A COMPARATIVE ANALYSIS OF MACHINE AND HAND PICKING HARVESTING METHOD IN TEA PRODUCTION, A CASE OF SOUTHDOWN ESTATE, CHIPINGE

BY

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A research project submitted in partial fulfilment of the requirements of a Bachelor of Science Honours degree in Agricultural Economics and Development

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CERTIFICATION OF DISSERTATION

The undersigned certify that they have read and recommended for submission to the department of Agricultural Economics and Development, in partial fulfilment of the requirements for the Bachelor of Science Honours Degree in Agricultural Economics and Development, a research project by Hluyo Beauty Nyasha entitled:

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Supervisor

Mrs T. Maparara

Signed...

Date………../………../………………….

DEDICATION

To my parents; my father Phillip and my mother Ronika and my two young sisters Kudzai and Tatenda.

ABSTRACT

For the past decades Southdown estate in Zimbabwe employed manual tea harvesting method, due to labour shortages and increase in labour costs tea harvesting became expensive. Although the estate adopted machine harvesting method in a quest to resolve imminent financial problems faced at Southdown the costs kept escalating. Therefore this study was undertaken to compare the two harvesting methods (hand harvesting method and machine harvesting method) in order to evaluate the costs and benefits for the two harvesting methods in tea production. In order to answer the first objective which was assessing the financial viability of machine versus hand picking in tea production a gross margin was used. The second objective was to compare costs and benefits of hand picking versus machine harvesting method and a cost and benefit analysis was conducted to attain the second objective.

The results revealed that machine harvesting method is more viable than hand picking because it yielded a higher gross margin of US $17639.36 as compared to hand harvesting method which yielded a gross margin of US $9534.34. The second objective was to compare the costs and benefits of machine and hand picking harvesting methods. NPV, IRR and BCR were used as decision criteria. NPV for machine harvesting method was US$28603.55 and US$21106.37 for hand harvesting method. IRR for machine harvesting method was 46% and for hand harvesting method was 34%. BCR for machine was 2.79 and for hand harvesting method was 2.19. Hence, the researcher concluded that machine harvesting is more viable.

A sensitivity analysis to changes in discount rate was conducted and the results show that NPV and BCR for both harvesting methods are viable even when discount rate is increased to 33% and 44%. IRR for both harvesting methods was not viable when discount rate was increased to 44%. From the results above it shows that machine harvesting method is more viable than hand harvesting method. Therefore the study recommends Southdown estate to employ mechanical harvesting method since it is more cost-effective than hand harvesting method.

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LIST OF ABBREVIATIONS AND ACRONYMS

NPV	Net Present Value
BCR	Benefit Cost Ratio
IRR	Internal Rate of Return
CBA	Cost and Benefit Analysis
GM	Gross Margin
TVC	Total Variable costs
TR	Total Revenue

CHAPTER ONE: INRODUCTION

1.1 Background of the study

Tea is an evergreen plant of the *theacia* family which originated from China in around 3000 BC (Kamau 2008). According to Ruan and Hardter (2001), tea consumption started in China and then spread to Japan, Korea and other different countries and today it is the second most common and healthiest beverage consumed on earth. Tea is a perennial crop which requires a minimum of four to five years to mature and start yielding green leaves. After maturity, tea develops into a bush which is believed to have a life of more than one hundred years (Barman, 2008). Like any other crops, the profitability of tea production both from an academic and empirical standpoint heavily depends on the level of costs and output relationships. Wijeratne (2003) asserts that harvesting policies and methods of tea have a profound influence on the sustainability of tea plantations due to their impact on cost of production and this is critical in developing countries.

In general, tea harvesting (also referred to as plucking) is an operation in which tender shoots are picked and it is usually done in two ways: manually and mechanically. The choice for any of these harvesting methods mostly centres on the level of costs associated with each method. The latter harvesting method started in Argentina and then spread to African countries like Malawi, South Africa and Zimbabwe respectively. In Malawi machines were adopted as a form of harvesting tea back in 1989 while in Zimbabwe machines were adopted in 1991. Currently in Zimbabwe, machines are used in all tea estates of Tanganda, Eastern highlands and Southdown estates.

As indicated earlier, many African countries (including Zimbabwe) have adopted machines due to high costs that are associated with manual harvesting. According to Wijeratne (2003), tea harvesting is an expensive operation in tea production and its costs account for a greater percentage of the total cost of production although, this percentage varies from region to region and from estate to estate depending on their plucking policies. In particular, a report by Tea Research Foundation (2000) confirms that tea harvesting usually accounts for about 35 percent of the cost of production in Zimbabwe. In addition to that, it accounts for 30-40% of the field costs and contributes to about 70% of the total labour force deployed on an estate. This high proportion is a result of the involvement of labour for manual plucking which is about 70 percent of the labour force employed on an estate. Hence it is considered to be the most labour intensive field operation in tea cultivation. Under average field conditions in Zimbabwe, the labour requirement for manual harvesting is about 10-12 workers per ha, which can be considerably reduced by mechanical harvesting.

Tea quality on the other hand has been argued to depend on the harvesting method (Wilkie, 1993). These methods fall into two categories which are manual plucking and machine plucking. Most farmers use manual harvesting whereby the pluckers would use their hands to pluck tea. Tea leaves are harvested by hand without causing mechanical injury and manufactured under optimal conditions in order to maintain quality (Nyasulu, 2006). Due to the sharp rise in the labour costs and shortage of manpower, along with the ever-increasing cost of production, the tea industries in Zimbabwe have become non-profitable (Ravichandran, 1997). Hand plucking became more expensive than machine plucking due to high cost of production caused by increase in labour costs therefore tea industry become less viable. It has been observed that due to labour shortage, low efficiency associated with manual plucking, increase in labour wages and additional manpower during peak season necessities mechanical plucking. However, tea attained using hand harvesting from continuous hand plucking field over a long period was found to be superior. Hand plucking is thought to be a better harvesting method. Tea harvested by machines produce low quality tea.

At Southdown Estate two harvesting methods are used which are hand and machines. Machine harvesting is done by a kawasaki machine and is operated by three people and on hand the pluckers use their hands where they pluck flush then the plucked flush are flung over the shoulder of the pickers into their baskets strapped at their backs. Hand plucking was most used at the estate but due to sharp rising in labour costs, shortage of man power along with the ever increasing cost of production the tea enterprise became less viable. Hand plucking became more expensive than machine harvesting method due to high cost of production caused by increase in labour costs therefore tea enterprise became less viable. Alternative-plucking methods had, to be used in order to keep the tea industry viable. The estate adopted machines to solve the problem.

There are still unsolved issues on which method to use between these two harvesting method which minimises labour costs in order to increase profits. Nyasulu (2009) and other researchers looked much into effects of mechanical harvesting method on quality and yield and observed that mechanical tea plucking is faster than hand picking but the quality of the end product and its value is very low. Little has been done on comparing costs of these harvesting methods as a result it remains unclear and there is no logically generated information on mechanical harvesting method. This study evaluates the two harvesting methods in order to determine the more viable method between hand plucking method and mechanical plucking method.

1.2 Problem Statement

Regardless of hand plucking being a prominent harvesting method used at Southdown estate, it is however subjected to high costs which resultantly affect the financial viability of tea production (Southdown Estate Annual Report, 2012). To curb for the increase in costs, machine harvesting method was adopted. However, surprisingly the estate is still experiencing an increase in costs of production which has in turn posed a lot of questions to whether the adoption of machine harvesting method was a better choice in trying to reduce the costs. Therefore the researcher seeks to confirm which method between the two approaches may be employed at the tea estate.

1.3 Research Objectives

The main objective of the study was to evaluate machine and hand harvesting methods in tea production.

The specific objectives are:

i. To assess the financial viability of machine versus hand harvesting methods in tea production.
ii. To compare the financial costs and benefits of machine versus hand harvesting methods in tea production.

1.4 Research questions

i. Which of the two machines or hand harvesting methods is financially viable in tea production?

ii. Are there any significant difference in the financial costs and benefits of machine versus hand picking methods in tea production?

1.5 Justification

Theoretically manual harvesting method is associated with high costs and high quality but from empirical perspective Southdown estate adopted machines with the aim to reduce costs and increase profits but up to date harvesting costs are increasing and there is no improvement on costs and profits are not increasing therefore there is need for further empirical analysis to compare the costs and benefits of hand and machine harvesting method**.**

Sustainability of tea industry depends on harvesting policies because they have great influence on the costs of production and quality of the end product. Therefore adoption of proper harvesting policies has become a vital component in tea cultivation, so it is important to evaluate the two harvesting methods which are hand harvesting and machine harvesting method in order to find out the efficient harvesting method that will enhance enterprise viability.

Literature on comparing costs and benefits of tea harvesting methods is limited since most researchers are focusing on the effects of harvesting methods on quality and yield of tea. Researchers like Burgess (2006) , Madamombe (2008), Nyasulu (2009), Saikia (2011) looked at the effects of harvesting methods on quality and yield and little have been done on comparing these harvesting costs, little is known on costs of these harvesting methods and the cheapest method so as to minimize costs in order to reduce harvesting costs hence increase profits. Maina (2009) assess viability of tea harvesting methods using net present value in Kenya, there is no related research that have been conducted in Zimbabwe. Therefore this study is going to assess viability of tea harvesting methods using gross margin analysis and cost and benefit analysis to compare costs and benefits of the two harvesting methods in Zimbabwe. Many authors have showed that machine harvesting is cheaper than hand theoretically hence practical exposure is limited, so there is need for a study to be conducted for better understanding.

This study is going to look at the costs and benefits and to determine whether machine harvesting method is financially viable so that tea growers would adopt a better method. Results of this study will provide tea investors in Zimbabwe especially Southdown Estate with the information of the more viable harvesting method, this will help the company to adopt the cheaper harvesting method and this will reduce harvesting costs.

