EVALUATION OF INTRODUCED CASSAVA PROCESSING TECHNOLOGIES ON PRODUCTION AND CONSUMPTION USING GOAL PROGRAMMING APPROACH

BY

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A DISSERTATION SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE IN AGRICULTURAL ECONOMICS OF SOKOINE UNIVERSITY OF AGRICULTURE. MOROGORO, TANZANIA.

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ABSTRACT

This study which evaluates the introduced cassava processing technologies on production and consumption using goal programming approach was conducted in Tongwe village (Muheza district) in Tanga region and Mikongeni village (Kibaha district) in Pwani region. Data for the study were collected from a sample of 120 households, 2 focus group discussions and by experimentation. The results of the study show that, the introduced cassava processing technologies are both technically and economically efficient. The machines such as engine powered chipper and grater consume 5 litres of fuel (petrol) to process about 1- 1.2 tonnes of fresh cassava. To process 5 kg of fresh cassava the machines take 3 minutes. Moreover, it takes about 1-3 days to obtain a final product (cassava flour) whereas traditional processing technology (sun-drying) takes about 6 days and wet and solid-state fermentation takes about 12 days. Analysis of the partial budget revealed that mechanized processing technologies generate an average profit of TZS 316.43 per kilogram dry weight compared to traditional processing technologies. Analysis of the consumer's preferences with respect to processing methods by probit regression analysis, factors such as quality of the products, household size, quantity consumed per year and price of those products were significant at $\alpha = 0.05$ level, suggesting that there is an increase in consumption behaviour. To estimate future trend of demand and hence production for processed cassava flour using goal programming approach indicated that about 128 571.4 tonnes can be produced in the two districts, if farmers use the said technology in full scale. The study concluded that, the use of mechanized processing technologies is more profitable. Therefore, the study recommended that, the farmers do adopt manual chipping machine for small-scale farming, moreover engine powered chipper and cassava grater for large-scale farming rather than using traditional processing technologies.

DECLARATION

I, Meda Theodory, do hereby declare to the Senate of Sokoine University of Agriculture that this dissertation is my own original work and that it has neither been submitted nor is it being concurrently submitted for degree award in any other Institution.

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Date

The above declaration is confirmed

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DEDICATION

This work is dedicated to my beloved parents; My father Theodory M. Mrimi and beloved mother Bibyana M. Mrimi who laid a good foundation of my education.

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LIST OF ABBREVIATIONS AND ACRONYMS

ARMA	-	Auto Regressive Moving Average
ASAE	-	American Society of Agricultural Engineers
BCR	-	Benefit Cost Ratio
CIAT	-	International Centre for Tropical Agriculture
CNG	-	Cyanoglucoside
DRC	-	Democratic Republic of Congo
FAO	-	Food and Agriculture Organization
FDG	-	Focus Group Discussion
Fig	-	Figure
GDP	-	Gross Domestic Product
GP	-	Goal Programming
HQCF	-	High Quality Cassava Flour
IITA	-	International Institute for Tropical Agriculture
IRR	-	Internal Rate of Return
LGP	-	Lexicographic Goal Programming
MAFS	-	Ministry of Agriculture and Food Security
MCDA	-	Multi-Criteria Decision Analysis
MCDM	-	Multiple Criteria Decision Making
MOA	-	Ministry of Agriculture
MOFP	-	Ministry of Finance and Planning
NBS	-	National Bureau of Statistics
NPV	-	Net Present Value
NPW	-	Net Present Worth
NSGRP		National Strategy for Growth and Reduction of Poverty (*Mpango wa Kukuza Uchumi na Kupunguza Umaskini Tanzania*)
OLS	-	Ordinary least square
PANTIL	-	Programme for Agricultural and Natural Resources Transformation for Improved Livelihood
SNAL	-	Sokoine National Agricultural Library
SUA	-	Sokoine University of Agriculture
TAC	-	Trading Agent Competition
TADENA	-	Tanzania Development Navigation Trust
TARPII	-	Tanzania Agricultural Research Project Phase II
TZS	-	Tanzanian Shillings
URT	-	United Republic of Tanzania

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background Information

Cassava (*Manihot esculenta* Crantz) is the starchy root crop that is grown almost entirely within the tropics. Although it is one of the most important crops in the tropical countries, it is little known elsewhere in some parts within the tropics, and considered to be a low grade substance crop (Cock, 2001).

Cassava ranks second in the list of staple food crops in developing countries after maize (Nweke, 2003). In sub-Saharan Africa, cassava is grown chiefly as human food, but it is also an important animal feed and has several industrial uses. Being one of cheapest source of food energy, cassava gives a carbohydrate production per hectare which is about 40% higher than rice and 25% more than maize. Thus cassava plays a major role in meeting developing countries' rising demand for consumption of both food and animal feed (Tonukari, 2004).

The total area harvested in the world in 2005 was about 16 millions hectares, with 57% in Africa, 25% in Asia and 18% in Latin America. About 15% of the world's population of cassava is exported to Europe and Japan as chips, pellets and/or starch. The starch is used in food industries, textiles, paper industries and in beer brewing. The remaining 85% of the world production is used within the producing countries for food (58%), animal feed (28%) and industrial uses (3%) where the wastage is about 11% (CIAT, 1993).

The area of land planted with cassava is greatest in Africa, but yields are lower than other continents, where in 2005 Africa, Asia and Latin America had 12 354 000, 3 429 000 and

2 649 000 hectares of land planted with cassava whereas productions were 109 755, 56 082 and 34 094 (000 metric tonnes) respectively (Prakash, 2008). Africa is the only part of the world where per capital food production has been declining in the last two decades, although cassava production has nearly double during the same period (De Bruijin and Fresco, 1999). Most cassava in Africa is produced by female farmers for food and is consumed near to where it is grown. There is a growing commercial market for cassava in Africa and men are gradually being involved in the production of cassava in Nigeria, Ghana and Democratic Republic of Congo (DRC) (FAO, 1995).

Cassava for human consumption is greatest in Africa, averaging to 409.5 g of fresh and dried cassava per capita per day. The highest consumption is found in Angola with 787 g per capita per day (Nhassico *et al*., 2008). The starch roots are the most commonly consumed part, but the leaves are also consumed as preferred green vegetable in many cassava-growing communities, especially in Central Africa (Hahn, 1998).

Both the tuber and leaves of cassava contain Cyanogenic glucosides, which may lead to toxicity if cassava is not properly processed. Safe consumption of cassava thus depends on successful removal of cyanogens. Depending on the processing methods used, the percentage of cyanide reduction varies from 70 to 100% (Nwapa, 1986). In order to minimize the cyanogens content, cassava is processed by different traditional methods, which includes fermentation (wet and solid-state) and drying. However, in solid state fermentation and drying, there is proliferation of spoilage and pathogenic micro-organisms on cassava, some of which may produce mycotoxins (Nwapa, 1986). The resulting flour is coloured thus not appealing to the consumer. This dissertation sought to evaluate the introduced cassava processing technologies on production and consumption using goal programming approach.

1.2 Problem Statement

In Tanzania, cassava is grown in most parts of the country. However, chief growing areas are Tanga, Mwanza, Pwani and Lindi regions. In recent years, cassava is also grown in other parts of the country as a result of Government efforts to stimulate local self-sufficiency in food supply (Nang'ayo *et al*., 2007); as such, making cassava the most important root crop in the country. Despite its importance, Tanzania is estimated to produce 6.3 million tons of cassava per year.

Cassava is very high in starch and can grow even in areas with marginal rainfall, with possibility of contributing greatly to livelihood support. This led to insistence from policy makers and other bodies in the past to grow cassava as a food security crop. The main inherent problems with cassava include high perishability of the edible roots within 2-3 days after harvesting, high level cyanogenic glucosides in some variation (Mlingi and Ndunguru, 2003) and low nutritional value as it is mainly composed of starch. These have led to marginalization of the crop in terms of production and consumption, which have made it more of a subsistence crop. In addition, there exists stigma in some transects of Tanzanians to regard cassava as a poor man's food, therefore reduced production and consumption of cassava and increased vulnerability of cassava farmers to poverty (Mlingi and Ndunguru, 2003).

One solution to the perishability problem has been to leave the crop in the field and harvest in piecemeal only where there is need but this is uneconomical because it ties up the land unnecessarily. Another one has been to transfer the risk by selling the crop to businessman while still in the field at price set arbitrary and often very low, which gives very little income to farmers and thus a disincentive to increased cassava production. A noble solution has been to process the roots into shelf-stable product, for example flour but the methods used are still inadequate as in most area they are tedious, rudimentary and unhygienic, often leading to insufficient processing and poor quality products (Silayo *at al.*, 2004). However, mechanical chipping of cassava roots instead of manual chipping has been introduced, but the technology has not yet been reached by majority of cassava growers in terms of knowledge and physical ownership. The cyanide problem has been successfully dealt with through proper processing, e.g. dry and wet fermentation (Silayo *at al.*, 2004). In recent years, the Programme for Agricultural and Natural Resources Transformation for Improved Livelihood (PANTIL) introduced the solutions of selection of low cyanide varieties and the processing machines which grant cassava prior to subsequent processing. Grating and chipping machines have been introduced in few villages in Pwani, Dar-es-salaam and Tanga regions as a detoxification-method. It is envisaged that the merits against traditional (wet and solid-state fermentation) methods in terms of efficiency and hence act as stimulant for future production and consumption is not yet established. Therefore, this research was proposed to establish the effectiveness of the technologies and evaluate the future cassava production and consumption due to the introduction of the cassava processing technologies.

1.3 Justification of the Study

This study will simulate the mechanical methods for cassava processing in those villages, where this technology has been introduced. Its effectiveness on cyanogenic glucosides removal and hygienic conditions will lead to high quality cassava flours which will increase consumption as well as boost the cassava production, also increase the income for the farmers hence raise the living standards.

The introduced cassava processing technologies go hand in hand with the development Vision 2025 and the accompanied “National Strategy for Growth and Reduction of

Poverty" (NSGRP) with a Swahili acronym MKUKUTA, both of which aim at modernizing agriculture for increasing contribution to the national Gross Domestic Product (GDP) (Mbogoro, 2005).

1.4 Objective of the Study

1.4.1 General objective

The overall objective of the study was to evaluate the introduced cassava processing technologies on production and consumption using goal programming approach.

1.4.2 Specific objectives

Specifically the study sought to:

(i) Assess the efficiency of cassava processing technologies in Tanzania.

(ii) Establish the comparative operating costs of cassava processing machines.

(iii) Study the consumer preference for cassava products versus different processing technologies.

(iv) Project future production of cassava resulting from introducing mechanized cassava processing technologies.

1.5 Hypothesis

(i) There is no significant difference in social economic factors affecting consumer preferences behaviour between mechanical processed and other technologies processed products.

1.6 Organisation of the Dissertation

This report is organized in five chapters. After this chapter, chapter two provides a review of cassava processing technologies and theories for future projection for production while chapter three presents the methodology including the description of the study area, sampling design, data collection tools and data analysis. Chapter four presents the results and discussions, followed by chapter five which present conclusion and recommendations based on the findings of the study.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Cassava Processing Technologies

Three cassava processing technologies have been reviewed in this study, which includes traditional processing technology, wet and dry (solid-state) fermentation and mechanical processing technologies which have been recently introduced in Tanzania.

Traditional cassava processing technologies used in Africa probably originated from tropical America, particularly north-eastern Brazil and may have been adapted from indigenous techniques for processing yams (Jones, 2003). The processing methods include peeling, boiling, steaming, slicing, soaking or seeping, pounding, roasting and drying. These traditional methods give low product yields, which are also of low quality (Montagnac *et al.,* 2009).

Wet and dry (solid-state) fermentation cassava processing technology is a combination of two processing technologies that means wet fermentation and dry (solid-state) fermentation, reported to be very efficient in cyanide removal (Montagnac *et al.,* 2009) but resulted in high losses in nutrients of high value, such as proteins, carbohydrates, minerals, and vitamins (Hotz and Gibson, 2007).

Mechanical processing technologies for cassava involve using chipping and grating machines, pressing devices, mills, gari fryers, and sifters (IITA, 1996). The technologies involves chipping, grating and crushing which are usually very efficient in cyanide removal because they completely rupture plant cells of cassava and allow direct contact between linamarase and linamarin (Cardoso *et al.,* 2005). The process for the mechanical processing technology can be visualized in chronological manner as presented in Fig. 1 below.

