm becomes compromised since the farmer may not have the energy and strength to manage the farm before old age (Orodho, 2002).

Gender has a major role to play as regards the yield of milk. In most of the farms that are managed by women, milk yield is always found to be higher than in farms managed by men (Jahnke, 1982). This could be due to the fact that most women are housewives in the rural set up and they can easily manage the cattle while doing other home chores. The number of cattle a farmer has will have influence on the amount of milk that will be received in his or her farm. The price of milk will have a direct relationship with the gross margin levels. High milk prices results to higher gross margin.

Gross margin and yield of milk will also determine the welfare of the farmers and their household. They will thus receive other benefits, for example, they can sustain the income to generate other economic activities and at the same time to provide for their necessities. Lower income levels will thus result to reduced benefits to the households.

CHAPTER THREE

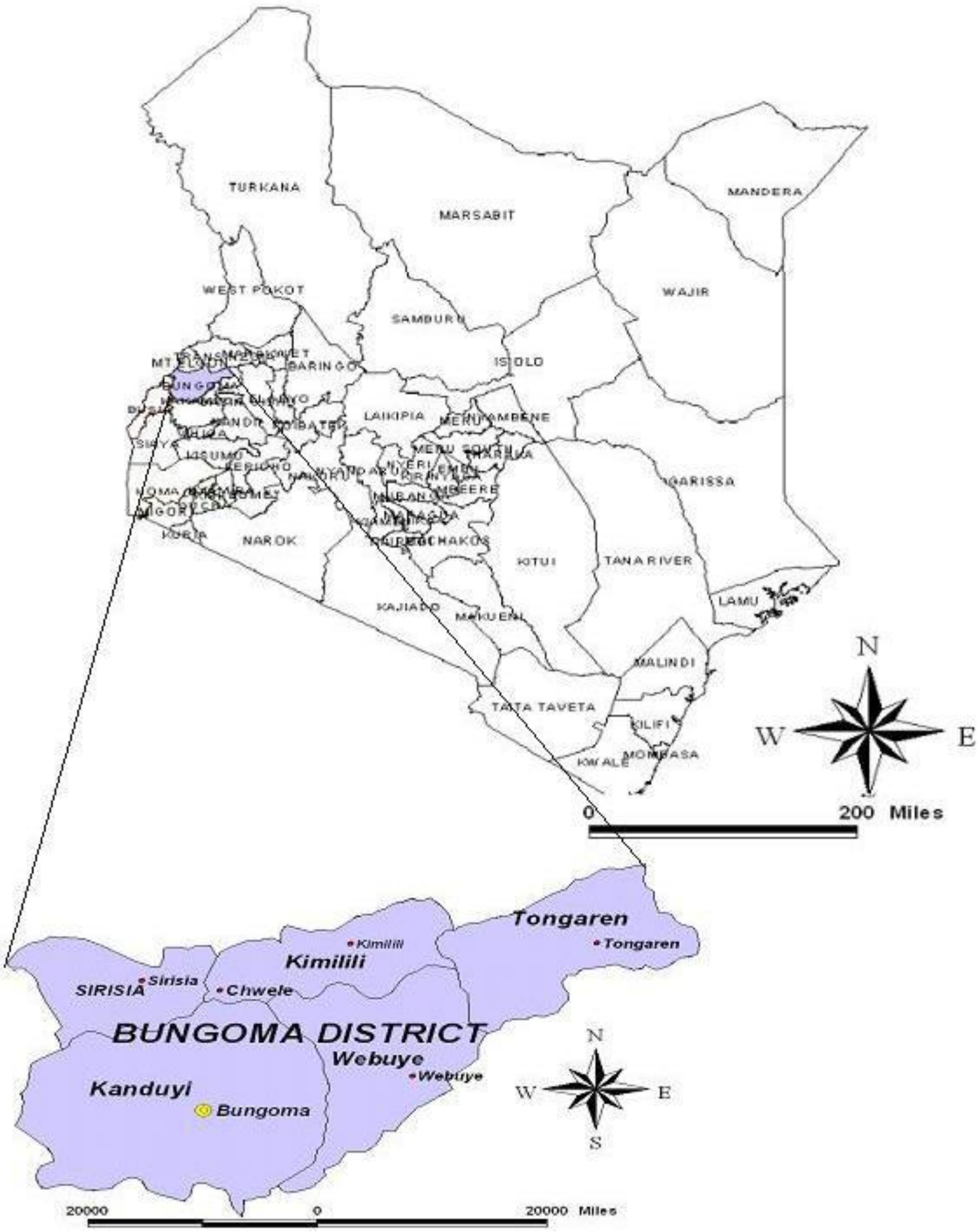
METHODOLOGY

This chapter on methodology entails the study area of the project, sampling design ad techniques, data collection and analysis, data processing and empirical analysis.

3.1 STUDY AREA

The study was conducted in the then wider Bungoma District where the prevalence of the disease is very high. Two divisions were purposively selected for the study, that is, Bungoma South and Bungoma East divisions. The two were purposively selected because it is where the disease prevalence is high and the push pull technology or strategy is also practiced. Bungoma is located in Western Kenya and borders Uganda. 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 Districts to the East, Busia District to the West and Teso District to the South West. Bungoma lies between latitude 0°25.3’ and 0° 53.2’ north and longitude 34° 21.4’ and 35° 04’ east. It covers an area of 2,068.5km^2, which is about 25 per cent of the total area of Western Province. Currently, the population of the greater Bungoma District is approximately 1.3 million people. Bungoma District, which was the second largest District in Kenya before the presidential decree to create more districts, has been recently sub-divided into four administrative districts: Bungoma South, North, West and East. However, the four administrative units are not autonomous and are still dependent on Bungoma South District which has Bungoma town as its headquarters (DDP, Bungoma 1996). Fifty six percent of the population lives on less than one US dollar / day.

Figure 1: Map of greater Bungoma District



3.2 SAMPLING DESIGN AND TECHNIQUES

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 65 respondents practicing the technology and another 65 respondents who did not practice PPT from the ten sub-locations. This resulted to a sample of 130 respondents for the study.

The actual sample size was calculated using the formula below (Kothari, 2004).

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

where; n = Sample size, Z= confidence level

p = proportion of the population, q = 1-p, E= allowable error.

since the proportion of the population is not known, p is considered as 0.5, and hence q= 1-0.5=0.5.