1.6 Organisation the study

The study consists of five chapters. Chapter one gives introduction, problem statement, objectives of the study and justification. Chapter two covers definition of terms, theoretical literature, empirical literature, insights from literature and conclusion. Chapter three presents introduction, research design, conceptual framework, study area, analytical framework and conclusion. Chapter four contains presentation of results and discussion and conclusion. Chapter five covers summary, conclusion, recommendations and areas for further study

CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

This chapter reveals related theoretical and empirical literature on tea harvesting methods. It to reviews studies on tea harvesting methods and highlights views of researchers concerning tea harvesting methods. It looks at how other researchers did their researches and the methods they used to analyse data.

2.2 Definition of terms

Hand harvesting

Burgess (2006) defines hand harvesting as a method of plucking out the shoots with two or more unfurled leaves, including the soft dormant shoots above the level surface of the tea bush using human labour, (men and women). On the other hand, Wijeratne, (2003) defines hand harvesting as the removal of 2-3 shoots leaving the true leaf and in some cases leaving immature shoots to enhance the sink capacity of the bush. In this study hand harvesting method is a selective method of harvesting tea whereby pluckers will pluck two leaves and a bud.

Machine harvesting

Machine tea harvesting is a method that involves the plucking out of leaves from the tea bush by two or more people alongside the bush rows using hedge trimmer type reciprocating blades which cut the leaves which are then blown by automatic air streams driven by engines into collecting containers attached on the machine, (Williames, 2011).

Plucking

Kamau (2008) defines plucking as the harvesting process in tea, which involves nipping off of tender apical portions of shoots consisting of a terminal bud and two to three leaves above the plucking table. According to Njoloma (2012) plucking is a collection of individual shoots containing two leaves and a bud (2 +bud) or three leaves and a bud (3 +bud). Plucking is the periodic harvesting of the young shoots, normally a bud and two to three leaves, above the plucking table and is either done by hand or mechanically (Tennakoon, 2007). In this study plucking refers to the term used for harvesting of tender shoots normally two leaves and a bud.

2.3 Theoretical concepts

2.3.1 Origins of tea

Tea (*Camellia sinensis)* is an evergreen plant belongs to the theaceae or camellia family. It is grown in tropical, sub-tropical and temperate climates of the world. Tea was first discovered in China where it has been consumed for medicinal purposes since 3000 BC (Ferrara, 2009). By the end of the sixth century, the Chinese began to regard tea as a beverage and China was the first country to use tea as a drink (Paul, 2004). In India tea plant was discovered in North East Assam during the early eighteenth century. The tea crop has been introduced to other parts of the world with diverse climatic conditions from its native habitat ranging from a Mediterranean-type climate to hot humid tropical.

There are two main varieties of tea which are camellia sinensis var sinensis which has relatively large leaves and camellia sinsesis var assamic with small semi erect leaves. The assamica variety originated from the forests of Assam in north eastern India and sinensis tea originated from Sichuan province in South western China (Kamau, 2008). These areas are normally characterized by monsoon climate with high rainfall and high humidity during warm wet summers and cool dry winters. Due to hybridisation currently the cultivars which are commercially grown exhibit characteristics between assamica and sinensis (Mondal, 2004). The tea plant has been introduced into and become naturalised in many areas of the world and is currently found in many countries and the main producing countries are Bangladesh, China, India, Indonesia, Sri Lanka, Burundi, Kenya, Malawi, Rwanda and Zimbabwe (Weatherstone, 1992). Tea has become one of the powerful commodities of commercial value during the colonial period.

2.3.2 An overview of tea production in Zimbabwe

Tea was first planted in Zimbabwe when Grafton and Florence Phillips used seeds they obtained from Assam, India to establish a small tea plantation on New Years Gift Estate in Chipinge (Tea research foundation, 2009). The couple had been involved in growing tea in India from these seeds came the first commercially grown tea plantations in the country and the Tanganda tea company. Now the two main growing regions in the east of Zimbabwe are Honde valley and Chipinge where there are cold winters for the bush to grow throughout the year. The tea industry in Zimbabwe is dominated by four major producers namely, Tanganda Tea Company, ARDA Katiyo, Southdown Holdings and Aberfoyle. These giants have their own tea estates in the Eastern Highlands and also have factories that produce black tea from their leaf. The industry is therefore vertically integrated and hence heavily dependent on primary agricultural production. The tea industry specializes in black tea production and processing.

Tea industry is of considerable importance in the national economy of Zimbabwe in terms of income generation, earning foreign exchange, employment generation and contribution to the national exchequer. Tea production in Zimbabwe provides an economic resource for employment of the local people and the national economy. The tea industry in Zimbabwe is currently responsible for a total direct employment of 17 000, supporting up to 76000 people. Zimbabwe now exports over 15000 tones of tea per year. This makes up 1,3% of the total global tea production. Zimbabwe's tea production is made up of three types of growers, namely the grower cum maker, comprising of large scale estates, the large scale commercial grower, of which there are now twenty black commercial farmers in the district. The majority are small scale out growers responsible for up to 4% of Zimbabwe's total tea production.

When well-managed, the crop can remain in production for over 100 years although productivity gradually declines over time. This means that unlike annual cropping systems, tea plantations require long-term investment in activities that are influenced by political and socio-economic factors at various levels. For instance, fear of nationalization may induce estate plantation owners to discount long-term investment as risky and opt for short-term profit maximization strategies (Merlin, 2002). Furthermore a combination of rising production costs, stagnating/ downward trend in prices, and higher opportunity costs of capital may discourage transitions and long-term investment (Iqbal , 2006). Tea plantation industry is a combination of industry and agriculture (plantation is a large estate on which crops such as tea, coffee are grown). Production of leaf is an agricultural activity while its processing is an industrial activity. Most of the large estates process raw leaf in their own factories (Merlin, 2002).

In Zimbabwe tea is concentrated in the eastern parts and this area falls under natural region 1. This area experiences high rainfall of more than 1 000 mm per annum and most falls throughout the year. The annual mean temperatures range from a minimum of 9° C to 12° C to a maximum of 25° C to 28° C (Phipps and Goodier, 1962). Soil temperatures have also been suggested as an important variable for tea yield where shoot extension rates are reduced at soil temperatures (30 cm depth) of 16 °C and below (Carr and Stephens, 1992). Tea areas in Zimbabwe lie between 24^0 N- 27^0N latitude and 88^0 N -95^0 N longitudes.

Southdown estate is located in Chipinge district and is 41km east of Chipinge town along eastern border road Chipinge and is in natural region one. Southdown Estate is recognized internationally on the map of the tea industry. It plays a vital role in the Zimbabwean economy. It is the second biggest tea producing company in the agriculture sector of Zimbabwe. The estate has 597 hectors of tea and is engaged in growing and manufacturing of tea. It is also involved in the manufacturing and packaging of tea for domestic and for foreign market. The estate export tea to European countries like United Kingdom as well as in Africa. On average the estate produces 27340 kgs of green leaf of tea per day, 2734 kg of made tea per day. Tea plucking is the most expensive operation at the estate it contributes about 70% of labour on the estate therefore it is an important element in the cost of production. Two methods are used to harvest tea at Southdown estate hand and mechanical methods and Kawasaki machine is used. Kawasaki machine has a daily target of 1200 kg per day and hand is pegged at 65kg per day. Plucking is normally done by task workers.

2.3.3 Tea Harvesting: Manual and Mechanical Harvesting Methods

The process of harvesting is known as plucking and is very labour intensive and costly Plucking is the periodic harvesting of the young shoots, normally a bud and two to three leaves, comprise the economic yield of the tea plant and is either done by hand or mechanically (Kamau ,2008). Tea is harvested from the top section of an actively growing stem. The shoots harvested usually consist of two or three leaves and a bud (Willson, 1992). In practice, plucking may also involve the removal of banjhi shoots (dormant buds), leaves and bud shoots, broken shoots and detached leaves. An adequate plucking regime should aim to supply the processing factory with sufficient leaf suitable for manufacture. Plucking is a vital aspect of tea production. Plucking accounts for about 20% of the total cost of production and accounts for about 60-70% of the total labour deployment in the garden (Saikia and Sarma, 2011). Bore (2009) state that cost of labour was challenging the economic viability of sustaining the tea industry.

Long plucking intervals and mechanical plucking was argued to have reduced tea yields and produced coarser leaf than short plucking intervals and hand plucking respectively (Owour and Odhiambo, 1993). The authors also stated that black teas plucked from short plucking rounds were superior to those from long plucking rounds as assessed by thea flavins, caffeine, brightness, the chemical aroma quality parameters and sensory evaluation. Kumau (2008) also mention that short plucking intervals ensure production of high quality tea. Ravichandran (1997) established that the quality of tea is affected by the growth rate of the pluckable shoots and improves as growth rate decreases. Kumau (2008) said that there are two processes involved in tea harvesting: fine plucking and course plucking, fine plucking standard, which involves plucking only the first two leaves and bud; the higher the quality course plucking involves plucking more than two leaves.

The quality of plucking determines the quality of tea to be manufactured, the cost of plucking has a major influence on the profitability of the enterprise (Wilkie, 1995). Mechanical harvesting methods are believed to have low costs and hand is associated with high costs due to shortage of labour. Labour is a scarce resource in estates these makes the demand for labour to increase. According to the law of demand and supply if demand of a product is high, supply will be low and prices of that commodity will rise so this is happening whereby supply of labour is low and demand is high and this lead to high costs in manual harvesting method since it requires more labour.

There are two harvesting methods which are hand plucking and mechanical plucking. On hand plucking the pluckers use their hands to pluck flush then the flushed are flung over the shoulder of the pickers into their baskets strapped into their backs. Hand plucking was thought to be the best plucking method was evolved in tea industries and this was due to high degree of shoot selection and minimum damage to the plant. Tea leaves were harvested by hand without causing mechanical injury (Owuor, Bowa, Kwacha, 2012). Hand harvesting is associated with good leaf quality and good made tea quality. Hand harvesting ensures removal of shoots of required maturity (standard) for production of better quality tea and to preserve die back and vegetative vigour of the tea bush (Wijeratne, 2003). According to Tea research foundation hand plucking produces good quality because it is selective whereby pluckers would be plucking the recommended two leaves and a bud hence little fibres are obtained. With hand plucking there is no mechanical damage of the plant; there is no removal of immature shoots thus increasing yield. Hand plucking requires large number of pluckers. Method of plucking was also found to have an impact on quality of tea. Owour and Odhiambo (1997) stated that hand plucked teas had higher theaflavins (TF), caffeine, brightness, and flavour index hence good quality.