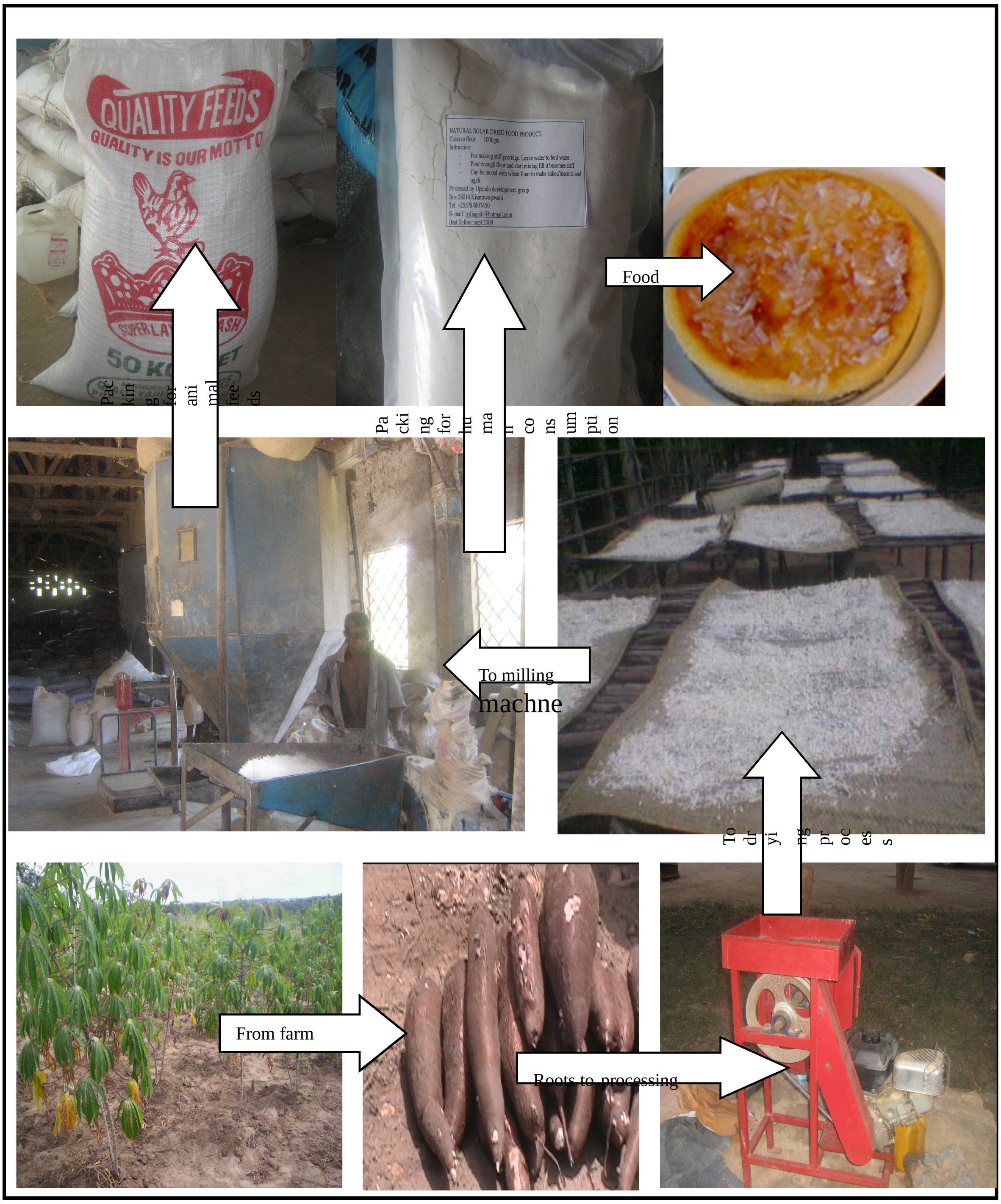
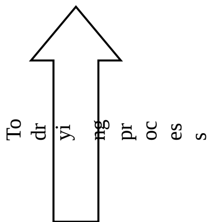


Figure 1: Mechanical processing technology for cassava.



2.2 Cassava Processing Efficiency

According to IITA (1996) cassava processing efficiency is mainly affected by size, shape, hardness, moisture content and type of equipment used. Due to the introduction of modern cassava processing technologies, IITA revealed that, there is a reduction in food losses during cassava processing from 22.3% to 10.1% and the labour input from 295.2 man-hours to 87.6 man-hours per 10 tons of cassava roots.

However, the efficiency of different processes in reducing cyanoglucoside (CNG) content of cassava was studied by Nambisan and Sundaresan (2006). Maximum retention of CNG (>80%) was observed in baked, fried and steamed roots. CNG retention in sun-dried chips varied from 30-60%, the retention being governed by the chip thickness. In case of cassava boiled in water, smaller chip size and sufficient water was found to be the ideal condition for maximum CNG removal. There was 25-75% CNG retention in this process, depending on the chip size used. The most effective method for CNG removal was by crushing fresh roots and subsequent sun-drying, whereby >95% CNG was eliminated. The studies indicated that the mode of processing greatly influenced the CNG content of cassava foods. It was concluded that since CNG can be greatly reduced by suitable processing, it may not be a limiting factor in the utilisation of cassava for food and feed purposes.

2.3 Costs of the Machines

Lazarus (2008) separated machine costs into time-related and use-related categories. Use-related costs are incurred only when a machine is used. They include fuel, lubrication, use-related repairs and labour. Time-related costs, also often referred to as overhead costs, accrue to the owner whether or not a machine is used. Overhead costs include time-related economic costs: interest, insurance, personal property taxes, and housing. Depreciation is both a use- and a time-related cost. Depreciation will be related to use to the extent that increased annual usage shortens years of life and/or reduces salvage value while not entirely use-related, the time-related costs are prorated over a 12 year economic life except where otherwise indicated. Computation of machinery overhead costs based on American Society of Agricultural Engineers (ASAE) formulas are as follows:

2.3.1 Interest

If the operator borrows money to buy a machine, the lender will determine the interest rate to charge (Davies and Patton, 2000). But if the farmer uses his or her own capital, the rate will depend on the opportunity cost for that capital elsewhere in the farm business. If only part of the money is borrowed, an average of the two rates should be used (Molenhuis, 2008). For example, assume an average interest rate of 8%, bearing in mind that inflation reduces the real cost of investing capital in farm machinery, and loans can be repaid with cheaper dollars, the interest rate can be adjusted by subtracting the expected rate of inflation which is 3%, so the adjusted or "real" interest rate is 5%. Therefore interest rate per year can be calculated as follows;

$$Interest / year = \frac{PC + SV + DP(Tshs / year)}{2} \times IR \quad \text{.....................................(1)}$$

Where:

PC	=	Purchase costs,
SV	=	Salvage value,
DP	=	Depreciation,
IR	=	Real interest rate.

Therefore, the interest cost hinders small farmers to purchase the farm machinery or run the machine.

2.3.2 Insurance

In law and economics, insurance is a form of risk management primarily used to hedge against the risk of a contingent loss. Insurance is defined as the equitable transfer of the risk of a loss, from one entity to another, in exchange for a premium, and can be thought of as a guaranteed small loss to prevent a large, possibly devastating loss. The insurance rate is a factor used to determine the amount to be charged for a certain amount of insurance coverage, called the premium. Risk management, the practice of appraising and controlling risk, has evolved as a discrete field of study and practice (Ritter, 2002). Moreover, insurance per annum can calculated as follows;

$$Insurance / year = \frac{PC + SV + DP(Tshs / year)}{2} \times INR \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ (2)$$

Where:

PC	=	Purchase costs,
SV	=	Salvage value,
DP	=	Depreciation,
INR	=	Insurance rate.

Therefore, insurance should be carried on farm machinery to allow for replacement in case of a disaster such as fire or tornado calamites. If insurance is not carried, the risk is assumed by the rest of the farm business (Ritter, 2002).

2.3.3 Housing cost

There is a tremendous variation in housing for farm machinery. Providing shelter, tools, and maintenance equipment for machinery will result in fewer repairs in the field and less deterioration of mechanical parts and appearance from weathering. Therefore, should produce greater reliability in the field and a higher trade-in value (Edwards, 2005). Housing cost per year can be calculated as follows;

$$H / year = P / m^2 \times m^2 SS \text{ ....(3)}$$

Where:

H	=	Housing,
P	=	Price,
SS	=	Shelter space required.

Therefore, the housing cost must be carries on by the farmer so as to protect the machines, thus yields benefits in the form of longer machine lives, reduced repairs, better appearance and greater convenience in working on machinery, hence more profit in the business resulted from good farm management (Dalsted, 2008).

2.3.4 Depreciation

Depreciation is a cost resulting from wear, obsolescence, and age of a machine. The degree of mechanical wear may cause the value of a particular machine to be somewhat above or below the average value for similar machines when it is traded or sold (Dumler *et al*., 2000). The introduction of new technology or a major design change may make an older machine suddenly obsolete, causing a sharp decline in its remaining value. But age and accumulated hours of use usually are the most important factors in determining the remaining value of a machine (Edwards, 2005).

Before an estimate of annual depreciation can be calculated, an economic life of a machine and a salvage value at the end of the economic life must be specified. The economic life of a machine is the number of years for which costs are to be estimated (Burton, 2005). It is often less than the machine's service life because most farmers trade a machine for a different one before it is completely worn out. A good rule of thumb is to use an economic life of 10 to 12 years for most new farm machines and a 15-year life for tractors, unless it is known that the machine will be traded sooner.

Salvage value is an estimate of the sale value of the machine at the end of its economic life. It is the amount, the farmer can expect to receive as a trade-in allowance, an estimate of the used market value if he or she expects to sell the machine outright, or zero if the farmer plans to keep the machine until it is worn out (Edwards, 2005). Actual market value will vary from these values depending on the condition of the machine, the current market for used machinery, and local preferences or dislikes for certain models. Therefore, depreciation per year can be calculated as follows;

$$Depreciation / year = \frac{PC - SV}{LS} \quad \ldots\ldots (4)$$

Where:

PC = Purchase costs,
SV = Salvage value and
LS = Life span of machine.

Therefore, depreciation is a non-cash expense of machinery ownership that must be recognized by the farmer. This is the amount of money that a farmer must put away every year so as to be able to replace the machine at the end of its expected life and also can be used in studies of taxation policy, investment behaviour, and a host of farm management studies, furthermore most often used to provide reliable estimates of what farm equipment either is worth or will be worth (Wu and Perry, 2004).

2.3.5 Taxes

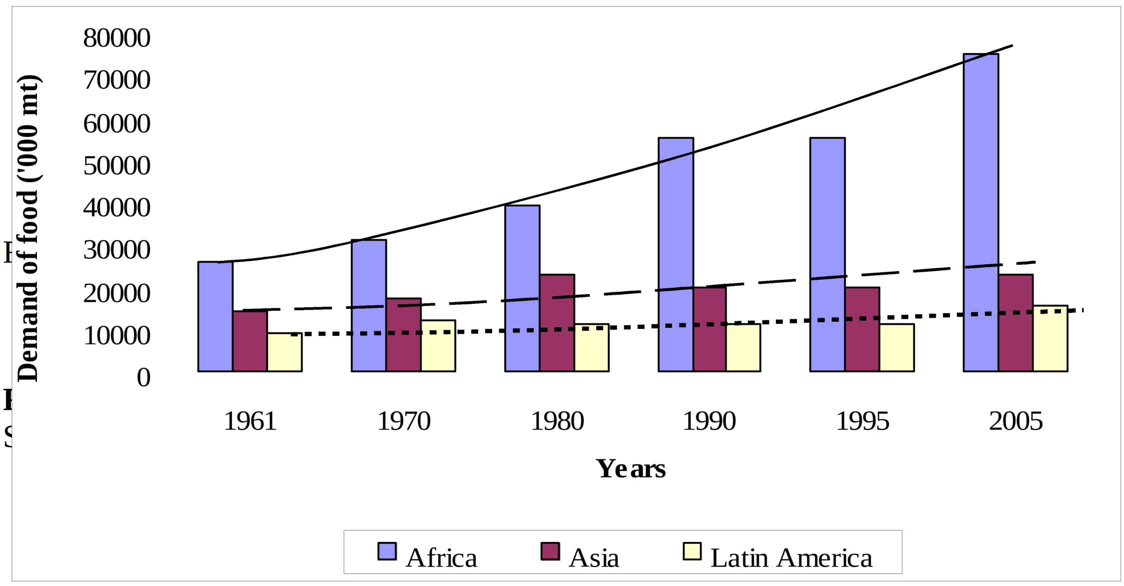
Taxes per year, in countries where farm machinery is taxed as personal property, such taxes could be calculated in a manner that depends on how taxes are a ssessed but in other countries there is no tax for farm machineries. For example Tanzania, there are no taxes for farm machinery so as to encourage agricultural mechanization (MOFP, 2009).

2.3.6 Operational Costs

The use-related costs such as fuel cost are calculated by multiplying the fuel consumption by the price of fuel, Lubrication cost is assumed to be 10 percent of fuel cost for heavy machines (Davies and Patton, 2000; Bakht *et al.*, 2009). The repair and maintenance costs are estimated by using total accumulated repair costs based on accumulated hours of lifetime use. Repair and maintenance calculations are based on American Society of Agricultural Engineers (ASAE) formulas, i.e., the total cost is then divided by accumulated hours to arrive at an average per hour cost estimate. The amount of annual use of a machine is an estimate of the number of hours a commercial farmer would use that particular machine in one year (Lazarus, 2008).

2.4 Demand for Cassava

Due to higher population growth rates and higher levels of cassava consumption the greatest growth potential for the use of cassava as a human food appears to exist in Africa. Equally, Asia has shown some signs of growth, while Latin America a slight decline.



Application of simple time trends to these data suggests that by the year 2015 African consumption could be approximately 91 million tonnes, Asia 26 million tonnes and Latin America 19 million tonnes per annum. This estimate represents an increase of approximately 21 million tonnes over the 1995 consumption level, and is close to the Food and Agriculture Organization (FAO) estimate of a 26 million tonnes increase between 1995 to 2005 (Figure 2).