Z=1.96 at 95% confidence level and E=8.5%

therefore,

$$n = 0.5 * 0.5 * \left[\frac{1.96}{0.085}\right]^2 = 132.92 \approx 130$$

3.3 DATA COLLECTION AND DATA ANALYSIS

Primary data were collected through a cross sectional survey, using structured questionnaires in the larger Bungoma district in Western province. A total of 130 farmers were sampled from two divisions of Bungoma South and Bungoma East. The two divisions were selected because of the high prevalence of the (NSD) and also having a high proportion of small-holder dairy farmers that practice the PPT. The questionnaire was designed to collect information on general household and socio-economic characteristics. The major information collected was on socio-economic characteristics such as age, education, gender, farm ownership, land size, household size, access to credit, access to extension services and distances to the market. Variables used to calculate the gross margin included the number of cattle, the milk yield per cow, and the cost of the inputs.

3.4 DATA PROCESSING

The data collected were processed using Statistical Package for Social Scientists (SPSS), STATA and Microsoft Excel. This included aspects like editing, coding, classification and tabulations. Processing of data yielded to descriptive analysis i.e. means, percentages, frequencies and crosstabs that were computed to generate social economic profiles of sampled producers and traders. The data collected were used in further analysis by use of models. In addition, chi-square was used to find out the significant difference to expect in the two or more sample means under comparison (Maddala, 1998).

3.5 EMPIRICAL ANALYSIS

There are different production functions with additional and specific assumptions. The use of a particular function depends on the nature of the problem. Using the Cobb-Douglas production function one incorrectly imposes risk-increasing effects of all inputs, and as a result, the optimal level of inputs (and output) must increase (Just and Pope, 1978). Consequently, incorrect conclusions are drawn in evaluating policies, i.e. planting Napier grass may imply increased risk, but actually the utility loss of a risk averse farmer will be greater than the one incorrectly estimated.

A study by Richard *et al.*, *(*1983) estimated a Log-linear Cobb-Douglas model using 2SLS to capture the effect of input mix on output in Southern Israel. Glewe and King (2001) and Brumm and Cloninger (1995) also made similar use of 2SLS. Logarithmic Cobb-Douglas type model has therefore widely been employed in production studies including studies on effect of credit on production and hence suitable for this study.

Of possible algebraic functions, Cobb-Douglas functions have been the most popular in farm analysis. This model provides a compromise between (a) adequate fit of the data, (b) computational feasibility and (c) sufficient degrees of freedom. In other words, the function is relatively "efficient user' of degrees of freedom. Such efficiency is important where research resources are limited and collection of farm data is expensive.

3.5.1 Determination of farmers' opinions on the extent of NSD infestation on farms

To achieve this objective, descriptive statistics were used. They entailed statistical analyses to determine the mean, percentages, frequencies and likert scale techniques in order to assess farmers' opinions on the extent of NSD infestation on their farms.

The study focused on farmers' views and opinions on the extent of NSD and also on its effects on dairy farming. The data collected included, disease risk perception, identification of disease by the farmers, their sizes of land that have been affected by the disease and also the effect of the disease on yield of milk. Disease risk perception was measured using the likert type scale on a three point scale with 1= Low, 2= Moderate, 3=High. There was also data on whether the farmers obtain extension services with regards to Napier Stunt disease. The frequencies, percentages, mean and cross tabulations were generated during analysis.

Cobb-Douglas production function was used to estimate the effects of NSD on milk production.

3.5.2 Determination of effects of NSD on milk production

The study sought to assess the effects of NSD on milk production and the Cobb Douglas production function was used to get the results. Table 1 illustrates the variables that were used to determine milk production. Key variables included those that were used in the second stage of the model and they were: milk price, total variable cost of production, number of cattle owned, access to extension service, access to credit, use of push-pull technology or strategy, gender of the respondents and farming experience.

Table 1: Description of variables for the Cobb Douglas two stage least squares

Abbreviation	Variable Name	Description	Expected Sign
Gender	If decision maker is male/female (male=1,female=0)	Dummy	-
ppt_prac	push pull adoption	1 if yes, 0 otherwise	+
feed_alt	If decision maker uses alternative feeds	1 if yes, 0 otherwise	-
Credit	Access to received credit	1 if yes, 0 otherwise	+
ext_serv	Access to extension services	1 if yes, 0 otherwise	+
Lnlandpr	log land proportion under NSD	Acres	+
Lnnocatt	Log for herd size	Number of cattle	+
Lnlnnap	log for area under napier grass	Acres	+
Lnlandsi	Log land size	Acres	+
Lnfarmyr	log for farming experience	Years	-
Lnmilpr	log for milk price	Kshs	+
Lnmilkyi	log for yield of milk	Litres	+

Since area of land under Napier Stunt Disease is an indirect variable influencing yield of milk and conditioned by direct variables such as farming experience, size of land and area of land under Napier grass, direct regression would result to inconsistent and inefficient parameter estimates. To avoid this, Two Stage Least Squares (2SLS) estimation method is used.

The estimation method is made up of two equations, which are run simultaneously using the [1]ivreg command in Stata that corrects for multicollinearity of the endogenous

[1] This ivreg command procedure is being done to take care of multicollinearity between farming experience (lnfarmyr) and error term

The ivreg command (or two-stage least squares; 2SLS) is designed to be used in situations in which predictors are endogenous. In essence, ivreg estimates two equations simultaneously.

explanatory variable with the purely exogenous variable (milk yield). The two equations are represented as follows:

Stage One:

$\ln Y = \alpha + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \beta_3 \ln X_3 + \mu$ 2

where, Y is the proportion of the Area under Napier Stunt Disease (acres), X_1 is land size (acres), X_2 is the area under Napier (acres), and X_3 is farming experience

This functional form is derived from a Cobb Douglas of the form:

$$Y = \alpha X_1^{\beta_1} X_2^{\beta_2} X_3^{\beta_3} \mu$$

Stage two:

$\ln Z = \alpha + \beta_4 \ln Y^* + \beta_5 \ln X_4 + \beta_6 \ln X_5 + \beta_7 \ln X_6 + B_a D_a + B_r D_r + B_c D_c + B_e D_e + B_f D_f$
$+ \mu$...3

where, $\ln Z$ is the natural logarithm of milk yield (Litres per acre), α and β are coefficients to be estimated, α is a constant term, X^* is the predicted value of the proportion of the area of land under Napier stunt disease (acres), X_4 is price of milk (Ksh/litre) X_5 is farming experience, X_6 is the herd size (number of cattle), D_a is the dummy for alternative sources of feed other than Napier grass, D_r is the dummy variable for PPT(1=PPT adopter 0=Non PPT adopter), D_c is access to credit dummy (1=access to credit, 0= otherwise), D_e is access to extension services dummy (1=access to extension services, 0= otherwise), D_f is gender of the farmer dummy (1-Male, 0-female), and μ - is the error term.