Due to shortage of labour and high labour costs in 1970s tea companies in Argentina introduced mechanized tea harvesting system later on African nations like Zimbabwe and South Africa also adopted tea harvesting methods. Shear harvesting shear was first used as an alternative to hand plucking and it started to be used in Japan (Wilkie and Malenga, 1995). Mechanical plucking also include motor driven machines which starts from hand held machines to tractor mounted harvesters like ride on machines. These harvesting machines require good ground conditions and evenly growing shoots (less number of generations) and trained canopies for better performance.

Therefore, the use of motorized machines is greatly limited by field conditions and pattern of shoot growth.

Mechanical plucking is one effective way to increase the productivity of labour in addition to stabilize labour deployment and bring more leaves to the plucking basket. Work done on mechanical plucking at Tocklai for the past years showed increase in productivity (Barbora, 1994). Although mechanical plucking is faster and cheaper, the quality of the product and its value is low (Bore, 2009). This process increases the rate of plucking and reduces the manpower involved. Main advantages of mechanical plucking are: high efficiency, low plucking cost, time saving, and uniform plucking table. But it has also some limitations like: decline in leaf quality, difficulty in use in high sloppy land, and difficulty in repair and maintenance of the machines.

Method of harvesting also influence yield and quality of tea leaves, the method of harvest affect type and number of shoots that remain on the bush after harvesting. If immature shoots are plucked this means that yield on the next plucking round is also limited (Latif, 2012). The quality of tea can be assessed at various stages first at the factory gate as soon as it arrives from the field, during processing in the factory and after manufacturing by sensory characteristics (Burges, 2006).

Harvesting machines range from hand held portable harvesters to tractor mounted types. Depending on their size, the weight of machine may vary from about 10 kg to about several tones. These machines are manufactured to fit the varying field conditions and pattern of shoot growth. Although, there are many types of motorized harvesters, their common feature is non-selectivity in harvesting of tea shoots **(**Wijeratne, 2003). Output of machines largely depends on the length of blades (harvesting section), the longer blades give a higher output than shorter ones. Further, the output also varies with the yield potential and the topography (mainly slope) of the tea land (Wijeratne, 2003).

Generally, use of machines gives fewer yields than manual plucking. In tea fields, continuous mechanical harvesting has declined tea yield remarkably (more than 50%). Low yield is mainly due to non-selective harvesting of shoots and damage to the maintenance foliage leading to extended plucking round (Wijeratne, 2000). Mechanical harvesting is non-selective in the sense that it can harvest more than what is recommended that is two leaves and a bud. The operators of the machine can hold the machine below the plucking table this will results in harvesting immature shoots that are supposed to be harvested in the next plucking round. This means that in the next plucking round there would be few mature leaves to be harvested hence yield is reduced. If harvesting machines are used only during peak cropping months, yield loss can be minimized to about 20-30% (Wijeratne, 2003). If labour was available machine would be used during peak season so as to reduce yield losses. Usually machine harvesting gives poor quality crops compared to manual harvesting. Crop harvested by machines consists of substandard shoots such as over mature (coarse) leaves and stems, and immature shoots or arimbus. (Wijeratne, 2003). These over mature shoots will affect the end product. It would be difficult to crush them in the CTCs process in the factory so the end product will have more fibres hence quality has been reduced.

2.4 Review of Empirical Studies

In a study to access the viability of different technologies (machinery) on a bean crop, Banda, (2006) and Kadyampakeni, (2004) used the gross margin. Variations across different technologies were found across the schemes. In the study they compared different pumps that are the motorized pump and treadle pumps. Farmers using the motorized pumps realized negative gross margins while those using treadle pumps realized a positive gross margin. The study shows that treadle pump is more viable than motorized pump. In their study the researcher noted that the gross margin analysis is viable in comparing different methods as in the case with the mechanical and hand harvesting methods in tea production.

Chagwiza (2008) used gross margin analysis to evaluate economic viability of sweet sorghum under different scenarios. The gross margin analysis was used to estimate the profitability of cultivation of sweet sorghum. In the study the researcher used gross margin analysis to compare sweet sorghum under four different scenarios which are small scale rain fed, improve rain fed, improved single with irrigation and double cropping with irrigation so as to make a choice on the production to follow. Chagwiza obtained a positive gross margin under small scale production meaning that small scale production is profitable and viable.

Mahoo, (2011) used a gross margin analysis to compare returns realized by farmers, traders and processors of jatropha production. The researcher used gross margin analysis to compare viability of jatropha traders, processors and farmers. The researcher used gross gross margin to compare viability of jatropha production under different stages. The aim was to find out the most profitable enterprise among farming, trading and processing. Mahoo found out that jatropha processing was the most profitable enterprise compared to farming and trading. Jatropha processing had the highest gross margin.

Owombo. Adiyeloja and Koledaye, (2012) also used gross margin to assess returns to amaranth vegetable production on gender basis. The study aims to evaluate viability of amaranth vegetable production. Findings of the study show that gross margin for an average female farmer was higher than that of a male farmer. Total costs for average female farmer was low compared to that of male farmer. Total revenue for an average female farmer was higher than that of male farmer. The results showed that amaranth vegetables enterprise is profitable female vegetable farmers are keener in production than their male counterpart.

Malik and Luhach, (2002) used the Net present Value (NPV), Internal Rate of Return (IRR) and the Benefit Cost Ratio (BCR) in determining the viability of a drip irrigation in the production of fruits. In their study the use of these methods found that fruit production was viable using drip irrigation.

Subed (2011) used BCR to compare viability of dry and wet processing of coffee. To compute a BCR the researcher first did gross margin for each method and then did BCR using results from gross margin. Dry processing method had few had few handling steps thus reduces costs. The researcher found out that dry processing is more viable than wet processing. Dry method had a higher BCR of 1.4 as compared to 1.2 of wet processing method.

Senkondo (2011) also used the NPV, BCR and IRR in analysing rainwater investments for dry season maize, rice and onions. Rainwater harvesting proved viable for these crops. The researcher in this study also determined how sensitive investments are to changes in variables. When the input costs were increased by 20% and selling price reduced by 20%, it was found that NPV was positive, IRR was above the cost of capital and the BCR was equally greater than one for maize and onion production only.

Kamwana (2010) used NPV and BCR to assess viability of irrigation technology in potato production. The researcher assesses viability of irrigation pumps which are motorized pump, tradable pump and drip. The reasecher found out that NPV under all irrigation pumps was positive meaning that all irrigation pumps are viable. The reasecher found out that drip irrigation is the most viable among the three irrigation technologies because it has a positive NPV and BCR is greater than one.

Osen Adams and Quam (2013) did cost and benefit analysis on cocoa production. They compared certified cocoa and conventional cocoa. The researchers used descriptive statistics, profitability analysis, gross margin and cost and benefit analysis to analyse data. Profitability analysis, gross margin analysis and cost and benefit analysis showed that certified cocoa production was more profitable than conventional production. The researcher did not do a sensitivity analysis which helps to examine the response of the decision criteria to changes in the input parameters.

Vishwanatha (2005) did a comparative study of mechanical and manual threshing methods in maize. The researcher used discounted and non-discounted methods to assess viability of two machines. The machines are maize thresher (engine model) and sheath removal maize thresher (engine model). The researcher used IRR, NPV and BCR these are discounted methods and payback period as a non-discounted method. The researcher found out that sheath removal maize thresher was more viable than maize thresher. Sheath removal maize thresher had a higher NPV, higher BCR and higher IRR than maize thresher. Payback period was the same for both machines; time taken to recover the initial investment was almost the same.

Maina and Kaluli (2009) assess viability of mechanical and hand harvesting of tea in Kenya. The researcher used NPV to assess viability of these two harvesting methods. The researchers found that mechanical harvesting method is cheaper and it reduces costs and has high yield comparing to hand harvesting method. NPV of machine harvested tea was as twice as much as the NPV of handpicked tea. This shows that mechanical harvesting method was more viable than hand harvesting method. The researchers only used net present value to assess viability of harvesting methods; they were supposed to use more than one method so as make a good conclusion.

Bayreath (2001) did a cost and benefit analysis to assess financial viability of irrigation systems in Kakuma district in Kenya. He investigated three fruit tree species in two different irrigation systems (macro and micro catchment). He used net present value, benefit cost ratio and internal rate of return as decision criteria for cost and benefit analysis. A sensitivity analysis was also carried out to investigate relative importance of input parameters and allow an error estimate. In his study he found out that macro catchment was more profitable and viable.

Omari (2009) used cost and benefit analysis of farming bamboo as a substitute for tobacco. He used primary data in his study and applied the framework of cost and benefit analysis to analyse the costs and benefits of tobacco and bamboo. The researcher used net present value as decision criteria and found out that bamboo farming is financially and economically viable than tobacco. Net present value for bamboo was higher than that of tobacco. A sensitivity analysis was also conducted to find change in the sign of net incremental benefit and there was no change in the sign of net incremental benefit.

(Ndiiri, 2011) did a cost and benefit analysis to quantify benefits of rice intensification (RI) over farmer practice (FP) of rice cultivation. He collected data using questioners and structured interviews to farmers practising both RI and FP. CBA was estimated using tabular analysis of all variable costs and income from fields. RI gave the highest BCR compared to FP. The reasecher found out that RI raises economic benefits. On the study the reasecher used BCR only to quantify economic of which this method has some limitations the reasecher was supposed to consider other measures like NPV in his study.