In Tanzania, the situational analysis showed that there is a big potential demand for cassava. The current supply of fresh unpeeled cassava for immediate domestic consumption is far below demand, with unsatisfied market. Peeled and dried cassava chips as raw materials for human food and processing industries are in short supply.

The same is experienced for unpeeled dried chips as raw materials for livestock feeds industries. Moreover, a long term potential is the market for fresh unpeeled cassava roots for starch processing industries (if well invested in) (TAC, 2004).

Demographic changes provide both a challenge and an opportunity for increased demand for cassava as a human food. On the other hand, the increasing urban population provides an opportunity to sell more cassava if the product is of good quality and competitive price. Domestically therefore, growing urbanization offers opportunities to develop new, or unexploited markets for cassava (Poonte, 2001). Increased demand for cassava and its products caused the emergence of different cassava processing technologies in different cassava growing areas in the world.

2.5 Consumer’s Preference for Cassava Processing Technologies Products

2.5.1 Quality of cassava products

In recent years, Sokoine University of Agriculture (SUA) and the Ministry of Agriculture and Food Security (MAFS) under a joint project (TARPII-SUA) in Tanzania, implemented two cassava post-harvest researches. One of these was on processing of cassava for human consumption (Project 029) implemented in Magindu village (Kibaha district) and Songabatini village (Muheza district). The few successes realized included introduction, testing and adoption of chipping and grating machines by two farmers groups in these villages, invention of Kebab-looking food product (*kibabu*), and formulation of wheat-cassava flour buns, chapatti and futari (Laswai, *et al*., 2005; Silayo *et al*., 2004).

Another TARPII-SUA research was cassava processing for livestock feeds (Project 010) for which cassava was established to be a good ingredient in the formulation of poultry and pig feeds which were highly needed by livestock keepers. This project was implemented in Miswe and Zogowale villages (Kibaha).

In additional to that, in Ghana and Nigeria there is high quality traditionally processed cassava products such as *agbelima, fufu, gari and kokonte* which are mostly preferred by the people (Onumah, 2006; Jumah *et al.,* 2008) have shown that traditional *fufu* accounts for the largest share 40% of the Ghanaian household budget for cassava food products.

2.5.2 Consumer’s income

In Africa, cassava is a marginalized crop in food policy debates because it is burdened with the stigma of being an inferior, a low protein food that is uncompetitive with glamour crops such a imported rice and wheat. Many food policy analysts consider cassava an inferior food because it is assumed its per capita consumption will decline with increase of per capita income (Nweke, 2003).

2.5.3 Education of the consumer

The consumers' education level also affected their preference for certain food products. Generally, people tend to process cassava roots mainly into traditional foods as *fufu* (Nigeria) or *bada/Makopa* (Tanzania). Widowati and Hartojo (2000) in their study on production and use of cassava flour in Indonesia revealed that more than 70% of those with formal education processed cassava into traditional foods while those with higher education level seemed to use cassava flour for preparing more alternative cassava products as buns, chapatti and chips.

2.5.4 Household size

Household size played a very important role in explaining preference in cassava processed products. Jumah *et al.* (2008) found that the mean household size to be four and the number of persons consuming certain cassava products per household was found to be three. This implies that over 70% of the persons in households were consuming cassava products. Other factors which have been seen to influence the preference for cassava processed products were age, sex and how frequently cassava products were eaten or quantity consumed (Tomlins *et al*., 2007).

2.6 Meaning and Interpretation of Net Present Value Analysis

The concept of net present value (NPV), or discounted cash flow, has been mostly used in investment's analysis because it incorporates the timing and magnitude of cash flows within the analysis (Fleming *et al*., 2006). The technique has also been used by Sherrick *et al*. (2000) to select one of the two projects, which were competing in terms of equivalent incremental cash flows or benefits between the two options and were cancelled by evaluating the NPV of one project minus the other. Moreover, NPV analysis has been also used in the economic evaluation of different projects or investment (Goliath, 2004; Carpenter, 2003). At this juncture, the meaning and interpretation of NPV analysis has to be discussed in detail as follows.

NPV is an indicator of how much value an investment or project adds to the firm. With a particular project, if C_t is a positive value, the project is in the status of discounted cash inflow at time t. If C_t is a negative value, the project is in the status of discounted cash outflow at time t, where appropriately risked projects with a positive NPV could be accepted. This does not necessarily mean that they should be undertaken since NPV at the cost of capital may not account for opportunity cost in comparison with other available investments. In financial theory, if there is a choice between two mutually exclusive alternatives, the one yielding the higher NPV should be selected. The following summarises the NPVs in various situations.

If NPV > 0, it means that the investment would add value to the firm, thus the project may be accepted. If NPV < 0, it means that the investment would subtract value from the firm, thus the project should be rejected and if NPV = 0, it means that the investment would neither gain nor loose value for the firm, thus the decision may be indifferent whether to accept or reject the project. In the late case, the decision should be based on other criteria, for instance, strategic positioning or other factors not explicitly included in the calculation. However, when NPV = 0 it does not mean that a project is only expected to break even, in the sense of undiscounted profit or loss (earnings). It will show net total positive cash flow and earnings over its life but can not be acceptable without testing the viability of the project. Therefore, there is a need to call for sensitivity analysis to test for the project viability.

2.7 Sensitivity Analysis for Testing Viability of the Project

This is a technique whereby the viability of a project is tested against possible variations in the size and timing of the estimated costs and benefits. The analysis shows how “sensitive” the project viability is to various changes in variables (Saltelli *et al*., 2008). The process of sensitivity analysis is used to recalculate the NPV, Internal Rate of Return (IRR) and Benefit Cost Ratio (BCR) all based on estimates of project costs and benefits which are subject to varying degrees of uncertainty and risk.

When projects are implemented the actual flows of costs and benefits may be significantly different from the estimates. This study utilized a sensitivity analysis to determine what size change in a variable would cause the project to become non-viable. These changes are called “switching values” (Howlett and Nagu, 2001). However, such sensitivity analysis becomes increasingly unhelpful in representing the combined effects of multiple sources of uncertainty as the numbers of parameters increase (NICE, 2008). This limitation necessitates the use of partial budget for further analysis.

2.8 Partial Budget Analysis for the Project

Partial budgeting analysis is a planning and decision-making framework used to compare the costs and benefits of alternatives faced by a farm business (Roth and Hyde, 2002). It focuses only on the changes in income and expenses that would result from implementing a specific alternative (Tigner, 2006). A partial budget only includes resources that will be changed. It does not consider the resources in the businesses that are left unchanged. Only the change under consideration is evaluated for its ability to increase or decrease income in the farm business (Dalsted and Gutierrez, 2009). The partial budget framework can be used to analyze a number of important farm decisions, including adopting a new technology, changing enterprises, choosing to specialize, hiring custom work, leasing instead of buying machinery, modifying production practices and making capital improvements. The structure of the analysis depends upon the nature of the decision being analyzed (Roth and Hyde, 2002).

The partial budget analysis has been used by Jefferies *et al.* (1970) for analyzing the potential economic returns of alternative range practices and they suggested that, partial budget analysis is suitable for field use by ranchers and range technicians. Also the partial budget analysis has been used to determine the economic benefits of antibiotic treatment of chronic subclinical mastitis caused by *Streptococcus uberis* or *Streptococcus dysgalactiae* (Swinkels *et al*., 2005). Furthermore this analysis has been also employed in a new technology and new production techniques of catfish farming (Aquaculture) in evaluating a proposed change to an existing aquaculture operation, the basic issue to be addressed is whether or not the long-term profitability of the farm will be improved (Hanson *et al*., 2007). Therefore, the partial budget analysis has been used in this study to evaluate the economic benefits of an introduced cassava processing technologies.

2.9 Projection Future Production of Cassava Resulting from Introducing Mechanized Cassava Processing Technologies

Itharattana (2003) attempted to forecast cassava production in Thailand at two levels, national and regional levels. Ordinary Least Square (OLS) was used to estimate the coefficients in each equation. Cobb-Douglas type was applied in the planted area equation while time series model was used in the yield one. Applying the model for the *ex-ante* forecast, the total production was expected to be almost the same in 2002 when compared with the previous year.

Weaknesses in the model still remain in terms of some specification errors. Thus, to make *ex-ante* forecast more useful, some policy variables should be added to reflect the real situation more. The situation above shows that there is need to employ goal programming approach for solving the multi-objective function.

The approach has been used in river flow forecasting which constitutes one of the most important applications in hydrology. Several methods have been developed for this purpose and one of the most famous techniques is the auto regressive moving average (ARMA) model. In the research reported here, the goal was used to minimize the error for a specific season of the year as well as for the complete series of years. Goal programming (GP) was used to estimate the ARMA model parameters. Shaloo Bridge station on the Karun River with 68 years of observed stream flow data was selected to evaluate the performance of the proposed (GP) approach. The results when compared with the usual method of maximum likelihood estimation were favourable with respect to the new proposed algorithm (GP approach) (Mohammadi *et al.*, 2006).

In literature, most of fishery related studies have used lexicographic goal programming (LGP) model for the fishery planning problem and the solution under the decision-maker's priority structure is considered as the optimal solution (Sharma *et al*., 2006). However, in different complex decision-making situations, the desired solution may not be acceptable under the imposed priority structure; that is, a better solution is always expected for which a number of priority structures may be considered (Sharma *et al*., 2003).

In this research, the LGP model was presented to evaluate the introduced cassava processing technologies (mechanical processing) and related activities and their economic impact on cassava production in Tanzania. The LGP model was designed to illustrate how LGP can be used for future projection in cassava production due to the introduced cassava processing technology and related activities with multiple objectives. The technique allows finding the optimal solution, based on the priorities of the goals in a decision-making environment. In this study, the LGP used to examine a set of goals and objectives as they relate to cassava production.

A major strength of goal programming is its simplicity and ease of use. This account for the large number of goal programming applications in many and diverse fields (Jones and Tamiz, 2002). As weighted or non pre-emptive goal programmes can be solved by widely available linear programming computer packages, finding a solution tool is not difficult in most cases. Lexicographic goal programmes can be solved as a series of linear programming models (Ignizio and Cavalier, 1994; Ignizio, 1976).

Goal programming can hence handle relatively large numbers of variables, constraints and objectives. A debated weakness is the ability of goal programming to produce solutions that are not *Pareto* efficient. This violates a fundamental concept of decision theory that, there is no rational decision maker will knowingly choose a solution that is not *Pareto* efficient. However, techniques are available (Tamiz *et al*., 1999; Romero, 1991; Hannan, 1980) to detect when this occurs and project the solution onto the *Pareto* efficient solution in an appropriate manner. The setting of appropriate weights in the goal programming model is another area that has caused debate, with some authors (Gass, 1987) suggesting the use of the Analytic Hierarchy Process (AHP) or interactive methods (Ciptomulyono, 2008; White, 1996) for this purpose.

CHAPTER THREE

3.0 METHODOLOGY

3.1 Description of the Study Area

3.1.1 Location of the study area

This research was conducted in two regions which are Tanga and Pwani regions. The regions are situated on the Eastern part of Tanzania mainland along the Indian Ocean coastal belt. Economically, the coastal regions have a typical agricultural economy with more than 90% of its population depending on agriculture. The research was conducted at Tongwe village in Muheza District (Tanga region) and at Mikongeni village in Kibaha district (Pwani region). These have been chosen because cassava is widely cultivated by many farmers and cassava processing technologies (both traditional and mechanical) are used. Moreover, the study areas are in close proximity to urban markets such as Tanga and Dar es Salaam where there is potential growing demand for cassava and its respective products.

3.1.2 Topography

As mentioned earlier, the study was conducted in Muheza and Kibaha districts. Muheza has a variety of relief features of highland areas, for example Usambara Mountains which are a part of the Eastern arc Mountains. The District rises gradually from the Indian Ocean shores towards the northern and mid-southern areas to about 400 m above sea level. Rolling plains adjacent to the East Usambara Mountains rise to 500 m above sea level. This gently undulating to rolling landscape has slopes of 2-10 degrees. The steeply dissected hills, with slope more than 15 degrees and over 30 degrees in some areas, tower over the rolling plains to about 1600 m in the East Usambara Mountains. The Pangani, Zigi and Mkulumuzi rivers flow into the Indian Ocean and form the main drainage of the district. The rivers also dissect the lowlands (Fig. 2).

Kibaha district is within the eastern zone of Tanzania which lies at an altitude of about 60 m above the sea level. The district is covered by sand loam soils and heavy clay waterlogged soils which are suitable for cassava, paddy, vegetables and pulse production. The Ruvu river that discharge water into the Indian Ocean, contributes much to the main drainage of Kibaha district. For more information about the location of the study area see Fig. 3.