Now we have the situation in which X_1 , X_2 and X_3 are exogenous and are instruments used to predict Y which is treated as an endogenous variable.

ln $Y*$ is used to indicate that it is the instrumented form of the variable x that is being used.

Farming experience has been used as an instrumental variable because it correlates with the endogeneous explanatory variables and it does not correlate with the error term in the explanatory variable. In other words, it is variable that does not itself belong in the explanatory equation and is correlated with the endogenous explanatory variables, conditional on other covariates.

A test for multicollinearity as shown in Appendices 2 and 3 showed that no variable was correlated to another one. The VIFs of all included variables were less than 10, which indicated that multicollinearity was not a serious problem in the reduced model.

3.5.3 Determination of the effects of NSD on the household income

The Regression Model

A linear multivariate regression model was used to determine the effects of the NSD and other variables on the household milk income. Linear regression refers to any approach to modeling the relationship between one or more dependent variables denoted by y and one or more independent/explanatory variables denoted by X, such that the dependent variable depends linearly on the unknown parameters to be estimated from the data. The general form of the relationship is presented in equation 6 (Theil 1997; Debertin 2002).

$$\boldsymbol{Y = a + bX} \quad \ldots\ldots\ldots \quad 6$$

where $\boldsymbol{X}$ is the set of explanatory variables and $\boldsymbol{Y}$ is the dependent variable. The slope of the curve is $\boldsymbol{b}$, and $\boldsymbol{a}$ is the intercept (the value of $\boldsymbol{Y}$ when $\boldsymbol{X} = 0$).

A study by Khuda, *et al*., (2005) on "Impact assessment of zero-tillage technology in rice wheat system: a case study from Pakistani Punjab", the gross margin was calculated and used as a dependent variable to run a regression. Regression analysis was used to test for the level of relationship or significance between the gross margin (dependent variable) and marketing costs (independent variables).

Y = f(X1, X2, X3, X4, e)

where

Y = gross margin (dependent variables)

X1 – X4 = marketing costs (independent variables, which include: transportation costs, labour cost, storage cost and trading material cost)

X1 = Transportation Cost

X2 = Labour Cost

X3 = Storage Cost

X4 = Trading Material Cost

e = Error term

Gross margin (Gross income minus total variable cost) per hectare as response function was estimated by using ordinary least squares (OLS). Functional forms considered were quadratic, Cobb Douglas type, semi-log and linear. The linear form showed a good fit.

Similar and related studies that have adopted the gross margin and linear regression models have been done by Huong (2009) on emerging supply chains of indigenous pork and their impacts on small scale farmers in upland areas of Vietnam, and also a study by Pham, (2007) on production and marketing of indigenous pig breeds in the uplands of Vietnam adopted the same model for analysis.

The gross margin for this study was computed as shown in equation 7;

$$I = \sum_{i=1}^{n} \left\{ \sum \left(P_i Y_i \right) \right\} - \sum_{i=1}^{n} \sum_{i=j}^{n} W_i X_j \ \} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 7$$

where; I is gross margin, P is the price of milk, Y is the quantity of milk produced, W is the price of input used, X is the quantity of input used.

The gross margin per cow per month was derived from total revenue (Sales of milk) less the total cost.

Major variable costs were classified as feeding costs (including Napier and dairy meal), labour costs, veterinary costs and other miscellaneous expenses.

Cost of Napier production per year was used as a proxy for the value of Napier grass fed to the animals.

Total revenue was obtained from daily milk production per cow multiplied by number of days the cow was milked per month.

Finally, the gross margin per month per cow was obtained by subtracting total cost per cow per month from the revenue per cow per month. Appendix 4 shows the summary of the variables used to obtain the gross margin.

Table 2: Description of Variables used in the gross margin model

Abbreviation	Variable Name	Description	Expected Sign
hous_siz	Household size	Numbers	-
ppt_prac	push pull adoption	1 if yes, 0 otherwise	+
milk_aft	Amount of milk produced	litres	+
milk_pri	Price of milk	Kshs	+
Age	Age of the respondent	Years	+
Mrtstatu	Marital Status of the respondent	1=male 0=female	-
nsd_ext	Access to extension services	1 if yes, 0 otherwise	-
Credit	Access to received credit	1 if yes, 0 otherwise	+
nsd_prop	Proportion of land under NSD	Acres	-
land_nap	Area of land under Napier grass	Acres	+

Table 2 above shows the description of Variables used in the gross margin model.

In this study the following empirical model was used:

$$\ln gm = \alpha + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7 + \beta_8 X_8 + \beta_9 X_9 + \beta_{10} X_{10} + \beta_{11} X_{11} + \mu \quad \text{……….8}$$

where $\ln gm$ is the natural log for the gross margin, X_1 is age of the household head in years, X_2 is the marital status of the household head, X_3 is the is household size, X_5 is the push pull practice, X_6 is proportion under Napier that is affected by NSD, X_7 is the size of land under Napier grass, X_8 is access to credit, X_9 is the access to extension services on NSD, X_{10} is the milk production after the inception of NSD, X_{11} is the current price of milk and μ is the error term. The significance of each variable was assessed using the *P*-value.

CHAPTER FOUR

RESULTS AND DISCUSSIONS

This chapter covers the results and discussions of the study. The section covers socioeconomic characteristics, descriptive statistics to assess extent of NSD, Cobb Douglas production function results and the gross margin model results.

4.1. SOCIOECONOMIC CHARACTERISTICS OF SAMPLED HOUSEHOLDS: A DESCRIPTIVE ANALYSIS

4.1.1 Marital status and gender of the respondents

The majority (90%) of the farmers were married while the rest were single. Twenty two percent of the respondents interviewed were women while the rest were men. Table 3 shows the varied percentages of the two variables across the divisions. Using the t- test, 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 marital status of respondents in the divisions. The majority of the respondents were men, implying that they are the head of the household and most of the decisions lie on them. The variation in percentage of the marital status across the divisions was not wide as compared gender.

