DETERMINATION OF THE EFFECTS OF HIV / AIDS ON FARM INCOME AND FOOD PRODUCTION ON COMMUNAL FARMS IN KAVANGO REGION

A THESIS SUBMITTED IN FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE IN AGRICULTURE (AGRICULTURAL ECONOMICS)

OF

THE UNIVERSITY OF NAMIBIA

BY

CECIL TOGAREPI

APRIL 2011

Supervisor: DR E.C. MUSABA

Co- Supervisor: MR S.K. KALUNDU

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ABSTRACT

The purpose of this study was to determine the effects of HIV/AIDS on farm income and food production in Kavango region. Representative farm models of communal farms for each of the two most common farming systems in Kavango region were developed. These are the riverline and inland farming systems, which were then used to determine the levels of farm income and food production at farm level under various HIV/AIDS scenarios in terms of changes in resource availability and gender, based labour loss. The scenarios used are (1) male adult illness (2) female adult illness (3) both male and female adult illness. Non-linear programming models were used and run in GAMS to determine levels of income and production for each scenario. Two representative models were used, one each for Mashare and Mile 30 ADCs. Farming systems in Kavango region were different in terms of income earned and sources, crop mix, and household sizes. The riverline farming system had more diversity in activities, and income sources than inland farming system. When the scenarios were applied to the models, the responses showed similar trend but the magnitudes were different with riverline farming system reporting bigger losses in income than the inland. More income and output were lost when it was a male who got ill than when it was a female who got ill. The models affirmed the findings that agricultural output is already low in the region and the effects of HIV/AIDS exacerbate the food security situation. The results also showed the importance of remittances and social grants such as pension as they remained as sources of income when other sources were depleted or no longer available. Recommendations proffered in this thesis include use of labour saving technologies and increased social

grants for affected households to ameliorate labour shortages caused by effects of HIV/AIDS.

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- All my friends and the Faculty staff for their support and encouragement and the Almighty God whose unwavering love and support carried me through. Thank you Lord for you never left me even in toughest of times.

DEDICATION

This work is dedicated to my sister and her family and all those individuals who supported me throughout this project financially, emotionally and academically.

DECLARATIONS

I, Cecil Togarepi, hereby declare that this study is a true reflection of my own research, and that this work, or part thereof has not been submitted for a degree in any other institution of higher education.

I, Cecil Togarepi, grant The University of Namibia the right to reproduce this thesis in whole or in part, in any manner or format, which The University of Namibia may deem fit, for any person or institution requiring it for study and research; providing that The University of Namibia shall waive this right if the whole thesis has been or is being published in a manner satisfactory to the University.

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CHAPTER 1: INTRODUCTION

1.0 Introduction

The purpose of this study was to determine the effects of HIV/AIDS on farm income and food production among communal farming households in Kavango region. This chapter outlines the magnitude of the HIV/AIDS problem in Namibia and Africa and the linkages between agriculture and HIV/AIDS. This study is useful to policy makers in that it provides some intervention strategies that can be used to ameliorate the impacts of HIV/AIDS on agriculture in Kavango region and Namibia at large.

1.1 Background

Agriculture is an important sector in the Namibian economy. It supports more than 60 percent of the country's population, which depend directly and indirectly on agriculture for livelihood. The agricultural sector contributes 5 – 10 % to Gross Domestic Product annually (9.6% in 2010) and 10.7% of export earnings (Global Finance, 2011).

The agriculture sector consists of two distinct sub-sectors, namely the commercial and communal sub-sectors. The commercial sub-sector consists of about 4, 000 farmers of mainly white settler population operating on 44 percent of the country's land. This sub-sector uses capital-intensive technology and concentrates on beef, dairy, sheep, and ostrich production.

The communal sub-sector on the other hand occupies 41 percent of the country's land, and supports around 140 000 families that represent 95 percent of the farming population (MAWRD, 1995). The communal sub-sector is characterised by low levels of productivity and high levels of food insecurity. Agricultural production is constrained by fragile soils, limited water resources, erratic rainfall, frequent droughts, inadequate production technologies, poor access to credit, markets, and rural infrastructure (MAWRD, 1995).

In addition to the above-mentioned factors constraining agricultural development in Namibia, the effects of Human Immunodeficiency Virus/Acquired Immunodeficiency Syndrome (HIV/AIDS) present another challenge to agriculture as in other countries in the sub-Saharan Africa. Of more than 40.3 million people living with HIV/AIDS globally, developing countries account for more than 95 percent of the cases and sub-Saharan Africa has more than 60 percent of all cases about 25.8 million where the disease has killed 10 times more than wars in Southern Africa. The disease is threatening lives of rural communities and reducing food production and has killed more than 7 million agricultural workers in 25 most affected countries since 1985. Southern Africa is the most affected region with high prevalence rate globally (FAO, 2002; Haacker, 2004 and UNAIDS, 2006).

In Namibia, by 2002, there was an estimated prevalence rate of about 22 percent among sexually active adults with Caprivi region having more than 40 percent prevalence rate

(SAPRN, 2006). By the end of 2010, there were about 174 000 - 200 000 people living with HIV/AIDS in Namibia (UN Statistics, 2009). AIDS is estimated to have caused a loss of up to N$8 billion to the Namibian economy in direct medical costs and indirect costs by year 2001 (Otaala, 2000). Projections from 2002 show that the HIV/AIDS pandemic could kill up to 26 percent of Namibia's agricultural labour force by 2020, the highest loss in the sub-region as shown in figure 1 below (FAO, 2002).

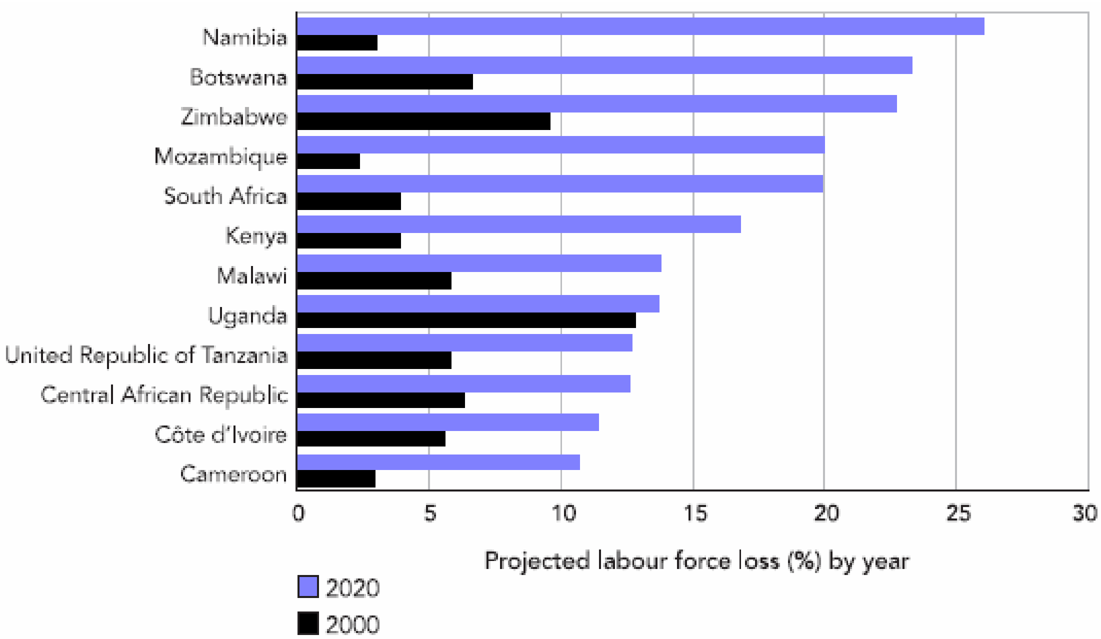

Figure 1: Projected agricultural labour force loss by 2020

Source: FAO, 2002

HIV/AIDS increases the burden on rural communities as many urban dwellers and migrant labourers return to their village of origin when they fall ill. This causes a rise in household expenditure to cover medical bills and funeral expenses, and reduces the number of productive family members while the number of dependents rises (FAO, 2002; SAPES-UNDP-SADC, 2000). HIV/AIDS affects mostly the sexually active adults between the ages of 15 and 49. This age group is the main source of labour for the subsistence agriculture, which is labour intensive because it has low levels of technology and mechanisation. Occurrence of labour shortages result in labour re-allocation, which leads to responses and coping strategies that often result in declining financial resources as well as an increase in food insecurity (White & Robinson, 2000).

The main problem posed by the disease however, is that the effects, responses and coping strategies follow different patterns, dimensions and magnitudes within countries, regions and among villages due to geographic and ethnic factors, religion, gender, age, marriage customs and agro-ecological conditions (Haslwimmer, 1996).

Prior to this study, in Namibia, a number of studies had analysed the effects of HIV/AIDS on communal farming households. These studies include; Abate *et al* (2001) that covered Omusati, Kunene, Oshikoto, Erongo, Khomas, Caprivi, and Omaheke regions, and Matanyaire and Timpo, (1999) which covered Caprivi and Oshana regions while FAO (2002) covered the Ohangwena region. However, up until this study, no study had been carried to determine the effects of HIV/AIDS on farming communities in Kavango region despite the HIV/AIDS prevalence rate of about 20% (Mendelsohn and Obeid, 2003). Majority of the people who live in the rural communities of Kavango region of Namibia are poor[1] and depend on what they produce for survival, hence there

[1] Poor is defined by the World Bank in 2008 as people who live on less than US$1.25 a day

is need to generate more information on how the communal farmers in Kavango are affected by HIV/AIDS. In particular, this type of information would be useful to policy makers and planners in order to come up with the design of policy intervention and strategies to help communal farming households in dealing with the adverse effects of the pandemic. In order to be relevant to policy makers, this study therefore, attempt to fill in the information gap and shed some light on the effects of HIV/AIDS on communal farming system in Kavango.

A review of the literature indicates that the effects of HIV/AIDS on farm households include: (1) increased direct costs of sickness and death, (2) reduced labour, making labour-deficient[2] households to become critically labour deficient thus affecting farm and off-farm activities (Matanyaire and Timpo, 1999; Hange *et al,* 1999). (3) Household food security is affected both by reduced own food production and off-farm income. Agricultural skills and other skills, agricultural knowledge and practices are lost due to AIDS. This leaves children and others who do not have adequate knowledge to continue production which leads to food security being compromised (Matanyaire and Timpo, 1999; Abate et al, 2001). (4) People are forced to sell livestock, land and other productive resources. In order to cover high costs related to HIV/AIDS such as ill health and death, the increase in the number of orphans thus reducing production capacity and affecting food security (Abate et al, 2001, Engh et al, 2000; Matanyaire and Timpo, 1999).

[2] Hange et al, (1999) defined worker sufficient household as a household with 5 or more workers and worker deficient as one with less than 5

(5) Burden on household resources, vulnerability and impoverishment of people affected by HIV/AIDS was found to increase as people are pulled away from their quotidian activities due to illness and death. (6) Disintegration of family networks and social immunity and worsening food security situations with depleted incomes and increasing costs (Tibaijuka, 1997 and Mutika, 2001).

Some of the common strategies used by households in Namibia and elsewhere to cope with HIV/AIDS include: (1) increased use of child labour, (2) children dropping out of school, (3) reducing area under cultivation, (4) reduction of off-farm activities, (5) switching to less labour intensive crops, (6) out migration in search of wage work, (7) reallocation of labour and time from agricultural work to non-agricultural care activities, (8) evidence from Tanzania indicate that affected households allocate a large share of total expenditure to medical care and funerals and (9) a smaller share to purchased food and “other” non – food items (Abate *et al*, 2001; ILO, 2000; Naidu and Harris, 2005).

The endemic agricultural problems faced in Kavango region, especially low yields and gender burdens on women who supply more than 60 percent of the farm labour (Hange et al, 1999) and increasing prevalence of HIV/AIDS in the region are a cause for concern with serious implications on food security at household level in Kavango region. Women are disproportionately affected by HIV and poorly informed about the epidemics and yet they are the ones who provide most of the labour on farms (UNAIDS, 2005).

Available literature has highlighted the predicted effects of HIV/AIDS on households. However, these studies have not addressed the impact on enterprise combination (mix) and in addition, these studies have not used any farm modelling and farm management approaches or economic models in analysing the impacts of HIV/AIDS on households. Despite the shortfalls of the previous studies in particular Abate et al (2001) and Matanyaire and Timpo (1999), the studies are useful to the current study in that they are a potential source of secondary data on levels of owned farm resources such as land, labour, draft power and capital and information on responses used by households under the influence of HIV/AIDS in Namibia.

1.2 Problem Statement

The problem addressed in this study concerns measuring the impact of HIV/AIDS on resource use and optimal enterprise combination and farm income as households operate under the influence of HIV/AIDS. This analysis is achieved by using a farm modelling approach such as Optimization Linear programming, simulation and enterprise budgeting. These approaches have not been used in Namibia previously to understand the impacts of HIV/AIDS. Thus, application of such approaches can generate information that will be of use to policy makers in designing coping strategies. The models are flexible and can capture the differences in resources and enterprises, which prevail in various farming systems, and hence can be used to measure the impacts of HIV/AIDS which relate to changes in resource availability and possible enterprises household can operate.

There is also inadequate information on potential intervention and resource needs of affected households for them to cope with increasing problems caused by HIV/AIDS. This study therefore, seeks to fill in the information gaps and address the problems that were not fully tackled in the previous studies pertaining to resource needs, and strategies that can be used to improve and ameliorate the effects of HIV/AIDS on communal farm households. In Kavango region, HIV/AIDS prevalence and cases have been increasing with an estimated prevalence of 20 percent (SARPN, 2006). In this study, an optimisation non-Linear Programming model representing communal agriculture in Kavango region was applied in the analysis. This model captured scenarios or changes in production, consumption, and resource use responses for households under various HIV/AIDS scenarios used in this study.

1.3 Objectives of the study

The objectives of this study were:

(1) To develop a framework for a representative farm model of communal farming systems in Kavango region.

(2) To determine the levels of farm income and food production and consumption at farm-level under various HIV/AIDS scenarios in terms of changes in resource availability. These scenarios include (i) adult male illness, (ii) adult female illness (iii) adult male and female illness at the same time.

(3) To draw implications for suitable policies and strategies for ameliorating the effects of HIV/AIDS on farming communities in the study area.

1.5 Methodology of the study

To achieve the above objectives, an optimisation non-linear programming approach was employed to formulate farm models which represent the main farming systems and the main farm activities that prevail in the surveyed areas. The representative farm models were estimated with the help of a multivariate statistical analysis (Principal Components and Cluster analysis) using SPSS version 17 for Windows. The representative farm models were run using General Algebraic Modelling system (GAMS 23.2). The models were then subjected to different scenarios under which households operate under the influence of HIV/AIDS. The HIV/AIDS scenarios are simulated using the non-linear format in GAMS to generate the optimal plans in terms of income and food production.

1.6 Data needs and sources

To formulate the farm models for this study, secondary data was obtained from two main sources. Firstly, the 2004 Baseline Questionnaire Survey MAWRD/FAO/TCP/NAM2801) on Farmer information needs Assessment for Decentralised Information Management and Improved Food Security in Kavango region. Secondly, from a survey carried out for FAO by the University Central Consultancy Bureau (UCCB) of the University of Namibia on understanding the impact and expanding the response of the farming sector to HIV/AIDS in Namibia. Data particularly from Omusati, Oshikoto and Caprivi regions, as well as relevant data from The Kavango Farm Management Survey of 1997 and Keyler (1995) on pearl millet subsector, Agricultural Statistics Bulletin of 2005 and CBS of 2006 were used.

Information on farmer characteristics and farm resource base and management, and produce marketing was selected for use in the study so that representative farms could be selected.

To develop an NLP model at farm level, data is required on a number of variables. These include (1) farm household characteristics, (2) farm characteristics – farm size, farm type, resource levels, input usage and production cost, and levels of output (yield levels) and gross margin. (3) Food consumption requirements of grain and nutrition (coefficients were obtained from CBS (2006), Mudenda, (1989), Storck and Emana, (1992), and McIntyre et al, (2001)). The main data source was collected using the farm level questionnaire survey of 179 communal farmers from the two major farming systems in Kavango region namely river line and mainland (inland). Kaisosi and Mashare ADCs represented the river line farming systems, while Mile 30 represented the inland system.

The models needed data on total farm size, total cultivated areas per crop, crops grown, yield per hectare, variable costs, seed costs per kg, ploughing costs, wage rates, selling price per kg, grain consumption requirements per capita, gross margin, crop revenue, nutritional requirements per capita, household farm income, size of household, capital, capital requirements per ha per crop, available labour, and labour requirements per hectare per crop. These sources were used because they provided relevant data for the study although primary data collected specifically for this study would have been preferred.

