ECONOMIC ANALYSIS OF VIRUS FREE SWEET POTATO PRODUCTION IN THE LAKE AND COASTAL ZONES OF TANZANIA

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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

A study was carried out to analyze the economics of virus free sweet potato and vine multiplication by smallholder farmers in two selected agro-ecological zones of Tanzania namely; Lake Victoria Zone and Coastal Zone. Specifically, the study aimed at analyzing yields of sweet potatoes and vines production of virus free varieties, analyzing cost and benefits of virus free sweet potato vines production by smallholder farmers and analyzing costs and benefits of sweet potato production of virus free varieties. Primary data were collected from 495 producers of virus free sweet potato and vines by means of survey questionnaire. Sampling procedures involved multistage sampling and simple random sampling techniques. About 362 farmers producing virus free sweet potato and 133 farmers producing vines were chosen from each zone using simple random sampling technique. The findings of the study showed that the benefit of virus free sweet potato production in Lake Zone was TZS 1 284 666 per hectare and that in Coastal Zone was TZS 1 159 525 per hectare. Furthermore, it was found that benefit of virus free sweet potato vine multiplication in Lake Zone was TZS 219 087 per hectare and in Coastal Zone was TZS 305 949 per hectare. The Benefit Cost Ratio obtained from virus free sweet potato production in Lake Zone was 5.04 and Coastal zone was 3.71. The Benefit Cost Ratio obtained from virus free sweet potato vine multiplication in Lake Zone was 2.91 and Coastal zone was 2.11. Furthermore, the study revealed that the yield and benefit of virus free sweet potato variety were relatively higher compared to local variety, hence the likelihood to attract farmers to continue producing sweet potato using virus free sweet potato variety planting material. Therefore, an investment in virus free sweet potato tuber production and vine multiplication is worth undertaking in both Lake Victoria and Coastal zones since farmers generate income and enhance food security.

DECLARATION

I, CASTORY KIBIKI, do hereby declare to the Senate of the Sokoine University of Agriculture that this dissertation is my original work, completed within the period of registration and that it has neither been submitted nor being concurrently submitted in any other University.

_____ _____

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DEDICATION

This dissertation is dedicated to the Almighty God who gives me strength and lights up my path, to my father Felix Mwalihehe Kibiki and to my mother Consolatha Arron Siwakwi, who brought me up and put down the foundation of my education.

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LIST OF ABBREVIATIONS AND SYMBOLS

BCR	Benefit-Cost Ratio
DAICO	District Agricultural, Irrigation and Cooperative Officer
DVM	Decentralized Vine Multipliers
FC	Fixed Cost
IRR	Internal Rate of Return
LVZ	Lake Victoria Zone
MD	Mass Distribution
NARS	National Agricultural Research Systems
NPV	Net Present Value
SACCOS	Savings and Credit Co-operative Society
SIDA	Swedish International Development Aid
SNAL	Sokoine National Agricultural Library
SP	Sweet Potato
SPSS	Statistical Package for Social Science
SPVD	Sweet Potato Virus Disease
TARI	Tanzania Agricultural Research Institute
TC	Total Cost
TR	Total Revenue
TVC	Total Variable Cost
TZS	Tanzania Shillings
VFSP	Virus Free Sweet Potato

CHAPTER ONE

INTRODUCTION

1.1 Background Information

Sweet potato is an important food crop in a number of countries (Mayanja *et al*., 2017). About 117 countries worldwide cultivate sweet potato producing about 105 million tons with a yield of 12 tons per ha (FAO, 2016). It is estimated that about 95% of sweet potato produce comes from developing countries (Prakash *et al*., 2018).

Despite the importance of sweet potato, the crop suffers from various problems including viral diseases. Daurov *et al*. (2018) showed that the importance of sweet potato in food security and income generation coupled with the viral diseases problem; and this increases the possibility of commercial growing of virus-free planting materials to be supplied to smallholder farmers. Important ways of controlling sweet potato diseases are to obtain healthy planting materials which are free from virus. Virus-free planting material is also resistant to fungus, bacterial and abiotic stress factors (Daurov *et al*., 2018). Tairo *et al*. (2004) found that there is a higher incidence and diversity of viruses infecting sweet potato in the Lake Victoria basin compared with the Indian Ocean coastal area. The study also showed that viral diseases alone can cause sweet potato yield reductions of 56 to 98%.

The ultimate goal of promoting the adoption of virus free sweet potatoe (VFSP) is to improve the wellbeing of sweet potato producers through higher yields which is crucial for enhancing food security and income generation (Adugna *et al.*, 2017). The introduction of VFSP seed amongst others involves commercial vine producers/suppliers engaged in sweet potato tuber production and vine multiplication (Stathers *et al*., 2018).

In 2012, Tanzania was the African's top producer of sweet potato with production of about 3.6 million tones followed by Nigeria which produced 3.4 million tones, Uganda 2.6 million tones, Ethiopia 1.2 million tones and Rwanda 1.0 million tones. According to National Bureau of Statistics from 2005/06 to 2009/10 a total of 2.4 million tones of sweet potato were produced on 567 000 ha and the land area decreased from 635 000 ha in 2007/08 to 576 000 ha in 2009/10 due to the pests, diseases and in other areas was due to replacing with other crops (URT, 2011).

Despite high annual production, average production is still far below the estimated sweet potato potential yield of 15-23 tons per hectare. The low productivity is contributed by numerous constraints both abiotic and biotic. The main biotic constraint is limited access to certified high-quality improved planting materials (Ngailo *et al*., 2015), which is partly exacerbated with prevalence of viral diseases and weevils infestations (Tairo *et al*., 2004 and Ndunguru *et al.,* 2008). Over reliance on tradition seed delivery system from farmer to farmer and/or recycling of owns seed from previous crop, not only contributes to further spread and persistent of Sweet Potato Virus Disease (SPVD), but also dissemination of inferior cultivars. Sweet potato for many years suffered lack of official system for production and delivery of certified planting materials (Bio-Earn report, 2008).

