ECONOMIC ANALYSIS OF APPLE PRODUCTION IN SOUTHWESTERN UGANDA

BY
NTAKYO PROSCOVIA RENZAHO

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DECLARATION

I Ntakyo Proscovia Renzaho, hereby declare to the best of my knowledge and understanding that the originality of the findings in this thesis is my work, and has never been presented at Makerere University or any other university for the award of a degree.

Signature.. Date. 28/08/08

Ntakyo Proscovia R.

This thesis has been submitted with permission and satisfaction from university supervisors:

Signature.. Date. 28.08.08

Dr. J. Mugisha

Signature.. Date...................................

Dr. G. Elepu

DEDICATION

To my late father Mr. James Renzaho and my mother Alice Renzaho whose inspiration for education has brought me this far.

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TABLE OF CONTENTS

LIST OF TABLES

Table **Page**

List of Figures

List of Appendices

LIST OF ACHRONYMS

FAO	Food and Agricultural Organization
FORRI	Forestry Resources Research Institute
ICRAF	International Center for Research in Agroforestry
KaZARDI	Kacwekano Zonal Agricultural Research and Development Institute
KARI	Kawanda Agricultural Research Institute
MVP	Marginal Value Product
NAADS	National Agricultural Advisory Services
NARO	National Agricultural Research Organization
NPV	Net Present Value
PMA	Plan for Modernization of Agriculture
SPSS	Statistical Package for Socio-Scientists
TVC	Total Value Product
UBOS	Uganda Bureau of Statistics

ABSTRACT

Apple production was identified by the National Agricultural Research Organization as a priority crop in Southwestern Uganda and has been widely promoted in the districts of Kabale, Kisoro, Kanungu and Rukungiri. This study focused on assessing the economic and financial viability of the apple enterprise in the highlands of Kabale where the crop was first introduced. Data were collected from 136 farmers, selected using multistage sampling technique and analysed using descriptive statistics, production and cost function models. Costs of production and returns at a research institute and farm level were analyzed to assess financial viability in apple production. While a Cobb-Douglas type production function was estimated to assess critical factors affecting apple production. The study further estimated a Cobb-Douglas cost function to determine cost elasticities of the major inputs.

Analysis of costs and returns indicated that labour costs accounted for the highest percentage (41.8%) of total production costs followed by organic fertilizer (27.5%). The NPVs of stream of profits obtained using sensitivity analysis with respect to yields and prices were all positive and the study concluded that apple production was a profitable enterprise. The scenario assuming average yields and a premium price of apples was more profitable with NPVs of Ug. Shs 95.8 and Ug. Shs 591.5 million at 28 and 6 percent discount factors, respectively. Estimates of the apple production function reflected organic fertilizer, farmers' experience and labour, as the most critical inputs. In addition, increasing returns to scale were exhibited. Further analysis revealed economies of scale in apple production depicting labour and fertilizer with high cost elasticities. The study therefore recommends that apple production should be promoted as a cash crop in southwestern Uganda with support of soft loans and sufficient extension services. Furthermore, improving small orchard management should be the means to meet any increased demands. There is need for further research to determine the demand for apples in Uganda and also establish the financial viability of apples as an intercrop.

CHAPTER ONE

INTRODUCTION

1.1 Background information

Apples account for 50 percent of the world's deciduous fruit tree production (University of Illinois Extension, 2007). The leading apple growing country is China, producing about 41 percent of the world's apples, followed by the United States. Turkey, France, Poland, Italy, the Russian Federation, Germany, Argentina, Japan and Chile follow in that order (www.geocities.com). According to the report by Foreign Agricultural Service, United States Department of Agriculture (2003), global apple production was estimated to decrease from 48 to 45 million metric tonnes due to lower production in China and the United States. In Africa the leading producing country is South Africa, followed by Egypt and Kenya.

In Uganda, the apple industry is still in its infancy. It started in 1999 when Forestry Resources Research Institute (FORRI) in collaboration with International Center for Research in Agroforestry (ICRAF) and Kawanda Agricultural Research Institute (KARI) started trials in the highlands of Kabale district with the aim to offer farmers, an alternative source of income (ICRAF, 2003). Whereas apples have been recommended for the highlands of Kigezi, Kasese and Kapchorwa, they have only been adopted in Kabale district (Jama *et al.*, 2004). Currently, apple production is being promoted in the highlands of Kabale, Kisoro and Kanungu districts where the high altitude (1500-2400m above sea level) offers a favorable climate for apple cultivation.

In Kabale, the leading producing areas are; Bubare, Kyanamira, Hamurwa, Kitumba, Maziba and Bukinda sub counties. Apples are propagated by two methods: grafting and budding and on average an apple tree takes four to five years to produce the first fruits. Two varieties are grown; Anna and Golden Dorset, while the common varieties on the Ugandan market are Golden delicious (yellow), Fuji (red), Fugi (white) and Granny Smith (green). Farmers sell fresh apple fruits to local supermarkets and in open markets directly to consumers. There is no well organized marketing system and post harvest handling is still a challenge according to farmers. However, United States Agency for International Development (USAID) preliminary economic estimates indicate that apples can be a profitable enterprise in Uganda if good farm management is practiced.

According to ICRAF, the Uganda government is investing US$ 2 million to promote fruit trees especially apples in southwestern Uganda. It is anticipated to be a major cash crop in the Kigezi highlands, where there are not many cash crops. Apples will supplement traditional subsistence crops such as sorghum and potatoes which generate little income for households. Turyomurugyendo *et al.* (2004) reported that apples are adapted to the highland conditions of Uganda and could be integrated into existing agroforestry systems. This would offer excellent opportunities for widening the limited range of available nutritive foods and income generating opportunities for the people living in Ugandan highlands.

However, Turyomurugyendo *et al.* (2004) cautioned that, extension into large scale production of apples should be cautiously done as it may be difficult to compete with imports, especially those from South Africa. In addition optimum production might be affected by farmers' limited experience and knowledge in management practices. Turyomurugyendo *et al.* further asserted that costs of production and storage may be the same as those in temperate zones and yet the mountainous people of Uganda may not have adequate resources to produce good quality and quantity. Nevertheless, there is room for further extension of apple production as demand often exceeds supply (Musana and Rubaihayo, 2001).

1.2 Economic significance of apples

Currently, most of the apples on the Ugandan market are imported mainly from South Africa, Kenya and China. Consumption of apples in Uganda has been steadily increasing as depicted by the quantities imported in the country in the last eight years (Table 1).

Table 1: Imports of apples into Uganda by value and quantity (2000-2007)

Year	Country of origin	Quantity tonnes)	Value ('000' USD)
2000	Kenya, United Arab Emirate	44.28	35.50
2001	Kenya, South Africa	50.06	26.99
2002	Kenya, South Africa	193.93	133.24
2003	China, Kenya, South Africa	427.56	272.85
2004	Belgium, Kenya, China, South Africa	559.53	297.62
2005	China, Kenya, South Africa	600.48	361.37
2006	Egypt, Kenya, South Africa and United Arab Emirates	783.67	373.46
2007	China, Italy, Kenya and South Africa	1,073.52	729.65

Source: Uganda Bureau of Statistics (unpublished data)

From 2000 to 2007, apple imports increased by 1,029.24 tonnes (95.8%) worth US$ 688,984.15. However, the average price per apple in the open markets and supermarkets standing at Ug.shs. 500 (equivalent to US$ 0.28) is still high for the majority of Ugandans. Therefore promoting apple growing in Uganda will save the country thousands of foreign exchange every year.

As noted by Falconer (1989), apple fruit is a very important item in the diets of people. Apples are about 85 percent water and also contain high levels of vitamins A and C, potassium, pectin and fiber. While it may simply provide a snack at work or while traveling, it may also be eaten during periods of famine (FAO, 1992). Over half the apples grown throughout the world are eaten fresh and most apple products are canned or bottled, dried or frozen (Lamb and Johnson, 2000). Apples are also used in a wide range of products such as pies, cakes, jams, juices and other dishes which include butter, applesauce, jelly and wine. The juice may be further processed into vinegar.

Apples may be raised from cultivated tree orchards or from agroforestry systems. Unlike in industrialized countries where fruit trees are intensively managed just like farm crops, in developing countries fruit production circuits are less organized (FAO, 2001). Apples can be grown in traditional home vegetable gardens in association with annual and perennial crops and livestock thus utilizing marginal land (Falconer and Arnold, 1989). Such systems are found almost everywhere in the tropics especially in densely populated areas typical of Kigezi highlands in Uganda. Nevertheless, they could contribute to food security and provide a good source of income to the households.

1.3 Problem statement

Southwestern Uganda is one of the regions with the highest population pressure of about 400 persons per Km^2 and most households derive their incomes from less than one hectare of land (UBOS, 2005). There is evident severe land degradation, yields are low and people are threatened with food insecurity (Chemning *et al.*, 2005). According to the Plan for Modernization of Agriculture (PMA), poverty eradication must focus on transforming poor farmers from producing predominantly for subsistence to producing for the market. The focus on subsistence farmers is to re-orient them towards commercial agriculture in order to have a significant impact on poverty eradication in the country. One of the government strategies to increase household incomes is to increase production, value and profitability of household agricultural production. This will be based on competitive and comparative advantage in production of high value agricultural products in terms of profitability and socio-economic returns.

Among the priority enterprises identified for southwestern Uganda is fruit production and specifically temperate fruits for the highlands (Nahamya, 2004). Apple production in particular is highly promoted in the highlands of southwestern Uganda. AFRICARE project has facilitated farmers to plant 5,500 apple seedlings for both income and nutrition (Anderson *et al.*, 2006). Equally, National Agricultural Advisory Services (2005) reported giving seedlings and technical knowledge to 36 farmer groups (900 farmers) growing apples.

Whereas a few nontraditional crops introduced in Uganda have been successful, others have failed leaving farmers disillusioned with even less income than before, a case of pyrethrum and vanilla. Chemining *et al.* (2005) predicted three future scenarios for apple production; "Apple becomes a significant cash crop; apple becomes a subsistence crop or the momentum on apples reduces and the enterprise fizzles out". This implies that there is an element of uncertainty and risk. Therefore, sufficient evidence especially regarding the cost structure and returns of apple production needs to be known before many farmers commit their resources into the apple enterprise. This study will contribute towards decision making in apple production by addressing the issue of how individual farmers can maximize profits through a cost minimizing strategy. In addition, it will provide insights on the most critical resources and inputs in apple production and how they influence the levels of output.

1.4 Objectives of the study

The main objective of this study was to conduct an economic analysis of apple production in Southwestern Uganda. The specific objectives were:

1. To determine financial viability of long term investment in apple production in Southwestern Uganda
2. To determine socio-economic factors affecting production of apples in Southwestern Uganda
3. To determine cost elasticities and the extent of economies of scale in apple production in Southwestern Uganda

1.5 Hypotheses

1. Apple production in southwestern Uganda is a profitable enterprise
2. The major factor limiting apple production in Southwestern Uganda is land shortage
3. Economies of scale do exist in apple production in southwestern Uganda

1.6 Significance of the study

The mission of the PMA is to transform subsistence agriculture to commercial agriculture. Therefore, this calls for promotion of high value crops to be able to achieve one of the objectives of the PMA of improving household food security through the market rather than emphasizing self sufficiency. In Uganda, there is lack of information on financial feasibility of long term investment in agricultural enterprises, fruit orchards inclusive. Promotion of apple growing involves many issues for farmers because it is a long term investment of land, labour and other resources. It is important for a farmer to carefully consider financial prospects before investing because apples require constant care and application of necessary inputs around the year. Growers have to decide whether they could allocate their resources to plant apple orchards or should use their resources for other crops.