Table 3: Marital status and gender of the respondents

Variables	**Divisions**					**χ^2(Chi square)**
	Malakisi	**Bumula**	**Sang'alo**	**Webuye**	**Kibabii**	
Marital status (%):						
Married	92	91	88	95	85	29.431***
Single	8	9	12	5	15	
Gender (%):						
Male	77	78	91	91	50	39.877
Female	23	22	9	9	50	

******* Statistically significant at 1%.

4.1.2 Age of the respondents

Table 4 shows the age distribution in numbers of the respondents as per the age. Most farmers were in the 40-51 bracket of age. It shows that the farmers were actively involved in farming before old age would catch up with them. Most of the men and women below 28 years were rarely involved in farming because most of them were pursuing education at different levels.

Table 4: Age of the respondents

Variable	**Divisions (Frequencies)**					
Age	**Malakisi**	**Bumula**	**Sangalo**	**Kibabii**	**Webuye**	**Total**
28-39	5	3	4	8	7	27
40-51	10	11	9	9	10	49
52-63	7	8	8	6	6	35
64-75	1	2	5	1	1	10
76-83	1	2	1	2	2	8
Total	24	26	27	26	26	129

The results being a representative of the larger population, they imply that most farmers are of the age of forty nine years. Normally, it is at this age that people have settled homes and mostly dwell in the rural areas where they can do their farming.

4.1.3 Experience of farming

Table 5 shows the mean number of years of farming, as a proxy for farming experience, and planting Napier across the five divisions. The number of years of farming and planting Napier grass each varied across the divisions with an average of 19.51 and 9.08

years respectively in the district. There was no significant difference in number of years in planting Napier grass in the divisions, [t (129) = 15.79, p>0.05]. There was also no significant difference in number of years in farming in the divisions, [t (129) = 17.73, p>0.05].

Table 5: Number of years in farming and planting Napier grass

Name of the division	Mean number of years in planting Napier grass	Mean number of years in farming
Malakisi	9.00	19.12
Webuye	7.96	15.69
Sangalo	7.88	19.79
Kibabii	8.95	22.14
Bumula	12.30	21.35
Overall mean	9.08	19.51

4.1.4 Credit and Extension Services

Approximately 40.8% of the total respondents received extension services regarding NSD while 28.5% of them received credit for the last five years as is presented in Table 6. This indicates that very few farmers received both extension services and credit facilities. This would negatively affect the performance of their farm activities since these services greatly promote agriculture in terms of purchasing inputs and managing them as well.

Table 6: Credit and extension services with regards to NSD (N=130)

Variable	Frequency	Percentage
Access to credit facilities (Yes = 1)	37	28.5
Access to extension services with regards to NSD (Yes = 1)	53	40.8

4.1.5 Land size distribution across the divisions

The land holdings (in acres) owned by the farmers across the five divisions is presented in Table 7. The overall relationship between land size and the divisions was statistically significant, [t (129) = 14.22, p<0.05]. The variation of land sizes across the divisions did not highly differ. Malakisi had the highest mean while Kibabii had the lowest. Most of the farmers in malakisi had large pieces of land compared to the other divisions. The farmers in Malakisi are able to plough more land and have higher yields if all other factors of production are held constant.

Table 7: Average land size distribution across divisions studied (N=130)

Variable	Divisions(means)					Total
	Malakisi	**Bumula**	**San'galo**	**Kibabii**	**Webuye**	
Average land size in acres	5.36	5.11	6.89	4.39	5.92	27.76
Percentage of ownership	19.3%	18.4%	24.81%	15.81%	21.32%	

4.2 DESCRIPTIVE STATISTICS TO ASSESS EXTENT OF NSD

4.2.1 Proportion of farmers' farms affected by Napier Stunt disease

The majority (98.5%) of farmers were having the disease on their Napier grass as shown in Table 8 below. This indicates that most of the farms in the study area are experiencing the adverse negative effects of the disease and it is negatively affecting their yield and subsequently their dairy production. Therefore, urgent measures are needed to curb the disease so that the farmers are able to enjoy the benefits of dairy farming.

Table 8: Proportion of farmers who indicated being aware of the disease on their farms (N=130)

Variable	Frequency	Percentage
Awareness of disease on the farmers' farms (Yes=1	128	98.5

4.2.2 Farmers affected by the disease, identification and perception

Table 9 indicates that all (100%) respondents interviewed indicated prevalence of NSD on their farms based on the symptoms of the disease as yellowing of leaves and stunted growth (92.3%), black spots on the stems (2.3%) and thin stems (5.4%). All the farmers (100%) were affected by the NSD. Disease risk perception was viewed as low, moderate and high by 32.3%, 53.1%, and 14.6% of the farmers, respectively. There was moderate risk perception because the farmers were trying to cope with the disease by using alternative feeds or if they can't afford they still feed their cattle with the affected Napier grass. The results indicate that the farmers can identify the unhealthy Napier grass and their perception on the disease shows that the disease is risky and is negatively influencing their livelihoods.

Table 9: Farmers affected by the disease, the identification and perception (N=130)

Variable	Frequency	Percentage
Farmers affected by disease	130	100
Yes=1		
Identification of the disease		
Yellowish leaves in color and stunted growth	120	92.3
Black spots in stems	3	2.3
Thin stems	7	5.4
Disease perception		
Low	42	32.3
Moderate	69	53.1
High	19	14.6

4.2.3. Size of land under Napier grass and proportion affected by NSD

Table 10 shows the proportion of land affected by NSD varied across the divisions. Overall, the average land size affected by NSD was 0.63 acres. The size of land under Napier grass and the divisions was statistically significant ($p<0.05$), which implies that there wasn't a high variation in sizes of land for each of the divisions as compared to each other. The results indicate that the sizes of land with Napier that have been affected by the disease were almost close to the overall size of the land panted with the grass. This means that the NSD affects the Napier grass to a great extent such that the yields are compromised.

Table 10: Size of land under Napier grass and proportion affected by NSD

Variable	Divisions				
	Malakisi	Bumula	San'galo	Kibabii	Webuye
Mean size of land under Napier grass (acres)	0.76	0.75	1.75	0.99	1.38
Mean size of land affected by NSD	0.44(57.89)	0.34(45.33)	0.89(50.85)	0.56(56.56)	0.70(50.72)

Note: Figures in parentheses represent proportion/percent of land under Napier grass affected by NSD

4.2.4 Milk production before and after inception of NSD across the divisions

The results presented below show the number of cattle that the farmers had before the disease compare to after the disease infested their Napier grass and it also further shows the milk production before and after the inception of the disease. As a result of the incidences of NSD, the average number of cows per farmer declined from 4.74 to 2.95, while the average milk production concomitantly reduced from 8.9 to 6.29 liters per cow per day (see Table 11). Milk production before the infestation of NSD and the divisions was statistically significantly different from zero [$t(129) = 15.82$, $p<0.05$] so was the milk production after infestation of NSD [$t(129) = 18.56$, $p<0.05$] meaning that there was a wide variation in production of milk across the divisions. NSD has significantly reduced milk production in the five divisions since its infestation. The trend is likely to continue if the disease is not contained. This is likely to affect negatively farmers' production, incomes, and general livelihoods.