Initiatives at some point each contributed specific interventions in developing and institutionalizing a sustainable seed delivery system in Tanzania, by strengthening and modernizing the existing traditional seed system (Mwiti, 2015; McEwan, 2016 and Mulongo, 2018). However, the delivery of improved planting materials remained low, inconsistent and unsustainable. The continuous efforts by sweet potato seed sector focuses on multiplication and delivery of improved varieties with emphasis on improved certified planting materials (Abidin *et al.,* 2017). The institutionalization of the

sustainable system is enhanced by the enforcement of seed certification standards, which guides on the multiplication and certification procedures for all grades of sweet potato seeds prior to selling (WEF, 2018 and Vernooy, 2017).

Mwiti (2015) and Daurov *et al*. (2018) reported that sweet potato production can be improved by solving the virus problem by initiating strategies of helping small holder farmers to access disease free planting materials which are essential for increasing yield for both consumption and profit. The project was designed to solve sweet potato associated problems by addressing the problem of lack of access to quality planting material. The mostly used strategies was Decentralized Vine Multipliers (DVM) and Mass Distribution (MD) to improve farmer access to quality sweet potato planting materials and promotional campaigns were designed to create awareness about benefits of using quality planting materials and consuming orange fleshed sweet potato (Mwiti, 2015). Agricultural Research Institutes have developed interests in developing VFSP varieties through bioinnovate project hopping to fight the problem of viruses in the traditional varieties but the issue of economic sustainability after project phase out has not been addressed (Amanda and Sindi, 2017).

The ICOPSEA project granted by the Swedish International Development Aid (SIDA) to National Agricultural Research Systems (NARS) in East Africa through Bioinnovate II program has been supporting the institutionalization of a sustainable seed system through technical and infrastructure supports to key actors in the seed delivery chain particularly vine multipliers and processors to increase sweet potato production and market (Tatwangire and Nabukeera, 2017).

However, farmers are reluctant to use certified seeds complaining that supply is limited and they are expensive. While vine multipliers also complained the demand for certified seed is low and production costs are high due to high certification standards requirement, that make the venture less profitable compared to traditional system. Thus, the aim of this study is to analyze the economics of VFSP seed system and production in the major sweet potato growing agricultural zones in Tanzania.

1.2 Problem Statement and Justification

The introduction of VFSP vine has been implemented by TARI since 2012 in promoting commercial production of quality sweet potato planting material in East Africa (ICOPSEA) through Bioinnovate Africa Program Phase II. The approach adopted in the implementation of this project has carried along with distribution of VFSP vines through *Marando bora* project to selected farmers who are subsidized by TARI in the production of vines and sell the vines to fellow farmers at an affordable price suggested by TARI. The focus of Marando bora project has been to ensure increased production of sweet potatoes while controlling the problem of viral diseases that tends to affect sweet potatoes productivity and hereby improving nutrition and food security among farmers. The implementation of Marando bora project by TARI is in line with the current move of promoting the adoption of new agricultural practices with the view of improving agricultural productivity and food security in the country specifically VFSP project as implemented is perceived to increase production and improve livelihood.

Despite the potential benefit of the VFSP project to farmers, there is limited empirical evidence on economic benefits to farmers from the sustainability of the disease free planting material production and distribution system. The lack of research insight limits and questions the assessment of acceptability and sustainability of the project especially

after the phase out of TARI subsidization. The literature is rich of knowledge on importance of VFSP on nutrition improvement and food security (Degu *et al*., 2015; Ferrari *et al*., 2017; Low *et al*., 2017; Prakash *et al*., 2018), problem of virus in yield reduction and need of VFSP vines (Tairo, 2012) but there is paucity of knowledge on cost and benefit of VFSPs to farmers and vine producers in growing zones.

Recognizing that there have been several similar and related projects in the country that have proved failure soon after project phase out, the study therefore aimed at analyzing the economics of VFSP among farmers and vine producers in growing regions of Tanzania for the purpose of drawing practical lessons for sustainability since the profitability spells out the sustainability of agricultural technologies of which VFSP is not an exception.

1.3 Objective of the Study

1.3.1 Overall objective

The overall objective of the study was to conduct economic analysis of virus free sweet potatoes for sustainable production of tubers and healthy vines of VFSP in Tanzania.

1.3.2 Specific objectives

i. To determine the yields of VFSP tubers and vines production compared to local varieties.
ii. To analyze profit of VFSP vine multiplication by smallholder farmers in comparison to local varieties.
iii. To analyze profit of sweet potato tuber production using certified virus free planting materials in comparison to local varieties.

1.4 Research Hypotheses

i. The yield of sweet potato tubers and vine production using certified planting materials as compared to local varieties are not significant.

ii. Production of certified virus free sweet potato vine is not a profitable as compared to local varieties.

iii. Production of sweet potato tubers using certified virus free vines is not a profitable activity as compared to local varieties.

1.5 Organization of the Dissertation

This study is organized into five chapters. The first chapter furnishes a general background to the study, involving problem statement, study objectives and hypotheses. The second chapter gives a critical review of relevant literature to the study while the third chapter presents a methodology with detailed description of the study area. The fourth chapter presents results and discussion while in the last chapter conclusions and recommendations drawn from the study findings are presented.

CHAPTER TWO

LITERATURE REVIEW

2.1 Definition of Key Terms and Concepts

2.1.1 Sweet potato (SP)

SP is a tuber that comes in various shapes, sizes, and colors (Monostori and Szarvas, 2015). Sweet potato varieties used for market are classified as a white-fleshed/orange-fleshed, according to the feel sensation experienced in the mouth when eating a cooked or baked sweet potato (Sugri *et al.*, 2017). The orange-fleshed potato with low dry matter content is sometimes referred to as a yam and the white-fleshed with high dry matter content as a sweet potato (Mudege and Grant, 2017 and SASHA Project, 2009).