There is need for documented information on apple production in Uganda to guide farmers produce for a competitive market. Farmers will be equipped with information to help them plan yearly operations, and analyze marketing strategies. It is important that farmers investing in apple production, know the production costs to enable them set breakeven prices and also calculate their profits derived from different market prices and buyers. The findings from this study will also provide a basis for farmers who may wish to acquire loans to invest in apple production as well as financial institutions who offer agricultural loans. Extension workers will use the results of this study to guide farmers to allocate resources more efficiently in apple production. Similarly, researchers will utilize the results in formulating appropriate strategies and technologies that will enhance integration of apples within the existing farming systems in Uganda. Furthermore, results of this study will be used by planners and policy makers to design policies that will promote apple production in Uganda.

1.7 Scope and structure of the study

This study attemptes to analyze the economic viability of apple production in Southwestern Uganda. Analysis was based on data from two main sources; financial viability analysis using the NPV method is based on data from a research institute orchard while the rest of the analysis is based on data collected from individual apple farmers in Kabale district. The survey was conducted in the year 2007 between March and June. This study is composed of five chapters. The first chapter gives an overview on apple production. It is followed by literature review in chapter two that focuses mainly on relevant work previously done as well as methodologies used in relation to the study objectives. Chapter three presents the methodology used to achieve study objectives. The results are presented and discussed in chapter four. Finally, the summary, conclusion and recommendations are presented in chapter five.

CHAPTER TWO

LITERATURE REVIEW

2.1 Investment analysis of agricultural projects

Selecting investments involves economic profitability analysis and financial feasibility analysis (Boehje and Ehmke, 2005). The purpose of economic profitability analysis is to determine the long run profits of the business whereas financial feasibility analysis determines the cash flows of an investment. Important financial viability indicators required by investors are mainly profitability and cash flow patterns associated with the investment.

According to Boehlje and Ehmke (2005) capital investment decisions that involve the purchase of items such as land, machinery, or equipment are among the most important decisions undertaken in business. Such decisions involve commitment of large sums of money and they affect the business over a number of years. As noted by Abadi *et al.* (2006) most investment strategies in agricultural projects require immediate expenditure whereas benefits accrue over time. As such there must be a considerable effort to evaluate investment alternatives thoroughly because the ability to foresee the future is imperfect. The use of discounting analysis of cash flows provides a sound framework for the economic analysis of agricultural projects because it accounts for the opportunity cost of key resources such as land and credit. Discounting of future costs and returns converts all numbers to present day value (Gittinger, 1982).

Financial and economic analyses provide the relevant evidence within the frameworks of discounted cash flows and cost benefit analysis in investment decisions. The value of the analysis as a decision tool hinges on its ability to capture a variety of costs and benefits and accurately predict the project outcomes. The criteria used are centered on economic ratios or parameters such as: pay back period, the net benefit, the rate of return, the net present value and the dynamic rate of return (Muirragui, 1992).

Pay back period is used primarily in financial analysis and tells the future year or point in time the project recovers its costs. It is therefore a measure of risk and not profitability (Donaldson, 1994). The selection criterion is to accept the project with the shortest pay back period or projects that meet the maximum allowable pay back period. Its major limitation is that it is biased against projects with large benefits occurring in later years (Gittinger, 1982).

Benefit cost ratio is another common criterion that is used to measure economic viability. It is defined as the sum of discounted benefits divided by the sum of discounted costs. Thus it provides a reliable indicator of profitability. Conversely, the results vary significantly with small inconsistencies of input (Donaldson, 1994). The benefit cost ratio also has limitations such that it may give incorrect rankings even among independent projects (Muirragui, 1992). It only compares the relative size of benefits to costs but does not show the actual magnitude of net benefits. Selection criterion is to choose all independent projects with benefit cost ratio greater or equal to one.

Another criterion commonly relied upon in project analysis is the internal rate of return (IRR). It is defined as the rate of discount that just sets the sum of the present value of future benefits equal to the sum of present worth of future costs. That is, to say, it sets the discounted net benefits equal to zero. It provides investors with a rod of comparison (the IRR value) to the opportunity cost of capital. Selection criterion is to choose a project if the rate of return meets acceptable private rate of return where the interest rate is greater than one.

IRR has been used in earlier studies to evaluate agricultural projects. For example, Parker *et al.* (1998) evaluated different training systems in apple production and found out that both slender spindle and central leader system were all profitable from a low IRR of 12 to a range of 25 percent. Gilead (2006) also used IRR to analyze cost-returns of small holder dairy production in Hai district in Tanzania and declared the project economically attractive in both the short and long run at a high IRR of over 50 percent.

The Net Present Value (NPV) is the most widely acceptable form of project analysis, it is defined as the present worth of the incremental net benefit or incremental cash flow stream of a project. It is considered by many project analysts to be superior to others for most cases and gives the analyst an approximation of the actual value, in profit or loss, of one plan compared to another at a given point in the future (Gittinger, 1982). The selection criterion for NPV is to accept a project if its NPV is greater than or equal to zero. Where choices between mutually exclusive projects are under study, the project with the higher positive NPV would be preferred.

In connection with the NPV, is the annual equivalent return, that is the annuity spreading the net present value evenly across the project life. It is also a useful method for comparing profitability of alternative land use systems ranging from short rotations in conventional agriculture to long term land use such as tree crops (Abadi *et al.*, 2006)

Previous studies have used the NPV criterion to examine financial viability of agricultural projects. Saleh (2007) examined industrial dairy husbandry projects in Tehran and declared them financially and economically justified. Conversely, the results of sensitivity analysis in respect to increasing operating costs and decreasing revenues indicated negative NPVs. Saleh attributed this to a greater impact of revenue decrease than increase in operating costs. Similarly, Parker *et al.* (1998) found that different planting systems in apple production were profitable under different price and production assumptions.

2.2 Theory of production

Production theory is a procedure and an economic tool that is used to determine the most efficient way to use resources to achieve a desired goal. The basic principle of the production theory is that with variable production techniques, a producer can choose various capital-labour combinations, all of which yield the same output but with varying overall costs (Griffin, 1987). There are over twenty functional forms used in production analysis including; quadratic, square root, Mitscherlich, spillman, resistance, modified resistance, transedental, CES, Generalized leontief, translog, generalized Cobb-Douglas, generalized power and generalized Box-Cox, among others (Hall, 1998; Griffin, 1987). The challenge is to choose the best form for a given task. The criteria according to Griffin may be grouped in four categories depending on whether they relate to maintained hypotheses, estimation, data or application. Certain forms exhibit two related properties; that is homogeneity and homotheticity. If production is found to be profitable for some input combination in a homogeneous production function, profit can be increased without bound by increasing inputs proportionately. On the other hand, homothetic production functions have a characteristic of a constant marginal rate of technical substitution (MRTS) when all inputs are increased proportionately (Samuelson, 1972). Most functions, in their complete forms require a geometrically increasing number of parameters to be estimated as the number of variables of main effect is increased.

2.3 Production functions

The production function is the quantitative model of the production process, which can be any technology that will contribute to the desired output (Wiens, 2007). A production function describes the physical relationship between the quantities of inputs and quantities of output (Derbertin, 2002; Doll and Orazem, 1984). Chambers (1982) asserts that in standard neoclassical analysis, under output and input price uncertainty or production uncertainty, output and input are related in a non-linear fashion via the production function.

According to Silberburg (2000) the neoclassical production function for a single output and two variable inputs can be written as $y = f(x_1, x_2)$ where y is the quantity of output and x_i is the quantity of the i^{th} factor input. Possible combinations of x_1 and x_2 have only one associated y value, assumed to be maximum possible output. If this was not the case for any bundle of inputs, the entrepreneur would always have to choose between several output levels and the highest available output would always be chosen (Chambers, 1988). However, such specifications do not take into account the fact that the choice of the coefficients is an economic decision (Mundlak *et al.*, 1999).

In their decision on a production plan, producers choose not only the level of inputs but also the technique of production to employ. The choice is guided by the same considerations that are attributed to the choice of inputs. Differences in such attributes result in differences in the crop compositions and as such in the employed production functions that constitute the implemented technology. Thus, even though the available technology is the same for all farmers the implemented technology is not. Consequently production functions are expected to vary among farmers (Mundlak *et al.*, 1999).

Production functions exhibit certain properties as presented by Chambers (1988). They include; If $x_i \geq x$, then $f(x_i) \geq f(x)$ (monotonicity); If $x_i > x$, then $f(x_i) > (x)$ (strict monotonicity). This implies that additional units of any input can never decrease the level of output, that is to say that all marginal productivities are positive. The second property is; $V(y) = \{x: f(x_i \geq y\}$ is a convex set (quasi-concavity), implying that the input requirement set is convex, thus justifying the law of diminishing marginal rate of technical substitution; $f(0_n) = 0$, where 0_n is the null vector (weak essentiality); $f(x_i,\ldots, x_i\text{-}1, 0, x_i\text{+}1,\ldots,x_n) = 0$ for all x_i (strict essentiality); the set $V(y)$ is closed and nonempty for all $y > 0$; $f(x_1,x_2)$ is finite, nonnegative, real valued and single valued for all none negative and finite x; finally, f (x_1, x_2) is everywhere continuous; and is everywhere twice-continuously differentiable. Chambers emphasizes that they do not represent a set of hypotheses to be maintained universally because some are contradictory.

Several econometric studies have utilized different forms of production functions both in agricultural and nonagricultural research. Echevarria (1998) estimated constant returns to scale agricultural production function, and reported that Canada agriculture was less labour intensive than services and industry while capital intensity was similar in the three sectors. The study involved only conventional factors of production; land, labour and capital.

Production functions have not only been applied to individual farms and countries but also in cross country analysis. The work of Mundlak (1999) shows that variations in agricultural output within various countries were largely accounted for by variations in capital and land and less by labour. Cross country analysis also revealed increasing returns to scale contrary to decreasing returns to scale in within country analysis.

In estimating the potential contribution of the physical characteristics of the boats to the level of fish output in Lake Victoria, Lokina (2004) found that 85 percent and 41 percent of the catch variation for Nile perch and Dagaa, respectively, was explained by the physical features of the boats. It was also reported that Cobb-Douglas production function was inadequate to represent the production structure of the fishers in the sample and preferred the translog production function for Lake Victoria fisheries data.

Ishaq *et al.* (2005) estimated a Cobb-Dauglas type of production function for livestock production in Pakistan and reported that livestock milk yield was more sensitive to change in capital. They found that a one percent increase in capital caused a 0.8 percent increase in milk yield, and small ruminant (goats and sheep) farming was a profitable enterprise with increasing returns to scale.

Koundouri and Nauges (2005) also estimated a production function for vegetables and cereal farmers in Cyprus separately by Generalized Method of Moments and reported a high adjusted-R^2 of 0.80 and 0.83 for vegetables and cereals, respectively. The Mill's ratio was also found significant at one percent level of significance and they concluded that ignoring risk considerations can cause inefficient estimates in stochastic production function. In a related study, Alene *et al.* (2006) asserted that stochastic frontier production function was not appropriate for multi-output agriculture involving intercropping of annual and perennial crops, because it underestimates resource use efficiency. Parametric distance functions and data envelopment analysis were recommended.

In what seems a special case, Hall (1998) applied a production function analysis in agronomic experiment to determine the response of corn, alfalfa and soybeans yields to agricultural limestone. Nonnested hypothesis test and costs of specifications revealed that only the translog function satisfied Cassels version of neoclassical theory, which require all three stages. The power function underestimated the yields and was inconsistent with agronomic technology. As noted by Chambers (1988), Hall concluded that if production function is purely a technical relationship, then specification of the function is not an exclusive economic exercise.