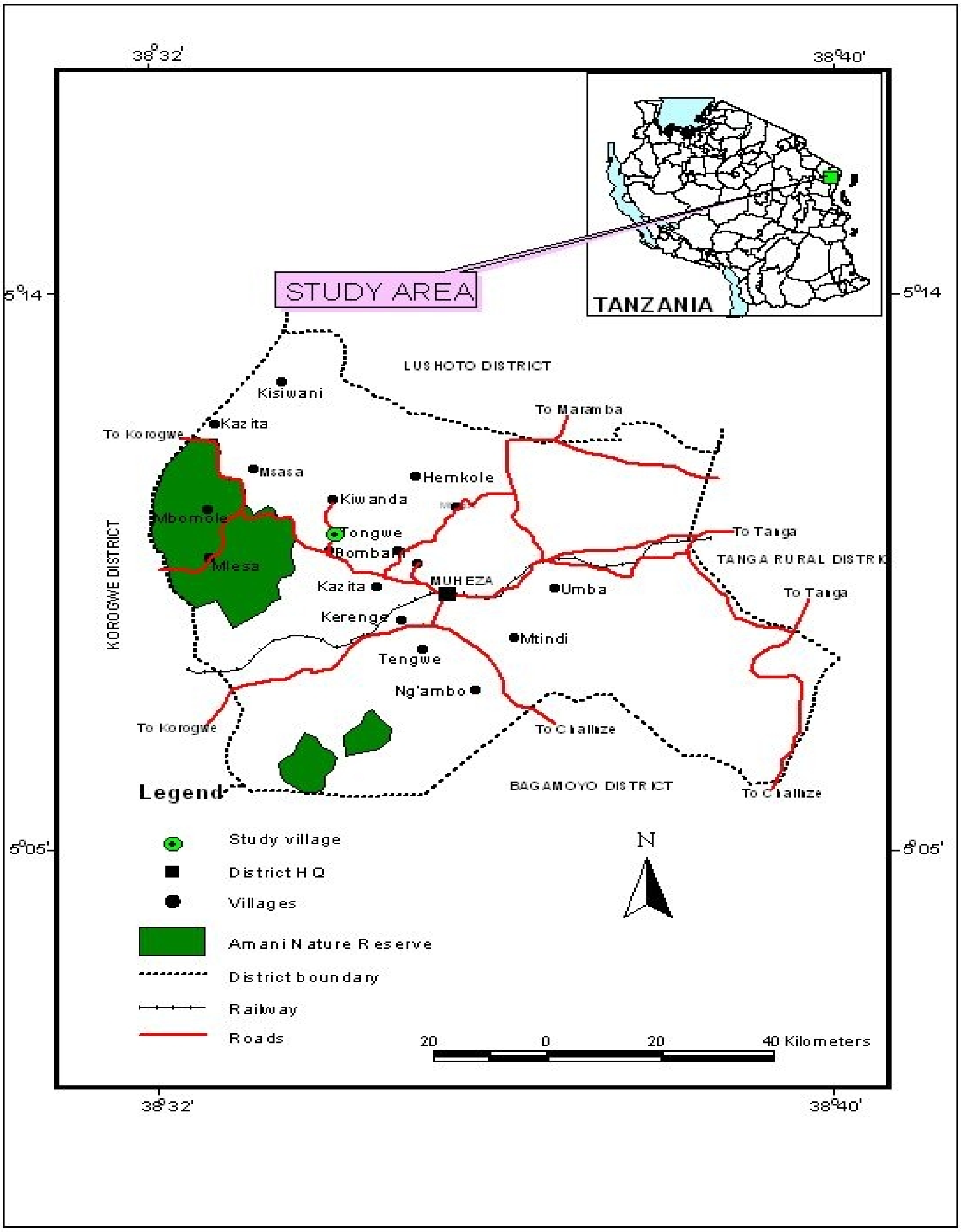


Figure 3: Map of Muheza district to show the study area.
(Source: GIS Office - SUA)

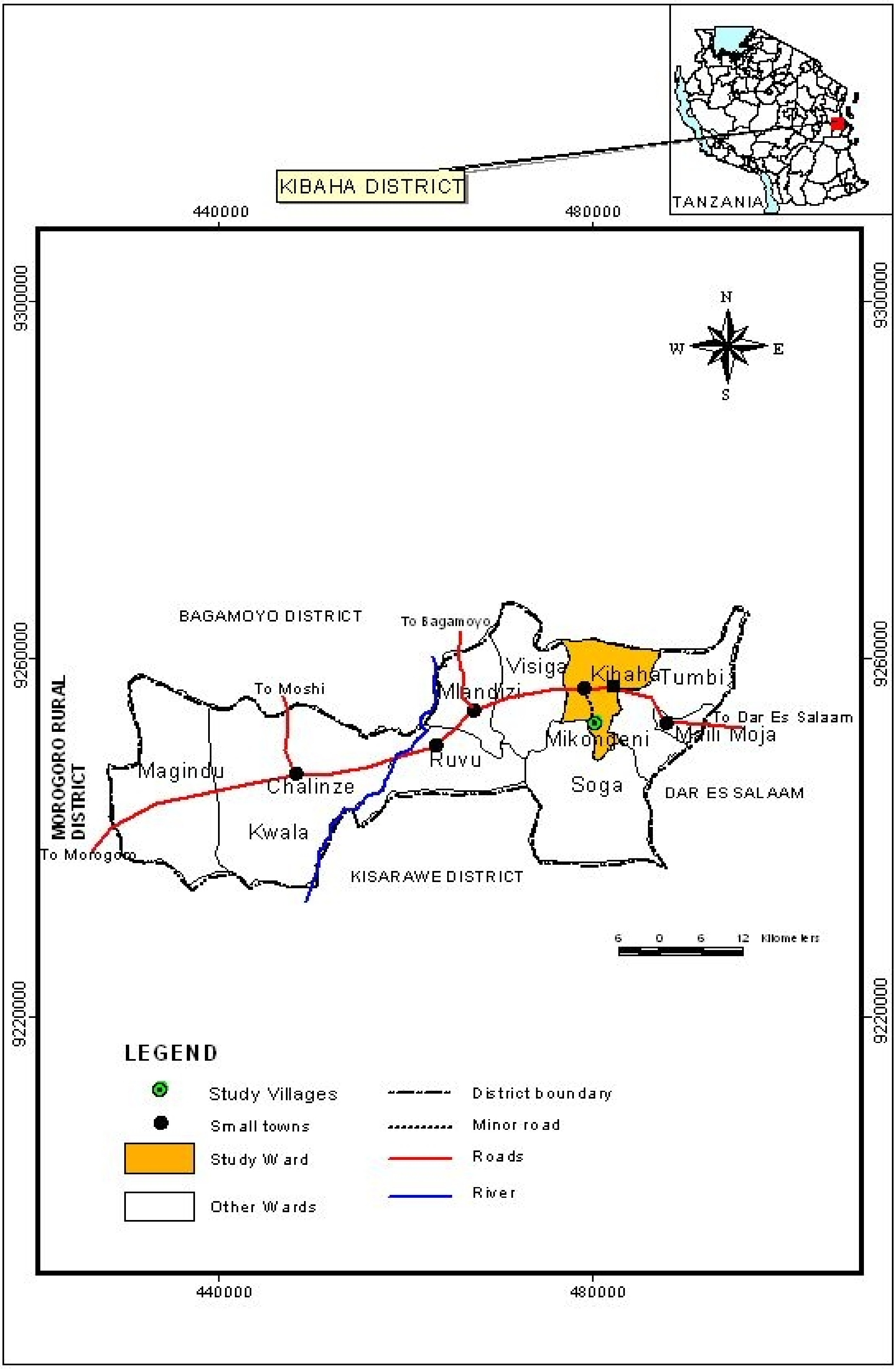


Figure 4: Map of Kibaha district to show the study area.
(Source: GIS Office – SUA)

3.1.3 Climate

The weather of the two regions is generally hot due to the influence of the ocean. The regions experience a tropical climate with an average temperature of 28^{0}C. There are two rain seasons, the main and short rain seasons, with the average of 1000 mm per year. The main rain seasons lasts for roughly 120 days between March and June. The rain is usually heavy and spread throughout the regions. This is also the main crop planting season for all crops, but especially so for the seasonal crops such as maize, paddy and cotton. The short rain season lasts for about 60 days between October and December. The rains are not evenly distributed and they are not very much reliable, suitable for short- term crops such as maize, cassava and paddy (NBS, 1997).

3.1.4 Economic activity

Economically, Pwani and Tanga regions have a typical agriculture economy with more than 90% of its population depending on agriculture. In the year 1996 Gross regional income of Pwani and Tanga regions were estimated as TZS 20.8 billions and TZS 92.8 billions respectively. Pwani region has lowest GDP per capita (TZS 28 149) while Tanga region has a GDP per capita of TZS 60 021. In 1994, Pwani and Tanga regions ranked last and 9th in the contribution to the National GDP, in which their contributions were 1% and 5.5% respectively according to NBS (1997). In 2002/03, Pwani and Tanga regions were among the most prominent cassava producing regions, contributing to about 17% of the total cassava produced in the country.

Cassava ranks the second after maize in terms of household producing it, area planted, and production volume in the country (MOA, 2003). In 2001/02 the crop contributed about 29% of food produced in the country preceded by maize which contributed about 49% of total volume of food (NBS, 2007).

3.2 Research Design

The research design for this study was a cross –sectional, where data were collected at a single point in time. The reason for choosing this design is simply because it is flexible, economical and easy to manipulate data and information (Bailey, 1994).

3.2.1 Sampling procedure and sample size

Purposeful sampling was used to select two villages where there is an on-going PANTIL cassava project. In this respect the village close to Kibaha town (Pwani region) and the other village more than 10 km off Muheza town (Tanga region), which situated along Arusha – Tanga main road were chosen, the villages were Mikongeni and Tongwe respectively. Then proportionate stratified sampling based on their income (i.e. those with low income versus those with high income) was employed. Thereafter, random sampling was employed to get a sample of 30 respondents from each stratum. Ultimately sample of 120 respondents were used for this study. A sample size of 30 respondents is deemed large enough (Wooldridge, 2008). The Central Limit Theorem (CLT) states that the average from a random sample for any population, with finite variance, has an asymptotic standard normal distribution. Most estimators encountered in statistics and econometrics can be written as functions of sample averages (Wooldridge, 2002). Therefore, the t-statistic was used as inference test of the model, based on the law of large numbers and the Central Limit theorem (CLT).

3.2.2 Theoretical and conceptual frame work

A conceptual framework helps to prevent fragmentation of knowledge statements. According to Kitani (1999), conceptual framework binds facts and provides guidance towards collection of realistic data and information.

Fig. 5 presents the conceptual framework for this study. The factors such as household income, household size, quantity consumed per year, quality of the product, age, education level and price of the products influence the consumer preference for the mechanically processed cassava products. The consumer preference influences consumption of cassava. Cassava consumption and other factors such as varieties in use, access to the market and processing costs lead to improvement in cassava production.

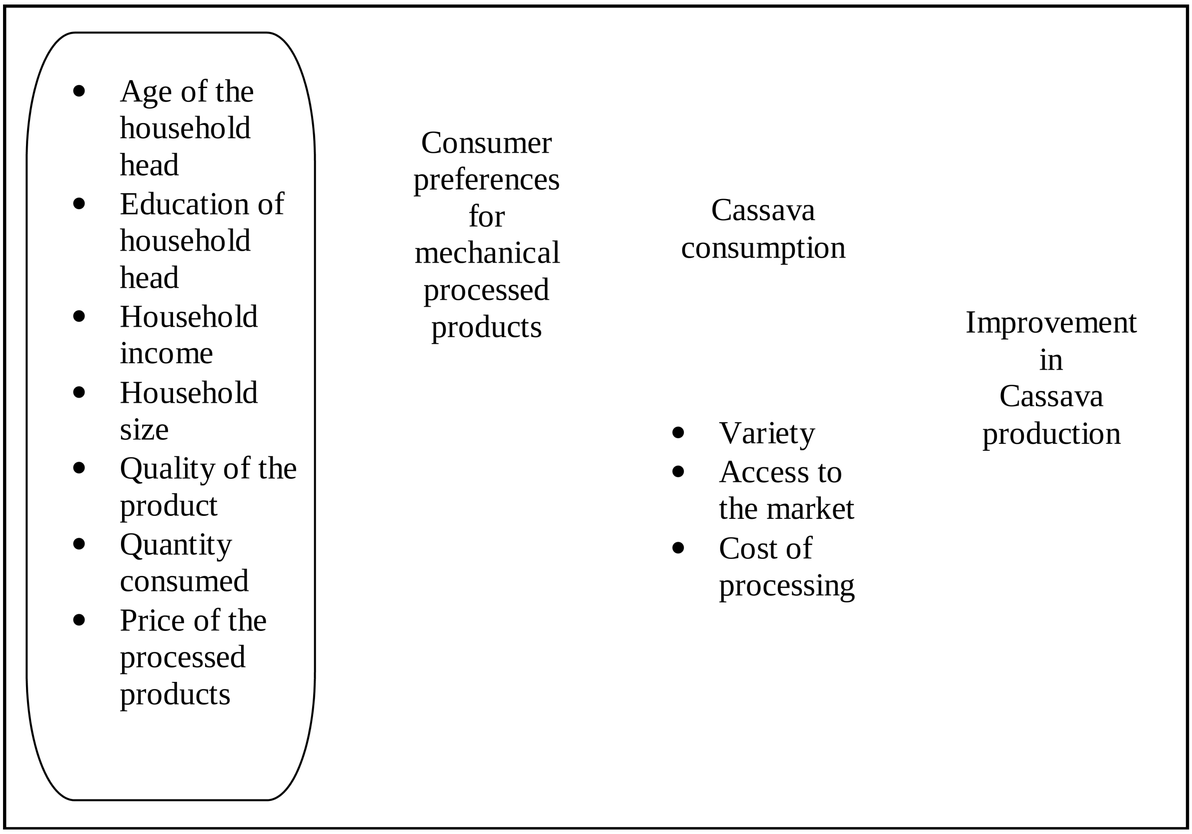


Figure 5: Factors determining cassava consumption and production.