To investigate the economic viability of planting bt maize seeds under smallholder farming conditions Mandikiana (2011) used a gross margin analysis. Data was collected from 90 households who were selected using purposive sampling through the use of the snowball method. To collect data, a questionnaire was administered through face-to-face interviews. Gross margin analysis revealed that bt maize is a more profitable option as compared to conventional maize seeds. Furthermore, econometric analyses, through use of the binomial regression model revealed that perceptions could be used to distinguish between users and non-users of bt maize seed in the Eastern Cape Province.

Hassena (2000) compare the profitability of manual and combine harvesting and threshing of wheat in the study area using a partial budget. The benefits were calculated by multiplying yield and price. Data was collected from a random sample of 160 farmers from two purposively selected districts. Economic profitability analyses indicate that combine harvesting is more profitable for the nation than manual harvesting and threshing.

2.5 Insights from literature

The literature above shows that many studies used gross margin analysis to assess viability and the researchers accept a project or an enterprise with either positive gross margin or higher gross margin. The researchers included variable costs only to compute a gross margin and fixed costs were not included. Other studies also used net present value and internal rate of return to assess viability the researchers accept a project higher net present value. To do cost and benefit analysis all studies did a net present value to compare costs and benefits while other researchers included benefit cost ratio and internal rate of return.

2.6 Conclusion

The chapter looked at empirical and theoretical literature of the study. The chapter highlights how other related studies have been carried out and their results. On theoretical the researcher find out that mechanical is associated with low costs relative to manual harvesting. As a result, many tea estates tend to prefer mechanical harvesting method as compared to manual. In the next chapter, the methodology which shows how the study was conducted is presented.

CHAPTER THREE: RESEARCH METHODS

3.1 Introduction

This chapter reviews research methods used. The chapter evaluates the methodological tools that are going to be used in order to answer objectives of the study. The chapter also discusses how the study will be carried out. It gives a brief overview of the study area, how data is collected as well as describing the techniques that are going to be used to analyse data. In assessing viability of an enterprise (tea production in this case), total costs are subtracted from the total revenue of the enterprise and gross margin analysis is going to be used. To compare costs and benefits of tea harvesting methods cost and benefit analysis will be used.

3.2 Research Design

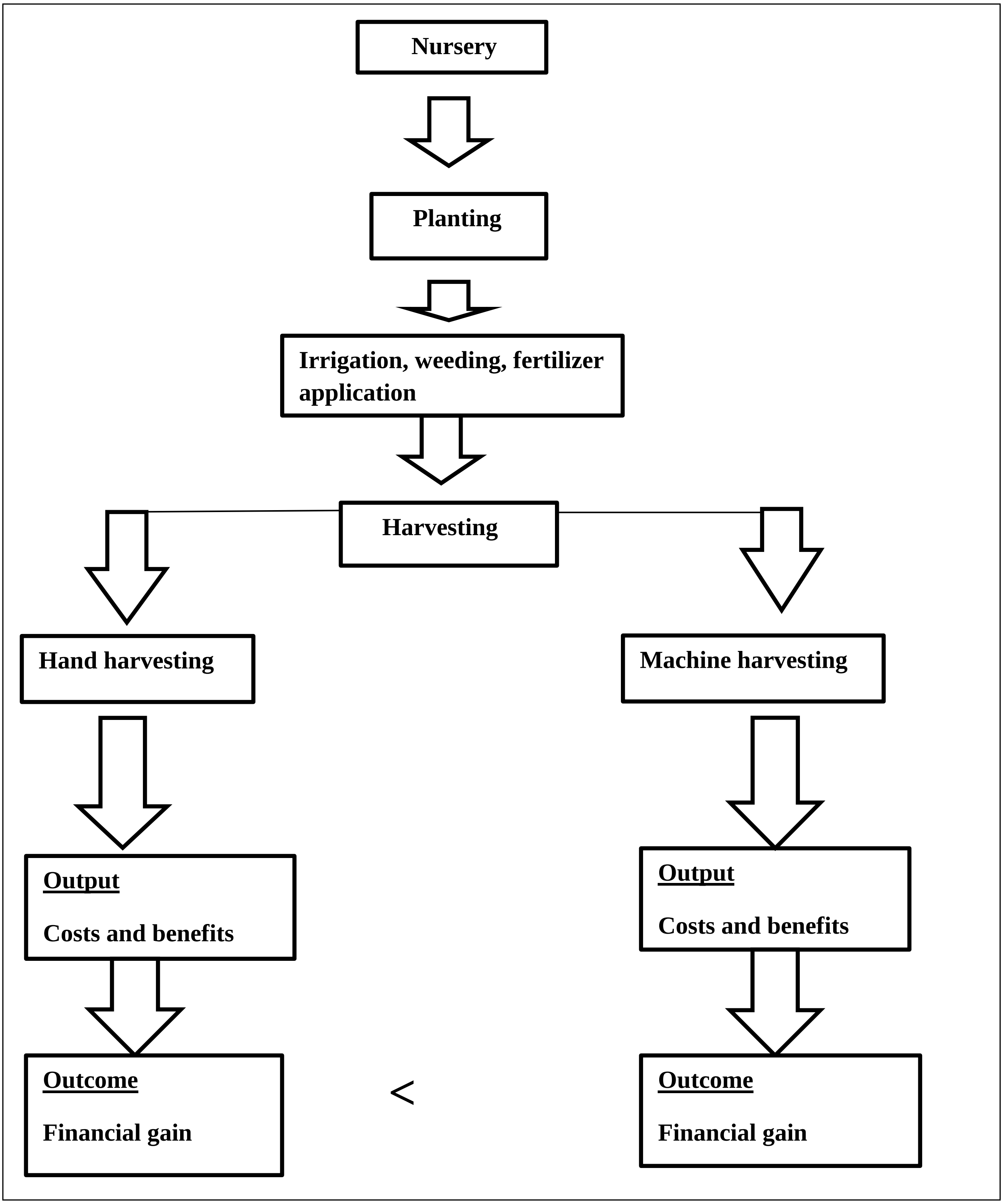
According to Burkingham and Saunders (2004), a research design is a plan or guide for data collection and interpretation, with sets of rules that enable the researcher to conceptualize and observe the problem under study. This definition supports the fact that a well-designed study enables the researcher to explore and find connections of a specific phenomenon. It guides the researcher in planning and implementing the study in a way that is most likely to achieve the intended goal.

The study uses both qualitative and quantitative methods. The procedures and methods used for data collection and analysis in this research follow an explanatory design. An explanatory method is used because of the nature of the study which is focusing on gathering facts and costs on comparing machine harvesting method and hand picking method at Southdown estate. The explanatory method is adopted in order to give justification on the position of comparing the two harvesting methods. The study is going to use secondary data and data will be analysed using Microsoft excel.

3.3 Conceptual framework

Tea seeds are first planted at the nursery in the polythene bag after that they are planted in the field at a spacing of 1.2 m inter-row by 75m in row. Irrigation is done during winter to prevent frost and fertilizer (compound T) is applied once a year at a rate of 500kg per hector, lime is applied at the beginning of each season to neutralize soil ph. Pesticides are also applied to prevent pests and disease but at a lower rate because tea is not easily affected by pests.

Tea is harvested five years after planting and it reaches its maturity stage of maximum production after ten years. After reaching its maturity stage it is deeply pruned after every three years to maintain height and to facilitate easy plucking. Foliar fertilizer is applied after harvesting to improve leaf quality and enhance leaf production. As indicated earlier, two methods are used to harvest or pluck tea; and these include manually and mechanically. The former harvesting method is associated with high leaf quality but it requires more labour of which labour is now scarce this lead to high costs Nyasulu (2009). It can also be harvested mechanically and a Kawasaki machine is used to pluck tea this method is associated with poor leaf quality but reduces costs. Figure 1 shows the conceptual framework.



Figue 1: Conceptual framework: own source

3.4 Description of the study area

The study was carried out at Southdown Estate. It is 41km east of Chipinge town along eastern border road to Chipinge. The site is at a latitude of -20, 2711200 and longitude of 32, 8240700 and at an altitude of 765meters above sea level. Chipinge is in natural region 1 the average annual rainfall received at the site per annum is1105millimeters and an average temperature of 17,3 degrees Celsius . The dominant rock types are dolorite, shale, schist, siltstone, sandstone, quartzite and gneiss. The soil ranges from sandy loam to red podzol on higher slopes to rich humus on the lower valleys. The soil ph ranges from 3 to 5. These soils show a relatively poor nutrient status and the substantial slopes characteristic of the areas of Othoferrallitic soils so they are not used for normal cultivation and are largely taken up by forestry and the growing of tree crops, especially tea and coffee (Nyamapfene, 1990). Tea is a perennial crop and it can grow up to one hundred years. Tea cultivation started in 1966 at Southdown Estate, 595 hectors of land is under tea plantation.

3.5 Analytical framework

3.5.1 Data analysis

Microsoft excel is going to be used for data analysis so as to achieve objectives. Quantitative analysis will involve gross margin and cost and benefit analysis. Specific analysis carried out per each objective is outlined below:

Assessing financial viability of hand versus machine harvesting methods.

A gross margin was used. Gross income refers to the total revenue that is obtained after selling the produce from tea per kilogram. To obtain gross margin, price per kg is multiplied by the quantity obtained from the tea plantations. In this case the researcher focused on the gross income per hectare for simplicity. Gross margin consist of;

Total variable costs

In this study they will vary depending on the method of harvest that will be implemented on tea production. Total variable costs include fertilizer, fuel costs, labour, herbicides, protective clothing. According to Chagwiza (2008), it is also important to look at composition of variable costs not only to compare the gross margin figures. In other words they say if possible all discrepancies have to be fully explored and are very necessary in case where items of variable costs incurred differs from farm to farm. Mechanical harvesting will be having different variable costs as to hand picking harvesting method. Variable costs will take the centre stage of the gross margin analysis. These will include direct labour, fuel, tools and herbicides only mentioning a few.