1.7 Study area

Kavango region is situated in the North East of Namibia. Kavango region is one of the fastest growing regional populations in Namibia (Yaron, Jansen and Maamberua, 1992). The region constitutes about 11 percent of Namibia's population and occupies about 5.5 percent of Namibia's total area (CBS, 2003). About 72 percent of the population live in rural areas and only 28 percent in the urban area (CBS, 2003). Kavango comprises of 55 percent communal land, 23 percent private farms and 15 percent conservation area. The majority (95%) of the population live within a narrow 5-10 kilometre strip along the South bank of the Kavango river terrace which is only 5 percent of the total area of the Kavango region.

Kavango receives an average annual rainfall of about 500 mm although the distribution between showers is very sparse. Although Kavango receives a lot more rainfall than most regions in Namibia, most still do not produce enough to cover their subsistence and the value of farm produce is many times less than that of cash incomes due to amongst others, endemic labour shortage, and little capital now exacerbated by the effects of HIV/AIDS, and low yields that are frequent due to long dry spells (Mendelsohn and Obeid, 2003). Most households are engaged in subsistence farming with mahangu (pearl millet) the main crop along the river and both mahangu and maize in the inland

(Mendelsohn and Obeid 2003). Many people along the river catch fish regularly as a source of food or for sell, while inland inhabitants sell crafts and carvings as well as wild fruits to supplement income and food (Mendelsohn and Obeid, 2003).The farm sizes range from 2-4 ha along the river and 3-6 ha in inland areas. Male-headed households tend to have more land cultivated, wealthier households cultivate more land than those without cash income and families that have draft power cultivate double the area of those without draft power or equipment (Mendelsohn and Obeid 2003).Cultivation methods are predominantly by animal draft (cattle) power 91 percent, 5 percent by hand and 3 percent by tractor. The households spend an average 100-160 days on cultivation per season, with women contributing 62 percent of all worked days, 33 percent by men, and the remainder by the children and the aged. (Mendelsohn and Obeid, 2003; Keyler, 1995). Normal harvest is about 100kg/ha, which is insufficient for the cereal needs of most households given sizes of the households. One household member requires about 115 kg of grain per year (Mendelsohn and Obeid, 2003).

Within Kavango region there are different farming systems but there are two main ones which, stand out and divided based on where the farm (village) is situated, categorised as either riverine or inland. This set up will help determine and differentiate the types of activities households are involved in within these two farming systems. For the purposes of this study, three Agricultural District Centres (ADCs) were covered in the survey and they are Mile 30, which is inland, Mashare and Kaisosi, which are both along the river (riverine).

1.8 Organisation of thesis

The thesis is organised into six chapters. The first chapter is the introduction to the study covering background information, problem statement and objectives of the study. The chapter also gives a brief methodology that was used in the study and the data needs and sources used. A brief description of the study area is also included. Chapter 2 gives a review of literature related to the study. In the review, the methods that were used in the previous studies on impacts of HIV/AIDS on communal farmers are highlighted together with the major findings from these studies. Chapter 3 covers the theoretical framework for the study of effects of HIV/AIDS on agriculture. Chapter 4 covers model development and formulation of representative farms. Chapter 5 covers the model results by scenarios and discussion of the results from the non-linear Programming models generated using GAMS. Chapter 6 provides summary of the study results, conclusions and recommendations.

CHAPTER 2: BACKGROUND TO THE PROBLEM

2.0 Introduction

This chapter starts by defining HIV/AIDS, and how it has progressed in Namibia and Kavango region in particular. The chapter also gives an overview of the linkages between HIV/AIDS and agriculture and effects of HIV/AIDS on smallholder farming. The chapter gives a critical review of methodologies that were used to study the impacts of HIV/AIDS on communal or smallholder farmers in Namibia and elsewhere and identifies the gaps on areas that need to be studied. The chapter concludes with a brief discussion of the choice of the appropriate method used in this study.

2.1 HIV/AIDS and the situation in Namibia

The acronym HIV/AIDS is a term now coined to mean the virus and disease it causes. It stands for Human Immune-deficiency Virus/ Acquired Immune- Deficiency Syndrome. HIV is the virus that destroys the immunity system of an infected person to such an extent that the individual is susceptible to a wide variety of diseases as the body is not able to fight any disease, a condition called AIDS. A person may carry the virus and is said to be HIV positive but may not exhibit any symptoms of being sick until the viral load exceeds a certain limit in which case the person starts to exhibit symptoms of AIDS. It is the opportunistic diseases that will make an individual ill, emaciated, incapacitated and then eventually die.

Individuals who suffer from AIDS can increase their life expectancy by eating a balanced diet rich in vitamins and minerals and taking antiretroviral drugs that slows down the virus from multiplying and thus postpones the advent of AIDS. HIV is spread in many ways but Southern Africa has predominantly heterosexual AIDS epidemics associated with unprotected sex. Use of condoms, abstinence until marriage and being faithful to one partner are some of the ways that are being promoted as key to reducing the spread of the virus.

In Namibia, the first cases of HIV/AIDS were recorded in 1986 when four people were diagnosed HIV-positive. The prevalence rate among adults (15- 49 years) in 2009 was 15.3% (UN Statistics, 2009). This shows a decline from a peak of 22.5% in 2003 (UNAIDS, 2006). Many areas have experienced a decline in the prevalence such as in Andara, Nyangana, Tsumeb and Otjiwarongo, whereas others such as Rundu, Swakopmund, Oshakati and Nankudu have experienced a marked increase in prevalence rate (UNAIDS, 2006). There are now approximately 204 000 (2007/2008) people living with HIV/AIDS of which 58% are women (UN Statistics, 2009, MHSS, 2008). At the same time, many people are dying of AIDS and many children are orphaned numbering around100 000 in 2006. Prevalence of HIV/AIDS in Kavango region ranges between 15 and 25 percent, and the region has experienced mixed results as some areas such as Andara and Nyangana have recorded a declining prevalence while other areas such as Rundu have recorded an increase in HIV prevalence (UNAIDS, 2006).

2.2 HIV/AIDS linkages with Agriculture

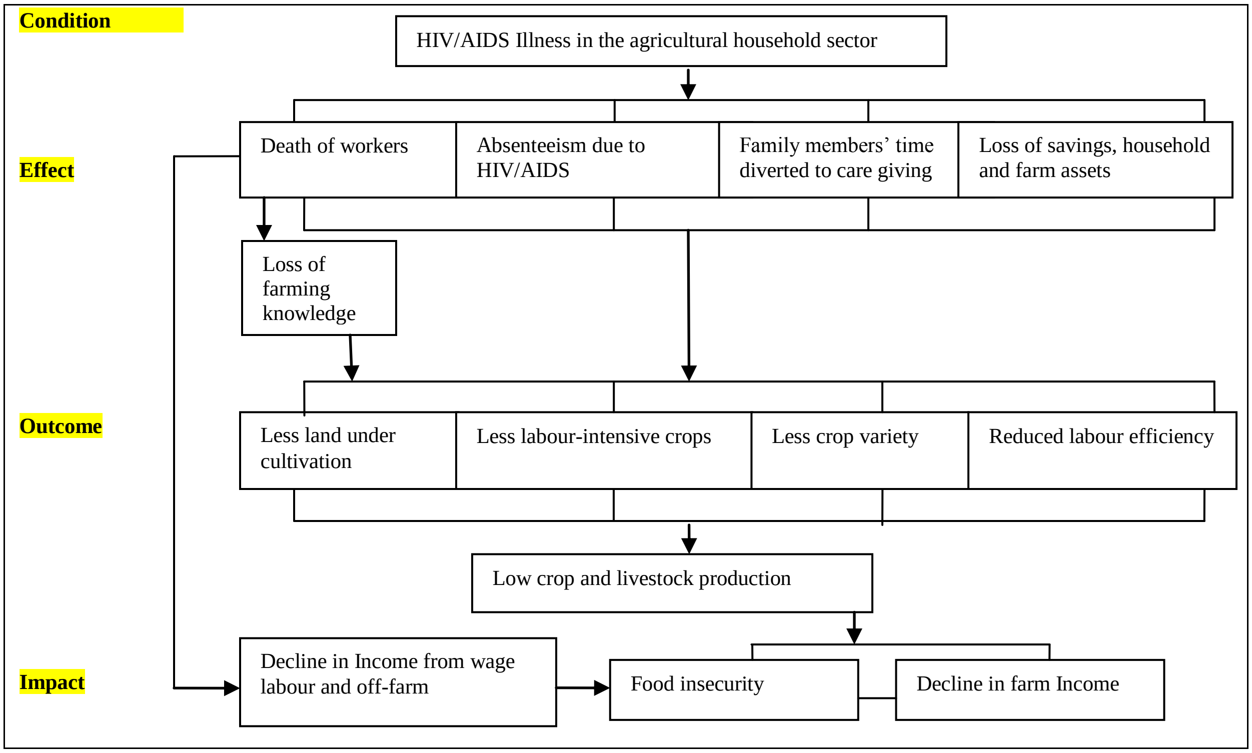

Figure 2: Conceptual framework for the impact of HIV/AIDS illness/disease on Agriculture

Source: Adapted from Asenso-Okyere, *et al*, 2010

In order to illustrate the linkages of HIV/AIDS and agriculture, a conceptual framework is presented in Figure 2 is above. The framework shows how HIV/AIDS affects agricultural production, food security and farm income through its direct influence on agricultural labour supply (Stokes, 2003, Asenso-Okyere, *et al*, 2010).

Almost all studies agree that HIV/AIDS causes illness and ultimately death in individuals that are affected by the disease. Once the disease has progressed into AIDS, the individual becomes prone to all opportunistic diseases, is incapacitated and eventually dies. The most direct effect on an individual, who is infected by the disease, is first illness, incapacitation and eventually death (FAO, 2000). The contribution of the individual to total available labour decreases as the illness progresses to total incapacitation and death and contribution of other household members to available labour also decreases as they forego productive work to care for the sick or mourn at death (Abate et al, 2000; Matanyaire and Timpo, 1999; Naidu and Harris, 2004, Haslwimmer, 1998).

Illness results in morbidity and sometimes mortality which reduce labour availability through absenteeism or death of agricultural producers/workers. The quantity and quality of labour to the household is affected as the sick may abstain completely or partially from work due to illness (Asenso-Okyere *et al*, 2010). When the sick person dies, the acquired knowledge is lost (Abate *et al*, 2000; Asenso-Okyere *et al*, 2010). Debts may increase due to costs of sickness and funerals, and savings and assets may be sold to defray these costs. Financial savings are usually the first to go followed by non-productive assets then eventually productive assets may also follow. The outcomes of the HIV/AIDS illness on a household may include reduction of cultivated area, cultivation of less intensive crops, reduction in variety of crops, reduction in livestock numbers. These result in decline in farm output and farm income, decline in income from wage labour and off-farm activities and consequently food insecurity (Asenso – Okyere, *et al*, 2010, FAO, 2000, Stokes, 2003; Matanyaire and Timpo, 1999; Abate *et al*, 2001, and Cohen, 2000).

2.2.1 Impacts on farm labour

Several studies have shown how HIV/AIDS affects farm labour. A study in Tanzania found that males with AIDS lost an average of 297 days of productive work over an 18-month period and women lost 429 days over the same period due to morbidity (Rugalema, 1998). Caring for the sick was also found to affect labour as labour for productive activities was lost due to reallocation of labour to caring for the sick. In a study carried out in South Africa, 7.5 hours per day were spend taking care for the sick (Booysen and Bachman, 2002 in Asenso-Okyere, *et al*, 2010 while a study in Zimbabwe found that 38.5 hours were spend per week taking care of the sick (Woelk, 1996 in Asenso-Okyere *et al*, 2010).

In Western Kenya, in a study on productivity of HIV-positive workers on tea farms, it was found that the quantity and quality of labour is affected during illness (Fox *et al,* 2004). HIV-positive workers' productivity was 4 -8kg/day less in the year and a half before they died compared to HIV –negative workers (Fox *et al*, 2004). Many studies including Uganda, Zimbabwe, Tanzania, Ethiopia, Rwanda, Thailand and Zambia have shown the effects of loss of labour due to care giving, illness, or death (Fox *et al,* 2004). In a Zambian survey, it was found that heads of HIV- affected household reduced their cultivated area by 53% resulting in reduction in crop production and by as much as 50 percent in some cases in Namibia (Abate et al, 2001). The results also showed that women were more concerned with food crop production while men focused on cash crop production.

2.2.2 Impacts on agricultural knowledge and innovation

Many studies have indicated that farm-specific knowledge is lost due to death of agricultural producers especially when these deaths occur as a result of HIV/AIDS. This is because most of the knowledge is transferred or shared through tradition, demonstrations and working together (Asenso-Okyere *et al*, 2010; Stokes, 2003, Abate *et al*, 2001)

2.2.3 Impacts on household savings and assets

Most of the studies carried out in Sub Saharan Africa have indicated that many people suffer losses in income and productive assets due to HIV/AIDS making households to be impoverished. Borrowing and selling of livestock increase in response to severe cash requirements after HIV/AIDS related illness or death (Rugalema, 1998; Abate *et al*, 2001; Engh *et al*, 2000, FAO, 2002; Asenso-Okyere *et al*, 2010). Stokes, (2003), Tibaijuka, (1997), and Rugalema, (1998), argued that in order to survive hardships caused by HIV/AIDS, households are forced to attend to immediacy of need in order to survive and thus do not plan or prioritise their spending. When they need money for medication or special food or funeral they immediately go to their savings, capital, assets or borrow to cover the costs at hand. Although income is generated from assets sales, it is immediately deployed to cover forced and increasing costs caused by the disease and with no opportunity to save (Abate et al, 2001, Mutangadura et al, 1999, Mutika, 1997).

2.2.4 Impacts on Nutrition

When households are affected by HIV/AIDS and their output is reduced and ability to purchase food is reduced as well as capacity to earn an income is reduced, they reduce consumption of food. For example, affected households in Malawi reduced their consumption by up to 30% (Thangata *et al*, 2007) and less than a quarter afforded to have at least 3 meals a day in Zimbabwe as well as in Cote d'Ivoire (Bechu, 1998).

2.2.5 Impact of HIV/AIDS on land ownership

In most communal areas of Namibia, land ownership is an important indicator of self-sustainability and food security. In regions where communities are patrilineal, and inheritance is practised, it is the relatives of the husband who inherit the resources when the husband dies living the children with no productive resources for their continued survival. In matrilineal societies, such as in Omusati, the children have no ownership and access to farming land that their father owned before his death and young widows face a risk of being chased away from the land and household when the husband dies thus left with nothing to survive on (Abate *et al,* 2001, Engh et al, 2000). Thus survivors are at risk of facing starvation, as they are disowned of the only productive resource, the land. However, it is also important to highlight that the government has put in place a law on inheritance by way of an inheritance act of 1995 that seek to protect the wife or spouse and children.

2.3 Survival and coping strategies

Neema (1998) states that coping mechanisms that are employed depend on socio-economic well-being of the household with richer households coping better as they are able to hire labour to replace lost labour, or substitute mechanisation and inputs and can maintain or increase their cultivated area and yield. Poorer households may reduce their cultivated area, and reduce cash flow and can withdraw children from school in order to beef up labour availability. Naidu and Harris (2006) found four main groups of survival strategies which households employ to alleviate the effects of HIV/AIDS. These are: (1) those that are aimed at alleviating the loss of income, (2) strategies aimed at surviving the financial cost, (3) strategies aimed at alleviating the loss of labour and (4) strategies aimed at using safety networks.

Table 1: Main Survival strategies households employ to alleviate effects of HIV/AIDS

1 Strategies aimed at alleviating the loss of income • encouraging employed people to join the household • diversifying income • remaining at work until the person can no longer work • dissolving the household • doing nothing • engage in casual labour in exchange for food and neglect farm activities	**2. Strategies aimed at surviving the financial cost** • utilising savings • disposing of assets, livestock, farm equipment and household items • borrowing • withdraw children from school • reducing consumption and cutting back on number of meals eaten per day (Muchopa and Mutangadura, 1998) • begging • adjusting household size and composition • applying for state assistance
3. Strategies aimed at alleviating the loss of labour • reallocating household labour • encouraging non-employed members to look for work • withdrawing children from school • working extra hours • reduce cultivated area • shift from cultivation of labour intensive crops to less labour intensive (Muchunguzi, 1998) • withdraw from productive activities especially land preparation, sowing and weeding as well as cutting on participating in social activities (Rugalema, 1998)	**4. Strategies aimed at using safety networks** • inter-household care and psycho-social support • inter-household financial support • fostering of children • transfers in from relatives and non-relatives • coping with discrimination

2.4 Models and approaches used to measure impacts of HIV/AIDS on agriculture

2.4.1 Descriptive studies

The studies that were done in Namibia so far have mainly used qualitative methods to analyse the effects of HIV/AIDS but not necessarily measure the impact of HIV/AIDS. Cross tabulations and frequencies were mostly used as well as descriptive statistics. Descriptive statistics were then applied to the data to obtain data summaries. The impacts of HIV/AIDS were observed or obtained through questionnaires but not modelled. Advantages of descriptive studies are that they are easy to interpret as they mainly use observations and data summaries such as graphs, frequencies, measures of central tendency, and cross tabulations. Disadvantages of descriptive studies are that they do not seek to find causal relationships on the observed population and do not measure the changes that occur in a population over the period. Some of the descriptive studies that were carried out in Namibia include Abate *et al*, (2001), Matanyaire and Timpo (1999), Engh *et al,* (2000), Hange *et al*, (1999). Other studies that used descriptive studies include Collins and Leibbrandt (2007) that studied financial impact of HIV/AIDS on poor households in South Africa and found that the households suffer losses of up to 7 month's income during funerals.