SP has marvelous potentials towards efficient and economic source of energy (Mohanraj and Sivasanka, 2014). It is the third most important root and tuber crop after cassava and yam. Sweet potato tuber and leaves are good source of pro-vitamin A, vitamin B, vitamin C, Calcium, Iron, Potassium and Sodium with a small amount of protein (Sindi *et al.*, 2012).

2.1.2 Vine multiplier

Vine multipliers are commercial vine producers/suppliers that are engaged in vine multiplication. The vine multiplier can be private or one who enters the seed system (vine distribution channel) through distribution agents such as NGOs and government and supply to the farmers (Ogero e*t al*., 2015).

2.2 Sweet Potato Production in Tanzania

SP is among of the staple food and source of income in growing regions of Tanzania (Netherlands Enterprise Agency, 2017). SP main production zones include Lake Zone, Southern Highlands and Eastern Zone. The sweet potato production promotes employment and food security for the rural poor. In Tanzania, the crop is generally considered as a relatively minor traditional food crop and is grown as a subsistence crop for food security as well as cash crop (Jones *et al.*, 2012).

In Tanzania, the majority of SP production is of white-fleshed varieties and is among of the five most important food crops in Tanzania in terms of area planted and harvested volumes behind maize and cassava. Tanzania produce an average of 2.4 metric tons of sweet potatoes annually making it the third largest producer in Africa (FAOSTAT, 2013).

A total of 1 076 320 farmers are engaged in sweet potato production in Tanzania, of which 1 040 772 farmers (96.7%) are in Mainland and 35 549 (3.3%) in Zanzibar. About 426 253 farmers engage in sweet potato production during short rainy season and 614 519 farmers during long rainy season. In Zanzibar about 18 885 and 16 663 farmers are engaged during short and long rainy seasons, respectively. The area which is used for sweet potatoes production in Tanzania is 331 475 ha of which 324 229 ha (97.8%) are in the Mainland and 7246 ha (2.2%) in Zanzibar. In 2016 to 2017 a total of 292 363 tons was produced of which 279 010 tons (95.4%) were in Mainland and 13 353 tons (4.6%) in Zanzibar (URT, 2014).

The crop is produced primarily for both consumption and household's income generation. SP is regionally very important in the Lake Zone where is produced by 99% of farming households regard the produced SP as a primary staple food (Sindi and Wambugu, 2012).

The crop is produced in large quantity in Lake Zone due to its advantage in food security especially for vulnerable households. It requires little land and able to be stored for several months. Improved sweet potato varieties first arrived in Tanzania in the Lake Zone from neighboring countries including Rwanda and Uganda. The common varieties include Jewel, Kabode, Kiegea, Simama, Mataya, Carrot Dar and Carrot C. After its introduction in the Lake Zone, improved varieties spread to other regions of the country whereby a small number of farmers cultivate improved variety, mostly white fresh sweet potato. Improved sweet potato varieties in Tanzania are handled by the same actors who deal with white fresh sweet potato.

2.3 Theoretical Framework and Empirical Methods

2.3.1 Profit maximization

Farmers have the objective of maximizing profit and the process of decision making of a peasant family involves production and consumption. A small-scale producer always operates for the aim of household economy, consumption and production decisions are assumed to be inseparable. This enables producers' focus on market channel with more impact on farm output profits. A small-scale producer chooses the level of output for each distribution channel in a manner that maximizes profit subject to cost of inputs (Dwivedi, 2004).

According to Janssen (2005) most studies that modeled farmer's decision making and assumed that farmers maximize profit and ignored the fact that decisions of farmers are normally motivated by multiple, often conflicting objectives including profit maximization and sustaining family consumption.

2.3.2 Cost and benefit analysis

The cost-benefit analysis has become an appropriate methodology to establish procedures to allocate scarce resources. Cost-benefit analysis has been known to economists for many years including French economist Jules Dupuit referred to the subject in early 1844. The applicability of the theory of cost-benefit analysis was firstly tested in the 1930s in the USA, by the engineers (Abebe, 2001). There are several measures that can be used to evaluate the economic viability of a project, each having its own advantages and disadvantages. But, in this study Internal Rate of Return (IRR) which may be defined as the rate of discount that reduces the NPV to zero, the Benefit Cost Ratio (BCR) and Net Present Value (NPV) are used.

The Net Present Value (NPV) is one of the discounted techniques and is given as the difference between the present value of benefits and the present value of costs. If the NPV of a project is positive, the implication is that the project is acceptable or desirable. If NPV is equal to zero the project is a marginal one, if the NPV is negative the project is not desirable and, therefore, it should be rejected (UNIDO, 1980). The limitation of the NPV measure is that the selection criterion cannot be applied unless there is a relatively acceptable estimate of the opportunity cost of capital.

The Benefit-Cost Ratio (BCR) is obtained by dividing the present worth of the benefits stream by the present worth of the cost stream, when the (BCR) is 1 or greater considering at a suitable discount rate then the project is to be accepted. But the greater limitation of this method is that it may lead to incorrect ranking among independent projects, and cannot be used for selecting among independent projects, and among mutually exclusive alternatives (Gittinger, 2001).

The Internal Rate of Return (IRR) is a widely accepted criterion in economic analysis. It is defined as the discount rate that makes the net present value of the incremental net benefit stream or cash flow equal to zero. More specifically, it is the maximum interest rate a project could pay for the resources used if it is to recover its investment replacement, maintenance and operating costs and still break even. The only limitation of IRR is that there are computation process complications and is obtained with narrow difference in two discount rates (Gittinger, 2001).