2.4 Returns to scale and economies of scale

Agricultural economists investigating long-run relationships among levels of inputs, and costs generally use concepts of returns to scale and size. Econometric studies which utilize production or profit functions commonly are concerned with returns to scale while synthetic studies of relationships between output and cost utilize returns to size (McClelland, 1986). However, the word scale is sometimes used to mean size (of a plant). Thus, increasing (decreasing) returns to scale could also be used to refer to economies (diseconomies) of size.

Samuelson (1972) explains that returns to scale are technical properties of the production function; $y = f(x_1, x_2, \ldots, x_n)$. If the quantity of all factors employed increase by the same (proportional) amount, output will increase. The three basic outcomes are identified as; increasing returns to scale, constant returns to scale and decreasing returns to scale. Furthermore, Samuelson claims that the concept of returns to scale was used to capture the idea that firms may alternatively face economies of scale or diseconomies of scale.

According to Varian (1992) economies of scale and diseconomies of scale refer to an economic property of production that affects cost if quantities of all input factors are increased by some amount. If costs improve proportionately, there are no economies of scale; if costs increase by a greater amount, there are diseconomies of scale; if costs increase by a lesser amount; there are positive economies of scale. Varian asserts that when combined, economies of scale and diseconomies of scale lead to ideal firm size theory, which states that per unit costs decrease until they reach a certain minimum, then increase as the firm size increases.

McClelland (1986) purported that some researchers and students in agricultural economics use scale and size interchangeably in discussing economies and diseconomies of large scale agricultural production. In an attempt to re-examine the difference, McClelland affirms that economies of scale is solely related to the particular production technology and does not require economic efficiency as one of its determinants. Whereas, economies of size requires the firm to be operating on its input efficiency locus and thus in an economic efficiency concept.

Rodda (2004) explains the different causes of economies of scale under two categories of external economies and internal economies of scale. External economies of scale occur when a firm benefits from lower costs as a result of the whole industry growing in size. Whereas, internal economies occurs as the output of the individual firm increases, a case that applies to apple production. This is attributed to shared fixed costs in the long run, financial economies in terms of obtaining credit at a lower interest rate; managerial economies and indivisibility of machinery or firm processes. Rodda stresses that internal economies of scale have a greater potential impact on the costs and profitability of a business.

2.5 Theory of cost functions

By definition, a cost function relates the total cost of production for a level of output to input factor prices and technical change. It shows that for any set of input costs and for any output level, the minimum total cost incurred by the firm (Nicholson, 1989) is;

TC = TC (r,w,q) where: TC is Total cost, r is cost of capital, w is cost of labour and q is output. Cost functions have general properties which include; non negativity, no fixed costs, monotonicity in output, monotonicity in input prices, homogeneity of degree one in prices, concavity, continuity and lastly a unique vector of inputs resulting from the first derivative of total costs with respect to input prices (Shephard's Lemma).

The principle of duality in the theory of production can be used to specify cost function from which the demand for factor inputs can be derived under certain assumptions of cost minimization and perfect competition. According to Doll and Orazem (1984), researchers can also estimate the cost function directly by observing costs and output data for a large sample of similar farms. Debertin (2002) describes a cost function as an inverse of a production function that underlies it multiplied by the price of the input. Each of the different input arrangements would produce a different level of cost and hence a cost function (Silberburg, 2000).

2.6 Studies done using cost function approach

The cost function approach has been used by economists in many studies for different purposes. Among others are studies on efficiency and productivity, estimating input demand, economies of size and investigating farm technologies. Hallam *et al.* (1999) used an econometric approach centered on the estimation of stochastic identities relating the total cost of each input to the levels of output to estimate the cost of the input per unit of output of various enterprises. Hallam *et al.* reported that Generalized Least Squares estimation provided expected results though it could not overcome the problem of negative coefficients.

In a study by Boyle (1982), a translog cost function was used to predict the behavior of fertilizer shares in response to proportionate changes in their own and substitute prices. The estimates of the own and cross-price demand elasticities obtained were inelastic. Elasticity of substitution between the fertilizers was insignificantly different from zero hence conforming to theory that fertilizers are perfectly complementary. Using a cost function to analyze the impact on profitability and costs of reforming the European Union Sugar production regime, Renwick and Revoredo (2004) found out that the 40 percent price cut resulted into largest gains in terms of economic efficiency compared to 25 percent price cut. Their findings also revealed that 40 percent cut in prices would lead to a great reduction in production if fixed costs were not adjusted.

Garcia and Randall (1994) analyzed a cost function to estimate the effect of fertilizer policy on the supply of wheat and corn in the United States and European Community. They reported that, the fertilizer demand elasticities were all less than zero (French and English wheat were -0.8758 and -1.0901, while the U.S. and French corn estimates were -0.9540 and -1.1516, respectively) implying that the demand for fertilizer reduced with an increase in the price.

Marcin (1991) applied a cost function to estimate derived demand for composite wood products and found that the parameters for the proxy for composite products was positive and significant in the generalized Cobb-Douglas cost function and in all unitary elasticity models. In a study to estimate technical efficiency in rice farming in North Central Nigeria, Okorua *et al.* (2006) estimated cost functions from which a system of minimum cost input demand equations were derived. Their findings showed a mean technical efficiency index of 81.6 and 76.9 for upland rice and lowland rice, respectively. Further evaluation of both systems using a t-test, revealed that the technical efficiency in upland rice production system was significantly higher compared to the low land production system.

Parikh *et al.* (1995) also used a stochastic cost function to estimate inefficiency by rice farms in Pakistan and found that small farms seemed to be more efficient than large farms. They reported that input utilization inefficiency had a wide variation of 41.5 percent to 3.0 percent with an average of 11.5 percent, implying that 11.5 percent of the cost incurred could be avoided without any loss in total output.

2.7 Perceived conceptual framework

Following neo-classical micro-economic theory, it is assumed that there exists at the farm level, a transformation function based on quantities of inputs and output. What happens to output as variable inputs are applied to a technical unit is depicted by the production function. However, economic analysis of the production process requires the consideration of costs and returns (Doll and Orazem, 1984). The central focus is the farmer at household level which is considered to be the planning unit and the resource base. The farmer must consider alternatives that are most profitable where profitability is determined by market forces. Cost functions are the first step in incorporating the impact of the market place on the farm enterprise.

The total operating cost per season for an apple farmer is the sum of the cost of each activity per hectare times the number of hectares. It is assumed that the intensity of use for such inputs or activities is likely to vary across farms for a given level of output. Consequently, per unit output costs are probably not uniform among a cross section of farms. The farmer will optimize profits when the average costs are equal to the marginal costs. Assuming the farmer performs p activities, to produce q apples, the cost to the farm of the ith activity, i = 1,...,p can be written as an identity: $TVC_{ij} = \sum C_{ij}Q_j$

Where: TVC_{ij} is the total variable cost of farm j of activity i

C_{ij} is the variable cost of activity i for farm j per unit of output

Q_j is the level at which farm j produces output

CHAPTER THREE

METHODOLOGY

3.1 The study area

The study was carried out in Kabale district in southwestern Uganda. The district exhibits a relatively favourable climate for apple production and a number of farmers have had the first harvest. Kabale district is bordered by Ntungamo district to the East, Kanungu and Rukungiri in the north and Kisoro in the west. The district also shares international borders with Democratic Republic of Congo (DRC) to the west and Rwanda to the Southwest.

The major economic activity in Kabale district is agriculture, comprising annual crops such as sorghum, beans, vegetables, field peas, potatoes and sweet potatoes in addition to livestock. Potatoes, sorghum and vegetables are the major food and cash crops. Agroforestry is another economic activity that was promoted in the district by World Agroforestry Center (ICRAF) as an intervention strategy for natural resource management. The district has productive soils and receives bimodal rainfall promoting varied agricultural systems and land use practices. However, there is a problem of land degradation and land fragmentation due to high population pressure and this leads to low agricultural output (Oslon and Berry, 1996).

3.2 Sampling procedures and sample size

Sample selection was done using multistage sampling techniques. Purposive sampling procedures were used to select respondents who comprised apple farmers, extension workers and service providers. Kabale district was purposively selected because it leads in apple production. From the district, leading apple growing sub counties of Kyanamira, Bubare, Bukinda, Hamurwa, Kamuganguzi and Kitumba were also purposively selected. National Agricultural Advisory Services (NAADS) service providers for the respective sub counties provided a list of all apple farmers from which those who had had the first harvest were selected as respondents. Subsequently, 20 farmers were selected from each sub county save Kyanamira and Bubare where 28 farmers were selected from each making a total of 136 farmers. More farmers were selected from Kyanamira and Bubare because they had more farmers than other sub counties. In addition, service providers from NAADS and National Agricultural Research Organization scientists working directly with apple farmers were also interviewed to back up primary data.

3.3 Data collection, data type and sources

Primary data were collected with the use of a pre-tested structured questionnaire. It was in three parts; the first part was meant to acquire general information about the farm/household (sex of the farmer, education level attained by the farmer, experience of farmer in apple growing, size of the household, sources of income and other crops grown). The second part was on costing of different activities/inputs and production levels in apple production, that is, farm size in hectares, land under apples, labour utilization (number of household members involved in apple production and hired labour), amount of seedlings planted and source, activities in apple production and their respective costs, equipments, fertilizers, agrochemicals, apple yields and farm gate prices. The third part focused on socio-economic factors such as; availability of extension services, types of intercrops, credit availability, production constraints and market information.

Secondary data sources included district production reports, NGOs and other organizations' (ICRAF, AFRICARE, NARO, Africa2000network and NAADS) annual reports, publications and other relevant sources. The major interest was on production estimates, number of apple farmers and acreage, NGOs and government's role in apple production, general limitations, strategies and opportunities of apple production.

3.4 Data processing and analysis

Data was entered in Statistical Package for Social Scientists (SPSS) to generate descriptive statistics such as, means, percentages and standard deviation of the general characteristics of apple farmers, use of inputs in apple production and output levels. Econometric analysis was done using STATA computer software package to estimate a Cobb-Douglas type production function and cost function. For each feasible amount of product, the cost of producing the product was computed using the cost minimizing combination of inputs thus obtaining the cost function. Excel spreadsheet was used to generate the net present value (NPV) under different assumptions.

3.4.1 Financial viability of long term investment in apple orchard

The Net Present Value discounted measure was used to analyze financial viability of apple orchards. Like many project analysts, the net present worth criterion was preferred for this study· for its simplicity, unambiguous quality, and straightforward way of selecting among mutually exclusive projects (Gittinger, 1996).

Mathematically; $$NPV = \sum_{t=0}^{n} \frac{B_t - C_t}{(1+i)^t}$$

Where; n = number of years, t = 1, 2,.........., 15

i = Discount rate

B_t = Benefits in each year

C_t = Cost in each year

This study used 28 and 6 percent as discount factors in computing the NPV. It was adopted from Uganda Centenary Development Bank which provides agricultural loans at an interest rate of 28 percent. Six percent interest is given to fixed deposit which in this case was considered to be the best low risk alternative available for off farm investment.

Production costs and returns estimates in this study were based on production records supplied by Kachwekano Zonal Agricultural Research and Development Institute (KaZARDI) which pioneered apple growing in Uganda at Karengyere in Kabale district. Yield patterns over 15-year life of the trees were also projected based on the yields of Karengyere orchard. Whereas, apples can have a productive life of up to 40 years, it was more realistic to consider apple production in the short run. Since apple is a non traditional crop in Uganda, its productive period is still uncertain. In addition the trend of climate changes may affect future production as temperatures continue to rise.