2.4.2 Econometric models

Econometric models apply mathematics and statistics to empirically measure a relationship postulated by economic theory on the basis of maximising producers' profits and consumers' utilities given certain constraints. Econometric models are flexible in specification and testing various assumptions as well as integration of dynamic lags and continuous response to changes in exogenous variables and uses statistical methods for parameter estimation. They use generally accepted calibration and validation procedures. They can take different functional forms and sets of different explanatory variables that can be tested (Olubode, 2006). They can capture dynamic patterns in a system. However disadvantages include difficulty in estimating parameters of large simultaneous equation systems and limited use of a priori information (Olubode, 2006). Furthermore, weaknesses include inconsistency of parameter estimates due to lagged variables and heteroscedasticity.

Some studies that used econometric methods to measure the impacts of HIV/AIDS on households include Amanor-Boadu, 2010, that studied the effects of HIV/AIDS and drought on changing cropping patterns in Zambia. It was found that HIV/AIDS had stronger explanatory power than drought on changes in cropping patterns. Fox *et al*, (2004) studied effects on productivity and attendance of tea estate workers who died or were medically retired because of AIDS related causes between 1997 and 2002 which showed that HIV infected workers plucked less tea and earned less in wages.

2.4.3 Mathematical Programming models

Mathematical programming models maximize consumer and or producer surplus subject to production and resource constraints (Hazel and Norton, 1986). They are used to investigate implications of multi-input and multi-output nature of agriculture production.

(Hazel & Norton, 1986). These models directly use production technology, support systems, fixed production factors, resource constraints and capacity levels information. Mathematical models can directly use different kinds of technical data or an a priori or data from experts. Mathematical programming offer several methods of analysis which are not easily captured in econometric models such as shadow prices of some explicit resource constraints and physical capacity to provide information that may be needed by decision makers (Olubode, 2006). However, mathematical programming models have problems in model validation, parameter estimation, and aggregation. Mathematical programming models assume that farmers have all the information to make profit maximising decisions but that is not the case in reality (Olubode, 2006). Mathematical programming models can either be single or multi-period, linear or non-linear models. Single period (static) models would focus on a period of one year or one season hence does not take into account changes that occur over time, while multi-period (dynamic) models can deal with the changes that occur over many years or seasons.

2.4.3.1 Linear Programming Models

Linear programming is a mathematical technique or decision tool, which is concerned with the determination of the best allocation of scarce resources to solving economic problems (Boehlje and Eidman, 1984). It involves modelling and solution procedures for the purpose of maximizing or minimizing the objective function of a given decision maker (Agrawal & Heady, 1972). In short a linear programming model maximizes the objective function (e.g. profits, food supply etc.), subject to the constraints of resource availability (e.g. land, labour, and capital, subsistence and nutritional requirements) (McConnell and Dillon, 1997; Emana and Storck, 1992; Turner and Taylor, 1998; McCarl, 2005; Mudenda, 1989; Meindetsma, 1997; William, 1990).

The advantages of linear programming are that it can handle more complex problems and provides optimal way of allocating resources. Sensitivity analysis can also be accommodated can generate shadow values attached to resources in scarce supply and the range of farm activity levels over-which the optimal solution remains stable (Stonehouse et al, 2002;Gittinger, 1995; Meindetsma, 1997). LP can show opportunity cost of a resource in an alternative enterprise and operates under assumptions of linearity, divisibility, certainty, non-negativity and independence (Adendorff and de Wit, 1999). Some of the disadvantages would arise when solutions are infeasible; no optimal solutions can be found and providing more than 1 optimal solution. There is also failure to deal with demand uncertainties.

Studies that used programming models include Gill, (2010) that modelled the impacts of HIV/AIDS upon food security of diverse rural households in western Kenya. The study used an ethnographic linear programming model to model to simulate household responses to an adult household member contracting HIV in order to examine the impact of HIV/AIDS upon food security and to determine on which types of households the impact is most severe. Four households were used comprising of 3 male headed and 1 female-headed household. The effects of HIV/AIDS were found to be more severe at initial stage of HIV infection since the household would be ill prepared. Households became food insecure when it was a female adult who got infected than when it was a male who got infected.

Thangata *et al*, 2007, used ethnographic linear programming model on a representative household with 3 scenarios, where there is no illness, there is adult female illness, and adult male illness. The impacts of HIV/AIDS on food production depended on patient's gender. Male labour was reduced by 33% in the first year of sickness and eliminated when he was incapacitated and later died which also released labour that was used for caring for him. Consumption was reduced by 30% to cope with loss of income and labour when male patient died. Female sickness on the other hand reduced land under cultivation by 50% but gradually increased after death.

2.4.4 Budgeting and marginal analysis techniques

Budgeting analysis and marginal analysis are applicable to simple problems with fewer constraints, and the more variables and constraints there are, the more complex, and tedious the process becomes.

2.4.5 Simulation

Simulation models employ systems of equations to model real-world relationships under a range of different circumstances. Simulation approaches are useful for depicting actual outcomes and provide a priori guidance to decision-makers. Simulation is a descriptive rather than an optimisation technique that involves developing a model of a real phenomenon and then performing experiments on that model. For farm simulation models, the data requirements are the same as that required for setting up a conventional linear programming model or applying simple budgeting methods. In the farm simulation model, items such as expenditure and income are generated or computed from multipliers or parameters, which are assembled before the model is made operational (Agrawal & Hardy, 1972). Simulation has been used widely in agriculture to make agricultural decisions concerning equipment, predict effects of policy alternatives as well as grain handling and distribution. Simulation models can involve stochastic, probabilistic events, or can be deterministic.

Advantages of simulation are that it allows us to model complex and dynamic phenomena. Simulation also permits experimentation and can answer the what if questions that arise in a dynamic situation. It allows compression of real time thus can predict behaviour of a system over the period of over a year (Cook *et al*, 1989). Some of the disadvantages of simulation are that though it may find a good solution, it does not provide a guaranteed solution. Another shortcoming of simulation is that it is a tool of solution evaluation and thus does not generate problem solutions, but rather the decision maker has to develop proposed solutions that can be tested for relative desirability using simulation (Cook *et al*, 1989).

Studies that used simulation include Jefferis *et al*, 2008, that studied the macroeconomic and household level impacts of HIV/AIDS in Botswana. The study used demographic and financial projections combined with economic simulation models. Economic growth was found to be reduced and household poverty increased. Three scenarios were used as follows: 1- with AIDS, 2- hypothetical without AIDS and 3- treatment scenario that combine current Botswana situation with treatment programme. Other studies that used simulation to measure impacts of HIV/AIDS include Alam *et al*, 2006, Ventolon *et al, 2008)* and Hladik *et al*, 2008.

2.5 Choice of an appropriate model for this study

It is important to note that so far, no known study has used mathematical programming or optimisation models or econometric models, to model the effects of HIV/AIDS on smallholder farmers in Kavango region or elsewhere in Namibia. It is therefore believed that this is the first study that applies Non –linear programming in order to improve the understanding of HIV/AIDS on smallholder farmers' income and agricultural production.

This study seeks to determine the effects of HIV/AIDS on farm income and production, thus a number of approaches are applicable including budgeting analysis, marginal analysis, agriculture sector model (mathematical/programming or econometric models - optimisation and non-optimisation models), and simulation models. Agriculture sector models are used as tools for analysing quantitative economic problems in the agricultural sector of an economy. Most of these models are used to analyse policy impacts on agriculture and therefore provide implications or suggestions for policy decisions. They are either econometric or programming/mathematical models (Olubode, 2006).

For the purposes of this study, mathematical programming using non-linear programming method is used based on the Cobb-Douglas production and utility functions. The Cobb-Douglas functions are used to represent the relationship of output to inputs (Barnett, 2007). Output elasticities measure the responsiveness of output to a change in levels of either labour or capital used in production provided *ceteris paribus* holds. This is especially applicable to the current study as the effects of HIV/AIDS are known to affect the available labour and capital as they are diverted for medical costs. The Cobb-Douglas functions can also be applied to utility. The constants and elasticities that are obtained from the Cobb-Douglas functions are then used in the farm household model to trace out the impact of different scenarios or shocks on household resource allocation and welfare. The next chapter will review household economic theory and its applications and its suitability for the current study.

CHAPTER 3: THEORETICAL FRAMEWORK

3.0 Introduction

This chapter examines the relationship between farm production, consumption and labour supply at farm household level. It further explores how HIV/AIDS affects farm income and production on communal farms by outlining the linkages between production and consumption decisions in the household. This chapter addresses these linkages in the context of a theoretical framework of consumer and producer theory which are captured in the household models (Singh *et al,* 1986). This theoretical framework is important for us to understand linkages between production and consumption decisions in the household and thus relevant for exploring effects of HIV/AIDS on farm income and production including the case of communal farms.

3.1 Consumer and Producer theory

Decision making process of the agricultural households has a recursive character. Production decisions determine farm profits which are a component of household income, which in turn influences consumption and labour supply decisions (Sing *et al,* 1998). Much of the household's production activities are for household's own consumption and a large proportion of the immediate subsistence needs of the household are provided for directly by members' unpaid work rather than through the market. A household is represented as a single decision-making unit that aims to maximise a joint household utility function for both market purchased goods and home produced goods (Himmelweit *et al*, 2001). A household's well-being can therefore be estimated by measuring changes in the standard of living that is the degrees by which people become better or worse off or calculating real income per head of the population. The choices of the individual consumer are shown to determine what is produced, thus individuals follow their own self-interest whether as producers deciding which one is the most profitable method of production or as consumers choosing which goods to purchase. Individual's preferences provide the basis for choosing between different goods and services in the neoclassical theory of consumption (Himmelweit et al, 2001).

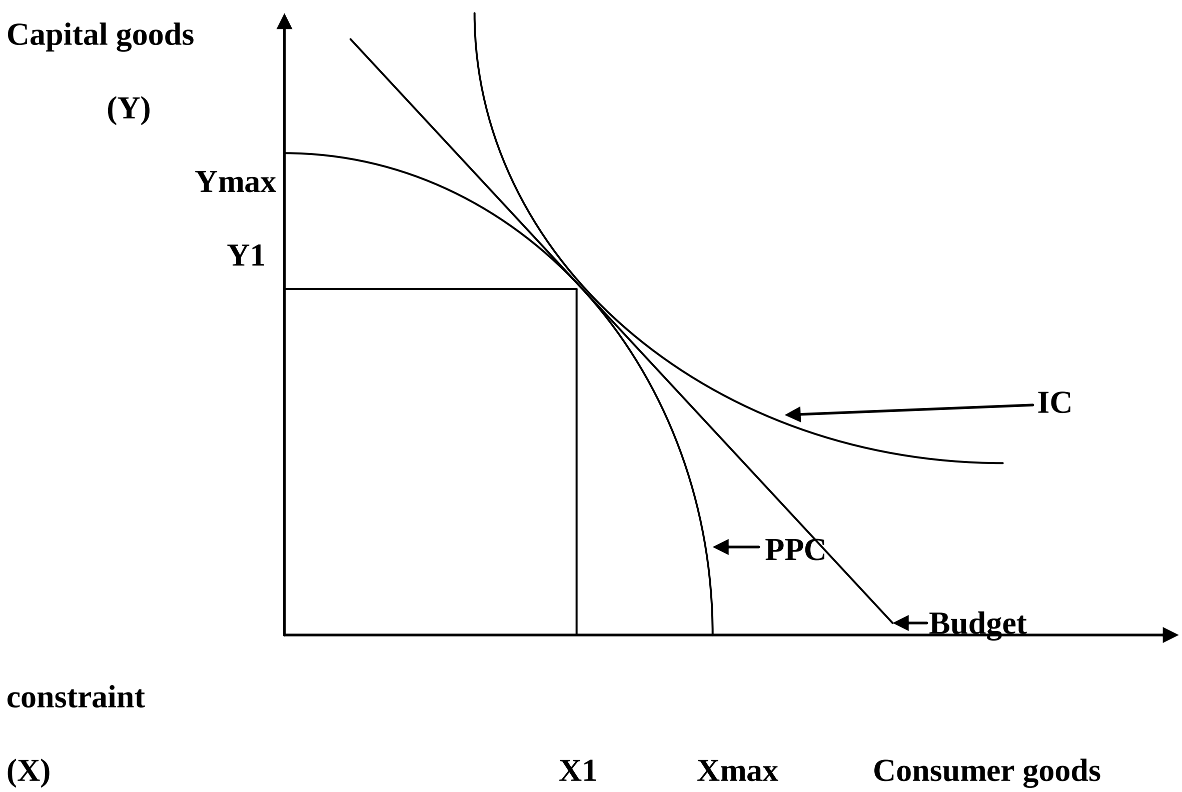

Figure 3: Production Possibility curve, Indifference curve and budget constraint

Source: Chidakwa and Kandenge, 2003 and Author of this study

The producer who is also a consumer will produce at point Y1 and X1 where all resources are used with maximum efficiency within the budget and satisfying consumption needs (Chidakwa and Kandenge, 2003). Any changes that might occur in the in the budget constraint (income available) would result in shifts of the IC (isocost) and PPF(production possibility frontier) and that would change the proportions of capital and consumer goods for the household.

3.2 Household models

Becker's approach considers the household as both consumption and a production unit. It consists of maximising utility subject to a production function and other constraints are restricted by the scarce time available and available income (Gibreel, 2009). Households are simultaneously engaged in production, consumption and labour decisions hence the farm household cannot be viewed as separately or independently maximising profits as a producer and utility as a consumer, thus in developing countries a household decisions are non-separable. A household is viewed as a rational utility maximiser and can be modelled as allocating its budget to minimize the cost of achieving a given level of utility. When pursuing utility maximisation, the household is faced with income constraint and price of goods to be purchased thus budget constraint (Himmelweit, *et al*, 2001; Parkin, 1998).

A household is modelled to represent its behaviour as both a producer and a consumer. This is done using formal models that abstract from complexities of the real world to concentrate on a few variables and investigating thoroughly the relationship between production and consumption, sometimes using mathematical modelling a great deal (Himmelweit, *et al*, 2001)

Production of crops which can be consumed or sold ceases to be regarded as non-market activity when basic needs are met and surpluses are exchanged for cash in the market. Thus such a production is regarded as a market activity directly comparable with other market activities such as wage employment. The point at which changeover between non-market and market activity takes place in relation to subsistence crop production depends on household member's wage rates in relation to the purchase price of food as well as on the structure of the household (consumer/worker ratio). Other constraints other than land may cause return to labour to fall. Land and labour are the major resources in small-scale African farming where capital assets tend to increase together with increasing availability of labour and land (Low, 1988).

Smallholder farmers in rural areas produce mainly for own consumption and their produce do not necessarily enter the market. Thus, household economics is suitable for analysis of non-market production at the household level. Consumption involves a production process at the household level, thus rural farm households are described as production/consumption units (Low, 1988).

Low, 1986, states that Chayanov introduced the concept of consumer/producer ratio to analyse the effect of changing household structure on production and income over the life cycle of a peasant household. He argued that at any given level of income, the days worked per worker increased as the consumer/worker ratio increased and thus the absolute level of family demands per worker increased. The volume of the family's activities depends entirely on the number of consumers and not at all on the number of workers. Household structure thus has an influence on production and consumption. It is important to note that high proportions of farm households are deficit producers who purchase part of their subsistence requirements (Low, 1988). Agricultural household models were used in many studies and have evolved over the years. Nakajima (1970) applied a household model for commercial farms that consumed part of their produce and output was valued in monetary terms a situation deemed not exist in Southern African rural areas. Low (1988) improved on the models to include a multiperson model suited for southern African households that assume that there exists some comparative advantage in crop production versus wage employment given the wage-rate differentials that face farm households in Southern Africa. However, theoretically, for this study focus will be on Sing's model.

3.3 Singh's model

In their household model, Sigh et al, (1986), identified total household income as the major constraint on crop consumption or family labour supply. The household cannot consume more crop or leisure than is allowed by its total income. With fixed prices, two components of the model are related only through income and only in one direction, from production side of the model to the consumption and labour supply side and rendering the model to be recursive (Singh et al, 1986).

Singh et al (1986) explained that the amount of labour applied to crop production can be determined independently of the amount of labour to be used. This is because the difference can be hired at a fixed wage. Accordingly, the amount of crop to be produced can be determined independently of the amount of crop to be consumed because the household can always buy or sell crop at a fixed price.

Since the household always prefers more income, it makes sense to maximise profits and then allocate the resulting income to crop production, the non- agricultural commodity, and leisure given the prevailing market prices (Singh et al, 1986).