3.2.3 Data collection

Structured questionnaires with both closed and open-ended questions, group discussions and observation were used as methods for collecting primary data. Data were collected through interview of the sampled households and key informants who were the village chairmen and agricultural field officers to each village. The key variables asked were the farmers (household) characteristics, household sources of income, cassava production, processing (traditional, wet and solid-state fermentation and mechanical) and consumption.

The experimentations were used to collect information on efficiency (in terms of operational, time, fuel consumption) of the mechanical processing technology from the study area. The experiments were conducted by taking 5 kg of chunks/pieces of pealed cassava into each machine (manual cassava chipper, engine powered cassava chipper and cassava grater). The time used to process the cassava by each machine was recorded by using stopwatch as a pilot, and then the experiments were repeated four times, whereas deep stick was used to measure the fuel level. Secondary data were collected by reviewing document from the respective District Agriculture Departments, Ministry of Agriculture, Food Security and Cooperatives, International Institute for Tropical Agriculture (IITA) reports, Sokoine National Agricultural Library (SNAL) and Internet.

3.3 Data Analysis

3.3.1 Analytical technique

Both the descriptive and quantitative analyses were employed in this study, based on the objectives stated. Descriptive analysis employed the use of means, percentages, and frequencies. The quantitative analysis involved the use of net present value, probit regression analysis and goal programming approach for forecasting the future of cassava production.

3.3.1.1 Net present value (NPV) of the machines

Net present value (NPV) or net present worth (NPW) (Lin and Nagalingam, 2000) is defined as the total present value of a time series of cash flows. It is a standard method for using the time value of money to appraise long-term projects. Used for capital budgeting, and widely throughout economics, it measures the excess or shortfall of cash flows, in present value terms, once financing charges are met and has been expressed as follows.

$$NPV = \sum_{t=1}^{n} \frac{C_t}{(1+r)^t} - C_o + \frac{R_n}{(1+r)^n} \quad \text{…………………………………………………………(5)}$$

Where;

NPV	=	Net present value,
C_t	=	Net cash flow,
C_o	=	Initial investment,
r	=	Discount rate in (%),
t	=	Time of cash flow and
R_n	=	Salvage value.

3.3.1.2 Probit regression analysis for estimating consumer's preference

The study employed the probit regression analysis to determine the significance of the number of factors which contribute to the consumer's preference (Eastwood *et al*., 1987) for cassava processed products to the household. Variables included in the model were income of the household, family size, number of years in schooling, gender of the household head, quality of the processed products, age of the household head and price of the processed products. In estimating probit regression model, the maximum likelihood estimation techniques were commonly used (Hennessy and Rehman, 2008; Victor, 2007; Feleke *et al*., 2005). The consumer's preference for mechanically processed products by the household was estimated by maximum likelihood methods as shown in equation (6) as follows;

$$Y = \alpha + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + ... + \beta_8 X_8 + \varepsilon \quad \text{……………………………………………..(6)}$$

Where;

Y	=	Preference for mechanical processed products (1= technology preference; 0 otherwise),
α	=	Constant,
X_1	=	Income of the household (low, high),
X_2	=	Quantity consumed by the household in bags,
X_3	=	Family size,
X_4	=	Price of processed cassava products,
X_5	=	Quality of the processed products (1= Mechanical processing technology; 0 otherwise),
X_6	=	Number of years in schooling,
X_7	=	Gender of the household head (1= male; 0 = otherwise),
X_8	=	Age of the household head,
ε	=	The error term.

3.3.1.3 Goal programming approach

Goal programming is a branch of multi-objective optimization, which in turn is a branch of multi-criteria decision analysis (MCDA), also known as multiple-criteria decision making (MCDM). It can be thought of as an extension or generalization of linear programming to handle multiple, normally conflicting objective measures (Pournamdarin, 2008). Each of these measures is given a goal or target value to be achieved. Unwanted deviations from this set of target values are then minimized in an achievement function. This can be a vector or a weighted sum dependent on the goal programming variant used as satisfaction of the target which deemed to satisfy the decision makers (Andrew *et al*., 2008; Diaz-Balterio and Romero, 2008). This approach was used to project the future production of cassava resulting in a change of cassava processing technologies and consumption behavior; and the linear programming software package (LP-WYE) was used for the analysis and it was formulated as follows;

Objective function

Max $Z(Q)$

Subject to $C_r(Q) - g_r = u_r^+ - u_r^-$, $r = 1 \text{ to } k$

Non-negativity

$$u_r^+, u_r^- \geq 0, \; r = 1 \text{ to } k \quad \text{...(7)}$$

Where;

$Z(Q)$	=	The production function for cassava maximization (Objective function)
G_r	=	The goal or target value
u_r^+	=	The positive deviation from the goal or target value set
u_r^-	=	The negative deviation from the goal or target value set
Q	=	Is a summation of Q_1 and Q_2 which are bitter and sweet varieties respectively
$C_r(Q)$	=	The constraints of the objective function were as follows:

The consumption is given the first priority level i.e.

$$C_o(Q) - G_{CO} = U_{CO}^{+} - U_{CO}^{-} \quad \ldots\ldots(8)$$

The variety is given the second priority level i.e.

$$V(Q) - G_V = U_V^{+} - U_V^{-} \quad \ldots\ldots(9)$$

The access to market is given the third priority level i.e.

$$M(Q) - G_m = U_m^{+} - U_m^{-} \quad \ldots\ldots(10)$$

The cost of processing is given the fourth priority level i.e.

$$C_c(Q) - G_c = U_c^{+} - U_c^{-} \quad \ldots\ldots(11)$$

The price of the processed products is given the fifth priority level i.e.

$$P_p(Q) - G_p = U_p^{+} - U_p^{-} \quad \ldots\ldots(12)$$

Where:

$C_o(Q)$ = Consumption function, G_{co}= Goal set for consumption, $V(Q)$= Variety function, G_v= Goal set for variety production, $M(Q)$ = The quantity of Cassava accessed to the market, G_m = Goal set for quantity to be accessible to the market, $C_c(Q)$ = Cost processing function, G_c = Goal set for processing cost, $P_p(Q)$ = The price function of the processed product, G_p = Goal set for the price for the processed products, U^+s, U^-s are the non-negativity deviation from the goal setting.

3.4 Limitation of the Study Methodology

Research regarding mechanical cassava processing technologies in particular, few has been carried out in Tanzania. It was thus very difficult to access relevant materials pertaining to the theme of this study, mainly in machine costs evaluation.

Most of the data were obtained through interviewing farmers and practical experimentation in those three technologies whose replies were subject to error due to inadequate knowledge, or faulty memory or because of untruthful replies evolved by consideration of pride or suspicious in case of the farmer's interview. Conversion units were also the problem since some farmers use local units (e.g. acre, bags, *debe*, tins). However estimation had been done to convert local units into standard ones such as kilogram (kg).

This research work is based in Tongwe and Mikongeni Villages in Muheza and Kibaha districts. The results of the study are based on cross-sectional data collection from limited number of observations (farmers) in selected area of Tongwe and Mikongeni village. Therefore, conclusion drawn from the study cannot be generalized for the whole country in most cases. Furthermore, the study gives what could be happening if mechanical cassava processing technologies are carried out through the entire country.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSIONS

4.1 Social-economic Characteristics of the Respondents

Characteristics of respondents interviewed have important social and economic implications towards factors influencing cassava production and consumption. For example, family characteristics such as age usually influence the quantity of the agricultural output. Therefore, this section describes the characteristics of sampled respondents, focusing on age, gender, household size and education level.

4.1.1 Age of the respondents

The distribution of farmers according to age is presented in Table 1. Results show that majority of the respondents (67.5%) were above 36 years of age and people with active age (17 to 55 years) constituted 80.8% of total respondents. Meanwhile, respondents aged above 55 years were 19.2%. Basing on the information above, it is clear that in the study area the working force is available and able to work in agriculture as their main economic activity but large percentage (48.3%) of the sampled cassava farmers are falling in the age of 35 to 55 years (Table 1).

4.1.2 Gender of the respondents

Result in Table 1, show that, about 63% of the respondents were male and the remaining 37% were female. Skewed results were expected since men are the household heads to whom the interview was directed. As far as cassava production is concern as observed by TADENA (2004), access and use of land for cassava production is not gender biased. Either of the sexes can get involved in cassava production. There is no bias when it comes to providing access to farmland for women. Likewise, there are no important cultural beliefs and practices that are likely to affect the development of cassava (Table 1). The results also show that 32% and 38% of the men and women respectively within sampled households were using mechanized cassava processing technology.

Table 1: Social-economic characteristics

Variable	Categories	Frequency	Percentage
Age	17-35	39	32.5
	36-55	58	48.3
	>55	23	19.2
	Total	120	100.0
Gender	Male	75	62.5
	Female	45	37.5
	Total	120	100.0
Household size	1-3	28	23.3
	4-6	71	59.2
	>6	21	17.5
	Total	120	100.0
Education level	No formal education	22	18.3
	Standard four (iv)	3	2.5
	Primary education	74	61.7
	Secondary education	21	17.5
	Total	120	100.0

4.1.3 Household size of the respondents

Results in Table 1, shows that about 23.3% of the households have 1-3 members and 59% of the household sizes have members ranging between 4 and 6 and only 17.5% of the sampled households were above 6 household's members. Therefore, majority of the households (76.7%) have 4 members and above, which signifies that there is enough work force due to the fact that majority of population in the study area fall in the age of 17-55 years.

4.1.4 Education of the respondents

Education is one of the factors that influence cassava production. A farmer with formal education is likely to be innovative or adoptive to new technologies than a farmer with no formal education whereas other factors remain constant. The study revealed a moderate rate of literacy in the study area. Results on level of education showed that respondents in the study area have attained formal education. The majority of sampled household heads in the study area (61.7%) and (17.5%) had attained primary education and secondary education respectively. These findings support the observation by the assessment of agricultural marketing information needs study (URT, 2004), which found that there is a large number of farmers with primary education and above. This shows that, the introduced cassava processing technology could be easily adopted in the study area because most of the farmers have formal education although the adoption depends with the efficiency of the technology and its profitability to the farmers.

4.2 Cassava Processing Technologies Used in Study Area

In Tanzania there are main three technologies that are commonly used for processing cassava; these are traditional sun drying of plain chunks (Makopa), traditional wet and solid-state fermentation and mechanical processing technology.

- Traditional (drying) cassava processing technology is consummated by peeling and cutting the fresh cassava into large pieces before being left for drying process (Fig. 6).
- Traditional wet and solid-state fermentation cassava processing technology is accomplished by peeling and cutting the fresh cassava into large pieces like in the production of unfermented chunks/pieces traditional (drying), then the chunks/pieces are soaked into water for 5-6 days, before being dried (Fig. 7).

Figure 6: Chunks that underwent solid-state fermentation

Figure 7: Wet-fermentation staff done by soaking in water

- Mechanical processing technology is sub divided into two processes, which are grating and chipping processes. The grating is a technology which processes peeled cassava to produce very tiny (grated) cassava particles (Fig. 13). The grated cassava therefore, is pressed in a pressing machine for dewatering process in order to reduce water content which contains cyanide and starch. Hence, it becomes easy to reduce the remained moisture content through sun-drying. The process is especially applied to varieties with high cyanide content.

The chipping process is a technology that produces small chips as compared to traditional (drying) and traditional (wet and solid-state fermentation) (Fig. 12). This is applied to varieties with low cyanide content. The type of equipments used are mostly made up of stainless still which are user friendly since it has harmless (poison free) effect to the products as well as consumers, for instance, rusting. See the equipment as follows;

Figure 8: Manual cassava chipping machine

Figure 9: Engine powered cassava chipping machine

Figure 10: Cassava grating machine

Figure 11: Cassava press

Figure 12: Cassava chips on drying process

Figure 13: Grated cassava

4.2.1 The technology applied by the respondents the sampled villages

Results in the Table 2, show that, 37.5% of the sampled farmers used the traditional processing technology (drying). In the study area, the traditional processing technology (drying) is mostly used because the farmers were not aware with mechanical processing technology. During the survey it was observed (through observation) that other farmers (non project participants) were admiring the way the machines were working efficiently. However, non project participants prefer the mechanical processing technology to other local processing technologies. This is due its short duration to obtain the final product (cassava flour), high quality and seems to reduce the cyanide content at more than 95% (IITA, 1996). The results of the technology applied were as follows;

Table 2: The technology applied or used by the respondents in the sample villages

Technology applied or used	Village where respondent live		Total	Percentage
	Mikongeni	Tongwe		
Mechanical	14	27	41	34.2
Traditional	26	19	45	37.5
Wet and Solid-state fermentation	20	14	34	28.3
Total	60	60	120	100.0

4.2.2 Technical efficiency of cassava processing technologies

In the analysis of technical efficiency the following parameters were observed on mechanical, traditional drying and traditional wet and solid-state fermentation. In the case of mechanical processing technology, the manual chipping process is so smooth that it does not need a lot of calories to run the machine. Maximum of two people are needed to operate the machine and it takes about 3 minutes and 30 seconds to process 5 kg of fresh cassava. The engine powered chipper and grating machines also use about 5 litres of fuel (petrol) to process 1- 1.2 tonnes of flesh cassava, taking about 3 minutes to process 5 kg of fresh cassava. A maximum of two people are needed to operate those machines chipping and grating of cassava to very small size particles result in drying time of about 1 to 3 days which is shorter compared with traditional drying and traditional wet and solid-state fermentation.