Annual production costs comprised labour, variable and fixed costs. Variable costs included; fertilizer, pesticides, packaging, organic fertilizer, stakes and ropes, while fixed costs comprised land and secateurs because other implements such as hoes, pangas, spray pump, spades and wheel barrows were used in production of other enterprises. The cost of apple seedlings and initial land preparation was considered as capital investment at the onset of the enterprise. Average inflation rates of goods (3.7%) and services (4.2%) for the previous 10 years were used to project input and labour costs while an inflation rate of 5.2 % on food prices was used to project returns after year six. All costs and returns were estimated in Uganda shillings. To compute gross income, all fruits produced were valued at Ug. Shs 4,000 per kg a price that was offered by supermarkets for good quality fruits. The difference between annual gross income and annual total costs is the net cash flow.

Like other previous studies such as Glover *et al.* (2002) it was assumed that year six costs and yields were representative of an average mature production year. This study further assumed that maximum yields are attained in the sixth year and the average productive life of the trees would be fifteen years (Musana, 2002; Parker *et al.*, 1998). This is also in agreement with previous studies (Abdul and Afzal, 2005) that indicated a productive life range between seven to forty years in the temperate region.

It was unrealistic to believe growers in Kabale would have a full apple crop every year the trees were in production. Projections were inevitably subject to a high degree of uncertainty about what would actually happen. Adverse weather conditions, diseases, poor management and poor pollination are some of the reasons yields would be lower than expected. It was also anticipated that prices might drop due to increased production since the crop had been widely promoted across other districts of Kanungu, Rukungiri and Kisoro. Therefore, sensitivity analysis was used to test what would likely happen to the earning capacity of the project if the price and yields of apples differed from the predictions (Mutsaers *et al.,* 1986).

The sensitivity analysis assumed three scenarios; average yields and a premium price of Ug.Shs. 4,000 per kilogram of apple fruits; average yields and a reduction of 25 percent on a premium price per kilogram thus selling at Ug. Shs 3,000 per kilogram and lastly a 10 percent drop in average yields and a premium price of Ug.Shs. 4,000 per kilogram of apple fruits. Twenty-five and ten percentages were adopted from similar studies (Parker *et al.*, 1998). The average yield pattern represents the output a grower could expect following recommended agronomic practices (Kachwekano ZARDI unpublished report).

3.4.2 Derivation of production and cost functions and model specification

Cost functions can either be derived directly from the farm cost data or indirectly from a production function. The disadvantage with deriving directly is that, individual farmers with similar fixed resources operate at different output levels because of limitations on other resources, risk and uncertainty and other related reasons (Carter and Dean, 1961).

The principal of duality in the theory of production was used to specify cost functions under assumptions of cost minimization and perfect competition.

The general Cobb-Douglas production function is expressed as;

$Y = f(X) = X_1^{\alpha} X_2^{\beta}$, α, β>0..1

Where Y is the quantity of output produced

X_1 and X_2 are the inputs employed in producing output Y

α and β are partial elasticities

From equation 1, the apple production function was expressed as a Cobb-Douglas type production function as follows;

$Y = f(X) = AX_1^{\beta_1} X_2^{\beta_2} X_3^{\beta_3} X_4^{\beta_4}$, β_1, $\beta_{,2}$ β_3, β_4>0...2

Where; Y is the quantity of apples produced (Kg)

X_1 is land allocated to apples (ha)

X_2 is labour used for all activities in apple production (person days)

X_3 is amount of organic fertilizer applied in a season (tonnes)

X_4 is the number of apple trees a farmer has

β_1 ....β_4 are coefficients estimated and represent the partial elasticities of output with respect to inputs

A is the technology parameter

Linearising equation 2, the production function is expressed as;

$InY = A + \beta_1 InX_1 + \beta_2 InX_2 + \beta_3 InX_3 + \beta_4 InX_4 + \varepsilon$ 3

Where ε is the error term

Aside the measurable inputs, there were other factors that may affect apple production and therefore were included in the model and presented as;

$$InY = A + \beta_1 InX_1 + \beta_2 InX_2 + \beta_3 InX_3 + \beta_4 InX_4 + \beta_5 InEXP + \beta_6 InEDUC + \beta_7 EXT + \varepsilon ......4$$

Where; EXP is farmer's experience (number of years) in apple production

EDUC is the farmers level of education (number of years spent in school)

EXT is number of times an extension officer visited the farmer in a season

Using Weighted Least Squares techniques the log linear function (equation 4) was estimated to determine the factors that affect apple production. Furthermore, marginal productivities of critical input factors in apple production were estimated to determine the returns of critical inputs in apple production.

The marginal productivities were calculated as follows:

$MP_{land} = \beta_1 Y/X_1$

$MP_{labour} = \beta_2 Y/X_2$

$MP_{organic\ fertilizer} = \beta_3 Y/X_3$

Where; Y and X are the geometric means of output and input factors, respectively.

β_1, β_2 and β_3 are estimated elasticities of land, labour and organic fertilizer, respectively.

Value marginal products (VMPs) were calculated by multiplying marginal productivities by 3,000; the then average price of a kilogram of apples

To determine cost elasticities and scale economies in apple production, a Cobb-Douglas cost function was estimated. Deriving a cost function dual to the Cobb-Douglas production function requires specification of a cost minimization problem facing the farming system. The general specification of any cost function begins with the general form (Marcin, 1991):

$C = g(W_i, \ldots\ldots W_n, Y)$ 5

Where: C is cost function

W_i is the input factor price, and

Y is producible output.

From equation 5, the total costs of producing output Y can be expressed as;

$$C = \sum_{i=1}^{n} w_1 x_i \qquad \text{.......6}$$

The cost function is then presented as;

$$C(Y,W) = \sum_{i=1}^{3} W_i X_i(Y,W) \qquad \text{.......7}$$

X_i (Y,W_i) are input demands

Combining equation 2 and 7, the cost minimization problem is then expressed as;

$$\text{Min } C(Y,W) = \sum_{i=1}^{3} W_i X_i(Y,W) \text{ Subject to } Y = f(X_i) \qquad \text{.......8}$$

Using a Lagrange method

$$\ell = \sum_{i=1}^{3} W_i X_i + \lambda (Y - AX_1^{\beta_1} X_2^{\beta_2} X_3^{\beta_3}) \qquad \text{.......9}$$

First order conditions w.r.t. X_i, λ

$$\frac{\partial \ell}{\partial X_1} = W_1 - \lambda A \beta_1 X_1^{\beta_1 - 1} X_2^{\beta_2} X_3^{\beta_3} = 0 \quad \ldots\ldots 10$$

$$\frac{\partial \ell}{\partial X_2} = W_2 - \lambda A \beta_2 X_1^{\beta_1} X_2^{\beta_2 - 1} X_3^{\beta_3} = 0 \quad \ldots\ldots 11$$

$$\frac{\partial \ell}{\partial X_3} = W_3 - \lambda A \beta_3 X_1^{\beta_1} X_2^{\beta_2} X_3^{\beta_3 - 1} = 0 \quad \ldots\ldots 12$$

$$\frac{\partial \ell}{\partial \lambda} = Y - AX_i^{\beta_i} = 0 \quad \ldots\ldots 13$$

Rearranging and algebraically solving the first order conditions in equations 10- 13 yields optimal values of inputs (Gowa *et al.*, 2001).

$$X_i = \lambda . Y \frac{\beta_i}{W_i} \quad \ldots\ldots 14$$

Where; i = 1, 2, 3

Taking ratios of the expressions in equation 14 to eliminate λ and Y, optimal values of X_1, X_2 and X_3 were determined. Substituting optimal values of X_i, into equation 8 the dual cost function of the Cobb-Douglas production function is obtained and expressed as;

$$C = \gamma . Y^{\frac{1}{r}} W_i^{\frac{\beta_i}{r}} \quad \ldots\ldots 15$$

Where;

$$\gamma = r(\beta_i)^{\frac{-1}{r}} \qquad i = 1,2,3$$

$$r = \sum_{i=1}^{3} \beta_i$$

Linearising equation 15, the generalized Cobb-Douglas type cost function is presented in equation 16

$$InC = In\gamma + \frac{1}{r}InY + \left(\frac{\beta_1}{r}\right)InW_1 + \left(\frac{\beta_2}{r}\right)InW_2 + \left(\frac{\beta_3}{r}\right)InW_3 + \varepsilon \text{ ....16}$$

Where;

γ is the constant

r is the returns to scale parameter.

$r > 1$ indicates diseconomies of scale, $r < 1$ indicates economies of scale and

$r = 1$ implies constant returns to scale and therefore neither economies nor diseconomies of scale.

In a reduced form equation 16 is expressed as;

$$InC = A + \alpha_0 InY + \alpha_1 InW_1 + \alpha_2 InW_2 + \alpha_3 InW_3 + \varepsilon \text{ ....17}$$

Where; C is the total cost of producing apples per hectare in one season (Ug. Shs)

Y is the quantity of apples produced in a season (kg per hectare)

W_1 is rent for one hectare of land per year (Ug. Shs)

W_2 is the labour wage rate per person day (Ug. Shs)

W_3 is the cost of organic fertilizer per tonne (Ug. Shs)

A is a constant

α_0, α_1, α_2 and α_3 are the parameters that were estimated. They represent cost elasticities and measure scale economies.

$A = In\gamma$, $\alpha_0 = \frac{1}{r}$ and $\alpha_i = \frac{\beta_i}{r}$ $i = 1,2,3$

3.5 Model justification

To answer the question whether apple production is financially viable, it is necessary to conduct a cash flow analysis. Discount cash flow analysis is used to factor in different time preferences for money invested today for return on that investment in the future. This allows different cash flow streams to be on the same present day basis. Such allowance is important for apple production where the main costs or cash outflows occur in the initial years while revenues are lagged and spread over many years. Thus the relevance of using NPV discounted measures in this study.

The production function describes the technological conditions of production. It gives the maximum possible output for given quantities of inputs. However, different producers produce different levels of output even if they use the same levels of every observed input. This is because producers at any time face more than one technique of production. Therefore the economic problem in apple production is to choose the techniques to be employed together with the choice of inputs and outputs. This can be guided by estimating a Cobb-Douglas type production function used in this study.

The minimum cost of producing a given level of output for some fixed factor prices is measured by a cost function and it is the primary means of describing the economic possibilities of a firm (Varian, 1992). Econometric estimation of enterprise input use and production costs offer a less expensive alternative to special surveys. A cost function is recommended as one of the techniques used to determine the combination of inputs which will result in that output providing maximum net income. However, the validity and nature of cost minimization is much less clear when production is uncertain (Pope and Chavas, 1994). Nevertheless, a cost function was relevant to this study since there was need to assume a cost minimizing behaviour when there is competition for resources (Mbuga, 2004) and input prices were assumed to be exogenously determined. It provides a convenient way to obtain supply and demand equations which is consistent with traditional economic theory (Marcin, 1991). It also has an advantage in that it can be specified from factor input prices for a given level of output.

3.6 Measurement of variables in the model

All measurable variables expressed in the production function were measured using standard units. Land under apples was estimated in acres and converted to hectares because it was easy for farmers to estimate an acre than a hectare. Labour was measured in person days, where a person day was considered to be eight working hours irrespective of gender and age. This was in conformity with the average time hired labourers work per day in most of the sub counties where the study was done. Gender and age were not considered because most operations were done by adults and the wage rate was not discriminative of gender.