Within the framework of an agricultural household model, linear programming characterisation of production has been used to investigate factors influencing the allocation of resources among several crops. Since agricultural household models integrate production and consumption decisions in rural farm households, to formulate them, data is needed on consumption expenditures (market purchased and subsistence), labour supply, farm and non-farm outputs, variable inputs, fixed farm assets, basic demographic characteristics, prices for consumption and production inputs, including wages.

Nonseperable model would be one in which consumption and production activities on the same households are used and recorded, while separable models use time series crop sectional data from a representative sample and group averages are used. According to Singh et al (1986), a static household model is developed with an objective to maximise utility subject to (i) production function (ii) time and (iii) budget constraint.

Singh et al, 1986 estimated the household model that maximises utility U (X_1,..,X_L) where arguments are household consumption of commodity i, with X_L denoting total leisure time.

Utility is maximized subject to a budget constraint.

$$Y = \sum_{i=1}^{L} Pi.Xi \tag{3.1}$$

Where Y is household's full income;

P_i = price of commodity i

X_i = quantity of commodity i

Total income of an agricultural household is assumed to be equal to the value of its time endowment, plus the value of the household's production less the value of variable inputs required for production of outputs, plus any nonwage, nonhousehold production income such as remittances as shown below:

$$Y = pLT + \sum_{j=1}^{M} qjQj - \sum_{i=1}^{N} qiVi - plL + E \qquad (3.2)$$

Where Y = total income

T = time endowment

Qj = output for j=1…m

V_i = non labour variable inputs, for I=1…N

L = labour demand

qj = price of Q_j

qi = price of V_i

E = exogenous income

Applications of the agricultural household model and extensions have been widespread (Findeis *et al*, 2003). An example is Pitt and Rosenzweig (1986) that extended the general agricultural household model by incorporating a household health production sector in which the household produced good and health which can both affect the production of farm output and provide direct additional utility to the household. Effects of short-term illness of farmers and their spouses on farm profits and labour supply and effects of alterations in food consumption on the level of household health can be analysed. Pitt and Rosenzweig (1986) showed how consumption, household constraints, farm production, and the efficiency of input and output markets are directly affected by changes in health of the household.

Models have used cross-sectional (typically a single year) as well as, more recently, panel data and multiple production periods to reflect the seasonality of production that is often critical when understanding household behaviours as well as to analyse household behaviours, including consumption, (household) labour supply, and hired labour demand (Findeis *et al*, 2003).

In most rural areas in developing countries, where households depend on agriculture for their livelihoods, perfect markets are not observed. The prevalence of HIV/AIDS in many countries especially in sub Saharan Africa, severely threatens adjustments through labour markets that might otherwise be possible. Illness and death of household members severely erodes the productive labour resources of agricultural households (Mutangadura *et al*, 1999; Rugalema, 1998a; Stokes, 2003). A problem encountered frequently in the estimation of farm household firm models is the existence of corner solutions. This problem is solved by aggregation of commodities and inputs. Cross-sectional data often lacks variation in input and output prices when applied at a regional level (Findeis *et al*, 2003). The agricultural household model for this study assumes a non-linear farm production function assuming that the marginal returns to labour decline with increases in production.

The farm household model is conceptualised as either separable or non-separable as shown below:

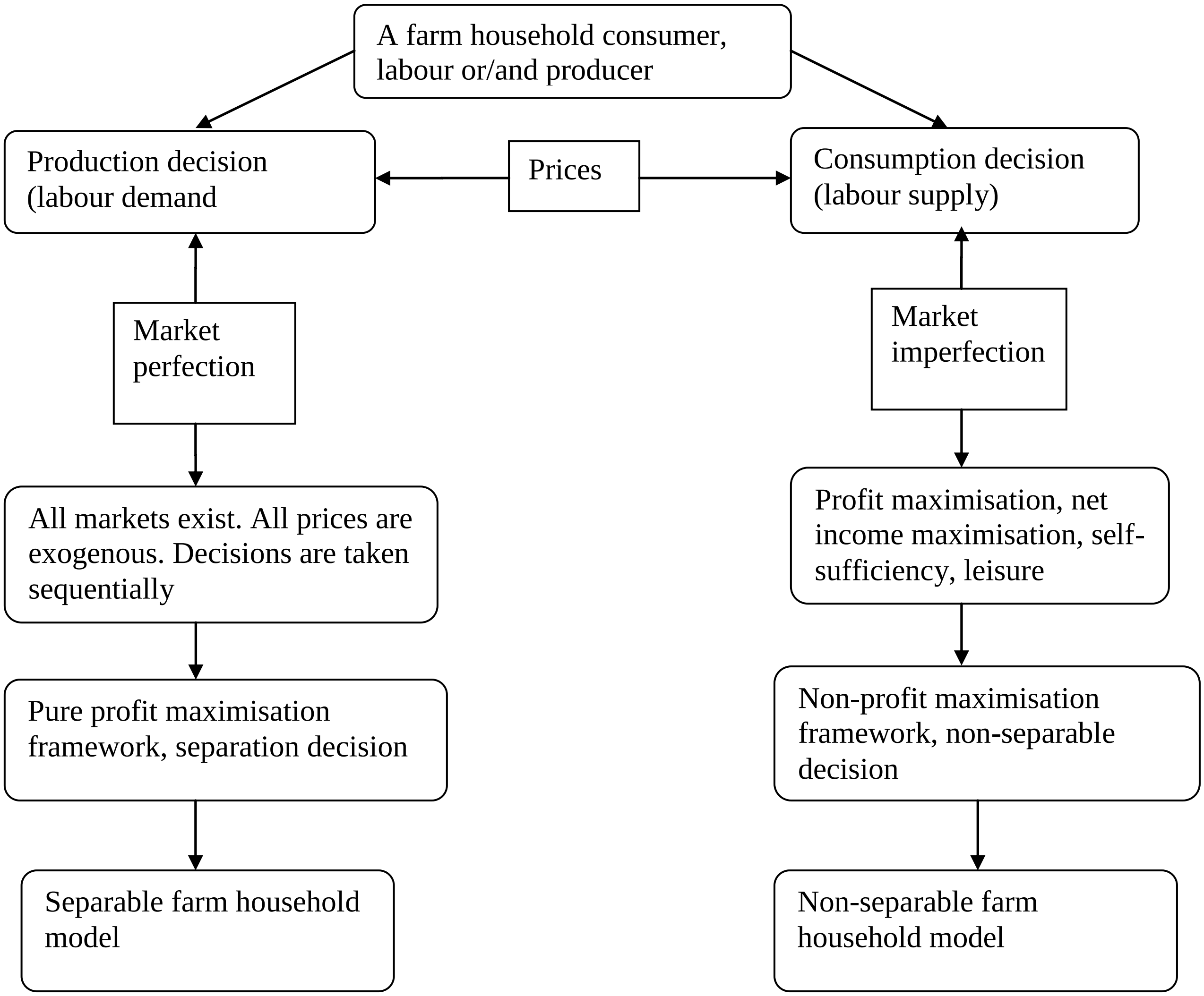

Figure 4: Theoretical structure of the farm household model

Source: Gibreel, 2009

3.4 Summary and implications of theory for the current study

The theory above has shown how production and consumption decisions in a household are linked. Production decisions determine farm profits which are a component of household income, which in turn influences consumption and labour supply decisions (Singh et al, 1986). Low (1988), illustrated that at household level an increase in the number of producers would effect an increase in the basic consumption requirement and that the ratio of farm production to the basic consumption requirement would fall as a result of an increase in the size of the household. Likewise, a decrease in number of producers would effect a reduction in output and thus reducing consumption requirement. This also applies in situations where reduction of labour supply is due to sickness or death as caused by HIV/AIDS as is the case in the current study and hence this approach is applicable to the current study.

The current study draws heavily on the household model by Singh *et al,* (1986) for multicrop environment. In Kavango, most households produce for home-subsistence needs, and there are few opportunities for off-farm incomes and a huge uncertainty about expected outcomes that depend upon weather thus they plant a variety of crops by intercropping to cover for the risk aspect. Pitt and Rosenzweig (1986) showed how consumption, household constraints, farm production, and the efficiency of input and output markets are directly affected by changes in health of a household. Likewise, the same concept can be applied to analyse impacts of HIV/AIDS on smallholder farmers' income and production in Kavango region for the current study using the Cobb-Douglas functions and the household model to show the effects of HIV/AIDS.

The next chapter embarks on model development for the current study drawing insights from procedures and assumptions highlighted in this chapter.

CHAPTER 4: MODEL DEVELOPMENT

4.0 Introduction

This chapter covers the salient aspects of model development by presenting the model and then describing the process of formulating the representative farms. Section 1 deals with NLP model formulation. Section 2 highlights available farm typologies used in Namibia. Section 3 looks at the process of establishing farm typologies for the current study using multivariate statistical analysis and selection of the representative farms for the surveyed areas grouped into two farming systems namely riverine and inland in Kavango region.

4.1 Mathematical formulation of the model for the study

The farm household model for this study follows a non-linear programming approach using Cobb – Douglas production and utility functions. The model consists of an objective function assumed to maximise utility subject to a number of constraints on production function, total available time, total available land, exogenous market prices, household budget and non-zero variables. The model depends heavily on Gibreel (2009), Singh *et al,* (1986) and Dorward and Mwale (2005). The behavioural equations of the model are specified as follows:

Max $U \leq \alpha_u Cm_i^{\alpha_m} Cl_i^{\alpha_l} \prod Ca_i^{\alpha i}$ 4.1

The model seeks to determine the effects of reduction in labour on the household income and agricultural production and how this influences resource allocation. The household derives its utility from consuming own produced goods, market-purchased goods and leisure.

Subject to

$\beta_{i,constant}\ \pi_j\ f_{i,j}{}^{\beta(i)} \geq C_{ai} + X_i$ Production function 4.2

The production function measures the maximum possible output obtainable from given amount of input and reflects the returns to farm self-employment.

L+ $lh \geq \sum_i f_{i,labour} \ + l_l$ time accounting identity 4.3

The time constraint shows the labour capacity of the farm household given the total available time.

A$\geq \sum_i f_{i,land}$ land constraint 4.4

Total available land is fixed in the short run and is not to likely to increase.

$y_x \ + \sum_i P_m X_i \ \geq \ \sum_i (p_i \ x_i \ + q_i \ f_{ij}) \pm wlh$ Income constraint 4.5

The income constraint measures the total income that the household generates and this should be more or equal to the expenditures that the household incurs.

$f_{xi} \geq 0, Ca_{i,} X_{i,} Cm_i \geq 0, l_l \geq 0, l_h \geq -L$ Non-zero variables 4.6

Where endogenous variables

U ≡ utility of consumption of own agricultural produce, market purchased goods and leisure

$f_{i,j}$ ≡ factor input j for the production of crop i,

$Ca_{i,}$ ≡ consumption of own produce

Cm_i ≡ consumption of market purchased goods,

Cli ≡ consumption of leisure

Xi ≡ marketed surplus of own agricultural output i,

xi ≡ market purchased commodities

lh ≡ quantity of sold (-) or purchased (+) labour

Exogenous variables

L≡ Labour capacity of the farm household

A ≡ Land endowment (fixed) of the farm household

Yx ≡ exogenous income (non-farm earnings and remittances)

P_i ≡ vector of price of commodity i,

P_m ≡ vector of farm gate price of own product I

qj ≡ vector of price of factor input j

w ≡ wage rate

Parameters

α_i, α_m , α_l , α_u, ... parameters of the utility function

$\beta_{i,} \beta_{ij}$ ... , parameters of the production function with output i, and input j.

Utility function specification

$$U_{hh} = C_{millet}{}^{\alpha 1} C_{maize}{}^{\alpha 2} C_{sorghum}{}^{\alpha 3} C_{market-purchase}{}^{\alpha 4} C_{leisure}{}^{\alpha 5} \qquad \textbf{4.7}$$

Total household utility is derived from the consumption of own produced millet, maize and sorghum as well as consumption of market-purchased goods and leisure time consumption.

U_{hh} is utility level

C_{millet} is consumption level of own production of millet

C_{maize} is consumption level of own production of maize

$C_{sorghum}$ is consumption level of own production of sorghum

$C_{maket-purchase}$ is consumption level of market purchased goods

$C_{leisure}$ is consumption level of leisure

$\alpha_1 \dots \alpha_5$ utility coefficient for consumption of own produced millet, maize, sorghum and market purchased goods and leisure respectively.

The model is based on the assumptions that:

- Household has access to off-farm employment
- Output of grain is retained for own consumption or sold if there is surplus

- Output is produced using family labour and hired labour
- Household maximises utility by consuming own output, purchased market goods and leisure
- Household has fixed area to grow crops (no rentals for land)
- Hired labour is constrained by available cash
- Household income cannot be exceeded by spending on purchased goods, labour, inputs, etc.
- Cash income is earned from sale of food/cash crops which equates to production, sale of food crops, earnings from off-farm work and remittances.

In this study, the production functions are assumed to have positive constant returns to land and labour. The utility is the function of the consumption desires of food crops (millet, maize and sorghum) in addition to consumption of market purchase of staples, other food and non-food items and leisure. The capital inputs include aggregate values for production inputs, tools for crop production and seeds (Gibreel, 2009).

The shares were set to the Kavango rural consumption expenditure items and shares with total rural Kavango average expenditure of N$18500 (CBS, 2006) see appendix 4, 8 and 10 for detail of items. GAMS was used to solve the equations (see appendix 3).

4.2 Cobb-Douglas Production functions and Models

Cobb-Douglas production function has been one of the most widely used functional forms in economics both in applied and theoretical work (Garcia-Verdu, 2005). Cobb-

Douglas production functions are assumed for production of millet, sorghum and maize. The Cobb-Douglas functions are used to represent the relationship of output to inputs. The exponents in the household specific production functions were set equal to measured factor/budget share for each good. The output elasticities measure the responsiveness of output to a change in levels of either labour or capital used in production *ceteris paribus* (Barnett, 2007; Komarek & Ahmadi-Esfahani, 2007). This applies to the current study where changes in the levels of labour and capital are brought about by the effects of HIV/AIDS. Leisure time was valued using the household relevant wage for off farm work, which is the opportunity cost of time (Komarek & Ahmadi-Esfahani, 2007; Garcia-Verdu, 2005). The difference between the labour parameters highlights that households use more family labour than hired labour as evident from the variables in the representative farms.

The exponents of the production function add up to one assuming constant returns to scale for this study. Under diminishing returns however, the sum would be less than 1 and greater than 1 under increasing returns to scale (Barnett, 2007; Komarek & Ahmadi-Esfahani, 2007). Households are assumed to maximize utility, as it is both a producer and a consumer that is bound to respond to any changes that affect any attributes as producer or consumer/labour (Gibreel, 2009). Farm households have been used in price policies, off-farm labour supply, technology policy, nutrition policy, downstream growth, labour supply, migration, income distribution, savings and family planning, risk and health. The farm household model was estimated using two dependent components namely production and consumption modules. Each module was estimated with standard consumer and producer approaches based on Cobb-Douglas functional forms. Cobb-Douglas is used in this study because the data is based on one season only and also that it is not complicated (Gibreel, 2009).

4.3 Scenarios used in the study

These scenarios are loosely based on Thangata et al, 2007.

Scenario 1: Adult male illness: when male falls sick, and the female has to take care of him. The male labour is lost from farm and non-farm activities, and the female labour is also lost as she takes care of the sick member of the household. This has effects on total available labour and total household income thereby affecting farm activities and eventually output and food security situation. Assumptions are that the male contributes 33% of total farm labour while the female contributes 62% of labour (Keyler, 1995, Hange *et al*, 1998). When the husband is sick the female can devote about 60% of her labour from farm activities to caring for the sick and this can range from 5.7 -14.3 hours per day devoted to caring for the sick (Asenso-Okyere *et al*, 2010).

Scenario 2: Adult female illness: The female is sick and no extra help from relatives is received. Her labour contribution is lost and part of female children's labour is also lost. However, when there is help, her labour contribution to farm activities is lost but the remaining labour is not compromised in cases where a relative comes to help in taking care of the sick female or where the sick female goes to her relatives to be taken care of.

The male labour is not affected much as they do not have responsibility to take care for the sick. With or without help, the female labour is lost as the helping relative has no contribution to farm labour as she will be taking care of the sick female.

Scenario 3: Both Adult male and adult female illness: Both male and female fall sick and available labour is reduced as well as income from non-farm activities as both are incapacitated. Only child and elderly labour is available with part of it going to caring duties. Labour is lost from the male (33%) and from the female (62%) leaving just about 5% of labour available from the children and elderly (Mendelsohn and Obeid, 2005; Keyler, 1995). Other effects such as agricultural knowledge may also be lost in the process. In this case, even if a relative comes to take care of the sick, he or she will not have time for farm activities as she will be occupied with caring duties.