2.3.3 Theory of the firm

This study is guided by three different economic theories these are theory of the firm, the consumer behavior theory, and the rational choice theory. Farmers have the objective of maximizing profit and the process of decision making of a peasant family involves production and consumption (Debertin, 1986; Nicholson and Snyder, 2008), if behaving rationally, these farmers always aim to maximize profit and utility. A small-scale producer always operates for the aim of household economy, consumption and production decisions are assumed to be inseparable. A small-scale producer chooses the level of output for each distribution channel in a manner that maximizes profit subject to cost of inputs. According to Janssen (2005), most studies that modeled farmer's decision making and assumed that farmers maximize profit and ignored the fact that decisions of farmers are normally motivated by multiple, often conflicting, objectives including profit maximization and sustaining family consumption. The level of profit is a motivating factor that guarantees that SP producers and traders generate sufficient earnings from their invested capital (Karuga, 2009).

2.4 Empirical Literature Review

Wuyah and Yusuf (2015) on their study on economic analysis of small scale sweet potato production employed correlation analysis point out that educational status, farm size and farming experience had strong positive correlation with sweet potato output and also applied Cobb Douglas production function which shows that the inputs employed in production explain significantly the variation in the level of output produced. Also their findings revealed that the cost of production per hectare by using labor power accounting for the highest cost item and the gross margin per hectare obtained was small compared to the cost of production. Factor inputs considered in sweet potato production are utilized inefficiently through efficiency ratios and confirmed that sweet potato farmers exhibited increasing return to scale.

Ahmad *et al*. (2014) examined the efficiency of SP farmers for food security and poverty alleviation which pointed out that sweet potato production is profitable and profit improvement mostly achieved for resource adjustment. Government should ensure timely supply of agricultural inputs at subsidized rate, provision of storage facilities and market for output produced in order to achieve food sufficiency and reduce poverty among farmers. Also the study revealed that higher yield of sweet potato can be achieved by improving sweet potato varieties and application of small quantities of fertilizer which enhance sweet potato to grow well and every small holder farmer will afford since the crop widely produced by rural poor.

Fuglie *et al*. (1999) revealed that the diffusion of virus-free roots increase sweet potato production and program of enhancing utilization of virus-free sweet potato seed in China is estimated to increase production by 3.965 million metric tons annually which is equivalent to a value of gross benefits of US$ 167 million per year. Benefit of virus-free

sweet potato seeds assumed to remain at the same level until 2020 in China. Furthermore, the study revealed that the rapid diffusion of virus-free roots can probably be best explained by its significant and noticeable effect on yield.

Ngailo *et al.* (2015) showed that sweet potato was preferred mostly because of high yield, high dry matter content, tolerance to diseases and early maturity. Farmers' need for improved extension service delivery, SPVD-tolerant cultivars, and coordinated market systems for sweet potatoes is high. Furthermore, the study revealed that allocation of land for sweet potato production majority varied from 1 to 2 ha per households. Also, there are multiple planting seasons and most farmers' plant sweet potato during January to March.

Mwiti (2015) assessed the willingness to pay for quality SP planting materials and revealed that the willingness of consumers to pay was highr for quality planting materials of New Polista, followed by Kabode and then New Ukerewe, Ejumula and then Jewel. Farmer-specific factors, location, asset endowments, and varietal attributes affect willingness to pay for quality planting materials. According to Ferrari *et al*. (2017) in order to increase seed quality among farmers it is important to extend the utilization of agronomic practices, positive selection, plot techniques and the use of certified seed. Increasing the virus free seed, the current multiplication process should be enhanced by improving the agricultural practices and increasing the proliferation bodies. In order farmers to have high quality seed, formal and informal systems must be complementary and dependent. The promotion of participative approaches in breeding, seed production and distribution would help to increase the complimentarily between the two systems.

Improving commercial seed production involves upgrading infrastructure such as screen houses, improving human capacity, training seed producers and vine multipliers,

supporting farmer organizations and agricultural institutions to establish collection centers. Market information systems and demand forecasting are needed by developing a seed producer calendar and seed delivery to align supply with demand (FAO, 2016). SP for Profit and Health Initiative (SPHI) was initiated to reduce child malnutrition and improve smallholder incomes by ensuring effective production and use of sweet potato. The SPHI is expected to improve 10 million households' lives by 2020 for 17 target countries and this goal can be achieved by ensuring that farmers have access to adequate quantities of quality seed varieties which meet end user preferences (Ogero *et al*., 2015). All these strategies require understanding farmer seed demand; tackling seed borne pests and diseases; capacities of conserving and multiplying seed in areas with a long dry season; increasing seed multiplication rate; implementing appropriate quality assurance mechanisms and identifying appropriate seed enterprise opportunities and distribution channels (Ogero *et al*., 2015).

2.5 Synthesis of Literature Review

Literature review is organized by systematically collecting the existing literature on the overall economic situation of sweet potato seed system and production. The reviewed literatures show that there is a high recognition of sweet potato seeds system and production. The reviewed literatures show that cost and benefits analysis is one of the measures of economic analysis from production and discussion based on advantages, and its applicability in measuring production performance. Also the literatures showed that the main target of initiating use of VFSP seeds is to ensure effective production of SP in order to reduce child malnutrition and improve income of smallholder farmers.

However, the reviewed literatures do not give clear information on the economic benefits of VFSP seeds as most of them focused on sweet potato sub-sector as whole and how

virus free seeds are produced for commercial purpose. This study therefore aimed at addressing this information gap focusing on economic analysis of VFSP production system.

2.6 Conceptual Framework

The conceptual framework stands as a guideline in identifying important variables which enhance efficiency of data collection and analysis. The conceptual framework for this study is shown in Figure 1 below.