Farmers' experience was considered to be the number of years the farmer had spent in apple production. Quantity of organic fertilizer used was estimated in terms of basins weighing 15 kgs and was later converted into tonnes. All apples produced were estimated in numbers and converted into kilograms. According to measurements done, about twelve apples were equivalent to one kilogram.

Farmers were asked how much money they spent per unit input used in apple production and this provided the costs of inputs used in the cost function. The cost of land was estimated in terms of rent paid per acre per season and it was later converted to rent per hectare per year. Labour costs were considered to be the average wage rate per person per day and family labour was also valued using the prevailing wage rate. The cost of organic fertilizer was estimated as cost per basin of 15 kgs which was later converted into cost per tonne. All costs were estimated in Uganda shillings.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Socio-economic characteristics of apple farmers

Results of this study are based on farm level data from apple farmers in Kabale district in southwestern Uganda. Out of 136 farmers interviewed, males constituted 65.4 percent indicating that apple growing was male dominated. This is typical of most cash and or perennial crops may be because men have a higher authority over resources than women especially on land. Table 2 shows the general socio-economic characteristics of the apple growers that were interviewed

Table 2: Socio-economic characteristics of households involved in apple production in Southwestern Uganda

Variable	Mean	Minimum	Maximum	Standard deviation
Age of apple farmers (years)	49.8	22	78	11.89
Education (number of years spent in school)	7.8	0	17	4.13
Household size	7	1	18	3.29
Average household income(million Ug.shs. per annum)	2.83	0.67	37.00	3.99
Average land owned per household (ha)	2.83	0.04	20.24	3.5
Land under apples (ha)	0.16	0.04	0 .81	0.13
Farmers Experience in apple growing (years)	5	2	10	1.5

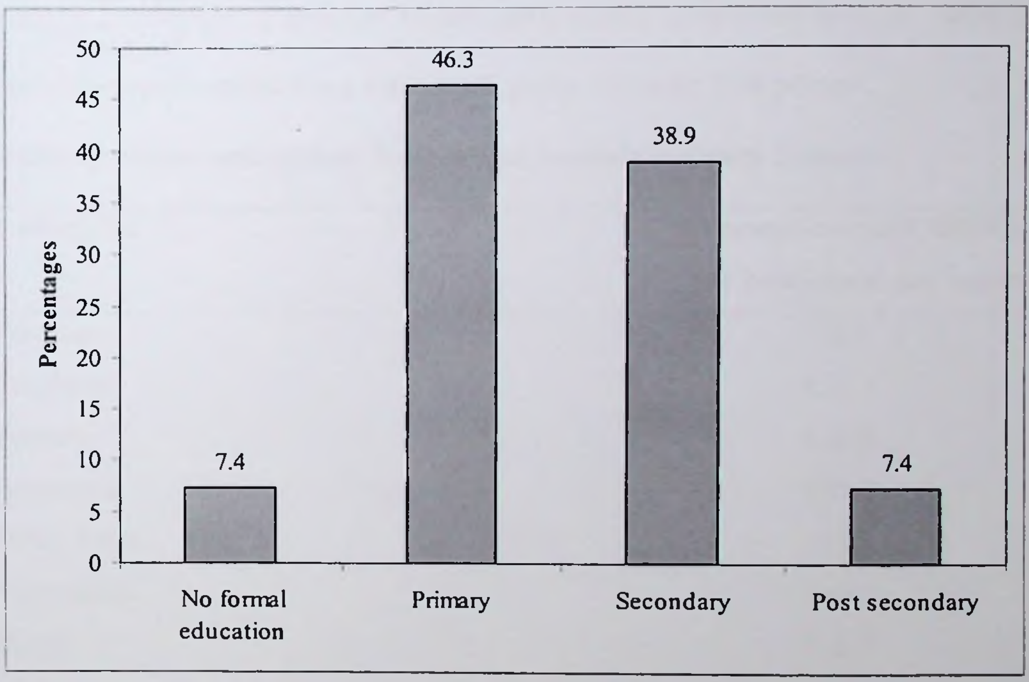
Apple farmers were in a range of different age groups. Their average age was 49.8 years with a variation of 11.89. Analysis showed that 74.3 percent of the farmers were above 40 years of age indicating that apple production is an enterprise that has attracted mainly the aged group. The explanation could be that the youth do not own land as well as capital for long term investment. In addition, the youth are more attracted to enterprises with quicker returns such as vegetables than long term enterprises.

The average experience of apple farmers interviewed was five years indicating that the enterprise was still in infancy. Among the farmers interviewed, the average number of apple trees recorded was 24, with a standard deviation of 34.17 signifying a large variability in the farm size. In connection, the average land size allocated to apples was 0.16 hectares with a standard deviation of 0.13 hectares indicating that farmers were still operating on a small scale. This could be attributed to small land holdings owned by farmers.

Results showed that the average land size owned per household was 2.83 hectares with a minimum of 0.04 hectares (Table 2) which is very small for a household that depends on agriculture. This limits expansion of area under cultivation for any particular enterprise and more so for perennial crops such as apples. In addition, small land holdings do not support sustainable production systems due to land degradation. As a result production levels reduce and hence affects expected returns.

Whereas a few farmers studied beyond secondary level, others did not have any formal education. The majority (92.6 percent) of farmers attended school; although many did not complete primary school, at least they had some primary education (Figure 1). Education affects many aspects of life including adoption and management of agricultural technologies (UBOS, 2006). Farmers with very low levels of education are difficult to train for specific operations that require skilled labour and consequently, production may remain low.

Figure 1: Educational attainment of apple farmers in Kabale



The average household size for apple growers was 7 persons, which is slightly higher than the national average of 5.1 persons in rural areas (UBOS, 2006). In the sampled households, males were more than females with an average of 4 and 3 persons, respectively. Since most farmers used family labour, it means that small households were generally more labour constrained than large households. However, it was observed that majority (55 percent) of the household members were below 20 years and mainly students implying that they offered limited farm labour.

The major source of household income for apple farmers was agriculture similar to other rural households in the country (UBOS, 2006). Table 3 shows the major crops from which apple farmers derived income. They included potatoes, sorghum, beans, vegetables, sweet potatoes and fruits whereas livestock was mainly goats and cattle benefiting only 29.4 percent of the farmers. Trees and Artemisia were also reported as sources of income in addition to non agricultural enterprises such as shops, hand crafts and wage employment for a very small group of about 29.9 percent.

Table 3: Major enterprises from which households earn income

Enterprise	Average income ('000 Ug. Shs) per household per annum
Potatoes	723.9
Sorghum	656.3
Apples	610.8
Artemisia	550.0
Other fruits	507.9
Vegetables	439.2
Beans	364.7
Trees	306.0
Sweet potatoes	170.3
Non agricultural enterprises	160.9
Cattle	1,008.2
Goats	216.0
Other livestock	892.9

Source: Primary data

The mean annual household income was about Ug.Shs. 2.83 million (US$ 1,814.1[1]) which was slightly more than the national annual household income of Ug. Shs 2.05 million (UBOS, 2006). The crop that raised the highest income was potato with an average of Ug. Shs. 723 thousand followed by sorghum, Ug. Shs. 656 thousand per annum. Non agricultural enterprises generated the highest average income, but only 29.9 percent of apple farmers were involved. This was attributed to farmers' inadequate skills in non agricultural enterprises due to low level of education of a majority of farmers. As such they have a comparative advantage in agriculture where low skills are required. It was noted that apple farmers derived their livelihoods mainly from annual food crops which explained low income since most of the produce was also consumed by the household. Apple production in particular ranked third high income generating crop, contributing 28.9 percent to household income, an indication that it is a potential cash crop for the people of Kabale.

4.2 Investment analysis in apple production

4.2.1 Estimates of costs and returns

The cost of production of apples varied widely from Ug. Shs 86.4 thousands to Ug. Shs 5.2 million per hectare depending on density of the orchard, its location and management practices. The greater the density of trees, the more labour and materials required hence the higher the costs involved. Labour services in different sub counties were offered at different wage rates which caused a difference in labour costs. The average annual expenses for apple production per hectare are displayed in Table 4.

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[1] Exchange rate: US $ 1 to Ug. Shs. 1,560

The overall annual total cost of production according to farmers' estimates was Ug. Shs 1.9 million. This was close to 2 million shillings spent annually per hectare at the Karengyere Research Institute orchard with about 800 apple trees.

Table 4: Production costs of apples per hectare per year

Costs	Quantities	Unit cost (Ug. Shs.)	Total costs ('000 Ug. Shs)	Percentage of total cost
Variable costs				
Labour (person days)	459	1,739	798.0	41.8
Pegs (bundles)	4	500	20.0	1.0
Pesticides (Dithane and Ridomil) kgs			96.9	5.1
Ropes (roles)	12	2,500	30.0	1.6
Organic fertilizer (tonnes)	17	30,000	523.9	27.5
Total variable costs			**1,404.0**	
Fixed costs				
Secateurs (depreciation)	4	4,000	16.0	0.8
Spray pump (depreciation)	2	40,000	80.0	4.2
Hoes	6	1,000	6.0	0.3
Land rent (Shs per ha /year)	1	400,190	400.2	21.0
Total fixed costs			**502.2**	
Total costs			**1,906.2**	

Labour costs were the highest accounting for 41.8 percent of the total annual production costs followed by organic fertilizer and land rent which accounted for 27.4 and 20.9 percent, respectively. As earlier found by Chemning *et al.* (2005), labour and fertilizer requirements are high in apple production and thus raise the total cost of production. Similar results were reported by Marchesini *et al.* (2005) in China where labour costs in apple production were the highest accounting for 34 percent of total production costs. Likewise, Glover *et al.* (2005) found that labour cost was the largest component of total production costs in organic apple production in Washington State, United States.

Further analysis of annual production costs and returns showed that apple production was profitable with average net returns of Ug. Shs 4.4 million per annum (Table 5).

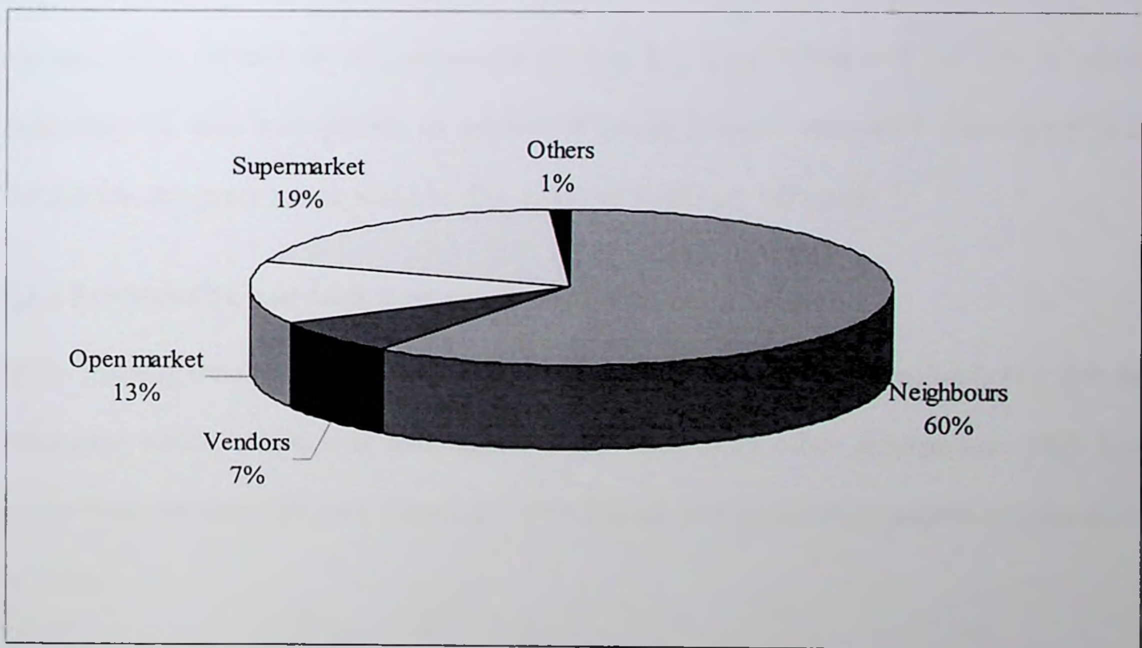
Table 5: Estimated average annual returns per hectare of apples

Variables	Sample farmers	Research institute (Karengyere Orchard)	t-test
Yield estimates (tonnes)	2.1	6.0	-16.5
Price per tonne (million Ug. shs.)	3.0	3.0	
Gross returns (million Ug. Shs.)	6.3	18.0	-16.5
Total cost (million Ug. Shs.)	1.9	2.0	-14.8
Net returns (million Ug. Shs.)	4.4	16.0	-15.3

Statistical analysis using a t-test showed that the mean yield at the research institute orchard was significantly ($P \leq 1$) higher than the mean yield obtained by farmers. The significant difference in yields also translates into a significant difference in net returns. The wide variation in yield obtained at the Karengyere orchard and by farmers was attributed to the difference in age of trees and management practices. The orchard at Karengyere had reached peak production stage of 6 years while most farmers' trees had not. However, the yields in both cases were low compared to the temperate region where yields of 17 to 25 tonnes per hectare have been reported (Marchesini *et al.*, 2005; Harry *et al.*, 2005). This could be explained by the difference in climatic conditions and variety variations.