Table 11: Mean milk production (in liters) before and after NSD outbreak across the divisions

Variable	Divisions						P-value
	Malakisi	Bumula	Sangalo	Kibabii	Webuye	Average	
1 a). Number of cattle before NSD	3.92	4.65	4.76	2.77	4.15	4.05	
1 b). Number of cattle after NSD	2.88	3.00	3.85	1.68	2.62	2.806	
Difference (b-a)	-1.04	-1.65	-0.91	-1.09	-1.53	-1.244	0.020
2 a). Milk production in litres before NSD	8.92	5.99	5.95	8.41	15.60	8.974	
2 b). Milk production in litres after NSD	5.35	4.60	4.21	6.18	11.46	6.36	
Difference (b-a)	-3.57	-1.39	-1.74	-2.23	-4.14	-2.614	0.001

4.3. COBB-DOUGLAS PRODUCTION FUNCTION RESULTS

Table 12 shows the Cobb Douglas 2SLS of factors influencing milk yield. The table also presents the coefficient estimates of the regressions. The model was significant at 1%, with 9 degrees of freedom. The R^2 indicates that the explanatory variables explained 49 % of the variance in the dependent variable. The coefficient is the change in the dependent variable resulting from a unit change in the independent variable while the sign on the coefficient (positive or negative) gives the direction of the effect.

Table 12: Estimates of coefficients of factors influencing milk yield contingent on NSD

Lnmilkyi	Coef.	Std. Err.	T	P>|t|
Lnlandpr	-0.130	0.084	1.550	0.023**
Lnfarmyr	-0.219	0.083	-2.640	0.009**
ppt_prac	0.252	0.125	2.010	0.347
feed_alt	-0.274	0.186	-1.470	0.044**
Gender	-0.179	0.152	-1.180	0.040**
ext_serv	-0.117	0.135	-0.870	0.387
Credit	-0.125	0.135	-0.920	0.358
Lnnocatt	0.916	0.119	7.700	0.000***
Lnmilpr	1.422	0.317	4.490	0.000***
_cons	-3.812	1.129	-3.380	0.001
Number of obs	120			
F(9, 110)	12.070			
Prob > F	0.000			
R-squared	0.496			
Adj R-squared	0.455			

Notes: Coef means Coefficient; Std. Err. is Standard Error

The results in Table 12 therefore indicate varied levels of significance both in magnitude and direction for some explanatory variables. The instruments are shown in Table 1 and are size of land, farming experience, and proportion of the area planted with napier grass and the instrumented variable is lnlandpr as shown in the table above. Several variables were found to significantly influence the yield of milk.

Among the socio-economic characteristics, gender was found to have a significant negative influence on yield of milk. Others which had negative influence, included farming experience, land under NSD and use of alternative feeds. Milk price and number of cattle had a positive influence on yield of milk.

Most of the variables which significantly affected milk yield were as per the expectation. Gender, that is change in farm management from female to male significantly influenced negatively yield of milk. This is clearly demonstrated by the milk decline of 0.179 litres as the management changed from female to male. This could be attributed to the fact that many women are housewives and have time to manage the dairy cows. Gender is a socio-economic variable, which is being used to analyze assigned roles, responsibilities, constraints, opportunities and incentives of people involved in agriculture. Gender roles and responsibilities in agricultural production systems vary from region to region according to culture, religion and socio-economic conditions (Jahnke, 1982).

As compared to crop production, the participation of rural women in livestock related activities is much higher. A majority of the females are engaged in fodder cutting, watering, cleaning of animals and their sheds etc. Milking the animals and milk processing are tasks that have also been attributed to the women folks. Manure collection, preparing dung cakes and the maintenance of animal sheds are also the exclusive activities of rural women (Jahnke, ibid). Overall, and except for grazing, women are involved in almost all livestock related activities from fodder cutting to milk processing. However, the level of involvement varies from one activity to the other (Jahnke, ibid).

Men are largely the decision makers for livestock production and are in charge of general herd management. However, women generally contribute more labour inputs in areas of feeding; manage vulnerable animals (calves, small ruminants, and sick, injured and pregnant animals), cleaning of barns, dairy-related activities (milking, butter and cheese making), transportation of farm manure and sale of milk and its products than men and children. Men own most of the livestock species and put up for sale animals and meat (Jahnke, 1982).

Constraints to livestock production such as lack of capital and access to institutional credit, competing use of time, poor technical skills and lack of access to improved extension services affect women more than men, and may further limit the participation of women and their efficiency in all-purpose livestock production (Niamir and Turner 1999).

Farmers who used alternative sources of feed other than Napier grass realised a drop in milk yield (coefficient = -0.274). The results indicate that a unit increase in the use of alternative feeds reduced the milk yield by 0.274 units The drop in milk production could be attributed to the inferior quality of the alternative feeds to Napier grass. This partly explains why Napier grass is widely used as feed and is the most preferred grass despite the infection by the NSD.

In parts of eastern Uganda and western Kenya, market prices for alternative feeds have doubled in the last year, as farmers have been forced to buy feeds to compensate for declining Napier production (Talim, 1998). This has made the disease have a significant negative effect on animal production since it is costly to buy the alternative feeds, which many farmers cannot afford and certainly, it decreases meat and milk production (Talim, 1998).

A negative relationship was reported for land under NSD and milk yield. This implies that NSD has resulted into low milk yields mostly due to tendencies by farmer to reduce their herd size (from two to one) as a result of reduced Napier to feed the cattle. The results indicate that a unit increase in acreage of the land under NSD reduced the milk levels by 0.130 units. The reduction of total milk yield was being attributed to the decline in herd size as a result of reduced Napier to feed the cattle since there was a drop in biomass. A related study by Orodho, (2006) indicates that while a healthy acre of Napier grass would provide enough feed to sustain four productive cows, plots affected by the disease may support only one or two animals, greatly reducing milk yields and income. This author also observed that many small holders who had lost up to 100 percent of their Napier grass because of the NSD had been forced to de-stock or sell off their entire herd.