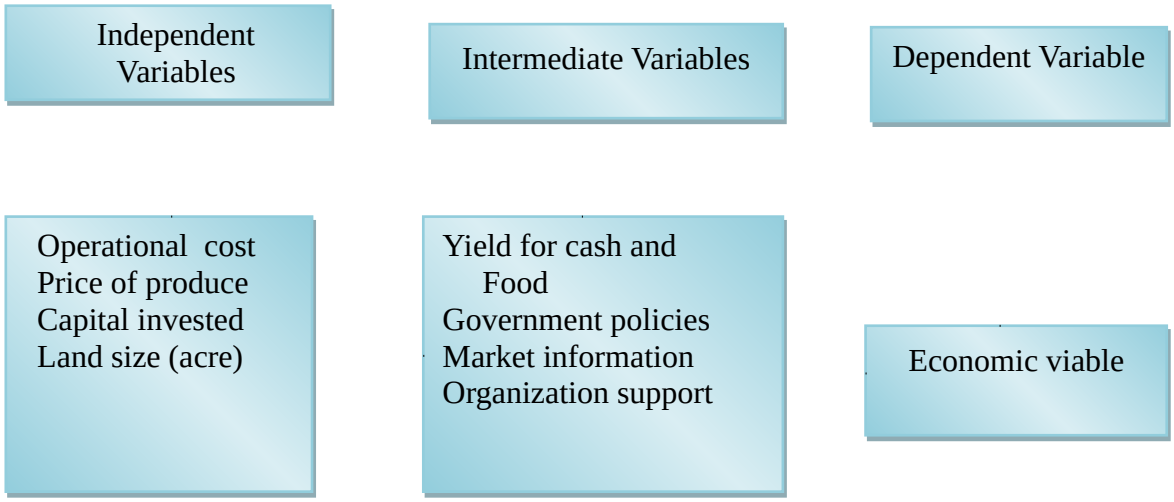

Figure 1: Conceptual Framework

Based on the main focus of this study, economic viability is the dependent variable which is conceptualized to be achieved from using virus free sweet potatoes vines and tubers. Economic viability is assumed to be influenced by both independent variables and intermediate variables typified in the diagrammatical framework. Realizing economic viability will depend on operational cost, price of produce, capital invested; land size and all these variables will depend on intermediate variables which are yield for cash and food, government policies, market information and organization support.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Description of the Study Areas

Justification for the selection of the study area

This study was conducted in four selected sweet potato main growing regions (Kagera and Mwanza) in the Lake Victoria zone (LVZ) and (Dar es Salaam and Pwani) in the Coastal zones of Tanzania. The Lake zone is located in North West of Tanzania in the Lake Victoria basin (Figure 2). LVZ is characterized by humid and overcast during wet season, windy and partly cloudy during dry season, and temperature varies from 16^{o}C and 27^{o}C. The annual rainfall in the LVZ is about 1001 mm and population of nearly 10 180 348 million people. It is the main sweet potato producing area with annual production of 71 007 tons per year (URT, 2012).

The Coastal zone lays along the Indian Ocean on the Eastern part (Figure 2). The zone is characterized by having a hot climate all year round, with two rainy seasons in the Northern part, and only one in the Southern part with annual rainfall of 1 150 mm with population is 5 463 668 million people. The zone is characterized by having a sandy loam soil type which is ideal for SP production. Furthermore, having the commercial city of Dar es Salaam, SP is one of the important commercial crops within the zone **(**URT, 2012).

The two agro-ecological zones were selected based on their experience in previous interventions in SP production system (McEwan, 2016; URT, 2017; Mulongo *et al.,* 2018) towards establishing a formal seed delivery system.