As far as traditional (drying) processing technology is concerned, the pieces are cut into large sizes as shown in figure 6 above and it takes about 6 minutes per 5kg to perform this activity. This causes the drying process of the processed cassava to take long time (about 6 days), therefore traditional processing technology is still less efficient in terms of time compared to mechanical processing technology.

Table 3: Technical efficiency of cassava processing technologies

Input	Traditional (drying) processing	Traditional (wet and drying fermentation) processing	Mechanical processing technology	
			Manual	Engine powered
Labour	1	1	2	2
Time (days)	7	12	1-3	1-3
Fuel kg/l	-	-	-	240-300
Duration to dry (days)	6	6	1-2	1-2
Quality	Poor	Relatively high compared to traditional (drying)	High	High

Nevertheless, the traditional (wet and solid-state fermentation) processing technology uses more water for washing and wetting, which is about two times of the other two processing technologies. The pieces used for traditional processing technology can also be used in the wet and dry fermentation, but take longer duration (12 days) than in traditional processing to obtain the final product (flour). Therefore, in terms of time, mechanical processing technology still is more efficient as it uses short time in processing than other processing technologies.

4.2.3 Economic efficiency of cassava processing technologies

The economic efficiency is the quantity of output times the value of that output divided by the costs of production, but in this study costs of production were taken as the costs of processing. The values of the output from traditional, wet and solid-state fermentation and mechanical processing were TZS 300, TZS 400, and TZS 600 respectively, while their costs of processing were TZS 125 (traditional), TZS 150 (wet and solid-state fermentation) and TZS 150 per kilogram (mechanical). Hence the results obtained were as follows; 2.4, 2.6 and 4 for traditional, wet and solid-state fermentation and mechanical processing technology respectively. Therefore, still the mechanical processing technology is superior to other processing technologies (Table 4).

Table 4: Economic efficiency of cassava processing technologies

Technology	Value of the output per kilogram (TZS)	Cost of processing (TZS)	Economic efficiency
Traditional (drying) processing technology	300	125	2.4
Traditional (wet and solid-state fermentation)	400	150	2.6
Mechanical processing technology	600	500	4.0

4.3 Comparative Cost of Cassava Processing Machines

The machines used for mechanical processing technology were manufactured by Intermech Engineering Ltd of Morogoro. There are three types of processing machines, which are chipping machines, grating machines and pressing machine. The chipping machines are of two models, that is manually chipping machine and engine powered chipping machine. Description of each is presented in Table 5.

Table 5: Model specification of processing machines

Machine	Model specification	Function	Life span (years)	Price (TZS)
	Manual	Cassava chipping	5-7	300 000
	Engine powered (5.5hp)	Cassava chipping	5-7	950 000
	Engine powered (5.5hp)	Cassava grating	5-7	1 210 000
	Hydraulic	Press grated cassava to remove significant amount of liquid (containing cyanide and starch)	5-7	495 000

The prices of those machines which are manual chipping, engine powered chipping, grater, and cassava presser are TZS 300 000, TZS 950 000, TZS 1 210 000 and TZS 495 000 respectively, each with a life span of 5-7 years as shown in Table 5.

4.3.1 Operating costs of the machines

Operating costs for machines comprise repair and maintenances cost, operators allowances, insurance, taxes and depreciation. Repair and maintenance costs were taken as 10% of the prices of each machine, due to being small machines as shown in the Table 6. The operators’ allowances have been estimated to be TZS 1 500 which is based on absentee’s fees in different project activities done by project participants. Therefore, payment was subdivided into different activities from preparation of fresh cassava to the drying processes, this suggesting that the machine operators’ allowance was TZS 400 out of 1 500 TZS per day. This makes a total of TZS 12 000 per month for a single machine operator of manually chipping machine. The machine needs two operators which costs TZS 24 000 per month, making TZS 72 000 (processing costs) for a processing season of three months (Table 6).

In case of engine powered chipping machine, two operators are also needed and it was suggested that, each operator may be paid TZS 400 per day, which makes a total of TZS 12 000 per month that means a cost of TZS 36 000 is incurred per processing season. Since two operators are needed to operate the machine, a total cost of TZS 72 000 is incurred per year. These estimations were also applied to cassava grating machine. Insurance and taxes were negligible thus not considered in the analysis (Table 6).

Table 6: Operational costs per year

Type of cost	Manual chipping machine (TZS)	Engine powered chipping machine (TZS)	Cassava grating machine (TZS)
Repair and Maintenances costs	30 000	95 000	121 000
Operators allowances	72 000	72 000	72 000

Insurance	-	-	-
Interest			
Taxes	-	-	-
Depreciation	40 000	129 300	164 300
Total	142 000	296 300	357 300

The depreciation cost was associated with tear and wear of the machine and was estimated by using straight line method. The machines with life span of 7 years have the salvage values of TZS 20 000, TZS 45 000 and TZS 60 000 for manual, engine powered, and cassava grating machines respectively.

4.3.2 Net present value of the machines

The Net Present Value (NPV) was used to test the worthiness of using the machines based on 7 years. The variables used were initial cost, average running cost, and average income discounting factor as shown in Table 7. Detailed information is attached in Appendices 5 to 7.

Table 7: Net present values of machines

Variables	Manual chipping machine	Engine powered chipping machine	Cassava grating machine
Initial cost (TZS)	300 000	950 000	1 210 000
Discounted cost (TZS)	140 571	308 115	345 247
Discounted benefit (TZS)	456 193	456 193	456 193
Discounting factor (%)[1]	20.0	20.0	20.0
(No of years)	(7)	(7)	(7)
NPV	1 465 481	1 844 168	2 093 064
Decision	acceptable	acceptable	acceptable

[1] Base on commercial banks recommendation

The results obtained in Table 7, show that all the NPVs for the three machines were positive, suggesting that any of the machines can be accepted. Furthermore, to ascertain the machine, BCR analysis was conducted and results are presented in Table 8.

Table 8: Benefit-Cost ratio analysis of the machines

Machine	Discounted benefits	Costs	Benefit-Cost Ratio
Manual chipping machine	456 193	140 571	3.25
Engine powered chipping machine	456 193	308 115	1.48
Cassava grating machine	456 193	345 247	1.32

Therefore, the manual chipping machine has highest benefit-cost ratio (3.25), which means that, benefits outweighs the costs hence more profit is realized using manual chipping machine as compared to other machines. However, the NPV and BCR for machines do not cover all costs and benefits of the project. In order to cover these costs and benefits sensitivity analysis was carried out to evaluate the project viability.

4.3.4 Sensitivity analysis to test viability of the project

Sensitivity analysis was employed for the mechanized technology with a projection of seven years to see the viability of the project. The NPV, IRR and BCR were calculated and the results were 743 585, 42% and 1.66 respectively as shown in Appendix 8; the value for BCR shows that the benefits outweigh the costs, which means that the project is viable. Furthermore, the changes to various key variables such as sales prices and operating expenses were done, where the decline of 5% of sales price caused the NPV to be 565 467 and IRR was 36% whereas an increase of 5% of the operating expenses caused NPV to be 564 230 with IRR of 36% (Appendix 5). Therefore the project is also viable since the changes of key variables also caused a small change in NPV and IRR was constant, that means consistence exists. Since the sensitivity analysis does not estimate the profit of the machines, partial budget analysis was employed to determine the profit realized by each machine as compared to traditional processing technologies.

4.3.5 Analysis of change from local to mechanized technology

The partial budget analysis was applied to calculate the economic benefits for mechanized cassava processing technology. The seven components (added costs, reduced returns, reduced costs, added returns, totals of the first two and the second two, and a net difference) were taken into consideration as follows.

4.3.5.1 The added returns for using the mechanized technology

Table 4 revealed that, there are added returns from introduced cassava processing technology, since processed cassava produced high quality cassava products hence the price rose from TZS 400 to TZS 600 per kilogram. The difference in price was TZS 200 which caused the added returns of TZS 200 000 per tonne. Also according to IITA (1996), the food losses were reduced from 22.3% to 10.1% of the fresh cassava, hence caused an added returns of TSZ 73 200 per tonne. Therefore, signified the total added returns of TZS 273 000.

4.3.5.2 The reduced costs for using the mechanized technology

This section considers the reduction in operating costs. The study revealed that, there is a reduction of time (6-9 days) to obtain a final product (cassava flour) by using the introduced cassava processing technology. Thus introduced technology can be used to process fresh cassava two to three more times compared to local processing technologies for the same period. The extra processing cost per kilogram compared to local technologies is TZS 200 which leads to TZS 200 000 processing cost per tonne, times two which is the lowest number of times the introduced processing technology can be done compared to local processing technologies, gives a total reduced cost of TZS 400 000. Therefore, the reduced cost per day is about TZS 50 000 (Table 9).

Table 9: Partial budget analysis resulting from a change to mechanized technology

Positive impacts		Negative impacts	
Manual chipping machine			
Added returns	TZS/tonne/day	Added costs	TZS/tonne/day
Increased return due quality	200 000	Depreciation	110
A gain from food losses	73 000	Repair and maintenance	85
Reduced costs		Labour	2 400
Cost due to reduction of Processing time (Duration)	50 000		
		Reduced returns	-
Total positive impacts	323 000	Total negative impacts	2 595
		Net benefit	320 405
Engine powered chipping machine			
Added returns		Added costs	
Increased return due quality	200 000	Depreciation	355
A gain from food losses	73 000	Repair and maintenance	260
Reduced costs		Labour	2 400
Cost due to reduction of Processing time (Duration)	50 000	Fuel	5 460
		Reduced returns	-
Total positive impacts	323 000	Total negative impacts	8 475
		Net benefit	314 525
Cassava grater machine			
Added returns		Added costs	
Increased return due quality	200 000	Depreciation	450
A gain from food losses	73 000	Repair and maintenance	330
Reduced costs			
Cost due to reduction of Processing time (Duration)	50 000	Labour	2 400
		Fuel	5 460
		Reduced returns	-
Total positive impacts	323 000	Total negative impacts	8 640
		Net benefit	314 360

4.3.5.3 The added costs for using the mechanized technology

This section considers the extra expenses of using the introduced cassava processing technologies. The study revealed that, the expenses are depreciation, repair and maintenance, labour and fuel. From Table 6 above, the depreciations of manual chipping, engine powered chipping and grating machines are TZS 110, TZS 355 and TZS 450 per day respectively (Table 8). Repair and maintenance cost for manual chipping, engine powered chipping and cassava grating machines are TZS 30 000, TZS 95 000 and TZS 121 000 per year, which also means TZS 85, TZS 260 and TZS 330 per day, respectively. Labour costs are about TZS 2 400 for three days of processing and drying, also the fuel costs are about TZS 5 460 per tonne for engine powered and cassava grating machines.

4.3.5.4 The reduced returns for using the mechanized technology

There are no reduced returns caused by mechanized processing technology over the traditional (local) processing technologies. Therefore the reduced returns of using mechanized technology are zero over traditional (local) processing technology.

The effect can be summarized by summing up the added returns and the reduced costs of using the mechanical technology, which make the aggregation of positive impact of using the mechanized technology. Hence summation of positive impact was TZS 323 000 per tonne while that of negative impact, is a summation of the added costs and the reduced returns of using the manual chipping machine, which is TZS 2595 per tonne. Therefore subtracting the negative impact from positive impact, then net benefit is TZS 320 405 per tonne, which means a net profit of TZS 320.40 per kilogram by using manual chipping machine (Table 10).

Table 10: Profit made by each machine

Machine	Total positive impact (TZS/tonne/day)	Total negative impact (TZS/tonne/day)	Profit made per kilogram (TZS)
Manual chipping machine	323 000	2 595	320.40
Engine powered chipping machine	323 000	8 475	314.53
Cassava grating machine	323 000	8 640	314.36

Table 10 indicates that the total positive impact made by engine powered and cassava grating machines was TZS 323 000 per tonne and the total negative impacts were TZS 8 475 and TZS 8 640 per tonne. Therefore subtracting the negative impact from positive impact, then net benefit are TZS 314 525 and TZS 314 360 per tonne, which means a net profit of TZS 314.53 and TZS 314.36 per kilogram for engine powered chipping and cassava grating machines respectively.