Gross margin analysis is a technique that is used to assess viability of an enterprise. Gross margin is a simplified tool but is a powerful tool for economic analysis (Mahoo, 2011). It makes it easier for one to compare viability and profitability of similar enterprises. Barnad and Nix (1979) states that use of gross margin widespread in the U.K about 1960 and it was first used by farm management advisors for analysis and planning purposes. Gross margin is static and does not take into account time value of money like other investment analysis. However gross margin as an analytical tool has some advantages these include its ability of rational variants for the operational structure of enterprise, it can draw logical interpretation of economic and technological parameters and it is easy to understand (Phillip, 2007).

In this study gross margin analysis is going to be used to estimate viability of two harvesting methods in tea production. In this study the production of tea is divided into hand and machine harvesting method. The gross margin (GM) analysis will be carried per hectare of tea production. In carrying out the analysis as the total variable costs will be subtracted from the total revenue. GM is going to use data on variable costs and revenue. Variable costs include fertilizer, herbicides, wages and fuel costs. Price per kilogram will be multiplied by the total output per hectare so as to come out with total revenue (TR). Tea production variable costs differ depending on the harvesting method used which is the centre of the study. However tea production harvesting methods are mechanical and hand harvesting. For hand harvesting there are no fuel costs and harvesting costs are different between these harvesting methods while other costs are the same. The Gross Margin analysis will take the following format

Table 1: Gross Margin Format

Gross Income (Price*Quantity)		**Xxxx**
Less Variable Costs	**Xxxx**	
Total Variable Costs		**Xxxx**
Gross Margin		**Xxxx**
Return per dollar invested (GI/VC)		

Source: format

Gross margin analysis would be derived using the following formula

GM = TR – TC

Where:

GM = Gross margin

TR = Total revenue

TVC = Total variable costs

Under the gross margin analysis, the decision rule is to opt for a harvesting method whose gross margin is higher than the other method in relative terms. With regards to the return per dollar as a measure of financial viability and sustainability of a project, a return per dollar above USD1.5 is generally accepted as a rough rule of thumb (Mahoo, 2011). In addition to that, a harvesting method whose return per dollar invested is relatively higher is considered more viable and sustainable.

3.5.2 Justification of the GM analysis

According to Chagwiza (2008) calculations of gross margin is a very important step in farm budgeting and planning. Johnsen (2003) concluded that gross margin is not a good measure of profitability but it is the most satisfactory measure of profitability at farm level. Gross margin enables one to compare directly profitability and viability of similar enterprises. In this study gross margin analysis is going to be used to assess financial viability of tea production under two harvesting methods hand and machine. DPI, (2008) stated that use of gross margin indicates clearly the areas where improvement is needed and gross margin analysis is very important. One can easily identify where improvement is needed so as to maximize profits.

3.5.3 Financial Viability

From literature, financial viability of an enterprise can be assessed using either a gross margin analysis, internal rate of return, payback period, net present value or the benefit-cost ratio. In this study, a financial comparison of costs between mechanical and manual harvesting method is conducted using a gross margin, cost benefit analysis and a sensitivity analysis (Mahoo, 2011).

Comparing financial costs and benefits of hand versus machine harvesting methods.

Cost and benefit analysis is going to be used. Cost and benefit analysis is a tool that is used to undertake evaluation of a project. Omari (2009) defines CBA as a systematically tool for estimating efficiency impact on policy. Cost and benefit analysis is an economic evaluation technique that analyse the generation of economic benefits and costs from a project (Dixon, 2013). It is mainly concerned with measuring and identifying, discounting future benefits and costs as present values in order to enable calculation of economic worth of project. CBA takes into account all costs and benefits incurred. Since the CBA involves an evaluation of discounted benefits and costs, the first step is to find a discount rate.

Cost and benefit analysis is normally used to calculate profitability of a project or an enterprise. It is widely used for economic and financial appraisal tool for projects. CBA is very useful whereby a choice has to be made out of many projects and is applicable when a project has stream of benefits and costs over time, more than one year. In agriculture sector cost and benefit analysis is mainly used for agriculture projects like irrigation schemes and at large estates like palm oil.

CBA takes into account the concept of time value of money a dollar invested today has more value than a dollar invested tomorrow. It assesses the costs and benefits of a project. If costs are more than benefits this means that the project is not viable hence reject the project and if benefits are more than costs then the project is viable hence accept the project. It also takes into account the concept of discounting whereby the present worth of a project would be discounted.

There are two types of CBA that is (1) financial cost and benefit analysis (2) social cost and benefit analysis. Social cost benefit analysis focuses on identifying, comparing and measuring the social cost and benefits of a program or project. The main purpose of social CBA is to help in social decision making and more specifically to facilitate efficient allocation of a society's resources and it's difficult to measure (Boardman et al, 2006). Financial cost and benefit analysis is articulated from ones perspective, group involved in project. Example expenses made by farm as well as benefits are considered in financial analysis.

This study used financial analysis to compare costs and benefits of tea harvesting methods. The researcher would compare benefits of hand harvesting with benefits of mechanical harvesting method. The benefits will be discounted from total revenue. For the project to be viable benefits must outweigh costs. Benefits would occur after five years because tea takes a span of four to five years to mature so benefits are going to be obtained on the sixth year. The time period for gross margin will be fifty years since most tea at Southdown estate is more than forty years and has a life span of more than forty years. Two methods were used to compare the costs and benefits of two harvesting methods. The cost and benefit analysis looks at estates income based on gross margin and costs. The benefits will be the discounted revenue. The methods used for decision criteria are NPV and BCR and IRR.

Net Present Value (NPV)

Net present value is the total of discounted costs and benefits and it shows the amount which the project will earn. The NPV of an investment is the sum of discounted future cash- flows matched with the initial investment, (Brigham and Ehrhardt, 2008). If NPV is negative this means that the project is not viable hence costs outweigh benefits and if NPV is positive this shows that the project is economically viable and a project with the highest NPV will be selected.

NPV would be computed from the following formula:

$NPV = \Sigma FV/(1+r)^t$

Where:
FV = Future value
r = discount rate
t = time period (year)

Benefit Cost Ratio (BCR) method

Benefit cost ratio is the ratio of discounted benefits and costs. The BCR method compares discounted benefits to the sum of discounted costs, (Kamwana, 2010). The BCR indicates how much benefit will accrue for every $1 of cost. BCR must be greater than one. An enterprise with a BCR greater than 1 indicates profitability of the enterprise.

Internal rate of return

The IRR is the discount rate used if discounting the project's costs and benefits will equate the project's NPV to zero (Mugido, 2011). The project with the highest IRR will be preferred. IRR will be computed from the following formula

$$NPV = \sum_{t=0}^{n} \left(\frac{(Bt - Ct)}{(1+r)t} = 0 \right)$$

Where

Bt are project income in period

Ct is project costs in period t

r is the appropriate discount rate

n is the number of years over which the income and costs of the project are taken into account.

Revenue

It is the total amount of money received after selling output and it is the value of output produced. It includes output produced per year and price per kilogram. Out produced the whole year by price per kilogram. It is measured by gross income and is computed from gross margin

Operating costs

These are costs associated with the operation as well as repair and maintenance of machines. It also includes equipment utilized and variable costs. These costs include input cost, labour costs. Costs of herbicides, fertilizers in other words it is the total costs of all variable costs.

Total enterprise costs

This is the value of inputs used in the production. Total costs of operating costs. The total costs are normally divided into two namely variable costs and fixed costs.

Returns/ benefits

This is the difference between gross income and operating costs.

3.5.4 Concept of discounting

Discounting is a process whereby present worth of a project would be computed. The discount rate is there to guide on the rate to which one is willing to give up consumption in exchange for additional consumption in future (Campel and Brown, 2003). This can be possible by discounting benefits and costs for each future time period then summarized to present value (Mahoo, 2009). The concept of discounting allows determination of either to accept the project which have cash flows then discounted it (Gittinger, 1982). The study is going to use NPV, IRR because they are easy to understand and it is the most straight forward discounted cash flow measure (Gittinger, 1982). It also permits one to make time dimension of benefits and costs streams into consideration. Discount rate must be selected in order to carry out a CBA. In this study discount rate was an average of the interest rate of seven banks selected by the researcher.

3.4.5 Sensitivity analysis

Sensitivity analysis examines the response of the decision criteria to changes in the input parameters. It also performs a task to evaluate the results and relates to the input factors that enters the calculations (Bayreuth, 2001). Sensitivity analysis would be carried out to capture the changes in parameters subjected to uncertainty that might alter the performance and decision making of two harvesting methods. Selected element would be used to measure while other elements remain unchanged. In the study the discount rate is going to be tested. Sensitivity analysis would be tested by changing discount rate. Discount rate is going to be adjusted upwards to determine whether the harvesting methods will be viable if discount rate increases.

3.6 Conclusion

The chapter looked at the methodology of the study, how the study is going to be carried out. The chapter also discuss about methods that are going to be used to achieve objectives which are gross margin analysis and cost and benefit analysis and how data is going to be collected, sources of data. The following chapter will discuss the results obtained.

CHAPTER FOUR: PRESENTATION OF RESULTS AND DISCUSSION

4.1 Introduction

This chapter focuses on the research findings. The chapter presents and discusses the results objective by objective. Data was analysed using the gross margin analysis in conjunction with the Cost and Benefit Analysis.

4.2 Financial viability of hand versus mechanical harvesting methods of tea.

The financial viability of tea harvesting methods was computed using gross margin analysis. Gross margins for the two harvesting methods (hand and mechanical) were calculated by subtracting total variable costs from the total revenue. The gross margin analysis was calculated per hectare. The researcher made the following assumptions during the computation of the gross margin per hectare (1) financial costs are expressed in United States (US $) (2) The Kawasaki machine used for tea harvesting consumes 3 litres of petrol per hectare. Table 2 shows the results of the gross margin analysis for the two harvesting method.