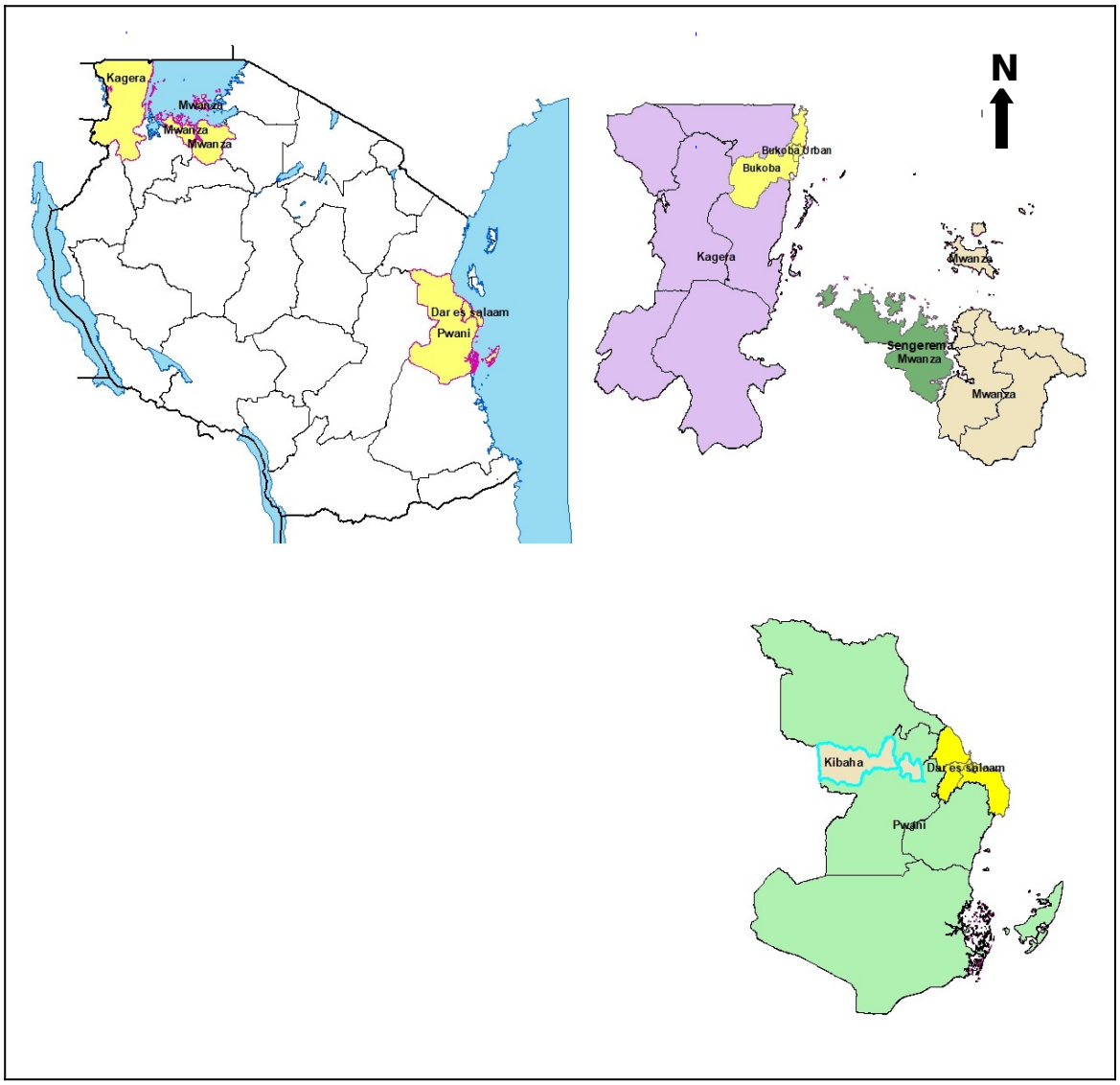

Figure 2: Map of Tanzania showing surveyed regions within agro-ecological zone

3.2 Research Design

The cross-sectional research design was used in this study. The design was selected since is suitable in descriptive and quantitative study for capturing data between and among variables SP production is a responsibility of both men and women; thus, the study focused on both men and women farmers. The unit of analysis was a farmer to whom a questionnaire was addressed in obtaining individual households information.

3.3 Sampling Procedures and Sample Size

Multistage sampling was applied in such a way that sampling frame was developed in partial units. Thus, sampling was divided into four stages namely; stage 1 Zones, stage 2 Regions, stage 3 District and stage 4 Wards within regions. The first stage was to select sampling units which is the growing zones, namely Lake Victoria and Coastal Zones, the second stage was to select regions within selected zones, namely Mwanza and Kagera in Lake Zone, Dar es Salaam and Pwani in Coastal Zone, then followed by the selection of Districts and finally Wards where the individual farmers were selected and interviewed.

Simple random sampling technique was used in this study whereby all sweet potato and vine producers were listed and randomly selected per each zone. Proportionate sampling was used to get number of respondents per each region. The sampling frame entailed 3956 VFSP actors, also these farmers grow traditional variety and the sample size constituted a total of 495 VFSP actors from selected wards. For the case of VFSP vine producers each producer covered 20 farmers, so for 3956 farmers, 198 were vine producers (3956/20 = 198). Sweet potato producers were 3758 (3956 – 198 = 3758). The final sample size involved 495 farmers from the two zones. The study applied the formula as per Kothari (2004) to get the sample size.

So sample size was obtained as follows:

$$n = \frac{N}{1 + N(e)^2} \quad \text{.....(1)}$$

Where: n = sample size, N = sampling frame, e = level of precision (sampling error 5%)

Sample size for vine producers

$$n = \frac{198}{1 + 198(0.05)^2} \qquad n = 133$$

sample size for sweet potato producers

$$n = \frac{3758}{1 + 3758(0.05)^2} \qquad n = 362$$

Therefore, the study sample size was (133 + 362) = 495 Respondent's breakdown in the study areas according to zone (Table 1).

Table 1: Respondent's breakdown in the study areas

Regions	Stratum	Sampling Fraction n/N	n/N X Sub-population
Kagera	1500	0.379	188
Mwanza	1256	0.317	157
Dar Es Salaam	275	0.069	34
Pwani	925	0.233	116
Total	**3956**		**495**

3.4 Data Types, Sources and Collection

Data collection exercise was done between February and March, 2019 in both zones when the crop was in the field. The collection of primary data was achieved by using structured questionnaires, from key actors in the sweet potato value chain: mainly farmers, decentralized vine multipliers (DVM), District Agricultural, Irrigation and cooperative officer (DAICO), Village extension officers and Sweet potato processors.

3.5 Data Processing and Analysis

3.5.1 Analytical tools

Both descriptive and quantitative analyses were employed in this study based on the objectives stated. Statistical Package for Social Science (SPSS ver. 20) was used to analyze descriptive statistics which are statistical measures of central tendency namely means, frequencies, and percentages. The quantitative statistics which involved cost and benefits estimation, benefit-cost analysis were calculated using Microsoft Excel 2007.

3.5.2 Descriptive analysis

Descriptive statistics were used to describe the responses, characteristics and some information trends. Descriptive analyses included means, frequency and percentages.

3.5.3 Analysis of yields of sweet potato tubers and vines production

Seasonal yields were obtained by considering cropped land and production. Thus land included area in hectare while production included amount of produce in ton per hectare which was measured using tons.

Mathematically yield was obtained as:

$Y = P/A$……...…….…….. (2)

Whereby; Y = Yield, P = Production and A = Area

3.5.4 Cost and benefit of vine and sweet potatoes production

In virus free vine and sweet potatoes production, the costs were classified into fixed costs and variable costs, depending on whether they are incurred only once during the establishment of an activity which is termed as establishment cost or whether they are incurred even after the activity is established, which is termed as operating costs. The costs were extracted from land preparation, tilling of land, planting materials, inputs, weeding, certification, harvesting and transportation.

3.5.4.1 Analysis of cost and benefit for vines production

In this section cost and benefit of vine production were analyzed by considering variables which are quantity of inputs and outputs, price, and cost of production which included rent, labor, transport, certification charges, and cost of planting materials.

Cost function

Total cost (TC) was obtained through the following formula;

TC = TVC + TFC…….…… (3)

Whereby:

TC = Total cost, TVC = Total variable cost, TFC = Total fixed cost (TFC)

TVC = PY (Price X Quantity of variable inputs)

Net benefit function

Net benefit was obtained using the formula below

NB = TR – TC…….…… (4)

Whereby:

TR = Total revenue, TC = Total cost

3.5.4.2 Analysis of cost and benefit of sweet potato tubers production

In this section cost and benefit of sweet potatoes production using virus free planting materials (PLM) were analyzed whereby variables were quantity produced, price, and cost of production which included rent, labor, transport and fertilizer.