4.4 Analysis of Consumer’s Preference of Cassava Flour by Method of Preparation

As noted in the methodology, the analysis was done to examine the consumer’s preference for cassava mechanically processing products. The study revealed that, there were consumers of the mechanical processed products versus non users. Consequently, the analysis was centred on variation of variables in relation to cassava consumption versus different technologies.

The results from the consumer’s preference for mechanically processed cassava products in Table 11, show the likelihood ratio statistic of the suggested model was significant ($P < 0.05$), correctly predicting participation in 74.2% of the cases. Therefore the most significant influencing consumer’s preferences factors for mechanically processed products of cassava were quality of the product, quantity consumed, household size and price of the processed products.

The quality of the products was one of the most influencing factors for consumer's preference for mechanically processed products; it is positively related to the consumer's preference and statistically significant ($p < 0.01$). Being of high quality products increased the probability by 0.497 (marginal effect) to opt for mechanically processed products. This result was confirmed by Onumah (2006), Laswai *et al*. (2005) and Silayo *et al*. (2004) who found that the high quality processed products were mostly preferred by people.

Table 11: Probit regression analysis results for consumer's preference

Variable	Coefficients	Std. Error	Probability	Marginal effects
Age	0.016	0.216	0.464	0.003
Gender	- 0.399	0.492	0.418	-0.074
Education	0.052	0.076	0.499	0.009
Household size	1.199	0.355	0.001*	0.223
Income level	0.396	0.451	0.379	0.074
Quality of products	2.312	0.591	0.000**	0.497
Quantity consumed	0.893	0261	0.001*	0.166
Price	-1.099	0.523	0.036*	-0.291
Constant	-3.630	1.375	0.008	

Log likelihood value = -26.24, Likelihood ratio statistics χ^2_8 = 94.11, Pseudo R^2 = 64.19%, % of correct prediction = 74.2%, Number of observation (N) = 120, **statistically significant at $P < 0.01$, *statistically significant at $P < 0.05$.

The quantity consumed by the household was statistically significant ($p < 0.05$) and positively related to the consumer's preference for cassava mechanically processed products (Table 11). This implies that a unit increase in quantity consumed increases the probability to prefer mechanically processed products by 0.166 (marginal effect).

Table 11 also indicates that household size was statistically significant ($p < 0.05$) and positively correlated to preference of the mechanically processed cassava products. This suggests that an increase in household size by one unit (person), increases the probability of preference to mechanically processed products by 0.223 (marginal effect).

The price of the product was statistically significant ($p < 0.05$) but negatively related to cassava mechanically processed products. This means that an increase in one unit for price caused a decrease in probability option to cassava mechanically processed products by 0.219 (marginal effect). This conforms with the Law of Supply and Demand which states that the high the price the low the quantity demanded and vice versa, at a given point in time *ceteris peribus.* Also there are other factors which contributed slightly with positive relationship but not significant like age and education whereas gender had a negative relationship.

Therefore, after having studied the consumer's behaviour the study aimed at projecting the future production of cassava in the study area, as a combined effect of introduced cassava processing technologies.

4.5 Projection of Future Production of Cassava Resulting from Mechanized Cassava Processing

The projection for the future production in cassava of the two districts (Muheza and Kibaha) was done by using goal programming approach. Muheza district is superior to Kibaha district in cassava production, but the total production of the two districts was taken as the bench mark for future projection for cassava production. According to the respective District Agricultural and Livestock Development Officers (DALDO), the production of Muheza and Kibaha districts were estimated at 75 000 and 5000 tonnes, respectively which make a total of 80 000 tonnes.

The study categorised production into two categories, that is sweet and bitter varieties of cassava, and results of production found to be with a proportionality of 5:3 respectively. According to this proportionality, the sweet varieties had production of about 50 000 tonnes and about 30 000 tonnes for the production of bitter varieties. This shows that, sweet varieties are more produced than bitter varieties due to their immediate consumption.

4.5.1 Formation of coefficient matrix for constraints

Any maximization function must involve constraints; the constraints used to maximize production of cassava in this study were consumption of cassava, varieties for cassava production, access to the market for cassava products, costs of cassava processing and prices for processed cassava. Therefore the coefficient matrix formed was as follows: the consumption of bitter and sweet varieties ratio was 1 500:2 000 tonnes and the goal or targeted value for this was set at 30 000 tonnes per year per village with the positive and negative deviations of 500 tonnes (Table 12).

The second constraint was variety, in good management (agronomic) bitter variety can produce up to 8 tonnes per acre and 7 tonnes for sweet variety, which in combination they can produce 15 tonnes, therefore the goal or targeted value set for that one was 18 tonnes with a positive deviation and negative deviation of 3 tonnes. The important concept to bear in mind here is that, bitter varieties produce more yield than sweet varieties.

The third constraint was access to the market. Table 12 shows that the constraint has 400:500 ratio of bitter and sweet variety accessed to market respectively, with a goal or targeted value of 20 000 tonnes from a bench mark of 15 000 tonnes. Also the positive and negative deviations were 5000 tonnes.

The fourth constraint was cost of processing. The observation made shows that there was no difference in cost of processing of neither bitter varieties nor sweet varieties and thereafter it was estimated to cost 150 TZS per kilogram which implies 150 000 TZS per tonne as processing cost. The positive and negative deviations were 50 000 TZS (Table 12).

Table 12: Coefficient matrix for optimization of cassava production

Constraints	Bitter variety in tonnes (Q_1)	Sweet variety in tonnes (Q_2)	Positive deviation from targeted value(U^+)	Negative deviation from targeted value (U^-)	Total
Consumption (t)	1 500	2 000	500	500	30 000
Variety productivity (t/acre)	8	7	3	3	18
Access to market (t)	400	500	5 000	5 000	20 000
Cost of processing (TZS/kg)	150	150	50 000	50 000	150 000
Price per tonne (TZS)	500	500	100 000	100 000	500 000
Total for each variety	30 000	50 000	-	-	-

The last constraint was the price of the processed products. The cassava flour processed from bitter varieties is more preferred, than the sweet cassava flour. Because it is difficult to differentiate them in the market, hence their prices were the same. The bitter cassava flour was TZS 500 per kilogram whereas TZS 500 also for sweet cassava flour. Therefore, taking the maximum price per tonne, a cost of about TZS 500 000 with a positive and negative deviations of TZS 100 000. This information is summarized in the Table 12 above.

4.5.2 Values of the program

The coefficients matrix formed (Appendix 4) ready for maximization process was estimated using linear programming software. Results indicates that the pivot value was 7.00 and the optimum solution found after first iterations and the maximum value for cassava production was 128 571.4 tonnes, which is the projection for future production of cassava for the two districts.

Appendix 4 also shows that, the disposal or slack variables were consumption, access to the market, processing costs and price of the processed products. Since the maximization of cassava production realistically did not use the entire quantity of each constraint available, provisions must be made for the non-use constraints in the final plan. These variables allow the non-use or changes to be made.

Furthermore, the objective of the study was to maximize production subject to those constraints mentioned above, with a goal or targeted value to be achieved. Therefore, the final (optimal) plan was to produce sweet varieties 2.57 times (Appendix 4) the previous production, setting aside the bitter varieties. This is due to reasons that, many farmers do not feel like to produce bitter varieties because the varieties take long time to mature in the field and tedious work in processing.

4.6 Final Evaluation Plan of the Mechanized Cassava Processing Technologies

The final evaluation for processing machines based on the analyses applied in this study were initial costs, net present value (NPV) and partial budget and benefit-costs ratio whereas the machines were manual chipper, engine powered chipper and cassava grater. The final evaluation is summarized in Table 13.

Therefore, based on the results obtained in this research, the final evaluation is that, for small scale production at farmer’s level it is better to use manual chipping machine because, it is first of cheaper compared to other machines. Secondly, it has a positive NPV (1 465 481) which can be accepted like other machines, that is engine powered chipper and cassava grater.

Thirdly, the partial budget analysis also showed that more profit (TZS 320.40 per kilogram) is made by using manual chipping machine compared to traditional processing technologies (TZS 400 per kilogram) whereas the engine powered chipping and cassava grater machines made a profit of TZS 314.53 and TZS 314.36 per kilogram respectively. Fourth, the benefit-cost ratio of the manual chipping machine is highest (3.25) compared to other two processing machines, which means that, the running costs for the manual chipping machines are lowest compared to the other two machines (Table 13).

Table 13: Final evaluation of the mechanized cassava processing technologies

Analysis	Manual chipper	Engine powered chipper	Cassava grater
Initial cost (price) (TZS)	300 000	950 000	1 210 000
Net present value (NPV)	1 465 481	1 844 168	2 093 064
Partial budget (TZS/kg)	320.40	314.53	314.36
Benefit-cost ratio	3.25	1.48	1.32

The probit regression analysis for consumer’s preference showed that high quality of the mechanised processed cassava products, quantity of cassava (flour) consumed by the household and household size increase the probability for consumption whereas increase in price reduces it. Due to that change (increase) in consumption behaviour, the production is expected to increase. Therefore, by using the goal programming approach, the future projection for cassava production is supposed to increase by 48 571.4 tonnes.

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

The quantitative analysis indicates that the mechanical cassava processing technologies are most efficiency compared to other two traditional processing technologies, which are traditional (drying) and traditional (wet and solid-state fermentation). The technical efficiency carried out showed that, there is a reduction in processing time from 12 days to 1-3 days. That means during the dry season, drying can take 10-12 hours, therefore within a single day the final product (cassava flour) can be obtained. During wet (rainy) season, the drying process can take 2 to 3 days to obtain the cassava flour. Furthermore, the economic efficiency of the mechanical cassava processing technologies was 4, the highest compared to 2.6 and 2.4 of the other two traditional processing technologies. This shows that the mechanical cassava processing technology is producing the products of high quality, hence high value with the comparison of the other two traditional cassava processing technologies.

Comparative costs of processing machines, for instance time-related costs such as interest, taxes and insurances costs are not paid. Other costs are use-related costs or operational costs which include fuel, lubrication, use-related repairs and labour also are minimal. The fuel consumption for engine operated machine was found to five litres for 1.5 tonnes of the peeled cassava roots. The manually operated chipping machine is so smooth to run therefore little labour costs. In order the machines to operate efficiently, two people are needed as the operators. The average running costs for machines differ from one machine to another. The manual chipping machine was having the lowest (TZS 140 571) average running cost per year whereas the engine powered and cassava grater machines were TZS 308 115 and TZS 345 247 per year respectively.

In additional to that, the benefit-cost analysis carried revealed that, manual chipping, engine powered and cassava grater machines were having the benefit-cost ratio of 3.25, 1.48 and 1.32 respectively. That means more profit is made using manual chipping machine followed by engine powered machine, and the last is cassava grater machine. Moreover, the use manual chipping, engine powered and cassava grater machine made a profit of TZS 320.40, TZS 314.53 and TZS 314.36 per kilogram respectively compared to other traditional processing technologies.

Based on the results of the probit regression analysis it can be concluded that quality of mechanically processed products, household size and quantity consumed per year were important factors that increase the probability of consumers' preference for mechanically processed cassava products versus different processing technologies in the study areas. On the other hand, price of the product was significant factor that reduce the probability of consumers' preference for mechanically processed cassava products versus different processing technologies in the study areas. Other factors such as age of household head, gender of the household head, education level and income level were not significant.

The introduction of mechanized processing technologies have resulted into the change in cassava consumption behaviour, hence increase in demand of the product. This has further stimulated production of cassava in the study areas. Based on goal programming approach the projection of the future production of cassava will be 128 571.4 from 80 000 (current production) tonnes per year.

5.2 Recommendations

Based on the observation that there is a potential improvement on cassava processing, which will ultimately have a positive impact on the rural livelihood in alleviating poverty due to increase in production, the following are worthwhile recommendations to be considered in improving mechanical processing technologies, production and consumption of cassava.

5.2.1 Mechanical processing technologies for cassava

Measures should be taken to improve the financial resources needed by cassava grower to engage in mechanical processing technologies rather than selling raw produce. This could be done through provision of credit facilities, which will improve their economies of scale in cassava processing and production.

(i) Small farmers should be encouraged to use manual chipping machines which have the lowest buying price and average running costs compared to engine powered chipper and cassava grater. The enterprises or processing companies are recommended to use engine powered chipper and cassava grater because they might have large scale processing which is not suitable to have manual chipping machine.

(ii) In order to minimize the problem of shortage of processing machines in the study area, private sector including traders with capital need to be encouraged to invest in provision of processing services to farmers. The government and financial institutions should play a major role in offering favourable conditions for credits.

(iii) Furthermore, the group's formation can solve the limited number of processing facilities where the growers can raise enough capital by mobilizing the little resources they have to finance processing machines/equipments. This will reduce transportation costs to the processing machine especially from most remote villages.

(iv) The development of less expensive and more efficient cassava processing machines or industry at the village level should be given priority. This is particularly important for the rural areas where hydroelectric power supply is almost non-exist. The government and other financial institutions should encourage Small Industry Development Organizations (SIDO), so that they can improve the designs of their machines and work for more improved designs for cassava processing.

(v) Training on cassava processing and packaging should be provided in order to cope with the growing market for cassava products.

5.2.2 Cassava production

Because of being attacked by diseases and pests, the study recommends that there is need for farmers to be provided with resistant varieties and appropriate farming practices as well as training from Agricultural Research Centres. This will boost cassava production in different parts in Tanzania and most of its people will be food secure, which ultimately have a positive impact to the rural livelihood and poverty alleviation.