Labour for weeding is the most time consuming and critical in achieving good yields. Farmers in Kavango weed their fields less frequently compared to other regions and this may explain lower yields often obtained in this region (Mendelsohn and Obeid, 2005). Each scenario presents with itself effects on labour availability, income and farm activities of the household. These effects are present and discussed in the results section. The different types of labour and proportions of income lost under each scenario are shown as a percentage of total income.

4.4 Farm Typologies used in Namibia

There are two existing classifications identified in Namibia by Low et al, (1999) and by NNFU (Undated) which are applicable for the current study. The classification approach used by Low et al (1999), distinguished between peasant family farm (PFF) and commercial family farms (CFF) on the basis of cash input costs, which are low for PFF and high for CFF, and use of non-household labour and support services provided to sustain production. NNFU further subdivided the peasant or smallholder and commercial into three broader categories.

4.4.1 NNFU farm typology

The farm typology by NNFU for the NCAs (Northern Communal Areas) classified the NCA farms into 3 broad farm types 1, 2, and 3 (see appendix 2 for a detailed description of the NNFU classification) The classification of the farm types is based on the following criteria:

(1) Number of livestock owned (cattle)

(2) Farm size and Land area cultivated

(3) Objective of production (Subsistence, subsistence and market, market)

(4) Farm power (DAP, tractor)

(5) Purchased inputs (input costs)

(6) Food security (grain meets consumption requirement)

(7) Marketable surplus

(8) Gender of household head

(9) Additional income available

(10) Farm labour (family or hired)

The above-identified NNFU variables are used in the current study to select variables for PCA (Principal Component analysis) and Cluster analysis for farm typology and formulation of representative farms.

4.5 Materials and methods

The Data used refers to 2003 and was obtained in 2003 (September) from surveys of 180 farmers in Kavango, drawn from 3 ADCs of Kaisosi, Mashare and Mile 30. In terms of Agro-ecological zones (farming system), Kaisosi and Mashare belong to the riverine and Mile 30 to the Inland. About a third of the entire sample was drawn from the inland and two-thirds from the riverine farming system. The sample of farmers was obtained using a systematic and stratified random sample. Two stage stratification by farming system and ADC and then within ADC was done. The 3 ADCs used were purposively selected. The 60 farmers within each ADC were stratified into 3 groups according to Youth, Male and Female.

4.6 Establishing Farm typologies

In this study mathematical programming was applied. Mathematical programming models provide a means of generating recommended solutions which have to be constructed for representative solutions to be effective. Multivariate statistical techniques provide a means of creating the required typologies when data is available. Thus factor/principal components and cluster analysis can be used for farm typification prior to building representative mathematical programming models (Kobrich et al, 2003)

The NNFU criteria and classification was applied to the current study. The above section identified NNFU variables that were used as key variables on which variable selection for the current study were based. The NNFU's broad farm types 1, 2 and 3 were also applied in the current study.

The data was analysed using multivariate statistical analysis procedures of principal component analysis and cluster analysis. The PCA was used to get key factors on characteristics that dominate the surveyed farms while cluster analysis was used to generate 3 groups (based on NNFU farm types) from selected variables obtained in the PCA procedure. Mean values of key variables that define each group were then calculated using one-way analysis of variance (ANOVA). The 3 groups or clusters obtained are average farms with similar activities and the most representative cluster is chosen to represent the ADC for further analysis.

4.6.1 Principal Components analysis

PCA is multivariate statistical procedure that is used to transform a number of correlated variables into a smaller number of uncorrelated variables called principal components. The first identified principal component accounts for as much of the variability in the data as possible and each succeeding component accounts for as much of the remaining variability as possible (Smith, 2002; Ghauri & Gronhaug, 2005; Milan, *et al*, 2003). In order to interpret the principal components that characterise the farms, a rotated matrix and varimax are used which identify the characterising factors on the farms according to main activities that take place (Milan, *et al*, 2003).

4.6.1.1 PCA results

Using NNFU (unknown year) characterising variables, PCA was run for each ADC namely Kaisosi (peri-urban river line farming system), Mashare (rural river line farming system) and Mile 30 (rural inland farming system). Rotated component matrix and varimax were used to interpret the PCA and only those variables with an Eigen value of more than 1 were used. The results are shown below:

Table 2: Rotated component matrix for Kaisosi ADC

Variables	Component			
	1	2	3	4
Farm Income	.861			
Number of hired farm workers	.794			
Hired animal draft power	.747			
Household members helping regularly with farm work		.944		
Total cultivated land size		.830		
Additional Income			.767	
Expenditure on seeds			.748	
Total number of cattle			.713	
Months farming satisfies basic household food needs				.929
% of variance	23.66	20.60	19.88	13.03

The results of PCA in Table 2 above indicated that there are 4 principal components for Kaisosi ADC, which explain about 77 % of total variance. The first principal component accounts for 23.7 %, the second accounts for 20.6 %, the third accounts for 19.9 % and the fourth component accounts for 13 % of total variation. The rotated component matrix for Kaisosi, Table 2 above, shows that the first principal component consist of factors that explain farm income and its subsequent uses, the second principal component explains family labour availability, the third principal component explains wealth, while the fourth component explain food security issue.

Table 3: Rotated Component matrix for Mashare ADC

Variables	**Component**		
	1	**2**	**3**
Additional Income	.777		
Farm Income	.758		
Total cultivated area	.722		
Number of hired farm workers	.676		
Total number of cattle		.756	
Months farming satisfy basic household food needs		.695	
Household members helping regularly with farm work		.684	
Hired animal draft power is the main means of cultivation			-.706
Expenditure on seeds			.638
% of variance	26.45	17.69	13.06

The results of PCA for Mashare ADC in Table 3 above indicated that there are 3 principal components for which explain about 57 % of total variance. The first principal component accounts for 26.5 %, the second accounts for 17.7 %, and the third principal component accounts for 13.1 % of total variation. The rotated component matrix for Mashare ADC, above, shows that the first principal component consist of factors that explain total household income and its subsequent uses for production, the second principal component explains family labour availability and food security, and the third principal component explains input and labour expenditures.

Table 4: Rotated Component matrix for Mile 30 ADC

Variables	Component			
	1	2	3	4
Total number of cattle	.848			
Total cultivated land size	.834			
Expenditure on seeds		.862		
Months farming satisfies basic household needs		.819		
Additional income		.650		
Farm income			.824	
Household members helping regularly with farm work	.558		-.636	
Hired animal draft power is main means of cultivation			.459	
Number of hired farm workers				.914
% of Variance	22.25	22.07	16.39	12.78

The rotated component matrix for Mile 30, Table 4 above, shows that the first principal component consist of factors that explain cultivated land size and cattle ownership, the second principal component explains food security and wealth, the third principal component explains farm income and family labour available, while the fourth component explain hiring of labour. The results of PCA for Mile 30 in Table 4 above indicated that there are 4 principal components which explain about 73.5 % of total variance. The first principal component accounts for 22.3 %, the second accounts for 22.1 %, the third accounts for 16.4 % and the fourth component accounts for 12.8 % of total variation

Table 5: Rotated Component matrix for the 3 Kavango ADCs

Variables	**Component**			
	1	**2**	**3**	**4**
Total number of cattle				.544
Total cultivated land size			.665	
Expenditure on seeds		.829		
Months farming satisfies basic household needs		.832		
Additional income	.443			-.578
Farm income	.798			
Household members helping regularly with farm work			.852	
Hired animal draft power is main means of cultivation				.549
Number of hired farm workers	.732			
% of Variance	21.6	15.3	13.3	12.4

The results of PCA for all 3 ADCs in Table 5 above indicated that there are 4 principal components which explain about 63.7 % of total variance. The first principal component accounts for 21.6 %, the second accounts for 15.3 %, the third accounts for 13.3 % and the fourth component accounts for 12.4 % of total variation. The rotated component matrix for the 3 Kavango ADCs, Table 5 above, shows that the first principal component consist of factors that explain income and ability to hire labour, the second principal component explains food security, the third principal component explains farm land availability and family labour available, while the fourth component explain cattle ownership and, hiring of draft power, and wealth.

4.6.2 Cluster analysis

The objective of cluster analysis is to discover natural groupings of the units in a sample in a group are called a cluster (Ghauri & Gronhaug, 2005). Cluster analysis differentiates and groups farms according to their homogeneity using Euclidian distances. Cluster analysis accomplishes this through the calculation of distance between cases with respect to clustering variables chosen for classification. The procedure then assigns cases that are closest to each other in distance to the same cluster. A one-way ANOVA is then used to check the differences between groups (Milan *et al*, 2003).

4.6.2.1 Cluster analysis results

For each ADC, three groups were obtained using cluster analysis and based on three types of farms identified by NNFU. A K-means cluster analysis was performed on data for 10 variables and factors drawn from NNFU and Low *et al* (1999) farm typology. This analysis is expected to find 3 groups of farm types in each ADC as per NNFU typology. This analysis differentiates and groups farms according to their homogeneity using the Euclidian distance (Milan *et al*, 2003).

Finally the mean structural (farm size, cultivated land area, etc.) technical and economic indicators that define each group were calculated. The differences between groups were checked using a one-way ANOVA analysis with a Student-Newman-Keuls mean comparison test. All the calculations were made using version 10 and 17 of the SPSS statistical package (SPSS, 1999 and 2009).The results of the obtained farm typologies and representative farms for the two farming systems in Kavango region were formulated and developed for the 3 ADCs with two for the river line system which has Kaisosi as peri-urban and Mashare which is rural and 1 for the Inland farming system represented by Mile 30. The results are shown below.

Table 6: Cluster analysis results for all 3 ADCs based on PCA results

Cluster	Kaisosi	Mashare	Mile 30	All 3 Kavango ADCs
	N	N	N	N
1	27	1	30	3
2	7	37	3	118
3	2	12	5	3
Total	36	50	38	124

4.6.3 Representative farms

Representative farms for each ADC and for all the 3 ADCs, were chosen in the above cluster with the most number of farms in each ADC and using the mean values that were generated by ANOVA for selected variables. The representative farms that were chosen are as follows, Kaisosi cluster 1 with 27 farms, Mashare cluster 2 with 37 farms and Mile 30 cluster 1 with 30 farms and for the 3 Kavango ADCs cluster 2 with 118 farms representing 75 % of usable cases, 74 % of usable cases, 79 % and 95% of usable cases respectively. These variables were used together with some coefficients generated in Abate et al (2001) based on NNFU farm typology and principal component analysis results, to build the programming model. The representative farm results are shown below:

Table 7: Representative farms for each ADC selected by discriminant cluster analysis

Variable	ADC				F - value	Significance
	Kaisosi N=27	Mashare N=37	Mile 30 N=30	Kavango 3 ADCs N=94		
Farm income (N$)	53.33	420.19	517	345.7	3.284	0.042[a]
Additional income (N$)	6352.67	3291.16	1137.43	3483.17	3.357	0.039[a]
Expenditure on seeds (N$)	44.33	42.05	60.25	48.52	1.413	0.249
Household members helping regularly with farm work	4.81	4.9	6.4	5.4	1.285	0.282
Number of hired farm workers	0.33	0.9	0.7	0.7	1.227	0.298
Total farm size (ha)	6.37	5	8.7	6.57	10.323	0.000[a]
Total cultivated area (ha)	4.04	3.37	4.73	4	3.187	0.046[a]
Hired draft power main means of cultivation	0	0.13	0.1	0	1.910	0.154
Months farming satisfies basic household food needs	4.44	4.95	4.1	4.5	0.512	0.601
Total number of cattle	12.96	20.1	13.27	15.9	2.94	0.058[b]

a, *significant at 5%, and* **b**, *significant at 10% significance level.*

The representative farms show that they are differentiated by 5 variables that are significant at 5% and 10% respectively. These are farm income and additional income, that show that Kaisosi generates very little farm income and high additional income compared to the other ADCs. Farm income plays an important role in Mashare and Mile 30 ADCs. Farm sizes and cultivated areas are also very different with Mile 30 showing the largest farms and cultivating the most area. Cattle numbers also distinguish these representative farms from each other. When this classification is compared to the NNFU typology, the above farms are food insecure as they do not produce enough to satisfy their consumption requirements, but they do not conform to the other criteria used such as that of farm size, livestock numbers and marketable surplus. The results suggest that the representative farms generated here range between type 1 and 2 of the NNFU typology but at the same time breaching the criteria on farm size, food security situation, livestock numbers and marketed surplus. These results suggest that classifying farms is a complex matter, and aggregation of data will dilute the differences, and also that the farm types will overlap depending on criteria used.

CHAPTER 5: MODEL RESULTS AND DISCUSSION

5.0 Introduction

This study applied a direct maximized non-linear utility function based on an underlying production function to assess the empirical effect of a wide range of HIV/AIDS scenarios for the surveyed farm households in Kavango region. A non-linear farm household programming model is applied to the representative farm household with different resource endowment in Kavango region. The results were used to describe the optimal values of the total surveyed area and for each of the ADCs. The procedure followed for the analysis was as follows:

1. Consumption (Cobb-Douglas Utility): consumption budget share – consumption parameters
2. Production (Cobb-Douglas production function): Input factor share –production parameters (assumed constant returns to scale)

Production parameters were then incorporated into a household model in GAMS with utility maximisation for the objective function subject to constraints from the endogenous variables. HIV/AIDS scenarios were then imposed on the model for the determination of the household's resource allocation, food consumption, marketed surplus and cropping pattern which defines household welfare under these scenarios. The grain prices used were obtained from Namibia Agronomic board (appendix 8). The first section presents the results on the effects of illness (scenarios) on the household labour and income sources. The second section presents the model results in GAMS using NLP Cobb-Douglas production and utility functions.

5.1 Effects of illness on household labour and income

It is assumed that there is a proportional relationship between labour and income as labour is reduced, the income that was generated in those activities in which the labour was used is also lost. Kaisosi ADC, a peri-urban area does not seem to generate any significant income from farm activities as shown below. Due to the fact that the analysis will focus on available household labour for farm activities and effect of changes brought by reduction in labour on production and income, Kaisosi will be omitted from further analysis and modelling.

Table 8: Kaisosi ADC household income by source

Income Source	Income amount by source (N$)
Fishing	441.14
Salary	9885.56
Remittances	2186.36
Pension	3000
Local beer	1289
Wild fruits	22.56
Total household income (with no sickness)	16824.62

Kaisosi ADC is a peri-urban settlement hence dependency on farming is little compared to other income generating activities.

Table 9: Mashare ADC Scenario 1Male illness

Income Source	Income generated (N$)	% of labour lost when male is sick	Income lost when male is sick (N$)	% labour lost from female when male is sick	Income lost by female when male is sick (N$)
Fishing	167.64	100%	167.64		
Livestock	859.77	100%	859.77		
Salary	6634.62	100%	6634.62		
Remittances	1322.22				
Pension	3000				
Local beer	852.86			60%	511.72
vegetables	825			60%	495
Shop and business	2262.5	100%	2262.5		
Wild fruits	61.8			20%	12.36
Carvings	205	100%	205		
crops	214	33%	70.62	36%	77.04
Total household income (with no sickness)	16405.41		10200.15		1096.12
Percentage of income lost	68.86%		62.18%		6.68%

In Mashare ADC when the male is sick, his labour contribution is lost on crop farming and livestock production and also his non-farm activities are abandoned leading to direct income loss. The male sickness leads to labour loss that translates to 62.18% of total household income. The female as the care giver when the male is sick loses earnings amounting to 6.68% of total household income due to time spend on care giving duties. Total effect on household income is 68.86% when male is sick. Major assumptions are that remittances and pension are not affected as a source of income and that the scenarios are run at peak labour requirements of a cropping season from land preparation to harvesting and threshing and that the sick person is severely ill and cannot contribute to labour for field work. Furthermore, males do not have a responsibility to take care of the sick, while women have to take care of the sick and are also the major contributors of farm labour (62% in Kavango compared to 33% for men). Women were found to devote 60% of their farm work time to taking care of the sick (Rugalema, 1998). Women also spend between 5.7-14.3 hours per day taking care of the sick and sick husbands (results from studies in Free state South Africa, Zimbabwe and Ethiopia: Asenso-Okyere *et al,* 2010). Thus although the male is sick and the female is taking care of him she does not completely abandon the rest of the activities but the labour time she devotes is greatly reduced. However in a study in Zambia, it was found that the female completely abandoned harvesting when the male was ill during that time. These assumptions apply to all the scenarios used in this study. It is further assumed that the male is the breadwinner earning a salary or wage, and that the female labour for other activities that are not farm activities are reduced by small percentage as children can do the tasks as well. These tasks include gathering wild fruits. The other activities that the female was involved in are affected as labour is diverted to other caring.