Returns also varied depending on fruit quality and the marketing channel used by the grower. For instance, growers who sold apples using direct market alternatives such as neighbors and open markets received higher returns than those who used wholesale marketing channels such as supermarkets. Findings from this study indicate that neighbors offered the biggest market as depicted in Figure 2.

Figure 2: Marketing channels used by apple farmers



The challenge is that selling direct to neighbours might be feasible to only small scale growers. In contrast, wholesale markets might be appropriate for large scale growers and the small scale growers who cannot perform direct marketing services themselves. A similar finding was reported by Parker *et al.* (1998) in a study to investigate economics of high density apple orchard management in North Carolina, United States of America.

Whereas 87.5 percent of sampled farmers indicated easy access to the market, lack of organized market was cited as a limiting factor to high returns from apples. Save one percent who indicated selling fruits in Kampala supermarkets, the other farmers sold them locally. The average distance to the urban market for the majority of farmers was 11.4 km, but some traveled as far as 47 km to the urban market in Kabale town. The average price offered by the supermarket was Ug. Shs 3,000 – 4,000 per kilogram depending on size and quality of apples. Whereas farmers who sold fruits directly to consumers, the price range was Ug. Shs 3,000 to 5,000 per kilogram.

4.2.2 Profitability and cash flow projections of apple production

When judging the profitability of an enterprise, it is important to determine how much the enterprise yields, when it is generated and the returns in other enterprises. Cash flow projections for a one hectare of orchard for a fifteen year production period are presented in Table 6.

Table 6: Net present value analysis for apple production: Assuming average yields and premium price (Ug. Shs 4000 / kg)

Year	Yield (tonnes / ha)	Gross income (million Ug. Shs)	Annual costs ('000' Ug. Shs) Labour	Fixed costs	Variable costs	Total costs (million Ug. shs)	Net cash flow (million Ug. shs)	Cumulative cash flow (million Ug. shs)
0	0	0	135.0	3,280.0	0	3.4	-3.4	-3.4
1	0	0	329.0	1,361.0	192.0	1.8	-1.0	-4.4
2	0	0	227.0	503.5	342.0	1.1	-1.1	-5.5
3	0.3	1.3	271.0	541.9	532.0	1.3	-0.1	-5.6
4	1.8	7.2	307.0	562.1	237.0	1.1	6.1	0.5
5	6.0	24.0	520.0	583.2	894.0	2.0	22.0	22.5
6	21.6	86.4	543.0	605.0	926.0	2.1	84.3	106.8
7	21.6	90.9	567.0	627.6	961.2	2.2	88.8	195.6
8	21.6	95.7	592.0	651.1	997.1	2.2	93.5	289.1
9	21.6	100.7	618.2	675.4	1,034.4	2.3	98.4	387.4
10	21.6	106.0	645.5	700.7	1,073.1	2.4	103.6	491.0
11	21.6	111.5	674.1	726.9	1,132.1	2.5	109.0	600.0
12	21.6	117.4	703.9	754.1	1,154.4	2.6	114.8	714.8
13	21.6	123.5	735.0	782.3	1,198.0	2.7	120.8	835.6
14	21.6	130.0	767.5	811.5	1,242.8	2.8	127.2	962.8
15	21.6	136.8	801.4	841.9	1,289.3	2.9	133.9	1,096.7
Total	**224.1**	**1,131.4**	**8,436.6**	**14,008.0**	**13,187.5**	**35.6**		
NPV at 28 percent discount factor							**95.8**	
NPV at 6 percent discount factor							**591.5**	

Results revealed that an apple orchard was worth Ug. Shs. 95.8 and 591.5 million per hectare at 28 and 6 percent discount factors, respectively. Results also indicate that farmers who establish a new apple orchard will experience net cash outflows for the first three years and will break even in year five. From the cumulative cash flows, it is shown that the minimum initial investment was about Ug. Shs. 5.6 million per hectare before any returns were realized. This was the most profitable scenario with high returns and relatively short payback period of about five years.

Results of sensitivity analysis assuming a 25 percent reduction in price of apple fruits are summarized in Table 7. It showed a Net Present Value of Ug. Shs 69.5 and 437.8 million at 28 and 6 percent, respectively and a net cash outflow of four years hence breaking even in year five. Although some fruits were harvested in the third and fourth year, the returns were not enough to cover total expenses. The pay back period in this case was five years which is similar to the payback period in the first scenario. The NPVs were Ug. Shs 26.3 and Ug. Shs 153.7 million lower than the average yield and high returns scenario. This means that output prices contribute significantly to net returns.

Table 7: Sensitivity analysis for apple production: Assuming a 25 percent reduction on premium price of Apples

			Annual costs (thousands Ug. Shs)					
Year	Yield (tonnes / ha)	Gross income (million Ug. Shs)	Labour	Fixed costs	Variable costs	Total costs (million Ug.shs)	Net cash flow (million Ug.shs)	Cumulative cash flow (million Ug.shs)
0	0	0	135.0	3,280.0	0	3.4	-3.4	-3.4
1	0	0	329.0	1,361.0	192.0	1.8	-1.0	-4.4
2	0	0	227.0	503.5	342.0	1.1	-1.1	-5.5
3	0.3	1.0	271.0	541.9	532.0	1.3	-0.4	-5.9
4	1.8	5.4	307.0	562.1	237.0	1.1	4.3	-1.6
5	6.0	18.0	520.0	583.2	894.0	2.0	16.0	14.4
6	21.6	64.8	543.0	605.0	926.0	2.1	62.7	77.1
7	21.6	68.2	567.0	627.6	961.2	2.2	66.0	143.2
8	21.6	71.8	592.0	651.1	997.1	2.2	69.5	212.7
9	21.6	75.5	618.2	675.4	1,035.0	2.3	73.2	285.9
10	21.6	79.5	645.5	700.7	1,073.1	2.4	77.1	362.9
11	21.6	83.7	674.1	726.9	1,113.2	2.5	81.1	444.1
12	21.6	88.0	703.9	754.1	1,154.8	2.6	85.4	529.5
13	21.6	92.7	735.0	782.3	1,198.0	2.7	89.9	619.4
14	21.6	97.5	767.5	811.5	1,242.8	2.8	94.7	714.1
15	21.6	102.6	801.4	841.9	1,289.3	2.9	99.7	813.8
Total	**224.1**	**848.7**	**8,436.6**	**14,008.0**	**13,187.5**	**35.6**		
NPV at 28 percent discount factor							**69.5**	
NPV at 6 percent discount factor							**437.8**	

Table 8 presents the third scenario assuming a 10 percent reduction in yields. It shows a Net Present Value of Ug. Shs 64.2 and 407.1 million at 28 and 6 percent discount factors, respectively, and was noted to be the least profitable. Analysis showed a net cash out flow for the first six years and a break even point in year seven. The NPVs were Ug. Shs. 31.6 and Ug. Shs. 184.4 million lower than in case of average yields and high returns. The large difference signifies the importance of maintaining average yield for higher returns.

Table 8: Sensitivity analysis for apple production: Assuming a 10 percent drop in yields and premium price (Ug. Shs 4000/ kg)

			Annual costs (thousands Ug. Shs)					
Year	Yield (tonnes / ha)	Gross income (million Ug. Shs)	Labour	Fixed costs	Variable costs	Total costs (million Ug.shs)	Net cash flow (million Ug.shs)	Cumulative cash flow (million Ug.shs)
0	0	0	135.0	3,280.0	0	3.4	-3.4	-3.4
1	0	0	329.0	1,361.0	192.0	1.8	-1.0	-4.4
2	0	0	227.0	503.5	342.0	1.1	-1.1	-5.5
3	0.2	0.9	271.0	541.9	532.0	1.3	-1.3	-6.9
4	1.3	5.0	307.0	562.1	237.0	1.1	-1.1	-7.9
5	4.2	16.8	520.0	583.2	894.0	2.0	-1.9	-9.9
6	15.1	60.5	543.0	605.0	926.0	2.1	-2.1	-11.9
7	15.1	63.6	567.0	627.6	961.2	2.2	61.5	49.5
8	15.1	67.0	592.0	651.1	997.1	2.2	64.7	114.3
9	15.1	70.5	618.2	675.4	1,034.4	2.3	68.2	182.4
10	15.1	74.2	645.5	700.7	1,073.1	2.4	71.8	254.2
11	15.1	78.1	674.1	726.9	1,113.2	2.5	75.6	329.8
12	15.1	82.2	703.9	754.1	1.154.8	2.6	79.6	409.3
13	15.1	86.5	734.9	782.3	1,198.0	2.7	83.8	493.1
14	15.1	91.0	767.5	811.5	1,242.8	2.8	88.2	581.3
15	15.1	95.8	801.4	841.9	1,289.3	2.9	92.8	674.1
Total	**156.7**	**1,268.5**	**8,436.6**	**14,008.0**	**13,187.5**	**35.6**		
NPV at 28 percent discount factor							**64.2**	
NPV at 6 percent discount factor							**407.1**	

Results indicate a range of four to six years to break even. This is important for apple growers who may wish to secure loans to cover the period in which the enterprise operates in a cash deficit position. It was noted that four to six years is a considerably long time thus making apple production a long term high investment enterprise. Besides, not many rural farmers can afford the magnitude of investment because they are resource constrained and their average annual household income is low. The implication is that apple production could remain a small scale enterprise for a majority of farmers.

Nevertheless, this analysis was based on apple production as a mono crop contrary to farmers' situation. Since different crops have different production costs and returns, it means that the NPV and pay back period could be different if an intercrop is incorporated in the NPV equation. Furthermore, it was observed that the highest cost incurred was during establishment and this was mainly the cost of seedlings. Implying that with initial support, many farmers could venture into the enterprise.