A negative relationship was observed between milk yield and farming experience. Although it is observed by Niamir (1990) that the farmers with more experience have the ability to properly manage the farms hence higher yields in milk. However this observation is contrary to the findings in this study. Orodho and Ajanga (2002) postulated that the disease is much more severe and prevalent in poorly managed fields. This has been observed by farmers who have decreased incidences in stands of Napier grass that are well-weeded and sufficiently manured.

A positive relationship was observed between milk price and the yield of milk. In reality, high milk prices act as a motivation to farmers to produce more. Therefore, consistent high milk prices may stimulate increases in milk production and correspondingly increases in gross margins. Market milk prices are reflective of a number of supply, demand and policy factors (Muriuki *et al*., 2003). Higher market prices may imply that the demand for the milk has gone higher or the supply of milk is lower to meet the demand. The government could also set a price depending on the prevailing economic status of a particular commodity.

The study revealed a positive relationship between the number of cattle and milk yield. This observation is expected since milk yield is a function of herd size, and particularly the number lactating dairy cows.

4.4. GROSS MARGIN MODEL RESULTS

The results in Appendix 4 indicate an average monthly gross margin per cow of Ksh 2758.9. Webuye had the highest estimate (KES 4325) followed by Kibabii (KES 4123). Sang'alo, Bumula and Malakisi each had an estimated gross margin of 1433, 2689 and 1782, respectively. Gross margins were higher in Webuye and Kibabii and this could be due to the high prices of milk per litre (Ksh 36 and Ksh 40), respectively (Appendix 4) .The major costs on the farms were mainly related to labour and feeding (Napier grass and concentrates).

Table 13 shows ordinary least square estimates of factors influencing gross margin per cow per month, at farm level. The table presents the coefficient estimates of a linear regression on factors influencing gross margin. The model was significant at 1%. The R^2 indicates that the explanatory variables are explained 63 % of the variation in the dependent variable.

Table 13: Ordinary Least Square estimates of factors influencing gross margin per cow per month at the farm level

Gross margin in logs	Coef	Std. Err.	T	P>|t|
hous_siz	0.035	0.018	1.550	0.100*
ppt_prac	0.020	0.221	1.090	0.025**
milk_aft	0.050	0.024	2.660	0.009***
milk_pri	0.123	0.011	11.540	0.000***
Age	0.245	0.011	-0.560	0.579
Mrtstatu	0.001	0.170	-0.140	0.745
nsd_ext	0.285	0.249	0.920	0.361
Credit	0.327	0.250	-1.890	0.022*
nsd_prop	-0.865	-0.182	-0.980	0.052**
land_nap	0.305	0.162	0.960	0.105*
_cons	1.605	0.739	1.890	0.061
Number of obs	129			
F(11, 117)	24.39			
Prob > F	0.000			
R-squared	0.635			
Adj R-squared	0.615			
Root MSE	1.248			

Notes: [1]See table one for definition of variables; Coef means Coefficient; Std. Err. is Standard Error

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

Factors influencing the gross margin per cow per month as response function were estimated by using ordinary least squares (OLS) (Table 13). A log-linear regression model was employed to identify factors influencing the gross margin levels at the farm level.

The coefficient is the change in the dependent variable resulting from a unit change in the independent variable while the sign on the coefficient (positive or negative) gives the direction of the effect. Seven variables were found to significantly influence the gross margin.

Among the socio-economic characteristics, house hold size was found to have a significant positive influence on gross margin per cow. Others which had positive influence included use of push pull practice, land under Napier grass, milk yield after inception of NSD, access to credit and price of milk.

Most of the significant variables were as per the expected signs. Household size significantly influenced gross margin implying that a one unit increase in household size leads to an increase in gross margin by Ksh. 0.035. Often, household size is used as a proxy for the availability of farm labour. This is to say that a large family is likely to provide adequate family labour which is much cheaper than the hired labour. This is likely to lead to an improvement in gross margin per cow. Farmers should be encouraged to exploit family labour.

As expected, there was a positive relationship between application of push pull practice on the farm and gross margin per cow. The results indicate that farmers who were practicing push pull were likely to realise high gross margin levels compared to those who were not using the practice (coefficient = 0.020). The results shows that by practising push pull technology there is an increase in gross margin by Ksh. 0.020 These results suggest that adoption of push pull practice leads to increase in milk yields and hence the gross margins. In a study on the economics of push pull technology or strategy, Khan *et al*. (2001) reported a cost benefit ratio of 2.2 in PPT relative to 0.8 from conventional farmers' practices in the entire study region. However, the inception of NSD has posed a serious challenge to the production of Napier grass. This study sought to establish the effect of NSD on gross margin per cow. The results indicate a significant negative influence of the proportion of land under Napier grass that is affected by NSD. The coefficient indicates that a unit increase in the land affected by NSD reduced the gross margin by a factor of 0.865. This compels the need to intervene to control NSD to manageable levels towards improving the gross margin.

A positive relationship was also reported for land under Napier and gross margin per cow. The result indicates that a unit increase in the land under Napier increased the gross margin levels by 0.305 units.

Expectedly, there was a positive relationship between milk yield and gross margin. The result indicates that a unit increase in milk yield leads to a 0.050 unit increase in gross margin per cow. This observation is fairly consistent with what has been reported in literature. In a study on relationships between technical, economic and environmental results on dairy farms in Netherlands, Rougoor *et al.* (1997) observed a positive relationship between milk yield and gross margin arguing that farms with higher milk yield per cow had lower feed costs due to lower maintenance requirements.

Similarly, a positive relationship was observed between milk price and the gross margin per cow. This is consistent with the norm in which high milk prices act as an incentive to farmers to produce more. Consequently, consistent increase in milk prices would imply increases in milk output and correspondingly increases in gross margin. Low gross margins for milk have been reported in Ethiopia (Ergano and Nurfeta, 2006). This was mainly attributed to low average milk yield and high feed cost. It has been argued that factors that could either reduce or increase expenses are in fact a source of risk to economic performance of the dairy business (Bailey, 2001). Some of these risks include milk prices, commercial feed prices, hired labour, crop /forage production among others. While one can tell the milk price right away, it is often difficult to measure milk production costs and profits (Bailey, ibid). The cost of milk production and its profitability is also affected by factors that determine farm-gate milk prices across the rural areas of Kenya (Muriuki *et al.*, 2003). As is evident in this study, increase in milk price has a positive influence on gross margin.

Access to credit facilities had a positive significant relationship with the milk gross margin. By farmers accessing credit, they can easily acquire inputs and materials to boost their dairy industry, thus produce more milk and hence achieve higher gross margins. The expected relationship between the gross margin per cow and cost of production was negative, but not significant.