3.5.5 Cost-benefit analysis

The Benefit Cost Ratio (BCR), Net Present Value (NPV) and Internal Rate of Return (IRR) analyses have been chosen for the present study due their simplicity and wide appeal among both financial experts and the uninitiated. The quantitative analysis which involved benefit-cost analysis was calculated using Microsoft Excel 2007. These ratios were computed as follows:

Net Present Value (NPV)

$$NPV = \sum_{t=1}^{n} \frac{B_t - C_t}{(1+i)^t} \quad \text{..... (7)}$$

Benefit-Cost Ratio (B/C)

$$\frac{B}{C} = \frac{\sum_{t=1}^{n} \frac{B_t}{(1+i)^t}}{\sum_{t=1}^{n} \frac{C_t}{(1+i)^t}} \quad \text{..... (8)}$$

Internal Rate of Return (IRR)

$$IRR where, NPV = \sum_{t=1}^{n} \frac{B_t - C_t}{(1+i)^t} = 0 \quad \text{..... (9)}$$

OR

$$IRR = LDR + (UDR - LDR)\left(\frac{NPV_1}{NPV_1 - NPV_2} \right) \quad \text{..... (10)}$$

Whereby; B_t = benefit in year t;

Ct = cost in year t;

t = 1, 2, 3...

n = number of years;

i = interest (discount) rate

LDR = lower discount rate at which NPV is positive;

UDR = upper discount rate at which NPV is negative;

NPV_1 = Net Present Value at the lower discount rate; and

NPV_2 = Net Present Value at the upper discount rate

The BCR indicator is equivalent to the ratio of the present value of benefits to the present value of costs. If there is no limitation of funds, the decision criterion is to accept BCR greater than 1.

3.5.6 Choosing the discount rate

In economic analysis the discount rate is the interest rate or the opportunity cost of invested capital. Usually, it is difficult to estimate an exact discount rate, however, the World Bank proposed 10 % to 12 % as an opportunity cost of capital for Tanzania. Therefore, the discounting rate adopted in the present study was 12 %. However, since many farmers in the study areas borrow from SACCOS, a lending discount rate of 18 % was also used as an opportunity cost of capital for the present study which was used to determine what might happen to NPVs.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Overview

This chapter presents the empirical findings of the present study. The findings are presented in a way that they allow a logical flow of ideas as governed by the study's objectives and hypotheses. The chapter begins with description of farmer's social economic characteristics, followed by yield of VFSP in the study zones, comparison of the benefits of VFSP production and vine multiplication in the study zones, Comparison of the benefits of SP production using certified virus free versus local planting materials in producing tubers and vines.

4.2 Socio-economic Characteristics

4.2.1 Age of the respondents

The mean age of SP producers using certified virus free planting materials was 41 years (Table 2). The study revealed that middle age groups were mostly involved in SP production in the study area. For the case of SP vine multipliers the mean age was 43 years. This implies that many of vine producers were in the active age category. The present findings are in line with Regnard (2006) who argued that age is among the factors which influence individual income generating capacity. Arguably, the accumulation of income mostly depends on age of an individual, since age determines individual maturity and ability to make economic decisions.

4.2.2 Education level of the respondents

Education level of the respondents amplifies the working efficiency. Skills and education are the key factors for improved SP production using virus free certified vines. The study

findings (Table 2) show that there is low level of literacy among respondents. For the case of vine multipliers the findings revealed that vine multipliers most of them attained secondary, certificate, diploma and university education level this is because operation in the vine production requires competence in terms of language especially English since training manual and directives mostly use technical language.

Table 2: Socio characteristics of the respondents from the survey

Statistics	**VFSP producers n=362**	**VFSP Vines producers n=133**
Age in years		
Mean	41.00	43.00
Minimum	23.00	27.00
Maximum	65.00	73.00
Sex (%)		
Male	31.70	51.30
Female	68.30	48.70
Education (%)		
None	3.30	-
Primary	71.30	9.30
Secondary	12.70	13.10
Certificate	1.70	31.00
Diploma	4.40	30.90
University	6.60	15.70

4.2.3 Sex of the respondents

Sex is among of the factors which influence income generating capacity of the household also has implication on the gendered roles and responsibility in the society. The study results (Table 2) showed that majority of improved sweet potato producers were women accounting to (68.3 %) of all respondents. This implies that women contribute more to the income generation through production of SP compared to men in the study area. About certified virus free vine production, men accounted to 52.3 % and women 47.7 % of the production. So the difference may be due to the fact that, SP is normally produced by

women. But in vine production there is much profit that's why men are more engaged than in potato production.

4.2.4 The variety of sweet potato grown in study area

The findings (Figure 3) revealed that improved variety is mostly grown in the study area, from the interview 54.1 % of respondents acknowledge of using improved varieties, and about 39 % were growing local varieties, 6.9 % were growing both local and improved materials.