Table 2: Gross Margin analysis results for hand harvesting versus mechanical harvesting methods at Southdown Estate

	Price/unit		Quantity/ h		$/ha		$/ha	
	MECH	**HAND**	**MECH**	**HAND**	**MECH**	**HAND**	**MECH**	**HAND**
Gross income							**29760**	**27900**
Variable Costs								
Admin service labour								
Supervisors	3.96	3.96	1	1	1330	1330		
Weighing cleck	2.97	2.97	1	1	99792	997.92		
Foreman	2.97	2.97	1	1	997.92	997.92		
Total					**3325.85**	**3325.85**		
Crop Maintenance								
Row opening	2.70	2.70	5	5	13.50	13.50		
Breaking back	2.70	2.70	5	5	13.50	13.50		
Flags removal	2.70		5		251.51			
Total					**278**	**27.00**		
Cultivation Labour								
Slashing labour	2.70	2.70	3	3	24.30	24.30		
Weeding	2.70	2.70	3	3	16.20	16.20		
Total					**40.50**	**40.50**		
Fertiliser Application (labour)								
Compound T (4l/ha)	3.78	3.78	4	4	15.12	15.12		
Foliar Fertilizer (4l/ha)	1.08	1.08	4	4	133.92	33.92		
Total					**149.04**	**149.04**		
Herbicide Application (labour)								
Round up	2.70	2.70	3	3	8.10	8.10		
Total					**8.10**	**8.10**		
Tea Harvesting	0.30	0.65	24800kg	23250kg				
Total					**7440**	**15112.50**		
Chemicals								
Round Up (2l/ha)	5.50	5.50	2 ltrs	2 ltrs	11.00	11.00		
Total					**11.00**	**11.00**		
Fertiliser								
Foliar (2l/ha*31)	3.30	3.30	62 ltrs	62 ltrs	204.60	204.60		
Compound T (500kg/ha)	48.50	48.50	500kg	500kg	485	485		
Total					**689.60**	**689.60**		
Fuel Costs								
Kawasaki Machine	4.62		1		143.22			
Two Stroke Engine	1.14		1		35.34			
Total					**178.56**			
Total Variable Costs/ha							**12120.64**	**19354.59**
Gross Margin		3.96		1		1330	**17639.36**	**9534.34**
Return per dollar Invested		2.97		1		997.92	**2.46**	**1.49**

Gross income per hectare for mechanical harvesting was $29760 whereas the gross income for hand harvesting method per hectare was $27900. It was made up of total output 24800kg multiplied by price per kg $1.20. Gross income for hand harvesting was obtained through multiplying output 23250kg and price per kg $1.20. Mechanical harvesting method yielded higher gross income relative to hand harvesting method. The difference may be attributed to the fact that fields under mechanical operations were given optimum amounts of inputs at the right time relative to fields under manual labour operations where human errors are highly prevalent. This fact may translate to increased output in fields under mechanical operations, hence the difference in gross incomes. The results were also a result of difference agronomic practices. Thus, there is high productivity in mechanical harvesting method relative to hand picking. However these results are inconsistent with literature which states that mechanical plucking results in reduced tea yields and produced coarser leaf which will translate in to less revenue as compared to hand harvesting method and mechanical harvesting method produces higher yield but of poor quality. (Owour and Odhiambo, 1993).

Total variable costs for mechanical harvesting method per hectare and hand harvesting method per hectare differ as shown by the Table 2. Mechanical harvesting method recorded total variable costs of $12120.64 while hand harvesting method recorded total variable costs of $19354.59. From the gross margins above hand harvesting method has high total variable costs as compared to mechanical harvesting method. This can be due to more labour that is required by hand harvesting method which is also expensive. Harvesting costs takes a greater percentage of total variable costs and is the most expensive operation in harvesting. This is supported by (Wijeratne, 2003) who found out that cost of harvesting account for a greater proportion of cost of production. Harvesting costs takes a greater share of field costs (Tea Research Foundation, 2000). This is caused by the fact that harvesting requires more labour than other operations that are done at the estate and is also different from other operation because it is done every day unlike other operations like fertiliser application and herbicide application. Harvesting is labour intensive of which labour for harvesting is now scarce these days and there is low supply for labour, high demand hence increase in costs.

Mechanical harvesting method recorded a greater gross margin per hectare of $17639.36 and hand harvesting recorded a gross margin per hectare of $9534.34. This is a result of variation in yield, gross income and total variable costs that build up each harvesting method. These harvesting methods are profitable because they both have a positive gross margin. Positive gross margin indicate that an enterprise is profitable and negative gross margin shows that the enterprise is not profitable (Chagwiza, 2008). However, mechanical harvesting method has greater gross margin as compared to hand harvesting method. Greater gross margin indicates that mechanical harvesting method is more profitable than hand harvesting method. The best selection criterion is to choose an enterprise with higher gross margin (Mahoo, 2011).

Mechanical harvesting method yielded a higher return per dollar of $2.46 relative to hand harvesting method with $1.49 (see Table 2). This means that in every dollar invested the estate get $2.46 for mechanical harvesting method. In every dollar invested for hand harvesting method the estate get $1.49. This difference may be supported by the fact that hand harvesting requires intensive manual labour which is expensive relative to mechanical harvesting which is capital intensive. Therefore mechanical harvesting is more viable than hand harvesting method because it has a higher return per dollar.

The following table shows components of operating costs of tea harvesting:

Table 3: Percentage components of total variable costs

	Hand-picking	**Machine harvesting**
% of harvesting labour costs	78.08 %	61.38%
% of bush management costs	4.78%	9.70%
Fuel costs	0%	1.47%
Admin costs	17.18%	27.44%

Source: survey source

Bar graph for components of total variable costs

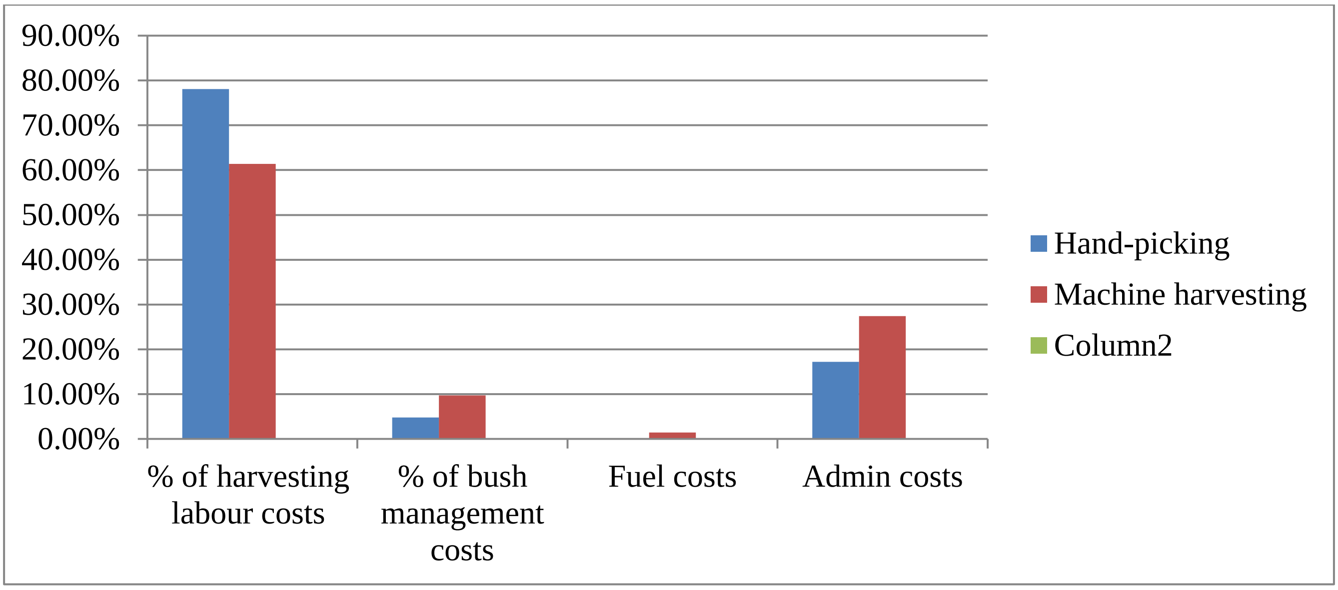


Figure 2: Components of variable costs: survey source

Figure 2 shows that harvesting accounts for a greater proportion of the total variable costs as compared to other operating costs. Harvesting labour for hand picking yielded a greater percentage of 78,08% as compared to machine harvesting method which yielded a percentage of 61,38%. This shows that harvesting labour is more costly than other operations. This also indicates that hand harvesting method is more expensive as compared to machine harvesting method.

4.3 Comparing the financial costs and benefits of hand picking versus machine harvesting methods.

Financial cost and benefit analysis was computed for the hand harvesting method versus mechanical harvesting method. IRR, NPV and BCR were used as indicators of financial performance in the long run. The study did not consider intangible costs and benefits because it looked at a firm level and firms are much concerned with tangible costs and benefits. Revenue from tea production was treated as financial benefits in the study. The life span for a tea bush is assumed to be 50 years. Discount rate used was 22% and is an average interest rate from banks. A sensitivity analysis was also carried out for changes in discount rates. Discount rate was increased to 30% and 44% to find out that if interest rate increases, whether the harvesting methods would be viable. The direct costs and benefits used in the study are explained below.