Table 10: Mashare ADC Scenario 2 Female illness

Income Source	Income generated (N$)	% of labour lost from male when female is sick with help	Income lost from male when female is sick with help(N$)	% labour lost from female when female is sick with help	Income lost from female when female is sick (N$)
Fishing	167.64				
Livestock	859.77				
Salary	6634.62				
Remittances	1322.22				
Pension	3000				
Local beer	852.86			100%	852.86
vegetables	825			60%	495
Shop and business	2262.5				
Wild fruits	61.8			50%	30.9
Carvings	205				
crops	214			62%	132.68
Total household income (with no sickness)	16405.41				1511.44
Percentage of income lost	9.21%				9.21%

It is assumed that when female is sick, she will be looked after by another female relative, thus male labour will not be affected. This will result in only the female labour being lost to farm and non-farm income activities she was involved in but the male labour will be available. The male has no care giving responsibilities (Thangata et al, 2007) thus his labour will continue to be available and he will continue to generate income as always. The male contributes significantly to the total household income although the female makes the biggest contribution in terms food production. The helper does not contribute labour to farm activities as she is only responsible for taking care of the sick person. Therefore only 9.21% is lost in income due to the labour loss from the female. It is however important to note that although the female contributes most of the labour to farm activities for food production, most of her labour contributions are not valued in monetary terms hence the percentage that is lost due to her illness might be understated.

Table 11: Mashare ADC Scenario 3 Both male and female illness

Income Source	Income generated (N$)	% of labour lost from male when female is sick without help	Income lost from male when female is sick without help (N$)	% labour lost from female when female is sick without help	Income lost from female when female is sick without help(N$)
Fishing	167.64	100%	167.64		
Livestock	859.77	100%	859.77		
Salary	6634.62	100%	6634.62		
Remittances	1322.22				
Pension	3000				
Local beer	852.86			100%	852.86
vegetables	825			100%	825
Shop and business	2262.5	100%	2262.5		
Wild fruits	61.8			100%	61.8
Carvings	205	100%	205		
crops	214	33%	70.62	62%	132.68
Total household income (with no sickness)	16405.41		10200.15		1872.34
Percentage of income lost	73.58%		62.18%		11.4%

The assumption in this scenario is that both male and female get sick. Whether they get someone to take care of them or not, their contribution to labour and income is lost from the household. The female loss in income is 11.4% while the male loses 62.18%.The total non-farm income that will be lost as a result of both male and female sickness and labour loss is 73.58%. The reason for this is pension and remittances will remain and a small portion of labour that may be contributed by the children and the elderly in the household will cover the portion left by the sick. However, should remittances and pension be affected this would mean no income from anywhere, thus losing 100% of their household income.

Table 12: Mile 30 ADC Scenario 1male illness

Income Source	Income generated (N$)	% of labour lost from male when male is sick	Income lost from male when male is sick (N$)	% labour lost from female when male is sick	Income lost from female when male is sick (N$)
Crops	605.71	33%	199.88	36%	218.06
Remittances	937.5				
Pension	3000				
Livestock	1393.75	100%	1393.75		
Local beer sales	142			60%	85.2
Carvings	1333.33	100%	1333.33		
Wild fruits	59.42			20%	11.88
Total household income (with no sickness)	7471.71		2926.96		315.14
Percent of income lost	43.39%		39.17%		4.22%

Male sickness in Mile 30 would reduce household income by 39.17% and female labour loss would cost the household income by 4.22%. This clearly shows that Mile30 does not have diversity in income generating activities and hence the bigger proportion of household income is contributed by pension and remittances. Thus only 43.39% of total household income will be lost as a result of male illness in the household. When the male was ill in Tanzania, the female reduced the time spend on farming activities (Rugalema) and crop production in Zimbabwe was reduced by 61% when the head of the household died due to AIDS, while in Zambia, cultivate land was reduced by 53% when the head of the household was ill (Asenso-Okyere *et al*, 2010).

Table 13: Mile 30 ADC Scenario 2 female illness

Income Source	Income generated (N$)	% of labour lost from male when female is sick with help	Income lost from male when female is sick with help (N$)	% labour lost from female when female is sick with help	Income lost from female when female is sick with help(N$)
Crops	605.71			62%	375.54
Remittances	937.5				
Pension	3000				
Livestock	1393.75				
Local beer sales	142			100%	142
Carvings	1333.33				
Wild fruits	59.42			50%	29.71
Total household income (with no sickness)	7471.71				547.25
Percent of income lost	7.32%				7.32%

When the female is sick the male labour and income are not affected. The female labour loss results in a loss of 7.32% in total household income. Thangata *et al* (2007) reported that impact of HIV/AIDS on food production depends on patient's gender, when it is the male, the household becomes food insecure and when it is the female the effect on labour and income is smaller.

Table 14: Mile 30 Scenario 3 both male and female illness

Income Source	Income generated (N$)	% of labour lost from male when female is sick with no help	Income lost from male when female is sick with no help (N$)	% labour lost from female when female is sick with no help	Income lost from female when female is sick with no help(N$)
Crops	605.71	33%	199.88	62%	375.54
Remittances	937.5				
Pension	3000				
Livestock	1393.75	100%	1393.75		
Local beer sales	142			100	142
Carvings	1333.33	100%	1333.33		
Wild fruits	59.42			100	59.42
Total household income (with no sickness)	7471.71		2926.96		576.96
Percent of income lost	46.89%		39.17%		7.72%

When both male and female are sick in Mile 30, their combined total loss of income to the household is 46.89%. The biggest proportion of household income comes from remittances and pension and there is lack of diversity in income activities. Females do not contribute a lot to household income as shown by only 7.72% of household income lost. This concurs with findings of Thangata *et al*, (2007) that female illness' effect on household labour and activities is limited as other members of the household especially the male are able to continue with their activities.

Table 15: Comparison of changes in household income in Mashare and Mile 30 ADCs as a result of the effects of HIV/AIDS

	Scenario 1	Scenario 2	Scenario 3
Mashare ADC	68.86%	9.21%	73.58%
Mile 30 ADC	43.39%	7.32%	46.89%

The table above shows that Mashare ADC suffers relatively higher losses in household income when there is illness due to HIV/AIDS in the household compared to Mile 30 ADC. This could be attributed to the many sources of income that Mashare ADC has and are consequently lost when there is illness whereas Mile 30 has limited sources of income and constant income such as pension and remittances contribute a significantly higher proportion to household income compared to other activities. This shows importance of social grants in poor households.

Table 16: Mashare ADC effects of illness by scenario

	Base Case	Scenario 1	Scenario 2	Scenario 3
Loss in income as a result of labour loss	0%	68.86%	9.21%	73.58%
Exogenous income (N$)	3291.16	1024.87	2988.04	869.52
Labour (labour days)	199.81	62.22	181.41	52.79
Seed (N$)	42.04	13.09	38.17	11.11
Variable input (N$)	350	108.99	317.76	92.47
Land (ha)	5	1.56	4.54	1.32

Table 16 above compares the effects of illness on the male, female and both male and female. The losses incurred by the household are greatest when both the male and female are ill and lowest when it is the female who is ill.

Table 17: Mile 30 effects of illness by scenario

	Base Case	Scenario 1	Scenario 2	Scenario 3
Loss in income as a result of labour loss	0	43.35%	7.32%	46.89%
Exogenous income (N$)	1137	644.11	1053.77	603.86
Labour (labour days)	299.45	169.64	277.53	159.04
Seed (N$)	60.23	34.12	55.82	31.99
Variable input (N$)	350	198.27	324.38	185.88
Land (ha)	8.7	4.93	8.06	4.62

Changes in total household income are highest when both male and female are sick as expected, followed by when the male is sick while lowest when the female is sick. This shows how females have many roles including taking care of the family which is not valued in monetary terms while the male is involved in activities that are valued in monetary terms. Thus, the significance of the female to household income contribution is greatly understated.

5.2 Model results by scenario

The model results are presented below showing the changes that are brought about by illness of either the male or the female or both. These results are compared to the base case, where there is no illness. For all the ADCs, there was no marketed surplus as they did not produce enough to meet their consumption needs. Mile 30 has fewer income generating activities than Mashare ADC, and the total household income for Mile 30 is lower than that of Mashare ADC.

Table 18: Mashare ADC scenario results

	SCENARIOS			
	Base Case	Scenario 1	Scenario 2	Scenario 3
Utility (Objective)	49.15	23.89	46.30	21.58
Consumption of own produced millet (kg)	274.22	86.32	249.19	73.34
Consumption of own produced maize (kg)	26.24	8.16	23.82	6.93
Consumption of own produced sorghum (kg)	6.11	1.9	5.55	1.61
Marketed surplus (kg)	0	0	0	0
Total millet production	274.15	86.32	249.19	73.34
Consumption of market purchased goods (N$)	2941.66	916.38	2670.78	777.55
Labour hired out (man days)	0	0	0	0
Leisure man days	76.58	23.82	69.52	20.20
Labour available for millet production(man days)	91.89	28.58	83.42	24.24
Labour available for maize production (man days)	20.83	6.48	18.91	5.50
Labour available for sorghum production (man days)	10.41	3.24	9.45	2.75
Millet seed purchases (N$)	30.57	9.52	27.76	8.08
Maize seed purchases(N$)	7.64	2.38	6.94	2.02
Sorghum purchases (N$)	3.82	1.19	3.47	1.01
Variable input costs for millet (N$)	230.59	71.81	209.35	60.92
Variable input costs for maize (N$)	79.61	24.79	72.27	21.03
Variable costs for sorghum (N$)	39.80	12.39	36.14	10.52

The sensitivity analysis of the scenario solutions are shown below with marginal values other than 0 and EPS tabulated. The effect of increasing the amount of variable by a unit is shown by the marginal value as an increase (+) or decrease (-).

Table 19: Sensitivity analysis for Mashare ADC base case

Variable	**lower**	**level**	**upper**	**marginal**
Income	-3291.16	-3291.16	+INF	-0.005
Time	-INF	199.81	199.81	0.064
Seed	-INF	42.04	42.04	0.008
varinp	-INF	350	350	0.002
Marketed surplus millet	.	.	+INF	-0.01
Marketed surplus maize	.	.	+INF	-0.061
Marketed surplus sorghum	.	.	+INF	-0.0142
Labour trade	0.1	0.1	+INF	-0.039

Table 20: Sensitivity analysis for Mashare ADC scenario 1

Variable	lower	level	upper	marginal
income	-1024.87	-1024.87	+INF	-0.008
Time	-INF	62.22	62.22	0.1
Seed	-INF	13.09	13.09	0.012
varinp	-INF	108.99	108.99	0.003
Marketed surplus millet	.	.	+INF	-0.015
Marketed surplus maize	.	.	+INF	-0.095
Marketed surplus sorghum	.	.	+INF	-0.222
Labour trade	0.1	0.1	+INF	-0.061

Table 21: Sensitivity analysis for Mashare ADC scenario 2

Variable	lower	level	upper	marginal
income	-2988.04	-2988.04	+INF	-0.005
Time	-INF	181.41	181.41	0.067
Seed	-INF	42.04	42.04	0.008
varinp	-INF	350	350	0.002
Marketed surplus millet	.	.	+INF	-0.01
Marketed surplus maize	.	.	+INF	-0.063
Marketed surplus sorghum	.	.	+INF	-0.0148
Labour trade	0.1	0.1	+INF	-0.041

Table 22: Sensitivity analysis for Mashare ADC scenario 3

Variable	lower	level	upper	marginal
income	-869.52	-869.52	+INF	-0.008
Time	-INF	52.79	52.79	0.107
Seed	-INF	11.11	11.11	0.013
varinp	-INF	92.47	92.47	0.004
Marketed surplus millet	.	.	+INF	0.016
Marketed surplus maize	.	.	+INF	0.102
Marketed surplus sorghum	.	.	+INF	0.237
Labour trade	0.1	0.1	+INF	-0.065

The model results concur with reported results from studies elsewhere such as Zambia, Malawi, Tanzania and Zimbabwe that effects of HIV/AIDS on labour and food production are dependent on the patient's gender. When the male is sick in Mashare ADC, utility decreases from 49.15 to 23.89, a 51.4% reduction, and when it is the female who is ill, utility decreases from 49.15 to 46.30, a 5.8% reduction and 56.1% reduction when both male and female are ill. The results suggest that any loss in labour is directly linked to a loss in income. Consumption of market purchases decrease from N$2941.66

to N$916.38 when the male is ill a reduction of 68.8% and when it is the female who is ill a reduction of only 9.2% is achieved.

Table 23: Mile 30 ADC scenario results

	SCENARIOS			
	Base Case	Scenario 1	Scenario 2	Scenario 3
Utility (Objective)	51.21	36.56	48.95	35.19
Consumption of own produced millet (kg)	294.67	166.92	273.1	156.49
Consumption of own produced maize (kg)	1	0.57	0.93	0.53
Consumption of own produced sorghum (kg)	0.4	0.23	0.37	0.21
Marketed surplus (kg)	456.24	258.36	422.82	242.21
Total millet output (kg)	750.91	425.28	695.92	398.69
Consumption of market purchased goods (N$)	2484.70	1407.45	2302.79	1319.49
Labour hired out (man days)	0.1	0.1	0.1	0.1
Leisure man days	70.73	40.07	65.55	37.56
Labour available for millet production(man days)	227.11	128.62	210.48	120.58
Labour available for maize production (man days)	1	0.57	0.93	0.53
Labour available for sorghum production (man days)	0.5	0.28	0.47	0.27
Millet seed purchases (N$)	59.76	33.84	55.39	31.72
Maize seed purchases (N$)	0.31	0.18	0.29	0.17
Sorghum purchases (N$)	0.16	0.1	0.14	0.1
Variable input costs for millet (N$)	344.52	195.17	319.36	182.97
Variable input costs for maize (N$)	3.61	2.04	3.34	1.92
Variable costs for sorghum (N$)	1.87	1.06	1.73	0.99

The sensitivity analysis on the solutions of the scenarios on Mile 30 ADC is shown below. Only marginal values that are not zero and EPS are shown.

Table 24: Sensitivity analysis for Mile 30 ADC base case

Variable	lower	level	upper	marginal
income	-1137	-1137	+INF	-0.007
Time	-INF	299.45	299.45	0.072
Seed	-INF	60.23	60.23	0.01
varinp	-INF	350	350	3.7E-4
Marketed surplus millet	.	456.255	+INF	4.29E4
Marketed surplus maize	.	.	+INF	-0.083
Marketed surplus sorghum	.	.	+INF	-0.102
Labour trade	0.1	0.1	+INF	-0.037

Table 25: Sensitivity analysis for Mile 30 ADC scenario 1

Variable	lower	level	upper	marginal
income	-644.11	-644.11	+INF	-0.009
Time	-INF	169.64	169.64	0.091
Seed	-INF	42.04	42.04	0.012
varinp	-INF	198.27	198.27	4.7E-4
Marketed surplus millet	.	258.364	+INF	.
Marketed surplus maize	.	.	+INF	-0.105
Marketed surplus sorghum	.	.	+INF	-0.129
Labour trade	0.1	0.1	+INF	-0.047

Table 26: Sensitivity analysis for Mile 30 ADC scenario 2

Variable	lower	level	upper	marginal
income	-1053.77	-1053.77	+INF	-0.007
Time	-INF	277.53	277.53	0.075
Seed	-INF	42.04	42.04	0.01
varinp	-INF	324.38	324.38	3.9E-4
Marketed surplus millet	.	432.82	+INF	EPS
Marketed surplus maize	.	.	+INF	-0.086
Marketed surplus sorghum	.	.	+INF	-0.106
Labour trade	0.1	0.1	+INF	-0.039

Table 27: Sensitivity analysis for Mile 30 ADC scenario 3

Variable	lower	level	upper	marginal
income	-603.86	-603.86	+INF	-0.009
Time	-INF	159.04	159.04	0.094
Seed	-INF	31.99	31.99	0.013
varinp	-INF	185.88	185.88	4.8E-4
Marketed surplus millet	.	242.206	+INF	EPS
Marketed surplus maize	.	.	+INF	-0.107
Marketed surplus sorghum	.	.	+INF	-0.133
Labour trade	0.1	0.1	+INF	-0.048

In Mile 30, consumption of own produced food (millet is the main crop) decreases from 294.67kg to 166.92kg when the male is ill, and to 273.1kg when the female is ill and to 156.49kg when both male and female are ill. This suggests that although women contribute most of the labour to food production, when they fall ill they do not take most of the labour with them and the rest of the labour remains productive whereas when it is the male who is ill the women have to give up most of their productive time to take care of the ill male. In South Africa women spend about 7.5 hours per day taking care of the ill (Booysen and Bachman, 2002), and up to 100 hours per week in Ethiopia nursing AIDS affected members (Asenso-Okyere *et al*, 2010).