This analysis shows positive NPVs for the three scenarios implying that apple production is profitable under the different price and yield assumptions. Similar results were reported by Abdul and Afzal (2005) in their study about returns on apple orchards in Pakistan. They found out that apple intercrops with wheat/tobacco and tomatoes all provided good cash flows at 12 percent discount factor. Relatedly, the study by Parker *et al.* (1998) indicated positive NPVs for apple production under different management systems in North Calorina. On the contrary, Abadi *et al.* (2006) reported negative NPVs in Australia agro forestry project a case that was attributed to high establishment costs and long maturity period of trees.

4.3 Socio-economic factors affecting apple production

Estimates of a Cobb-Douglas type production function using Weighted Least Squares techniques are presented in Table 9.

Table 9: Estimates of the apple production function

Explanatory variables	Elasticities	Robust standard errors	t-values	p –values
Constant	3.266	0.712	4.58	0.000
Land area (ha)	0.014	0.089	0.16	0.875
Labour (person days)	0.287	0.142	2.01	0.046
No. of apple trees	0.025	0.145	0.17	0.863
Organic fertilizer (tonnes)	0.774	0.116	6.37	0.000
Farmers' experience (years)	0.461	0.185	2.49	0.014
Education of the farmer	0.053	0.126	0.43	0.671
Number of extension visits	0.132	0.129	1.03	0.307
Adj R-squared	63.62 %			
Sum of weighted deviations	3.049e+05			
Sample size (n)	136			

Organic fertilizer, experience and labour had the highest input elasticities in that order. It follows that they are the critical variables in apple production. The model was a good fit since it could explain 63.6 percent of variation in apple output. Results revealed that an increase of one percent in person days spent on apple activities would increase output by 0.28 percent. The significance of labour at 5 percent level means that labour is a major factor in apple production. However, elasticity of 0.28 indicates that labour was inelastic implying that it would require a significant increase in labour to impact on apple output. The explanation is that apple production is labour intensive as shown by the average labour required per hectare of 459 person days per year and requires all the recommended practices (pruning, defoliation, training, spraying, weeding and thinning) to be timely carried out to raise substantial output.

In a related study, Mon and Holland (2005) affirmed that organic apple production was more labour intensive than conventional production. High elasticities of labour have been reported in production of other crops such as; groundnut production in Malawi (Edriss and Mangisoni, 2004) where average labour required per hectare was 60 percent of the total labour required for all farm activities.

The coefficient of organic fertilizer applied in apple fields was 0.77 and was significant at one percent level. The implication is that an increase in organic fertilizer applied by one percent would cause a 0.8 percent increase in apple output. Elasticity of 0.8 is less inelastic implying that increasing amount of organic fertilizer applied in apples would increase output substantially. Mon and Holland (2005) reported similar find Washington State where organic apple production produced higher returns to l capital.

Farmers' experience in apples was also significant at 5 percent level with a coeffi about 0.46. Its coefficient shows that it is inelastic implying that apple yields incre linearly in farmers experience. Nevertheless, experience in apple production is factor, as some of the important operations such as training, defoliation, prun spraying require skill which is accumulated over time. In addition these resul expected for this study because experience equally implies age of trees and o expected to increase with tree maturity up to peak production at six to seven years.

Results further indicated that, an increase of one percent in land under apple pro increased apple output by 0.01 percent but it was not significant. Allocating a big land to apple production did not translate into significantly high production. acreage is associated with high labour input and yet labour was a constraint farmers. As such specific operations were not timely carried out thus negatively a output. In addition, the spacing of trees which determines the density of the varied among farmers. Farmers with large acreage tended to use relatively larg between trees compared to those with small land. Another possibility could be th orchards are associated with technical inefficiency which is in agreement with studies such as Lau and Yotopolus (1971), Kumbhakar (1994) who found out th of less than ten acres were relatively more economically efficient.

Similarly, number of apple trees, education level of the farmer and number of extension visits were not significant. In case of apple trees it was expected because the trees were of different ages as depicted by the variation in farmers' experience. Most of the trees had not reached peak production and therefore their number did not cause a significant variation on output

Formal education of the farmer was not statistically significant as per results of this study. A coefficient of 0.1 percent is highly inelastic implying that formal education had no influence on output in apple production. This was anticipated since both the educated and non educated farmers were trained in apple production technologies. In agreement with Walingo (2006), agricultural technologies require special training on the project. Otherwise, the level of general education alone cannot predict the attainment of expected output though it enhances the earnings potential of individuals.

The coefficient of number of extension visits was 0.13 which is highly inelastic. This was attributed to the system used by NAADS service providers, where farmers are trained in groups other than individual visits. In this respect, it was recognized that number of trainings attended by the farmer would have yielded more meaningful results. Nonetheless, the importance of visiting individual orchards should not be minimized because individual inefficiency and diseases which affect production are easily identified.

It is evident from Table 9, that production elasticities for all inputs were below unity, implying that increasing the respective inputs by one percent would increase apple output by less than one percent. Conversely, the return to scale parameter was 1.71 indicating increasing returns to scale. Farmers were still operating into irrational stage 1 region of the production function where the inputs employed were not efficiently utilized. The finding of increasing returns to scale in apple production is not isolated. Similar findings have been reported by other scholars such as Kalawoke and Ojo (2007) in food crops, Paris and Caputo (2004), Gowa *et al.* (2001) in clonal coffee and Lwasa (1994) in dairy production.

4.3.1 Marginal productivities and value products of major inputs used in apple production

The marginal productivities and their respective value marginal products (VMPs) are presented in Table 10. The input factor with the highest marginal productivity was organic fertilizer, followed by labour and land. Results further indicate that the marginal value products of labour was Ug. Shs 1,544 which was below the average labour wage rate of Ug. Shs. 1,739. It proposes that it was not cost-effective to add more labour in terms of person days in apple production. This contradicts the significance of labour depicted by the production function. It could be attributed to a higher wages relative to apple fruit prices. In addition most farmers' trees had not attained optimum production. In a related study, Bagamba *et al.* (2007) found out that labour in bananas in low altitude had low marginal returns, which they attributed to higher wages relative to prices.

Similarly, the marginal value product for land was very low (Ug. Shs.55.3) compared to the unit cost of land (Ug.Shs 404,190), an indication that it was not worth increasing land under apple production. This was also due to the fact that land was inefficiently utilized because the apple trees had not reached peak production. It could also be attributed to overestimation of land under apple production since the plots were not physically measured. For similar reason, it was not cost effective to add more organic fertilizer into the production system since its marginal value product was also below its marginal input cost.

Table 10: Estimates of marginal productivities and marginal value products of major inputs in apple production

Variable	Geometric mean	Elasticities	Unit cost (Ug. Shs)	MPP	VMP (Ug.Shs)
Labour	2.23	0.287	1,739.0	0.514	1,544.59
Land	3.03	0.014	404,190.1	0.018	55.31
Organic fertilizer	1.12	0.774	32,794.1	2.758	8,275.65
Output	3.99				

4.4 The cost structure for apple production

Results of the estimated cost function showed that yield and labour cost elasticities were significant at one percent level while cost of land was significant at 5 percent level (Table 11). Coefficient signs were all positive implying that total cost in apple production varied positively with output and factor prices. This is in conformity with cost function properties of non-negativity and non-decreasing in factor prices.

Table 11: Estimates of cost elasticities in apple production

Explanatory variables	Cost elasticities	Robust standard errors	t-values	p –values
Constant	3.634	2.197	1.16	0.101
Yield (kgs)	0.151	0.048	3.16	0.002
Cost of labour per person day	0.890	0.273	3.26	0.001
Cost of land per hectare	0.169	0.076	2.20	0.030
Cost of organic fertilizer per tonne	0.003	0.052	0.07	0.946

Cost of labour had the highest coefficient of 0.889 an indication that total costs in apple production were grossly affected by labour costs. This is consistent with the results on cost analysis in this study and further reinforced by the significance of labour in the production function. It follows, therefore, that total costs could be minimized considerably by reducing the cost of labour.

The cost of land also significantly affected total cost of apple production though it was inelastic. This means that production costs increase less than linearly in land prices. The significant impact of land costs on total production costs was expected because land in Kabale is highly valued and continues to appreciate. The economic implication is that farmers with large orchards were incurring high expenses in terms of opportunity cost. As also noted by Parikh *et al.* (1995), small orchards would be more efficient than big farms for apple growers. Farmers could also explore high density orchards on small acreage as an option to reduce total costs.

The cost of organic fertilizer did not significantly affect total production costs. This is because majority of farmers used home made organic fertilizer hence did not incur a high cost. It was also noted that farmers were ignorant of how much fertilizer to apply at a particular stage consequently less of organic fertilizer was applied on some farms. A similar situation was observed by Parikh *et al.* (1995) in Pakistan where farmers were using less manure than cost minimizing quantities. Since organic fertilizer significantly increases production at low costs, it becomes a major factor that could be maximally utilized by apple growers.

Furthermore, the cost function estimates showed that the total cost elasticity with respect to output was less than one hence illustrating economies of scale in apple production. This was anticipated because yields as well as costs are expected to increase each successive year as the trees mature to peak production. Thus, economies of scale in this case was due to diffusion of fixed costs over increasing units of output. Economies of scale have been reported in production of other crops such as sorghum in Eastern Uganda (Ainembabazi, 2004).

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMENDATIONS

5.1 Summary

Apple production in Uganda started in the highlands of Kabale district and has been promoted in neighbouring districts. Preliminary studies indicate apples as a potential cash crop in the southwestern highlands. The objectives of this study were; to determine financial viability of apple production based on estimated costs and returns per hectare; assess social economic factors affecting apple production and finally determine cost elasticities. Primary data was analyzed using Microsoft Excel spread sheet to compute NPV, and then SPSS and STATA were used to generate descriptive statistics and estimation of production and cost functions respectively.

The data used were obtained from two sources: Data used to analyze financial viability was got from Karengyere orchard, a research project for Kachwekano Zonal Agricultural Research and Development Institute under National Agricultural Research organization (NARO). The rest of the analysis was based on primary data obtained from 136 apple growers in Kabale district through a survey. Primary data was collected using a pre-tested questionnaire administered in form of an interview between March and June, 2007.

Sensitivity analysis with respect to changes in price and yields exhibited positive NPVs implying that apple production is a viable enterprise. Estimates of a Cobb-Douglas type of production function revealed that labour, organic fertilizer and experience (age of apple trees) in apple production significantly affected output, while land, education of the farmer and number of apple trees were not significant. Organic fertilizer had the highest marginal productivity followed by labour and land.

A Cobb- Douglas cost function was also estimated to determine cost elasticities. The findings indicate that unlike organic fertilizer, cost of land, labour and output significantly affected total production costs. The cost elasticity with respect to output was below one hence economies of scale was associated with apple production.

5.2 Conclusions

Results from this study indicate that apple production in southwestern Uganda is a profitable enterprise as depicted by positive NPVs. Therefore, the hypothesis that apple production is a profitable enterprise is accepted. However, a pay back period of five to seven years indicates that it is a long term investment. It is also established that apple farmers are yet to achieve maximum output since the average yield of apples from the research institute orchard was significantly higher than that of farmers' orchards. Considering the mean acreage under apples of 0.16 hectares also leads to a conclusion that a majority of farmers were small scale.

From the analysis of production costs, labour costs account for the biggest percentage of total production costs. It requires 459 person days per hectare annually for all the different operations. Thus, it is concluded that apple production is a labour intensive enterprise. This study also establishes that there was no organized marketing system for apples which affects returns from the enterprise.

The major limiting factors in apple production were labour, organic fertilizer and experience of the farmer whereas land did not significantly affect output as stated in the hypothesis. Thus, the hypothesis that land was the most critical factor was rejected. It follows that organic fertilizer and labour were the critical variables to be exploited for future increase of apple production. Results further confirmed that apple production was still in its infancy as depicted by increasing returns to scale and farmers' mean experience of five years.