Direct financial costs

The assumptions made were that the costs are higher for both harvesting methods during the first year due to expenses that were related to land preparation. Costs for year two up to year five were low as there were no expenses for land preparation. Tea harvesting machines were assumed to be purchased in the sixth year because this is the year of production, this explain the upshot of costs in the sixth year. More labour is employed for harvesting, harvesting requires a lot of labour this cause costs to rise in this year. In year seven costs decrease because machinery costs are not included. The life span for machine was assumed to be five years hence need to replace them after every five years starting from year six

Direct financial benefits

From year one to year five there is no revenue received because tea takes four to five years to reach harvesting stage depending on the climatic conditions hence at Southdown estate takes five years to reach harvesting stage. Revenue starts from year six. Revenue increase from year six to year 12 and then remain constant up to year 50. This is attributed to the fact that from first year of harvesting tea yields increases for ten years that is when it reaches its maturity and from there the yields will remain constant they can also vary depending on agronomic practices in the fields. Mechanical harvesting method is more beneficial as compared to hand harvesting method because it has more benefits than hand harvesting method. Mechanical harvesting method is more worthwhile project relative to hand harvesting method. Difference in benefits are attributed to the fact that hand harvesting incurred more cots than hand harvesting these reduces revenue for hand harvesting method. The annual revenue for mechanical harvesting method is higher as compared to hand harvesting method.

4.3.1 Financial Cost and benefit Analysis

In order to determine the financial worth of the hand harvesting versus the machine harvesting method a financial CBA was done. The findings of the financial CBA are presented in Table4. The assumptions made in the CBA are; (1) the production cycle for tea bush was assumed to be 50 years (2) discount factor of 22% was used. (3) Depreciation for machine was 10% per annum.

Table 4: Cost and benefit analysis for hand and mechanical harvesting method.

	Tea harvesting methods	
Measure	**Hand picking method**	**Machine harvesting method**
Present value (benefits)	38893.12	45432.87
Present value (costs)	17786.75	16829.30
Net Present Value (NPV)	21106.37	28605.55
Internal Rate of Return(IRR)	34 %	46 %
Benefit cost Ratio (BCR)	2.19	2.79

Source: survey source

The NPV shows the present value of the future streams of revenue produced by an investment. In this regard, mechanical harvesting method yielded a higher NPV of $28605.55 relative to hand harvesting method with $21106.37. This suggests that mechanical harvesting method is more appropriate and worthy to invest than hand picking method. This is consistent with the literature which believes that mechanical harvesting method is better than hand harvesting method. Maina (2009) also found the same results in his study whereby the NPV of machine harvesting method was twice as much as the NPV of hand harvesting method.

In terms of BCR, mechanical harvesting method is more worthy as compared to hand harvesting method with BCRs 2.79 and 2.19 respectively. A project with a higher BCR should be considered first as more appropriate when choosing based on BCR (Mugido, 2011). However according to this study both mechanical and hand harvesting methods are feasible due to the fact that they both have BCR which are greater than one. Mechanical harvesting method is more financially attractive than hand harvesting method because it has a higher BCR. Higher BCR recorded in mechanical harvesting method can be explained by higher yields and revenue obtained relative to hand harvesting methods. This is supported by Ndiiri (2012) who states that higher BCR was explained by higher yields. The results show that benefits outweigh costs; in this case every one costs incurred is equivalent to two benefits. More benefits are obtained from mechanical harvesting methods since it has higher BCR.

A project is worth to accept if it has IRR above market rate of return or discount rate. With regard to IRR, mechanical harvesting method with a high IRR of 46% relative to hand harvesting method with 34% is more worthy. Literature states that a project with a higher IRR is more worthy than the other (Omari, 2009). However according to this study both mechanical and hand harvesting methods are feasible in the sense that there IRRs of 46% and 34% respectively exceeds the market rate of 22%. However mechanical harvesting method is more worthy to invest as compared to hand harvesting method since it has a higher IRR. This is also supported by (vishwanatha, 2005) who also reported the same results whereby he found out that IRR for maize threshers was above market rate of return. The investment on both maize threshers was feasible because the internal rate of return was higher than the market rate of return.

4.3.2 Sensitivity analysis

Sensitivity analysis was carried out to determine whether the harvesting methods would be viable if the discount rate changes. Discount rates were adjusted upwards for both harvesting methods. Discount rate was increased to 30% and 44% .The results of sensitivity analysis are shown in Table 5.

Table 5: Sensitivity analysis for hand picking versus machine harvesting methods

	Discount rate					
	22%		**30%**		**44%**	
Measure	**Hand picking**	**Machine harvesting**	**Hand picking**	**Machine harvesting**	**Hand picking**	**Machine harvesting**
Present value (benefits)	38893.12	45432.87	19939.99	23967.82	7836.49	9690.00
Present value (costs)	17786.75	16828.30	12455.85.	11923.32	8112.33	7880.44
Net Present Value (NPV)	21106.37	28605.55	7484.14	12044.51	998.29	1809.57
Internal Rate of Return(IRR)	34%	46%	20%	31%	4%	9%
Benefit Cost Ratio (BCR)	2.19	2.79	1.6	2.01	1.1	1.2

Source: survey data

Table 5 shows that changes in discount rate will not affect status of BCR and NPV. However changes in discount rate affect status of IRR. BCR and NPV prove to be stable if there are changes to discount rate. If discount rate increases to 30% and 44% NPV is always negative this shows that it is viable if there are changes to discount rate. BCR is always above 1 this indicates that changes in discount rate will not affect BCR. However increase in discount rate affects IRR. If discount rate increases to 30% and 44% hand harvesting method will not be profitable since IRR will be below discount rate. Table 5 also displays that changes in discount rate will not affect status of BCR and NPV. However changes in discount rate affect status of IRR. BCR and NPV prove to be stable if there are changes to discount rate. If discount rate increases to 30% and 44% NPV is always negative this shows that it is viable if there are changes to discount rate. BCR is always above 1 this indicates that changes in discount rate will not affect BCR. However increase in discount rate affects IRR. If discount rate increases to 30% mechanical harvesting method proves to be viable since it yielded IRR which is above discount rate but if it increase to 44% mechanical harvesting method will not be profitable since IRR will be below discount rate.

The analysis established that the outcome for mechanical harvesting method is more financially attractive as compared to hand harvesting method. Therefore, we conclude that mechanical harvesting is a more proficient method towards obtaining more profits and benefits than investing in hand harvesting method. Increase in interest rate will affect viability of both harvesting methods. Mechanical harvesting method is more stable to changes in discount rate as compared to hand harvesting method.

4.4 Conclusion

The results above indicate that for both methods benefits outweigh costs which imply that the two methods are financially viable. However the results confirm that mechanical harvesting method is more financially viable relative to hand harvesting method. Mechanical harvesting method yielded a higher gross margin and return per dollar as compared to hand harvesting method. Mechanical harvesting method recorded higher IRR, BCR and NPV than hand harvesting method. This implies that mechanical harvesting method is more cost-effective than hand harvesting method

CHAPTER FIVE: CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

This chapter presents the summary of the whole study as well as highlighting on the issue of recommendations and the areas in which future studies can benefit from and gives the overall conclusion of the study.

5.2 Summary

The study is a comparative analysis which compares hand picking and machine harvesting method in tea production. The first objective of the study is to assess financial viability of hand picking and machine harvesting method. The second objective is to compare costs and benefits of the two harvesting methods. To achieve the first objective the study employed a gross margin analysis then the cost and benefit analysis was used to attain the second objective.

Two gross margins were computed for hand harvesting method and mechanical harvesting method. Mechanical harvesting method yielded a higher gross margin of $ 17639, 36 relative to hand harvesting method which had gross margin of $ 9 534,34. Return per dollar for mechanical harvesting method is higher which is 2, 46 as compared to hand harvesting method of 1,49. In this regards, mechanical harvesting method proves to be the most viable and profitable harvesting method as compared to hand harvesting method.

Cost and benefit analysis for fifty years was computed for two harvesting methods. Discount rate used is an average of interest rate for seven banks that were selected by the researcher and the discount rate is 22%. NPV, IRR and BCR were used as a decision criterion for comparing costs and benefits of the two harvesting methods. A sensitivity analysis was also carried out to determine whether the project would be viable if discount rate changes. NPV and BCR for mechanical harvesting method were higher as compared to hand harvesting. This shows that mechanical harvesting method is more feasible than hand harvesting method. IRR for both harvesting method was greater than market rate of 22% meaning that the two methods are feasible. IRR for mechanical harvesting method was 46% and for hand harvesting method is 34%. However, mechanical harvesting method had a greater IRR meaning that it is more feasible than hand harvesting.

Results from the study shows that mechanical harvesting method is more viable than hand harvesting method. Mechanical harvesting method is more feasible than hand harvesting method since it yielded greater IRR, NPV and BCR. The sensitivity analysis shows that if discount rate increases all harvesting methods will be viable under NPV and BCR and will not be viable under IRR.

5.3 Conclusions

The following conclusions were made from the study:

5.3.1 Assessing the financial viability of machine versus hand harvesting method.

The results confirmed that mechanical harvesting method is more viable than hand harvesting. Both harvesting methods are viable since they have positive gross margin whereby mechanical harvesting method had gross margin of $ 17 639,36 and for hand harvesting method is $ 9 534.34. Both have a return per dollar which is above one but mechanical harvesting method has a return per dollar of 2.46 and hand harvesting method has a return per dollar of 1.46. However mechanical harvesting method is more viable because it has a higher gross margin and a higher return per dollar.

5.3.2 Comparing the financial costs and benefits of machine versus hand harvesting method.

The results indicate that benefits outweigh costs this shows that both harvesting methods are viable but mechanical is more viable because it yielded more benefits than hand harvesting methods. NPV and BCR are not affected by increase in discount rate for both harvesting methods and both harvesting methods are viable if discount rate increases. IRR is affected by increase in discount rate, hand harvesting method will not be viable and mechanical harvesting method will be viable at 30% and will not be viable at 44%. It would be beneficial and profitable to the estate if it uses mechanical harvesting method only and eliminate hand harvesting method.

5.4 Recommendations

The study makes the following recommendations: In light of the results obtained in this study, the researcher recommends Southdown estate to use mechanical harvesting method because it is more viable, feasible and profitable. The results also established that mechanical harvesting method reduces costs in tea production since benefits outweigh costs as compared to hand harvesting method. Since mechanical harvesting method is capital intensive this helps reduce the need to hire more labour to operate in the field as the machines substitute labour demand.