The implication of this study is for the farmers, through the extension service, to seek for control measures of the NSD. Previous studies as reported in the News Agriculturalist Report, 2005 have demonstrated that uprooting infected plants and replacing them with healthy canes has been applied with some success. It has been proven that the soil around infected plants cannot harbor the disease, so replanting in the same place is possible (Orodho, 2005). The leaves of diseased plants can be safely fed to livestock - the phytoplasma does not persist in their manure - but roots should be burned or buried. Farmers are encouraged to identify clean planting material, either by selecting canes from parts of their land that are some distance from any infected plants, or by buying planting material from other areas where disease incidence is low.

The extensionists in the District have also been urged to create 'designated clean zones' where unaffected planting material can be obtained for distribution (News Agriculturalist report, 2005). The Government can also intervene to support the farmers by offering credit to enable them buy clean planting materials once they are done with the infected ones. The extension agents can then offer guidance to the farmers on how best to plant the Napier and maintain the farm.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5.1 CONCLUSION

This study was designed to assess the socioeconomic effects of Napier Stunt Disease (NSD) on small holder dairy production in Bungoma District. It is apparent that the significant negative impact of NSD on the yield of Napier grass and on some of the socioeconomic variables studied suggests that there must be appropriate interventions in place to curb the spread of the disease. This study has elaborated on this need and it is envisaged that the outcome of this research will offer scope for additional studies in this area.

The proportion of area under Napier Stunt Disease has had a negative effect on the yield of milk. This calls for a quick solution to curb the disease because it threatens food security and incomes. Applicable measures and strategies together with extension services should be promoted in the region and sensitize farmers on the best remedial measures to be undertaken while awaiting research to come up with a long lasting solution.

Interestingly, gender had a negative influence on milk production. This suggests that there is a relatively poor performance of dairy cows on farms managed by men. It is noteworthy that women play a pivotal role in enhancing dairy productivity. Their roles include the feeding of the dairy cattle, in the production and processing of milk and in the management of the calves. In this study, it was evident that NSD negatively affected dairy cattle on many farms thus reducing the economic empowerment of mostly women farmers.

Price of milk has had a positive relationship on the yield of milk. It is thus important for policy makers to take note of this important aspect and all the relevant stakeholders involved in marketing should then offer correct market prices to the farmers so that they are informed and are able to compete effectively to promote their standards of living.

Overall, the negative effect of NSD on most of the economic variables in the study area is apparent. The NSD is thus leading to decline in area of land under Napier grass which has consequently led to reduced biomass hence reduced feed for the livestock and consequently reduced milk production thus dwindling returns of the small holder farmers in the area. Thus, there is need for more studies in research to come up with a long lasting solution of curbing the disease.

5.2 RECOMMENDATIONS

Research

It is apparent from this study that the role of research towards addressing the Napier Stunt Disease (NSD) cannot be overemphasized. Short term efforts that include adoption of appropriate agronomic packages such as uprooting and burning of all diseased plants and establishing new Napier grass stands after six months, and the application of correct quantities of manure and inorganic fertilizer have been recommended and should be promoted for increased adoption by the affected farmers. However, there is need for researchers to seek for long term solutions that include the development and release of Napier grass varieties tolerant to NSD. This, coupled with the application of sound agronomic practices, would greatly assist in arresting further the spread of the diseases and consequently reduce the decline in economic losses experienced by the affected farmers. To achieve this, it would need concerted efforts of multidisciplinary teams that should include: pathologists who will be able to diagnose the root cause of the disease, agronomists who will specialize in areas such as irrigation and drainage, plant breeding, plant physiology, soil classification, soil fertility, weed control, insect and pest control. , animal nutritionists who can best advice on alternative feeds to substitute Napier grass and germplasm experts who can collect genetic resources and breed them to a resistant variety. Additionally, further socio economic studies would elucidate some of the production constraints within the affected farms.

Technology transfer

It is needless to over-emphasize the fact that the technological packages emanating from research should receive wider dissemination for increased adoption by affected farmers. This study reveals that extension services to sensitize farmers on the negative socioeconomic effects of the NSD on dairy cattle productivity were minimal. The study recommends that there should be increased efforts to disseminate and upscale extension services as regards the short term control of NSD to affected farmers in the study area. This would be attained through strengthened research - farmer - extension linkages. The development of extension and farmer manuals would be ideal in informing the affected farmers better on the options of addressing the problem.

Access to credit facilities

The observation made during the study revealed that most farmers in the study area were relatively poor, that is living on less than a dollar per day, and could not afford essential inputs for improved Napier grass production, and consequently increase dairy cattle productivity. This study recommends the provision of credit facilities to the farmers through the formal institutions, such as Agricultural Finance Corporation and micro finance institutions, such as the increasingly popular village banks.

Expected application of the results

The study provides useful information on the socioeconomic effects of the NSD on dairy productivity of the small scale farmers. It also provides insights on specific socioeconomic parameters that farmers, extensionists, researchers and policy makers can apply in designing appropriate interventions towards mitigating against the negative effects of NSD on overall dairy productivity in the study area and in other areas where NSD is increasingly becoming a disease of economic importance.

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APPENDIX

Appendix 1

QUESTIONNAIRE

ASSESSMENT OF THE SOCIOECONOMIC EFFECTS OF THE NAPIER STUNT DISEASE ON SMALL SCALE DAIRY PRODUCTION IN BUNGOMA DISTRICT, KENYA

The purpose of this study is purely academic and above all, to generate knowledge that would be useful to the above mentioned study. 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 be useful in improving dairy production.

Section A: General data

1. Date of Interview……………………………………………………
2. Enumerator's name …………………………………………………
3. District…………………………………………………………………
4. Division………..……………………………………………………
5. Location………………………………………………………………
6. Sub-location………………………...
7. Village……..