Table 28: Comparison of Mashare and Mile 30 base cases

	Mashare ADC Base Case	**Mile 30 ADC Base case**
Utility (Objective)	49.15	51.21
Consumption of own produced millet (kg)	274.22	294.67
Consumption of own produced maize (kg)	26.24	1
Consumption of own produced sorghum (kg)	6.11	0.4
Marketed surplus (kg)	0	456.24
Total millet output (kg)	274.22	750.91
Consumption of market purchased goods (N$)	2941.66	2484.70
Labour hired out (man days)	0	0.1
Leisure man days	76.58	70.73
Labour available for millet production(man days)	91.89	227.11
Labour available for maize production (man days)	20.83	1
Labour available for sorghum production (man days)	10.41	0.5
Millet seed purchases (N$)	30.57	59.76
Maize seed purchases (N$)	7.64	0.31
Sorghum purchases (N$)	3.82	0.16
Variable input costs for millet (N$)	230.59	344.52
Variable input costs for maize (N$)	79.61	3.61
Variable costs for sorghum (N$)	39.80	1.87

Mashare ADC has a lower utility than Mile 30, and produces less output compared to Mile 30 and also consume more market purchased goods than Mile 30. However, Mile 30 has more available labour compared to Mashare ADC, and more land available for crops. The results show that there are differences in terms of farming system and Mashare has more financial resources compared to Mile 30. Mashare ADC produces less food compared to Mile 30 and consumes more market purchased goods than Mile 30; this could be due to the fact that they have the income to purchase the food to meet their consumption requirements.

Table 29: Comparison of Mashare ADC and Mile 30 ADC scenario 1 results

	Mashare ADC scenario 1	Mile 30 ADC Scenario 1
Utility (Objective)	23.89	36.56
Consumption of own produced millet (kg)	86.32	166.92
Consumption of own produced maize (kg)	8.16	0.57
Consumption of own produced sorghum (kg)	1.9	0.23
Marketed surplus (kg)	0	258.36
Total millet output (kg)	86.32	425.28
Consumption of market purchased goods (N$)	916.38	1407.45
Labour hired out (man days)	0	0.1
Leisure man days	23.82	40.07
Labour available for millet production(man days)	28.58	128.62
Labour available for maize production (man days)	6.48	0.57
Labour available for sorghum production (man days)	3.24	0.28
Millet seed purchases (N$)	9.52	33.84
Maize seed purchases (N$)	2.38	0.18
Sorghum purchases (N$)	1.19	0.1
Variable input costs for millet (N$)	71.81	195.17
Variable input costs for maize (N$)	24.79	2.04
Variable costs for sorghum (N$)	12.39	1.06

When the male is sick, the household becomes food insecure (Thangata *et al*, 2007). These results confirm findings from other studies by Thangata *et al*, 2007 and Gill, 2010. Utility decreases by a big margin while consumption of own produced and market purchased goods decrease greatly. Leisure days are also reduced maybe due to caring activities that increase as a result of illness of the male. The ability to purchase food from the market is reduced due to reduced income. Labour availability also decreases resulting in low output. Since the male is the main breadwinner and takes paid work, when he is ill, the amount of household income is greatly affected as he is not able to work and earn an income. The female who contributes about 62% of labour to farm activities is forced to commit her time to taking care of the ill thus the farm activities are affected and not only does the household lose the male labour but part of the female labour as well (Gill, 2010; Thangata *et al*, 2007). In Kenya when a male head of the household died, this led to the household suffering 68 percent reduction in the value of net agricultural output (Yamano and Jayne, 2004 in Jayne *et al*, 2005).

Table 30: Comparison of Mashare ADC and Mile 30 scenario 2 results

	Mashare ADC scenario 2	**Mile 30 ADC scenario 2**
Utility (Objective)	46.30	48.95
Consumption of own produced millet (kg)	249.19	273.1
Consumption of own produced maize (kg)	23.82	0.93
Consumption of own produced sorghum (kg)	5.55	0.37
Marketed surplus (kg)	0	422.82
Total millet output (kg)	249.19	695.92
Consumption of market purchased goods (N$)	2670.78	2302.79
Labour hired out (man days)	0.1	0.1
Leisure man days	69.52	65.55
Labour available for millet production(man days)	83.42	210.48
Labour available for maize production (man days)	18.91	0.93
Labour available for sorghum production (man days)	9.45	0.47
Millet seed purchases (N$)	27.76	55.39
Maize seed purchases (N$)	6.94	0.29
Sorghum purchases (N$)	3.47	0.14
Variable input costs for millet (N$)	209.35	319.36
Variable input costs for maize (N$)	72.27	3.34
Variable costs for sorghum (N$)	36.14	1.73

The utility, consumption of own produced food and market purchased food for Mashare is higher than that for Mile 30 when the female is ill. Mile 30 spend N$2302.79 compared to N$2670.78 spend by Mashare household. The reduction in utility and consumption when the female is ill is very small, and the results are close to the base scenario. Income and labour of other family members including the male member are less affected as they do not have caring responsibilities. In some cases, a relative of the female will come to take care of the ill female (Thangata *et al*, 2007) although she does not contribute to farm labour. This will make the labour of the other members available and continue to earn an income.

Table 31: Comparison of Mashare ADC and Mile 30 scenario 3 results

	Mashare ADC Scenario 3	**Mile 30 ADC Scenario 3**
Utility (Objective)	21.58	35.19
Consumption of own produced millet (kg)	73.34	156.49
Consumption of own produced maize (kg)	6.93	0.53
Consumption of own produced sorghum (kg)	1.61	0.21
Marketed surplus (kg)	0	242.21
Total millet output (kg)	73.34	398.69
Consumption of market purchased goods (N$)	777.55	1319.49
Labour hired out (man days)	0	0.1
Leisure man days	20.20	37.56
Labour available for millet production(man days)	24.24	120.58
Labour available for maize production (man days)	5.50	0.53
Labour available for sorghum production (man days)	2.75	0.27
Millet seed purchases (N$)	8.08	31.72
Maize seed purchases (N$)	2.02	0.17
Sorghum purchases (N$)	1.01	0.1
Variable input costs for millet (N$)	60.92	182.97
Variable input costs for maize (N$)	21.03	1.92
Variable costs for sorghum (N$)	10.52	0.99

When both the male and female are ill, the utility for Mile 30 is higher than that of Mashare ADC, and the value of consumption of own produced and market purchased goods are higher as well. Variable costs are higher for Mile 30 ADC than Mashare ADC. It seems as if Mile 30 has more family members to cover for the ill members and continue farm activities albeit at a reduced scale than Mashare ADC. Pension and remittances are very important especially in times when income is depleted from other sources. During the times when both the male and females are ill, to survive when there is little food, the household reduces food intake and meals per day and supplement with wild fruits (Conroy in Thangata *et al*, 2007; Dorward and Mwale, 2005). Labour that is lost as a result of the head of the household or spouse is difficult to replace (Jayne, *et al*, 2005).

CHAPTER 6: SUMMARY OF RESULTS, CONCLUSIONS AND RECOMMENDATIONS

6.0 Introduction

This chapter gives a summary of results from the models. Conclusions that were arrived at from the results are also given as well as the recommendations of the study. The chapter is divided into three sections, the first section presents the summary of results, and the second section presents the conclusions while the third section presents the recommendations of the study.

6.1 Summary of results

The model results show that effects of HIV/AIDS on the household income and production are gender dependent which concurs with (Gill, 2010; Thangata *et al*, 2007, Asenso-Okyere *et al*, 2010). More income is lost when it is the male who falls ill compared to when it is the female who is ill. When the female falls ill, very little is lost in terms of income and production (between 7% and 10% reduction), however when it is the male who falls ill, percentage reduction in income and production is between 43.35% and 68.86%. Moreover, the model results showed that riverline farming system has a lot more activities that contribute to household income than the inland farming system. There is heavy dependency on pension and remittances in the inland farming system than the riverine farming system. This is shown by the percentage loss of household income when both male and female fall ill. The riverline loses about 73.58% of its household income while the inland farming system loses about 46.89% provided remittances and pension are not affected as sources of income. The households respond by reallocating resources as well as depending on aid, remittances and social grants. Cash constraints are compounded during illness and death when medical and funeral costs rise and care giving by members reduces their income earning potential. Assets are sold especially after a male death or illness in the family. Utility of the household decreased by a bigger margin when it was the male who was ill as compared to the female being ill. The households were shown to be dependent on market purchased goods and food aid as their own production was not enough to satisfy their consumption requirements and no surplus was produced for the market. Mile 30 ADC had marketable surplus of millet in all scenarios. Mashare ADC results concur with findings by Barnett (1998) that there is endemic labour shortage and food shortages faced by households. Reduction to weeding labour is critical as this leads to lower yields, and thus adequate labour is needed during this time.

6.2 Conclusions

The study concludes that the effects of HIV/AIDS worsen the livelihoods of the affected households. The effects of HIV/AIDS are severe on the household when it is the male who falls ill as he is the one involved in income generating activities and the main breadwinner and the fact that the female will abandon her activities to take care of him. However, when the female falls ill, her contribution to labour for food production is lost but the male labour continues to be available as he does not have caring responsibilities. Thus families that lose the male to HIV/AIDS are worse off than those that lose a female as the results suggest and also found by Thangata *et al*, 2007). This could be due to gender-based biases in agricultural programmes that equip males more than women (Jayne *et* al, 2005). The scenarios used in the study are derived from actual situations and the models have shown that households experience financial stress with HIV/AIDS effects as they are forced to dispose of assets and savings. The study also revealed that agricultural production is affected by other external factors in addition to the effects of HIV/AIDS that impact negatively on farm activities as labour availability is reduced. The inherent problems that affect agricultural production could be inadequate rainfall and poor soils. Thus the study concluded that agricultural production already experiences low yields due to other factors and HIV/AIDS worsens the food security situation by depleting financial and labour resources rendering many households into dissolution. The results have also shown that the riverline farming system households have more financial resources than that of the inland farming system and would therefore experience higher financial losses due to the effects of HIV/AIDS than the inland farming system. There is high dependency on social grants (pension) and remittances for affected households both in the inland and riverline farming systems indicating that introduction of social grants aimed at households affected by HIV/AIDS would help lessen the burden of the effects of HIV/AIDS. The effects of HIV/AIDS which lead to labour shortages and loss of income are gender dependent and more severe when it is the male who is ill than when it is the female. There are differences in factor endowments between regions and farming systems that lead to varied effects of AIDS-related mortality on agricultural households (Jayne, *et al*, 2005).

6.3 Recommendations

The study recommends that for agricultural production to improve even in the absence of HIV/AIDS, there is need for drought resistant, early maturing, high yielding varieties of seed as the yield levels are very low and many households do not meet their food requirements and have to rely on food aid and market purchases. There is need to introduce production of cash crops for income generation. It is farther recommended that labour saving technologies such as tractors, minimum tillage, firewood saving technology, etc, need to be considered for rural communities and provision of these services at subsidised rates since most households are already poor and cannot afford high fees as they are faced with other activities that require financial input. The study concurs with the recommendation by Jayne *et al*, (2005) for increased support for agricultural science and technology development, extension systems and input and crop market development to improve the agriculture sector's potential to raise living standards in highly affected communities. HIV/AIDS only worsens their financial standing, resource availability and input and labour supplies are reduced. There is need for strategies that address labour shortages by focusing on peak labour bottleneck periods such as weeding and planting and this concurs with (Jayne *et al*, 2005). Although it is agreed that labour saving technologies may help certain types of households and regions, Jayne *et al* (2005) argue that use of labour saving technologies or crops has been over generalised hence the findings of this study should be used within the areas of research but with proper assessment of needs of the affected households.

The study further recommends that affected households be afforded a social grant in cash and kind to help households meet their food and financial obligations. With money, they are able to purchase food on the market if they cannot cultivate due to labour shortage or sickness. Introduction of subsidised medical fees especially for the rural households would help ease their financial problems and avoid depletion of resources available to them for other basic needs. Moreover, there is need to assess the needs of affected households and identify how best they can be helped whether financial, material or food.

Due to limitations of this study, especially that it used a static model, to fully understand the effects of HIV/AIDS on the households, a dynamic (multi-period) model would be suitable as well as a detailed survey that would have data on labour requirements for specific activities such as land preparation, weeding, harvesting and threshing to unravel the activities most affected by HIV/AIDS effects. This study used highly aggregated data and data from one season only thus labour requirements are also aggregated and not divided according to activity, this should be addressed by further research. Detailed data to labour requirements for each activity and using an ethnographic programming model would be suitable to further explain and understand the effects of HIV/AIDS by labour type as shown by Thangata *et al*, (2007) and Gill, (2010). Use of cross-sectional data does provide information on impacts of HIV/AIDS on afflicted households but only at a particular point and it is therefore ideal to do a study that would analyse the situation of a household before being afflicted, during illness, the post death and recovery process to better understand the dynamics of the effects of HIV/AIDS (Jayne *et al*, 2005). The effects of HIV/AIDS on an agricultural household are complex and dynamic thus a long term and detailed study is needed. It has to be noted that even within a particular agricultural system, there is heterogeneity in the effects of HIV/AIDS and also resource endowment of households and appropriate programmatic responses to AIDS may be household specific, depending on gender and household position of the deceased individual and initial vulnerability prior to the onset of illness (Jayne, *et al*, 2005; Thangata *et al*, 2007).

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APPENDICES

Appendix 1: FREQUENCIES of HIV/AIDS related responses from Omusati, Oshikoto and Caprivi regions

Most Important reasons given	**Frequency**	**Percentage of respondents**
Use savings to cover medical costs	22	13.2
Livestock sold to cover medical costs	23	13.8
Assets sold to cover medical costs	12	7.2
Reduction in farming activities attributed to HIV/AIDS	19	11.4
Reduction in area cultivated attributed to HIV/AIDS	31	18.6
HIV/AIDS major cause of food insecurity	28	16.8
Member of household infected by HIV/AIDS	40	24
HIV/AIDS related death experienced in the household	44	26. 1
Medical costs increased due to HIV/AIDS	21	12.6
Loss of productive labour force due to HIV/AIDS	96	58
Farming time lost due to HIV/AIDS	39	23.4
HIV/AIDS increased use of child labour	22	13.2
HIV/AIDS related sickness main cause of reduction in labour supply	31	18.6
Labour shortage not related to HIV/AIDS but to endemic labour shortage	39	23.4

Source: Extracted from Abate et al (2001)

Appendix 2: Farmer Typology Adopted by the NNFU

Type	Main elements of description	Sub-type		Market integration
Type 1: Small-scale subsistence farming	Family farm producing mostly, if not entirely, for subsistence. Different levels of household food security are achieved.	**1A.**	Often women alone, no livestock (or only few small-stocks), small field (less than 3 ha), no input (except labour), food insecure every year, no additional income,	Food insecure, no market integration
		1B	Sometimes women alone, few livestock, small field (less than 3 ha), no input (except labour), relative food security (at risk), no additional income but sometimes a pension	Relatively food secure (but at risk), no market integration
		1C	Some livestock (less than 20), field from 3 to 5 ha, low input intensity (possible use of tractor and improved seeds), food secure every year, sometimes additional income	Possible limited marketable surplus depending on the year
Type 2: Small-scale mixed strategy farming	Family farm producing for subsistence and for the market. Market integration varies from poor to good. Farm workers may be employed from time to time.	**2A**	Some livestock (between 30 to 50) with access to cattle post, access to DAP and regular use of tractor service, medium field (5 ha), low input intensity (seeds), regular additional income, labour hired in	Small marketable surplus every year
		2B	Relatively large herd of cattle (more than 50) with access to cattle post, access to DAP and regular use of tractor service, relatively large field (more than 5 ha), low to medium input intensity (seeds), regular additional income, labour hired in	Medium marketable surplus every year
Type 3: Large-scale market oriented farming	The farm produces primarily, if not entirely, for the market. It is owned either by one family or by a group (e.g. close co-operation). It often employs several farm workers.	**3A**	Large herd of cattle (more than 100) with access to cattle post, access to DAP, tractor and transport, large field (up to 50 ha), medium input intensity (seeds and fertiliser), regular additional income, labour hired in,	Relatively high market integration
		3B	Close co-operation, small enterprise	Relatively high market integration
Type 4: Agro-business	Very large-scale farm producing only for the market. It is a company type and employs a farm manager, farm workers...			