The reasecher also recommends Southdown estate to use hand harvesting method in areas that are inaccessible to machines because machines cannot operate in terrain areas. The estate should introduce machines in gardens where tea is harvested by hands so as to reduce production costs.

However, Southdown estate is advised to invest in training and education to their workers who operate the machines because if machines are not properly handled will result in physical damages of the plants. Therefore the company will benefit from reduced costs of both crop and machine damages.

5.5 Suggested Areas of Further Research

There are several numbers of estates in Zimbabwe, but the researcher only focused on Southdown estate located in Chipinge district. However, the researcher would recommend other researchers to include other estates in Zimbabwe like Tanganda tea estates, Katiyo tea estate and Eastern highlands in their studies. This will assist them in observing whether similar results can be obtained.

In this study the researcher did not look at intangible costs and benefits so other researchers can do the same study including intangible costs and benefits.

On mechanical harvesting the researcher looked at one machine which is Kawasaki machine only of which there are other machines that are used to harvest tea like shears, ride on machine and other machines that are used worldwide. Future studies can also include the cost of these machines in their studies which will help in assessing financial viability or when comparing costs and benefits for other machines included which have not been used in this research.

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APPENDIX

Appendices 1: CBA for Manual harvesting method

year	total revenue	total costs/hectare (USD)	PV Costs (DF=22%)	PV Benefits (DF=22%)	Present value	IRR
1	0	4057.3	3325.655738	0	-3325.655738	-3325.66
2	0	2740.7	1841.373287	0	-1841.373287	-1841.37
3	0	2740.7	1509.322366	0	-1509.322366	-1509.32
4	0	2740.7	1237.14948	0	-1237.14948	-1237.15
5	0	2740.7	1014.056951	0	-1014.056951	-1014.06
6	20400	6247.695	1894.788918	6186.872746	4292.083828	4292.084
7	20400	4926.295	1224.620712	5071.207169	3846.586457	3846.586
8	20500	4926.295	1003.787469	4177.103301	3173.315833	3173.316
9	20600	4926.295	822.7766137	3440.556897	2617.780284	2617.78
10	21000	4926.295	674.4070604	2874.888383	2200.481323	2200.481
11	21200	4926.295	552.7926724	2378.90842	1826.115748	1826.116
12	21500	6247.695	574.647937	1977.518212	1402.870275	1402.87
13	30600	4926.295	371.400613	2306.978928	1935.578315	1935.578
14	30600	4926.295	304.426732	1890.966335	1586.539603	1586.54
15	30600	4926.295	249.5301082	1549.972405	1300.442297	1300.442
16	30600	4926.295	204.5328756	1270.469185	1065.936309	1065.936
17	30600	4926.295	167.649898	1041.368184	873.7182862	873.7183
18	30600	6247.695	174.2781206	853.5804789	679.3023583	679.3024
19	30600	4926.295	112.6376633	699.6561302	587.0184669	587.0185
20	30600	4926.295	92.3259535	573.4886313	481.1626778	481.1627
21	30600	4926.295	75.67701106	470.0726486	394.3956376	394.3956
22	30600	4926.295	62.03033694	385.3054497	323.2751128	323.2751
23	30600	4926.295	50.84453847	315.8241391	264.9796006	264.9796
24	30600	6247.695	52.85473306	258.8722452	206.0175121	206.0175
25	30600	4926.295	34.16053378	212.1903649	178.0298311	178.0298
26	30600	4926.295	28.00043752	173.9265286	145.9260911	145.9261
27	30600	4926.295	22.9511783	142.5627284	119.6115501	119.6116
28	30600	4926.295	18.81244123	116.8546954	98.04225415	98.04225
29	30600	4926.295	15.42003379	95.78253719	80.3625034	80.3625
30	30600	6247.695	16.02968174	78.51027639	62.48059465	62.48059

31	30600	4926.295	10.36014095	64.35268556	53.99254461	53.99254
32	30600	4926.295	8.491918813	52.74810292	44.25618411	44.25618
33	30600	4926.295	6.960589191	43.23614993	36.27556074	36.27556
34	30600	4926.295	5.705400976	35.43946716	29.73406618	29.73407
35	30600	4926.295	4.676558177	29.04874357	24.3721854	24.37219
36	30600	6247.695	4.861451033	23.81044555	18.94899452	18.94899
37	30600	4926.295	3.142003613	19.51675865	16.37475504	16.37476
38	30600	4926.295	2.575412797	15.99734315	13.42193036	13.42193
39	30600	4926.295	2.110994096	13.11257636	11.00158226	11.00158
40	30600	4926.295	1.73032303	10.74801341	9.017690377	9.01769
41	30600	4926.295	1.418297565	8.809847055	7.39154949	7.391549
42	30600	6247.695	1.474371515	7.22118611	5.746814596	5.746815
43	30600	4926.295	0.95290081	5.919005009	4.966104199	4.966104
44	30600	4926.295	0.781066238	4.85164345	4.070577212	4.070577
45	30600	4926.295	0.640218227	3.976756926	3.336538698	3.336539
46	30600	4926.295	0.524769039	3.259636825	2.734867786	2.734868
47	30600	4926.295	0.430138556	2.671833463	2.241694906	2.241695
48	30600	6247.695	0.447144556	2.190027428	1.742882872	1.742883
49	30600	4926.295	0.288993924	1.79510445	1.506110526	1.506111
50	20400	4926.295	0.236880266	0.980931393	0.744051128	0.744051
total	1193400	247274.575	17786.75167	38893.12328	21106.37161	34%
BCR	2.186634412					

Appendices 2: CBA for mechanical harvesting methods

year	total revenue	total costs/hectare (USD)	PV Costs (DF=22%)	PV Benefits (DF=22%)	Present value	IRR
1	0	4057.3	3325.655738	0	-3325.655738	-3325.6557
2	0	2740.7	1841.373287	0	-1841.373287	-1841.3733
3	0	2740.7	1509.322366	0	-1509.322366	-1509.3224
4	0	2740.7	1237.14948	0	-1237.14948	-1237.1495
5	0	2740.7	1014.056951	0	-1014.056951	-1014.057
6	26040	5156.295	1563.791226	7897.361093	6333.569868	6333.56987
7	26040	4531.295	1126.42822	6473.246798	5346.818578	5346.81858
8	26080	4531.295	923.3018197	5314.090444	4390.788624	4390.78862
9	26200	4531.295	756.8047702	4375.853918	3619.049148	3619.04915
10	26500	4531.295	620.3317789	3627.835341	3007.503562	3007.50356
11	26900	4531.295	508.4686712	3018.52059	2510.051919	2510.05192
12	27000	5231.295	481.1619132	2483.394964	2002.233051	2002.23305
13	27200	4531.295	341.6209831	2050.647936	1709.026953	1709.02695
14	29760	4531.295	280.0171992	1839.057455	1559.040256	1559.04026
15	29760	4531.295	229.5222945	1507.424143	1277.901849	1277.90185
16	29760	4531.295	188.1330282	1235.59356	1047.460532	1047.46053

17	29760	4531.295	154.2074002	1012.781607	858.5742064	858.574206
18	29760	5231.295	145.9258592	830.1488579	684.2229987	684.222999
19	29760	4531.295	103.6061544	680.4498835	576.8437291	576.843729
20	29760	4531.295	84.92307737	557.7458061	472.8227288	472.822729
21	29760	4531.295	69.60907981	457.1686936	387.5596137	387.559614
22	29760	4531.295	57.0566228	374.7284373	317.6718145	317.671815
23	29760	4531.295	46.76772361	307.1544568	260.3867332	260.386733
24	29760	5231.295	44.25611378	251.7659482	207.5098344	207.509834
25	29760	4531.295	31.42147514	206.3655313	174.9440562	174.944056
26	29760	4531.295	25.7553075	169.1520749	143.3967674	143.396767
27	29760	4531.295	21.11090778	138.6492417	117.5383339	117.538334
28	29760	4531.295	17.30402277	113.6469194	96.34289665	96.3428966
29	29760	4531.295	14.18362522	93.15321264	78.96958742	78.9695874
30	29760	5231.295	13.42190903	76.35509233	62.9331833	62.9331833
31	29760	4531.295	9.52944452	62.58614125	53.05669673	53.0566967
32	29760	4531.295	7.811020099	51.30011578	43.48909568	43.4890957
33	29760	4531.295	6.402475491	42.04927523	35.64679974	35.6467997
34	29760	4531.295	5.24793073	34.46661904	29.21868831	29.2186883
35	29760	4531.295	4.301582566	28.25132708	23.94974452	23.9497445
36	29760	5231.295	4.070570744	23.15682548	19.08625473	19.0862547
37	29760	4531.295	2.890071597	18.98100449	16.09093289	16.0909329
38	29760	4531.295	2.368911145	15.5582004	13.18928926	13.1892893
39	29760	4531.295	1.941730447	12.75262328	10.81089283	10.8108928
40	29760	4531.295	1.591582334	10.4529699	8.861387568	8.86138757
41	29760	4531.295	1.304575683	8.568008116	7.263432433	7.26343243
42	29760	5231.295	1.234514863	7.022957472	5.78844261	5.78844261
43	29760	4531.295	0.876495353	5.756522518	4.880027165	4.88002717
44	29760	4531.295	0.718438814	4.71846108	4.000022267	4.00002227
45	29760	4531.295	0.588884274	3.86759105	3.278706776	3.27870678
46	29760	4531.295	0.482692028	3.170156598	2.68746457	2.68746457
47	29760	4531.295	0.395649203	2.598489015	2.202839812	2.20283981
48	29760	5231.295	0.374401292	2.129909028	1.755507736	1.75550774
49	29760	4531.295	0.265821824	1.745827073	1.480005248	1.48000525
50	29760	4531.295	0.217886741	1.431005797	1.213119056	1.21311906
total	**1205280**	**224453.375**	**16829.30368**	**45432.85603**	**28603.55235**	**46%**
BCR	**2.699627797**					