Section B: Farmer characteristics

8. Farmer's Name/Household head…………………………….…………

9. Farmer's Gender [ ] Male = I Female= 2
10. Age of the farmer:________(**please enter date of birth, if known**):[19___]

11. Designation of land management: owner=1 [ ] manager =2[ ] worker =3[ ]

12. Marital status of the respondent(**please tick one**) Married= 1[ ], Single= 2[ ], Widowed= 3[ ] divorced =4 [ ]

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

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

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

15. For how many years have you been farming?...

16. Have you planted Napier Grass?

    Yes=1[ ] No=2[ ]

17. Where? [ ] On my farm [ ] Rented land [ ] Neighbour's farm [ ] By the road side [ ] others (specify) _________________

18. For how many years have you been planting Napier Grass?...................................

Section C: Napier Stunt Disease and Napier Grass characteristics

19. Are you aware of the Napier stunt disease?

    Yes=1 [ ] No =2[ ]

20. How do you identify Napier stunt disease?

    a………………………………………………………………………

    b……………………………………………………………………....

    c………………………………………………………………………

    d………………………………………………………………………

21. How do you perceive the Napier Stunt disease on your farm?

Low=1 [ ] Moderate=2[ ] High=3[ ]

22. Do you practice push-pull on your farm?

Yes=1 [ ] No=2[ ]

23. Do you use commercial feeds to supplement Napier grass?

Yes=1 [ ] No=2 [ ]

24. If yes, which one?

1=Dairy meal [ ] 2= Cotton seed cake [ ] 3=others, specify ………………

25. How much in kgs of the commercial feed does one cattle feed per month?...............................

26. What is the price of the feeds per kg?

Feed	**Price per kg**
Feed one (Dairy meal)	
Feed two (cotton seed cake)	
Feed three(others)	
Feed four(others)	

Section D: Napier grass productivity

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

b. How much of your land is under cultivation? .... (Acres)

c. How much of your cultivated land is under Napier? .... (Acres)

28. Is any portion of your farm affected by the Napier stunt disease?

Yes=1[ ] No=2[ ]

29. If yes, what proportion of your cultivated Napier Grass has been affected by the disease? ………… (Acres)

30. What is the number of cattle in your farm? ....

b. How many dairy cattle were you able to feed from unaffected Napier grass? …............

c. How many dairy cattle are you able to feed from the affected Napier grass? ....

31 What is your daily milk production before the inception of the disease in your farm? .... (Litres)

b. What is your daily milk production after the inception of the disease in your farm? ……………………..Litres)

32. What is the intended use of the milk?

Strictly, for sale=1 [ ] strictly for own use=2 [ ] Own use but surplus for sale=3 [ ]

If other, specify=4 …………………………………………………….

33. If you do sell, what is the current price of milk per litre? ....

34. Do you use fertilizer in planting Napier grass?

Yes=1 [ ] No=2[ ]

35. If yes, how much do you apply in kgs per acre? ....

36. How much is the price of the fertilizer in ksh per kg? ....

37. Please indicate the costs per acre of the various inputs/materials that you use to establish a Napier grass stand.

Input/material	**Cost per acre**
A Hired Labour	
B Planting materials(splits, cuttings)	

C Fertilizer	
D others(specify)	

38. How many dairy cattle did you have before the Napier stunt disease occurred in your farm? ....

b. How many cattle do you have after the Napier stunt disease in your farm? ....

39. Do you have alternative sources of feed for your cattle apart from Napier grass

Yes=1[ ] No=2[ ]

Section E: Socioeconomic information

40. What are your main sources of income?

Main source of income	**Tick as appropriate**
Cash crops	
Food crops	
Dairy products	
Salary/wages	
Remittances	
From investment	

41. Occupation (**Tick appropriately**)

Full time farmer	
Self employed	

Government employee	
Private sector employee	
Others, please specify	

Section F: Institutional factors

42. Have you ever received credit?

    Yes=1 [ ]   No=2 [ ]

b. If yes when was the last time you received credit?

43. Have you had extension services for the last one year?

    Yes=1 [ ]   No=2 [ ]

44. Have you ever received extension advice on Napier stunt disease?

    Yes=1 [ ]   No=2 [ ]

45. What is the distance to the market in km? ....

THANK YOU

Appendix 2: Variable Inflation Factor for the Cobb Douglas model

Vif

Variable	VIF	1/VIF
Lnlandpr	1.35	0.74
Lnfarmyr	1.19	0.84
ppt_prac	1.13	0.88
feed_alt	1.54	0.64
Gender	1.83	0.54
ext_serv	1.63	0.61
Credit	1.18	0.85
Lnnocatt	1.5	0.67
Lnmilpr	1.62	0.62
Mean VIF	1.44	

Appendix 3: Variable Inflation factor for the Gross Margin model

Vif

Variable	VIF	1/VIF
hous_siz	1.26	0.79
ppt_prac	4.20	0.24
milk_aft	1.2	0.83
milk_pri	3.28	0.30
Age	1.17	0.85
Mrtstatu	1.65	0.61
nsd_ext	1.32	0.76
Credit	1.17	0.85
nsd_prop	1.62	0.62
land_nap	1.45	0.69
Mean VIF	1.83	

Appendix 4. Descriptive summaries and corresponding standard deviations of various socio-economic and farm characteristics

	Division											
	Overall, N = 130		Malakisi, n= 26		Bumula, n= 23		Sangalo, n= 33		Kibabii, n= 23		Webuye, n=23	
	Mean	Std. Dev	Mean	Std Dev	Mean	Std. Dev	Mean	Std Dev	Mean	Std. Dev	Mean	Std. Dev
Household size (Persons)	8.68	4.51	9.35	5.61	9.74	5.52	7.36	3.11	8.95	3.43	8.54	4.54
Number of years of schooling	10.98	3.46	12.76	3.95	10.04	2.87	10.45	2.84	10.77	2.74	10.92	4.26
Number of years Napier has been planted	9.08	6.56	9.00	8.51	12.30	5.94	7.88	7.36	8.95	5.03	7.96	3.89
Distance from the farm to the market (km)	2.89	2.20	3.75	2.97	3.49	2.40	2.84	1.91	1.00	0.57	3.17	1.30
Size of land under cultivation (acres)	3.93	3.27	4.04	4.16	3.83	2.59	4.48	4.22	3.07	2.05	3.92	2.11
Average number of cattle	4.74	2.60	4.81	3.01	5.13	3.05	4.36	2.58	4.86	2.32	4.69	2.04
Current price of milk (Ksh)	35.61	11.95	29.12	13.34	34.43	17.02	38.33	7.77	39.95	6.70	36.00	10.83
Total cost per cow per month (Ksh)	156.77	160.31	205.02	178.18	160.79	178.20	101.68	96.01	177.61	169.49	158.08	174.05
Revenue per cow per month (Ksh)	3386.8	4363.5	1971.3	1341.4	2813.9	2677.7	1535.0	1049.1	4612.5	3195.4	6622.4	7812.1
Gross margin per cow per month (Ksh)	2758.9	2482.3	1782.2	1237.2	2689.9	2566.1	1433.3	1024.0	4122.6	2087.7	4325.2	3458.7