(i) Farmers are encouraged to plant more of bitter varieties because they produce high yield per hectare, they are highly resistant to diseases compared to sweet varieties and are less attacked by wild animals (pigs and rats) even though they take long time to mature.

(ii) More research should be conducted on the diseases affecting cassava production and that treatment for those diseases is made clear to the farmers.

5.2.3 Cassava consumption

The specific government policies and programs should be made to enhance cassava consumption which can focus on three main areas; food security, income generation and nutrition. Hence the following areas may be vital:

(i) Organizations like program against Malnutrition and the Ministry of Agriculture, Cooperatives and Food Security to look at ways of improving and promoting on how cassava can be prepared and consumed to increase its attractiveness.

(ii) Farmers and other consumers should be made aware of the new products which can be made cassava/cassava flour such as *kibabu*/*kibabu*, bans or *maandazi*, chapatti, biscuits, chips and bread/cakes. Education like programs may be used to help consumers adopt these new foods that use cassava as principal ingredients.

(iii) Development and enhancement of quality and standards of cassava to ensure food and feed safety.

(iv) Improvement on value addition, such as to support producers and processors and also ensure that marketing is improved. One way would be making sure transport costs are minimized by maintaining good roads from production to consumption areas.

(v) Enhanced deliberate nutrition programs that can lead to increased use of cassava in the diet; like feeding programs in hospital and schools.

(vi) Deliberate promotional campaign programs on the nutritional aspects of cassava products.

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APPENDICES

Appendix 1: Farmer's Questionnaire for Cassava

Questionnaire No……………………. Date of interview………………….. Interviewer's name………………… Farmer's name……………………….

Division……………… Ward………………..Village………………………

Section 1 Farmer's characteristics

Age of respondent………………………………………

Gender of the respondent……………………………….

Level of education of the respondents

1=No formal education [ ] 2=Primary education [ ] 3=Secondary education[ ] 4=Post secondary education [ ]

Household composition

Age group(years)	Male	Female
Below 17		
17 – 50		
Above 50		

Main source of income

1=Sales of the crops [ ] 2=sales of the livestock [ ] 3=Off- farm income [ ]

1.6 What about the income of the household? 1= Low [ ] 2= High [ ]

Section 2. Cassava production, processing and consumption

2.1 Cropping pattern 1=Monocropping [ ] 2= Mixed cropping [ ]

2.2 What is the total land area (farm size) for crop production........................ha

2.3 What is the total land for cassava production..ha

2.5 Please indicate type, amount and price of agrochemicals do you use in cassava production

Agrochemicals	Type	Amount(kg/lit)	Price in Tsh
Fertilizer/Manure			
Insecticides			
Pesticides and control			

2.6 If you don't use one or all of the above agrochemicals, please indicate the reasons

1=Expensive [ ] 2=Not available [ ] 3=Others (specify) [ ]

2.7 Which cassava variety do you produce?

1= Sweet variety [ ] 2= Bitter variety [ ] 3= Both [ ]

2.8 Do you process your cassava roots? 1=Yes [ ] 2=No [ ]

2.8.1 If No in question 2.8 above, give reasons and possible solution

Reasons	Possible solutions

2.9 Which processing technology do you prefer?

1= Mechanical processing technology [ ] 2= Traditional processing technology [ ]

3= Wet and solid-state fermentation processing [ ]

2.10 Which processing technology do you use?

1= Mechanical processing technology [ ] 2= Tradition processing technology [ ]

3= Wet and solid-state fermentation processing [ ]

2.11 If any of the above indicate as shown below

Technology (Indicate no. given above)	Time used to process(days/hrs)	Labour in processing (Manday)	Cost for processing (Tsh)

2.12 Which processing technology do have high quality product?

1= Mechanical processing technology [ ] 2= Tradition processing technology [ ]

3= Wet and solid-state fermentation processing [ ]

2.13 Production and consumption of cassava

Variety	Production(bags)	Self- consumption(bags)	Sales(Tsh/bag)
Sweet cassava			
Bitter cassava			
Total			

2.14 What are the major problems facing you in cassava production?

i) ………………………………………

ii) ………………………………………

2.15 What should be done to improve cassava production?

i)……………………………………ii) ………………………

Thank you for your cooperation

Appendix 2: Observations for cassava processing machines

Station name …………………………. Division……………………………

Ward…………………………………..Village………………………………

Section 1: Station characteristics

2.1 Type of processing

1= Chipping [ ] 2= Grating [ ] 3=Both [ ]

2.2 Years in business……..years

2.3 How do you receive cassava for processing?

1=Delivered to you [ ] 2= you go by yourself [ ]

2.4 Apart from cassava are there other agricultural products, which you normally process?

1=Yes [ ] 2=No [ ]

2.4.1 If yes, mention them ……………………………………………………………..

2.5 At what price do you process cassava produce from farmers?

Cassava root ……..Tsh/Kg. Processed cassava ………Tsh/kg

2.5.1 Give the total revenue for processing cassava in 2007/2008 …………..Tsh.

2.6 What are the costs of the machine and operation incurred per year?

Type of cost	Tsh/day/month	Amount(Tshs)/year
Services/Maintenances		
Operators allowances		
Insurance		
Interest		
Taxes		
Depreciation		
Total		

2.7 What quantity of cassava do you process?

1)……….Kg/day 2)……….Kg/season 3)……….Kg/year

2.8 Is the above quantity maximum for you to process for one season?

1=Yes [ ] 2=No [ ]

2.9 If no what quantity can you process for one season…….kg and for one year………….kg

3.0 If it is manually operated, how many labourers are required per day the same amount as that of engine powered?.........................labourers.

3.1 How about energy required to operate the manually operated machine?

1= Low [ ] 2= High [ ]

3.2 If it is engine powered machine, how much fuel does it require to process one kg of cassava?................L/kg

3.1 Point out the most serious problems you face in processing your product

………………………………………………………………………………..

……………………………………………………………………………………

Thank you for your cooperation

Appendix 3: Guideline for FGD on cassava processing technologies

Village name………………………… Discussion date ……………………..

1.0 Situation on cassava processing

1.1What are the types of cassava processing technologies do you use in your village?

1.2 Which is mostly used by the farmers?

1.3 Why is it mostly used?

1.4 Which cassava processing technology is mostly preferably than the others?

2.0 Efficiency of cassava processing technologies

2.1 Which cassava processing technology is efficient in terms of?

(i) Labour?

(ii) Time?

(iii) Cyanide/ Bitterness removal?

(iv) Other costs?

3.0 Quality of the processed products

3.1 Which cassava processing technology produces the high quality products?

3.2 Why it produces the high quality products?

4.0 Suggestion for improvements

4.1 In your opinion, what are the improvements to be done in those technologies?

Appendix 4: Matrix for optimal plan for cassava production

Coefficients matrix

				Bitter tonne (Q_1)	Sweet tonne (Q_2)	Positive deviation (U^+)	Negative deviation (U^-)
Net Revenues				30000	50000		
1 Consmptn	tone	30000	>	1500	2000	500	500
2 Variety	tone	18	>	8	7	3	3
3 AccMrk	tone	20000	>	400	500	5000	5000
4 Costp	shs %	150000	>	150	150	50000	50000
5 Prc	shs %	500000	>	500	500	100000	100000

Evolution of the optimal plan for: Cassava production

****

Iteration Number	Incoming variable	Outgoing variable	Pivot value	Net Revenue
1	Sweet	Variety	7.00	0.00

- - Optimum solution found after 1 Iterations - -

Press <RETURN > to continue . . ?

- - Maximum value of Net Revenue = 128571.429 - -

The Plan : N.R. range for which each activity level stays constant
********** (with the incoming variable)

		Level	Lower limit N.R.	Present	Upper limit
Sweet	tone	2.571	26250.000(Bitter)	50000.000	OPEN

Press <RETURN > to continue . . ?

Activities not in optimal plan
****

		Present N.R.	N.R. needed before entry
Bitter	tone	30000.000	57142.857

```
Press <RETURN > to continue . . ?

Binding constraints     Resource supply range over which the M.V.P. is constant
*******************               (with the outgoing variable)
                          M.V.P.      Lower limit        Present     Upper limit
                          $/unit          Level
Variety  tone            7142.857    0.000(Sweet   )    18.000     105.000(Consmptn)
------------------------------------------------------------------------------------------------------


Press <RETURN > to continue . . ?

Slack constraints
*****************
          Lower limit  Surplus          |Upper limit                 Surplus
Consmptn              tone              | 30000.000               24857.143  |
AccMrk                tone              | 20000.000               18714.286  |
Costp                 shs               |150000.000              149614.286  |
Prc                   shs               |500000.000              498714.286  |
--------------------------------------------------------------------------------------------------

. . arrays now being cleared .
```

Appendix 5: NPV analysis for manual chipping machine

Years	0	1	2	3	4	5	6	7
Initial cost	300000							
Running cost		72000	72000	72000	72000	72000	72000	72000
Annual depreciation		67500	57857	48214	38571	28928	19285	9642
Repair and maintenance		30000	30000	30000	30000	30000	30000	30000
Tax and Insurance		0	0	0	0	0	0	0
Total costs		169500	159857	150214	140571	130928	121285	111642
REVENUE		300000	375000	412500	453750	499125	549037.5	603941
NET BENEFIT		130500	215142	262285	313178	368196	427751	492298
Salvage value		232500	174642	126428	87857	58928	39642.	30000
Discount factor		0.8333	0.6944	0.5787	0.4822	0.4018	0.3348	0.2790
Disc. Cash outflow		302500	270684	224950	193400	171651	156529	145763
NPV		1465481						

Appendix 6: NPV analysis for engine powered chipping

Years	0	1	2	3	4	5	6	7
Initial cost	950000							
Running cost		84900	87541	89095	90805	92683	94753.2	97028.02
Annual depreciation		213750	183214.3	152678.6	122142.9	91607.14	61071.43	30535.71
Repair and maintenance		95000	95000	95000	95000	95000	95000	95000
Tax and Insurance		0	0	0	0	0	0	0
Total costs		393650	365755.3	336773.6	307947.9	279290.1	250824.6	222563.7
REVENUE		300000	375000	412500	453750	499125	549037.5	603941.3
NET BENEFIT		-93650	9244.714	75726.43	145802.1	219834.9	298212.9	381377.5
Salvage value		736250	553035.7	400357.1	278214.3	186607.1	125535.7	95000
Discount factor		0.833333	0.694444	0.578704	0.482253	0.401878	0.334898	0.279082
Disc. Cash outflow		535500	390472.5	275511.3	204483.2	163339.9	141912.5	132948.2
NPV		1844168						

Appendix 7: NPV analysis for cassava grater machine

Years	0	1	2	3	4	5	6	7
Initial cost	1210000							
Running cost		84900	87541	89095	90805	92683	94753.2	97028.02
Annual depreciation		272250	233357.1	194464.3	155571.4	116678.6	77785.71	38892.86
Repair and maintenance		121000	95000	95000	95000	95000	95000	95000
Tax and Insurance		0	0	0	0	0	0	0
Total costs		478150	415898.1	378559.3	341376.4	304361.6	267538.9	230920.9
REVENUE		300000	375000	412500	453750	499125	549037.5	603941.3
NET BENEFIT		-178150	-40898.1	33940.71	112373.6	194763.4	281498.6	373020.4
Salvage value		937750	704392.9	509928.6	354357.1	237678.6	159892.9	121000
Discount factor		0.833333	0.694444	0.578704	0.482253	0.401878	0.334898	0.279082
Disc. Cash outflow		633000	460760.2	314739.2	225082.3	173788.7	147821.1	137872
NPV		2093064						

Appendix 8: Sensitivity analysis for the mechanized processing technologies

Discounted Cash flow								
Costs	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7
Fixed Capital	2460000							
Working Capital	79500							
Operating Costs		79500	70080	85421	89897.5	98887.25	108775.98	108226.27
Financial Costs		553500	474428.57	395357.14	316285.71	237214.29	158142.86	79071.429
Total Costs		633000	544508.57	480778.14	406183.21	336101.54	266918.83	187297.7
Discount Factor (20%)	1	0.833333	0.6944444	0.5787037	0.4822531	0.4018776	0.334898	0.2790816
Discounted Costs		527500	378130.95	278228.09	195883.11	135071.67	89390.577	52271.351
Sum (A)		1656476						
Benefits								
Revenue		1235000	1543750	1698125	1867937.5	2054731.3	2260204.4	2486224.8
Discounted Revenue		1029167	1072048.6	982711.23	900818.62	825750.41	756937.87	693859.72
Sum (B)		6261293						
BCR		3.779888						
Net cash flow		602,000	999241.43	1217346.9	1461754.3	1718629.7	1993285.5	2298927.1
Disc Cash outflow		501,667	693917.66	704483.13	704935.52	690678.74	667547.3	641588.37
NPV		743,585						
IRR		42%						
Sensitivity Analysis								
Sensitivity Analysis	% Change	IRR	NPV					
Base	0	42%	43,585					
Decline in sales price	-5	36%	565,467					
increase in operating exp	5	36%	64,230					