Source: NNFU farm typology

Appendix 3: Typical GAMS model for Cobb-Douglas function

```
$TITLE MASHARE ADC HOUSEHOLD MODEL

$OFFUPPER OFFLISTING ONSYMXREF
$ONTEXT
THIS IS A HOUSEHOLD FARM MODEL WHICH ASSUMES COBB-DOUGLAS
PRODUCTION AND UTILITY FUNCTIONS. THE CONSUMPTION SIDE OF THE
MODEL IS REPRESENTED BY THE LINEAR EXPENDITURE SYSTEM. A
DIRECT UTILITY MAXIMISATION APPROACH IS FOLLOWED
WHEREBY THE UTILITY OF CONSUMPTION IS MAXIMIZED SUBJECT TO
LAND, BUDGET AND LABOUR TIME CONSTRAINTS. THE OBJECTIVE IS TO
EXPLORE THE RESPONSE OF FARM HOUSEHOLDS TO THE IMPACTS OF
HIV/AIDS ON LABOUR AND CAPITAL AND HOW RESOURCE ALLOCATION
IS INFLUENCED AND HOW PRODUCTION AND INCOME ARE AFFECTED.
$OFFTEXT

Set
        q       OUTPUT  /MILLET, MAIZE, SORGHUM/
        c(q)     OWN CONSUMPTION  /MILLET, MAIZE, SORGHUM/

        F       FACTORS OF PRODUCTION

        /LAND         LAND RENT (Namibian Dollars)
         LABOUR       LABOUR USED (Days)
         SEED        SEED AMOUNT USED (kgs)
         VARINP      VARIABLE INPUT USED (Namibian Dollars)/

PURINP(F)     PURCHASED FACTORS
            / VARINP/;

Table     coeff(q,f)        production function coefficients
                        LABOUR     SEED      VARINP
        MILLET             0.75       0.03       0.21
        MAIZE              0.68       0.03       0.29
        SORGHUM              0.68       0.03       0.29

Parameters       eff(q)           output function constants
        /      MILLET       2.66
               MAIZE       0.88
               SORGHUM      0.41/;


Parameters         elau(c)         utility function coefficients
```

```
        /       Millet        0.16
                Maize         0.04
                Sorghum       0.02 /;
PARAMETERS
        YBAR    EXOGENOUS INCOME /3291.16/;
*RANS   TRANSFERS       /0/;

Parameters          priceo(q)
        /MILLET             3.72
         MAIZE              2.77
         SORGHUM            3.72/;

Parameters         pricei(F)

        /land              1
         labour            5
         SEED              11.15
         varinp            1/;

Parameters          limits(F)
        /LAND         5
         labour      199.81
         SEED         42.04
         VARINP       350/;

Scalar md market distance in km /0/;
Scalar t transport cost in ND per km /0/;
Parameter MPr(q) farm household market price after transport cost in ND;
         MPr(q) = priceo(q)-t*md;
variables
        utility       utility

positive variables
        output(q)     production of agricultural output (kgs)
        market(q)     marketed surplus of agricultural output (kgs)
        input(q,f)    factors of production
        price(q,f)    agricultural input price (Namibian Dollar per kg)
        oprice(q)     agricultural output price (Namibian dollar per kg)
        consump       consumption of agricultural output (kgs)
        leisure       leisure by farm household  (days)
        LABTRADE      hired-out labour (days)
        con           consumption of market purchased goods  (Namibian Dollar)
        TLAND         total land endowment (hectares)
Equations
```

```
        obj        objective function
        Prodn      production function
        Balance    goods constraint
        Income     income constraint
        Time       time constraint
        Restric    factor endowment costraint
        LANDRES    TOTAL LAND ENDOMENT;

OUTPUT.LO("MILLET")      = 0.01;   OUTPUT.LO("MAIZE")      = 0.01;
OUTPUT.LO("SORGHUM")      = 0.01;

INPUT.LO("MILLET",F)      = 0.01;   INPUT.LO("MAIZE",F)      = 0.01;
INPUT.LO("SORGHUM",F)      = 0.01;
* Starting values
utility.lo    = 0.1;
output.lo(q)  = 0.1;
input.lo(q,f) = 0.1;
consump.lo(c) = 0.1;
leisure.lo    = 0.1;
LABTRADE.LO   = 0.1;
*##############################  1. UTILITY FUNCTION
Obj..         utility =E= con**0.3*prod(c,consump(c)**elau(c))*leisure**0.1;
*############################## 2. PRODUCTION FUNCTION Prodn(q)..
output(q)=E= eff(q)*prod(f,input(q,f)**coeff(q,f));
*############################## 3. HOUSEHOLD PRODUCED COMMODITY
BALANCE #########
Balance(q)..    output(q) =G=  market(q) + consump(q);
*############################## 4. HOUSEHOLD BUDGET/INCOME
CONSTRAINT ###########
Income..        sum(q,market(q)* MPr(q))+ LABTRADE*pricei("LABOUR")+ YBAR
=G= sum((q,PURINP),pricei(PURINP)*input(q,PURINP)) + con*1;
*############################# 5. LABOUR TIME COSTRAINT
#########################
TIME..          LABTRADE + leisure + sum(q,input(q,"labour")) =L=limits("labour");
*############################# 6. RESOURCE ENDOWMENT CONSTRAINT
#################
RESTRIC(F)..   sum(q,input(q,f)) =l= limits(f);

LANDRES..   sum(q,input(q,"LAND")) =l= limits("LAND");

*LANDEND..       sum(q,input(q,"LAND")) =l= LIMITS("LAND") ;

Model farmhh/all/;
```

```
farmhh.OPTFILE = 1 ;

SOLVE farmhh MAXIMIZING UTILITY USING NLP;
OPTION DECIMALS=2 ;

*#### SET UP TABLES TO REPORT OUTPUT

PARAMETER priceo1(q)      BASE HOUSEHOLD SECTORIAL OUTPUT;
PARAMETER pricei1(F)      BASE FACTOR INPUT;
PARAMETER utility1        BASE UTILITY LEVEL;
PARAMETER market1(q)      BASE COMMODITY MARKETED SURPLUS;
PARAMETER LABTRADE1       BASE LABOUR HIRED-OUT(SOLD);
PARAMETER consump1        BASE HOUSEHOLD OWN PRODUCED
CONSUMPTION;
PARAMETER con1            BASE MARKET CONSUMED PRODUCE;
PARAMETER leisure1        BASE LEISURE CONSUMPTION BY HOUSEHOLD;

*#### DISPLAY OUTPUT
############################################################
*                   REPORT ON FARM HOUSEHOLD MODEL
$Stitle report on solution

Sets Qrep   /TQV,OUTPQ,INPUTQ, MKPURG,MKSURP,OWNPROD,OPRICE/
    CREP   /LABOUR,LAND,MONEY, LBOR-SHDPR, LAND-SHPR, CAPIN/
    OBJE   /OBJECTIVE/;

Parameters  CROPREP     VARIABLE SUMMARY
         CONMARG     MARGINAL PRODUCT OF INPUT FACTOR
         OBJFUN      UTILITY VALUE
         CONWPROD    CONSUMPTION OF OWN-PRODUCE;

CROPREP(q,"OUTPQ")        = OUTPUT.L(q);
CROPREP(q,"MKSURP")       = MARKET.L(q);
CROPREP(q,"OWNPROD")      = CONSUMP.L(q);
CROPREP(q,"OPRICE")       = PRICEO(q);
CROPREP(q,"TQV")          = CROPREP(q,"OUTPQ")*CROPREP(q,"OPRICE");


*CONMARG("CAPIN")        = CAPIN.M;
CONMARG("LABOUR")        = TIME.M;
CONMARG("LAND")          = LANDRES.M;
CONMARG("MONEY")         = -INCOME.M;
CONMARG("LBOR-SHDPR")    =
CONMARG("LABOUR")/CONMARG("MONEY");
```

```
CONMARG("LAND-SHPR")      = CONMARG("LAND")/CONMARG("MONEY");
OBJFUN("OBJECTIVE")       = UTILITY.L;

*#### DISPLAY OUTPUT
############################################################
DISPLAY UTILITY.L, market.L,  consump.L, con.L;
Display OBJFUN,CONMARG,CROPREP,  LABTRADE.L,leisure.L, INPUT.L,
RESTRIC.M,INPUT.M;

*#### SET UP TABLES TO REPORT OUTPUT
*PARAMETER output1(q)       BASE HOUSEHOLD OUTPUT;
*PARAMETER input1(q,f)      BASE FACTOR INPUT;
*PARAMETER utility1         BASE UTILITY LEVEL;
*PARAMETER market1(q)       BASE COMMODITY MARKETED SURPLUS;
*PARAMETER LABTRADE1        BASE LABOUR HIRED-OUT(SOLD);
*PARAMETER consump1(q)      BASE HOUSEHOLD OWN PRODUCED
CONSUMPTION;
*PARAMETER con1             BASE MARKET CONSUMED PRODUCE;
*PARAMETER leisure1         BASE LEISURE CONSUMPTION BY HOUSEHOLD;

*output1(q)       =  output.L(q);
*       input1(q,f)      =  input.L(q,f);
*       utility1         =  utility.L;
*       market1(q)       =  market.L(q);
*       LABTRADE1        =  LABTRADE.L;
*       consump1(q)      =  consump.L(q);
*       leisure1         =  leisure.L;
*       con1             =  con.L;

*#### DISPLAY OUTPUT
############################################################
*DISPLAY OUTPUT.L, INPUT.L, UTILITY.L, market.L, LABTRADE.L,
consump.L, leisure.L,con.L;

*DISPLAY utility.lo, output.lo, input.lo, consump.lo, leisure.lo;
*DISPLAY utility.m, output.m, input.m, consump.m, leisure.m;
*DISPLAY utility.up, output.up, input.up, consump.up, leisure.up;

$Stitle report on solution
*Set  mrep  headings of shadow price table
*/crop-price, input-price/

*Hrep  headings of total outcome table
*/crop-prod, marktsurp/;
```

```
*Parameters  croprep    crop report summary
*resultrep  outcome report summary (ND) ;

*croprep(q,"crop-price")   = priceo(q);
*croprep(f,"input-price")  = pricei(F);
*croprep(f,"input-prod")   = output(q);

*resultrep(q,"crop-price") = output.L(q);
*resultrep(q,"marktsurp") = market.L(q);
*resultrep(q,"owncon") = consump.L(q);
*resultrep("marktpur") = con;
*resultrep("leisure") = leisure1;
*resultrep(q,"utility") = utility1;


*Display  croprep, resultrep ;
```

Appendix 4: Kavango rural consumption and Expenditure items and shares

Item	Food & beverages	housing	clothing	health	education	furnishings	Transport & communication	Leisure/other	Total
% share	51	17	5.1	1.2	2	5.8	7.6	10.2	100

Source: CBS, (2006)

Rural Kavango total average expenditure is N$18500. The food share expenditure is 51% which is assumed to cover at least 12 months therefore own production covers 4.44 months and market purchased food covers 5.56 months. This was applied to all ADCs.

Appendix 5: Animal draft power in Kavango region

	No cattle	1-30 cattle	More than 30 cattle	donkeys
% of households with draft power	49	39	12	97

Source: Mendelsohn and Obeid, 2005

Appendix 6: Labour requirements in Kavango

	Manual hand hoe	**Animal draft power**	**Tractor**
Ploughing	13 days	4 days	2-3 hours
Planting	8 days		
Weeding	27 days		
Harvesting	7 days		
Threshing	7 days		
Total labour requirements per ha/person	62 days		

Source: Mendelsohn and Obeid, 2005

Appendix 7: Production coefficients matrix

Mashare ADC				Mile 30 ADC		
Labour	Seed	Other (varinp)		Labour	Seed	Other (varinp)
0.75	0.03	0.21		0.84	0.03	0.13
0.68	0.03	0.29		0.71	0.03	0.26
0.68	0.03	0.29		0.71	0.03	0.27

Appendix 8: Production Constants

Mashare ADC		Mile 30 ADC
2.66		3.26
0.88		0.74
0.41		0.58

Appendix 9: Representative farms from cluster analysis.

variables	Kaisosi N=27	Mashare N=37	Mile 30 N=30
Farm income	53.3	420.19	517
Additional income	6352.67	3291.16	1137.43
Expenditure on seeds	44.3	42.05	60.25
Number of members of the household	10.37	10.4	10.77
Household members helping regularly with farm work	4.81	4.9	6.4
Number of hired farm workers	0.33	0.9	0.7
Total farm size (ha)	6.37	5	8.7
Total cultivated area (ha)	4.04	3.37	4.73
Own draft power main means of cultivation	0.78	0.7	0.8
Hired draft power main means of cultivation	0	0.13	0.1
Millet area planted 2002/3 (ha)	2.74	1.99	3.6
Maize area planted 2002/3 (ha)	0.92	0.88	1.05
Sorghum planted 2002/3 (ha)	1	0.9	1
Millet yield during 2001/2 (50kg bags)	7.8	7.04	7.28
Maize yield during 2001/2 (50kg bags)	1.58	3.74	2.68
Sorghum yield during 2001/2 (50kg bags)	2	1.69	1.79
Months farming satisfies basic household food needs	4.44	4.95	4.1
Total number of cattle	12.96	20.1	13.27
Total number of goats and sheep	29.38	25.4	10.3

Appendix 10: Consumption Function represented by the utility function

$$U_{hh} = C_{millet}^{\beta 1} C_{maize}^{\beta 2} C_{sorghum}^{\beta 3} C_{marketpurchase}^{\beta 4} C_{leisure}^{\beta 5}$$

Mashare ADC		
	Total value (N$)	Shares
Millet	2099.047	0.16
Maize	493.2465	0.04
Sorghum	227.8692	0.02
market purchased		
food	4016.596	0.30
clothes	683.6759	0.05
housing	2278.92	0.17
Education	268.11	0.02
Health	160.8649	0.01
Transport	1018.811	0.08
Furnishings	777.5138	0.06
Leisure	1367.352	0.10
Total expenditure	13405.41	1.00

Mile 30 ADC		
	Total value (N$)	Shares
Millet	662.67	0.15
Maize	71.14	0.02
Sorghum	45.27	0.01
market purchased		
food	1501	0.34
clothes	228.0572	0.05
housing	760.1907	0.17
education	89.43	0.02
health	53.66052	0.01
transport	339.85	0.08
furnishings	259.3592	0.06
leisure	456.1144	0.10
Total Expenditure	4471.71	1.00

All food share as given above has an expenditure share of 51% which is assumed to cover 12 months therefore own production covers 4.44 months and market purchased covers 5.56 months, this method applies to all ADCs. Of the 4.44 months we know

Appendix 11: Grain Price News

Location	Product	Price type	Aug'09 Lata N$			Aug'09 Kg N$			Sept'09 lata N$			Sept'09 kg N$			Price Direction
			low	high	avg	low	high	avg	low	high	avg	low	high	avg	
Oshakati	Mahangu grain	Mill gate	70.00	75.00	72.50	4.67	5.00	4.84	70.00	75.00	72.50	4.67	5.00	4.84	→
	Maize grain	Mill gate	40.50	41.10	40.80	2.70	2.74	2.72	41.40	41.55	41.48	2.76	2.77	2.77	→
	Mahangu grain	Retail	70.00	80.00	75.00	4.67	5.33	5.00	70.00	80.00	75.00	4.67	5.33	5.00	→
	Maize grain	Retail	-	-		-	-		-	-		-	-		□
Katima	Mahangu grain	Mill gate	41.40	41.55	41.48	2.76	2.77	2.77	41.40	41.55	41.48	2.76	2.77	2.77	→
	Maize grain	Mill gate	41.40	41.55	41.48	2.76	2.77	2.77	41.40	4.55	22.98	2.76	2.77	2.77	→
	Mahangu grain	Retail	57.45	62.40	59.93	3.83	417	4.00	57.45	62.40	59.93	3.83	4.17	4.00	→
	Maize grain	Retail	45.00	45.00	45.00	3.00	3.00	3.00	45.00	45.00	45.00	3.00	3.00	3.00	→
Rundu	Mahangu grain	Mill gate	41.40	70.00	55.70	2.70	4.67	3.69	41.40	70.00	55.70	2.76	4.67	3.72	→
	Maize grain	Mill gat	41.40	41.55	41.48	2.76	2.77	2.77	4.40	41.55	41.48	2.76	2.77	2.77	
	Mahangu grain	Retail	60.00	90.00	75.00	4.00	6.00	5.00	60.00	90.00	75.00	4.00	6.00	5.00	→
	Maize grain	Retail	30.00	45.00	37.50	2.00	3.00	2.50	30.00	45.00	37.50	2.00	3.00	2.50	
Oshakati	Unfermented mahangu flour (5kg	Retail	33.95	35.00	34.48	6.79	7.00	6.90	33.95	35.00	34.48	6.79	7.00	6.90	→
	Fermented mahangu flour (5kg)	Retail	35.00	55.00	45.00	7.00	11.00	9.00	35.00	55.00	45.00	7.00	11.00	9.00	→
	Maize flour (5kg) topscore	Retail	32.95	35.79	34.37	6.59	7.15	6.8	32.95	35.99	34.47	6.59	7.20	6.90	→
Katima	Unfermented mahangu flour (5kg)	Retail	27.00	33.95	30.48	5.40	6.79	6.10	27.00	33.95	30.48	5.40	6.79	6.10	→
	Fermented mahangu flour (5kg)	Retail	–	–		-	-		–	–		-	-		
	Maize flour (5kg) topscore	Retail	2.95	35.99	32.97	5.99	7.20	6.60	32.95	35.99	34.47	6.59	7.20	6.90	→
Rundu	Unfermented mahangu flour (5kg)	Retail	31.40	32.95	32.18	6.28	6.59	6.44	31.40	32.95	32.18	6.28	6.59	6.44	→
	Fermented mahangu flour (5kg)	Retail	–	–	0.00	–	–	0	–	–	0.00	–	–	0	→
	Maize flour (5kg) topscore	Retail	30.85	35.99	33.42	4.99	7.19	6.09	30.85	35.99	33.42	4.99	7.19	6.09	→

A 'Lata' is assumed to be a15kg bucket.

"-" indicates that no product was traded

Source: Namibia Agronomic Boards (2010)