Marginal value productivities of land and labour were lower than their marginal factor costs while that of organic fertilizer was higher than its marginal cost. It was therefore concluded that it was not worth increasing labour and land, whereas additional organic fertilizer could be used to increase output. Furthermore, the output cost elasticity of 0.151 implied that total production costs increased by less than one percent hence economies of scale in apple production. Thus the hypothesis that economies of scale exist in apple production in southwestern Uganda is accepted.

5.3 Recommendations

The government of Uganda through the ministry of agriculture should encourage and support more farmers to grow apples as a cash crop since it is a viable enterprise. However, majority of farmers acknowledged lack of relevant information on management of apples. Thus, agricultural researchers should make an effort to avail a complete package of relevant information that can be easily accessed by interested farmers. In connection to this, sufficient extension services is a critical need if apple production project is to be as high yielding as predicted.

The study established that apple production requires long term high capital investment as depicted by the pay back period of four to seven years, a fact that was also advanced by farmers as a challenge to increased production. In this regard, it would be appropriate for the government of Uganda to establish agricultural credit schemes that can support farmers with long term soft loans. Such loans can be channeled through specific banks such as post bank where government has authority to dictate on interest rates or by strengthening village banks with more capital. Furthermore, when apple production increases as anticipated, market prices will be expected to reduce with no reduction in production costs. Consequently, farmers will face competition with imported apples on the market. It is therefore a responsibility of the policy makers to introduce favourable policies to enable apple growers compete favourably in the market.

The coefficient of labour was inelastic though significant implying that there would be very little increase in output by increasing labour. Therefore efficient utilization of labour through labour saving technologies should be the option particularly in weeding and defoliation. This will increase returns from apples through increased output and significant reduction of production costs.

Finally, based on the findings of this study, large orchards were associated with very high costs and management related constraints. Therefore, apple growers should examine the economic advantage of improving small orchard management as a means to meet any increased demands for apples other than increasing on acreage. In addition, high levels of fruit quality will be necessary to capture premium market prices in the region. Furthermore, it is important that apple growers form associations through which they can improve the selling prices and hence increase apple returns. Most important, farmers must be encouraged to be patient with the crop since it requires experience to raise optimal output.

5.4 Recommendations for further studies

It is important that the demand for apples in Uganda is determined. The low investment in terms of acreage could be due to the failure of farmers to observe a significant demand for apple fruits. It was observed that farmers intercrop apples with different crops, and different crops are associated with different costs and returns. Therefore, it is recommended that a study on financial viability of apples as an intercrop be carried out to establish the profitability under farmers' situation. There is also need to direct research efforts towards generation of labour saving technologies so as to reduce the time spent on apple activities. This study further recommends research on optimization of resources to determine the most profitable resource combination in apple production. As to what extent resources are utilized in apple production both in terms of allocative and technical efficiency also needs to be answered. It was particularly noted that most farmers were ignorant of how much organic fertilizer to apply at what stage and this remains a challenge to research.

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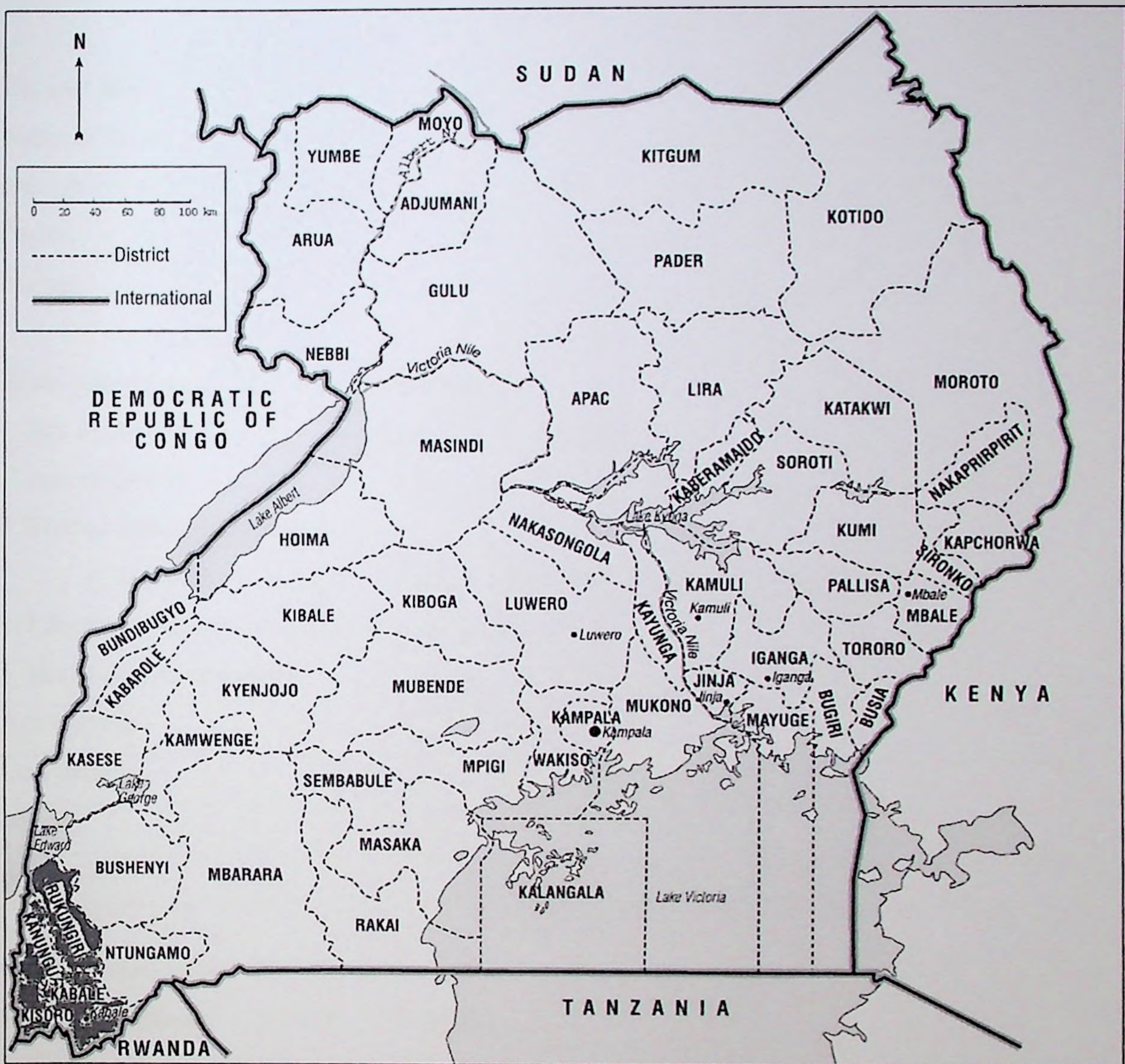
Appendix i

Figure 3: Map of Uganda showing the study area



APPENDIX ii

ECONOMIC ANALYSIS OF APPLE PRODUCTION

IN SOUTHWESTERN UGANDA

Survey Questionnaire for farmers

Farmer identification

Name of farmer...

Sub county...

Parish...

Village..

Socio –economic and demographic data

1. Sex of farmer 1. Male 2. Female

2. Age of farmer...(Years)

3. Marital status of a farmer

1. Married 2. Single 3. Widow /widower 4.Divorced /separated

4. Educational level (years spent in school)..Years

5. House hold composition

Age (years)	Male	Female	Total
Less than 10			
10 – 20			
Above 20			

6. Who makes major farming decisions?

1. Husband 2. Wife 3. Family

7. What are your major sources of income?

	Source	Income /season / year
1		
2		
3		
4		

Land distribution

8. How much land do you own?...acres

9. How did you acquire the land?

1. Inherited 2. Purchased 3. Leasehold / Rented 4. Borrowed

10. Does the status affect major decisions on farmland use? 1. Yes 2. No

11. If yes in what way?...

....

....

....

12. If you were to rent one acre, how much could you rent it out for one year?........Ug.shs

13. How much land was under cultivation last year?..acres

14. How much land is under apple growing?..acres

15. How many apple trees do you have ....

16. Would you wish to expand? 1. Yes 2. No

17.If yes why have you not expanded?...

....

18. If no, why?...

....

19. Where is the site of the apples? 1. Uphill 2. Low land 3. 1 and 2

20. What is the Spacing of your apples...............

21. What is the common crop intercropped with apples?..................................

22. How many years have you spent in apple production?..

23. Which varieties do you have?...

Labour and other input costs

24. Labour inputs per hectare in apple production

Activity	No. of workers	No. of days	Person days	Cost/day/head	TC
Land preparation					
Seed bed preparation					
Planting					
Weeding					
Applying organic manure					
Applying chemical fertilizer					
Training					
Pruning					
Defoliation					
Applying pesticides					
Fruit thinning					
Harvesting and transporting home					
Marketing costs (transport, mkt dues, others (specify)					

25. Physical inputs used in apple production in a year

Type	Source	Frequency(no. of times in a season)	Quantity used (kgs / litres / No)	Unit cost (Ug.shs)	Total value (Ug.shs.)
Seedlings					
Manure					
Inorganic fertilizers					
pesticides					
Others (specify					

26. Fixed input used in apple production

Type	No. of inputs	Year of purchase	Original cost	Expected life of the input	Total cost	Present value	
Ropes							
Pegs							
Shovels							
Spades							
Pangas							
Hand hoes							
Knapsack sprayer							
scissors							
Wheel barrows							
Others (specify)							

27. **Apple yields and marketing (last Year)**

No. of trees that have fruited	Amount produced (no/kgs)	Amt consumed at home	Amt given away	Amt wasted	Amt Sold	Unit cost (Ug. Shs.)	Total value (Ug. Shs)

28. To whom do you sell your apples? 1. Neighbours 2. Vendors 3. open market 4. Super market 5. Others (specify)

29. What is the distance to the market?...Km

30. How accessible is the market 1. Easily accessible 2. Not readily accessible

31. Agronomic practices

	Activity	**Frequency (in a year)**	**Time of the year**
1	Weeding		
2	pruning		
3	defoliation		
4	Fertilizer/manure application		
5	Pesticide application		
6	Harvesting		

Extension services and credit

32. What is the farmer's main source of capital for farming?
    1. Own savings
    2. Sale of produce
    3. Loans from neighbours
    4. loan from traders
    5. Loans from credit intermediaries
    6. Bank loans
    7. Others (specify)
33. Did you acquire a loan for apple production? 1. Yes 2. No
34. If yes how much?....................................(Ug.Shs.)
35. How much did you pay back last year?......................................(Ug. Shs.)
36. How accessible is the credit? 1. Readily accessible 2. Not readily accessible
37. What is the main source of extension messages?
    1. None
    2. Other farmers / neighbours
    3. Govt. extension agents
    4. NGO extension agents
    5. Radio / TV programmes
    6. Input traders
    7. Researchers
    8. Others (specify)
38. How many times did an extension officer visit you last season?..................................
39. How much did you pay for each visit?...Ug. Shs
40. Have you received any assistance from any organization? 1. Yes 2. No
41. If yes what assistance have you received and from which organization?

    1. Technical advice 2. Training 3. Inputs

    4. Marketing 5. Credit 6. Others (specify)

42. What are the major constraints / challenges in apple production and what solutions do you suggest?

	Constraints / Challenges	Suggested solutions
1.		
2.		
3.		
4.		
5.		
6.		
7.		
8.		
9.		

41. Farmers' perspective on apple production…………………………………………………………