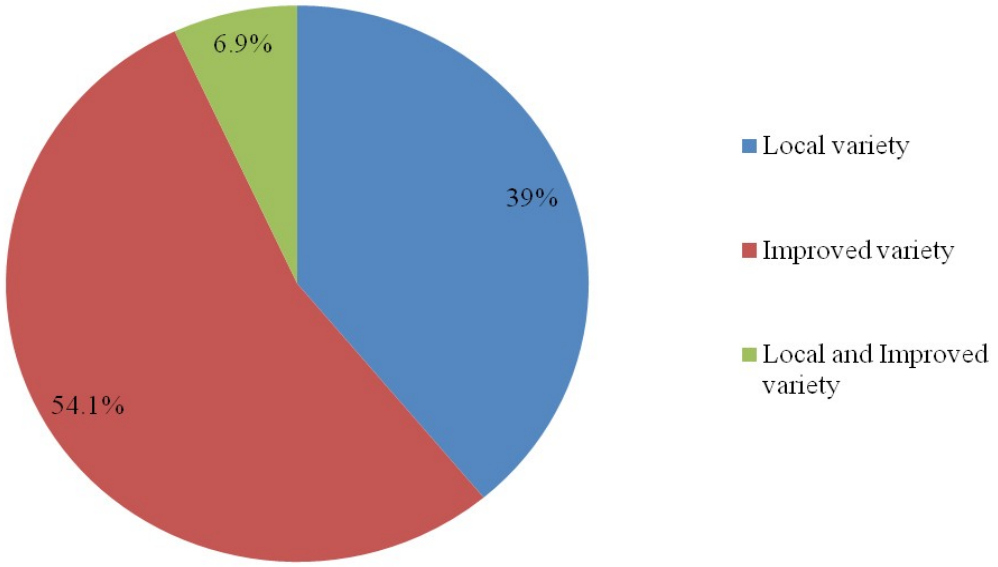

Figure 3: Statistics of sweet potato variety grown in study area

4.2.5 Distance from vine multipliers

The study findings revealed that 51.1 % (Table 3) of the interviewed respondents reported that distance from their farms to the vines multiplier is less than 10 km. About 29.1 % of the farmers were close to vine multipliers. This indicates that smallholder farmers using certified virus free vines have access to vines in their areas within reachable distances.

4.2.6 Changing planting materials

The study findings indicate that about 48.9 % of the respondent farmers changed or started with improved planting materials each season (Table 3). This indicates that smallholder farmers understand that in order to have a good harvest the planting materials should be free from diseases, thus it is important to start with planting material which are virus free each season in order to maintain the cleanness of the planting materials. Furthermore, 41.2 % of the interviewed respondents changed their planting material after two seasons.

4.2.7 Reasons of growing specific variety

The findings in Table 3 indicated that 68.8 % of the interviewed respondents pointed out that resistance to virus disease, early maturity and high yields were among the factors considered when selecting a particular sweet potato variety.

4.2.8 Scouting for pest and diseases

Most smallholder famers are aware about pest and diseases affecting sweet potato production which leads them to be able to scout the crop in the field frequently. The results indicate that 85.7 % of smallholder farmers are scouting for pest and diseases (Table 3) particularly for virus diseases. If the virus is seen, farmers provide report to the extension officers and gets an advice including changing of vines in specific time.

4.2.9 Major pest and diseases affecting sweet potato

About 26.0 % and 24.6 % of respondent farmers reported aphids and weevil as the major pests respectively, while 20.4 % reported signs of viral diseases as their challenge (Table 3). The results indicate that certified VFSP vines are most preferred by smallholder farmers in the growing area since they are free from virus infection.

4.2.10 Source of advice in the production of virus free sweet potato

The findings (Table 3) of this study revealed that smallholder famers learned about good agronomical practices (GAP) from extension agents, nearby research centres and from fellow farmers accounting for 27%, 24% and 22% of the respondents respectively.

4.2.11 Tillage technology used in the farm

The study findings (Table 3) revealed that 40.1 % of the respondent farmers use hand hoe technology in the farm cultivation. This indicates that mostly of sweet potato smallholder farmer’s still use hand hoe technology. Moreover, 23.2 % of the smallholder farmers use animal traction in the cultivation activities.

Table 3: Farming characteristics towards growing VFSP

Statistics	Frequency n=362	Percentages
Distance from vine multipliers		
<10Km	185	43.00
>20Km	55	27.00
>100Km	17	4.7
None	105	29.1
Changing planting materials		
After each season	177	48.9
After two seasons	149	41.2
No changes	36	10.0
Reasons of growing specific variety		
Diseases-resistant, maturity and yield	74	68.8
Large root tubers	8	2.2
High dry matter	95	26.2
Sweet and palatable	2	0.6
Good for sale of fresh roots	8	2.2
Scouting for pest and diseases		
Yes	314	86.7
No	48	13.3
Major pest and diseases		
Sweet potato weevil	89	24.6
Whitefly	64	17.7
Jongoo (Miliped)	39	10.8
Aphids	94	26.0
Virus like diseases	74	20.4
None	2	0.6
Source of advice		
Fellow farmer	79	21.8
Extension agent	96	26.5
Vine multipliers	23	6.4
Research centres	86	23.8
Agricultural programs-radio/TV	70	19.3
Fellow farmer and Vine multiplier	8	2.2
Technology used		
Hand hoe	145	40.1
Animal traction	84	23.2
Tractor	23	6.4
Hand hoe and Animal traction	70	19.3
Tractor and hand hoe	40	11.0

4.2.12 Main source of labor used in sweet potato production

Table 4 shows a proportion of labour used in sweet potato production in the surveyed zones. The results indicate that majority (48.1 %) of the interviewed farmers use both family and hired labour, and 38.4 % use only family as the source of labour. So smallholder farmers have an advantage of using family as a source of labour which reduces production cost.

Table 4: **Main source of labour used in sweet potato production**

Source/Type of labour	Frequency	Percent
Family	139	38.4
Hired	49	13.5
Family and hired	174	48.1
Total	**362**	**100.0**

4.1.13 Fertilizer application

Table 5 presents the proportion of farmers using fertilizers. Only 22 % of the farmers use fertilizer in sweet potato production. This results show that majority of the sweet potato farmers (77 %) in the surveyed areas do not use fertilizer in sweet pototo production.

Table 5: **Fertilizer use**

Applications	Frequency	Percent
Use fertilizer	81	22.4
No. fertilizer application	281	77.6
Total	**362**	**100.0**

4.3 Comparison Between Virus Free and Local Variety Sweet Potato Tubers and Vines Production

The comparison of tubers and vines production of sweet potato using virus free and local variety per hectare in kg were presented in table 6. Production was relatively higher in the production of both vines using VFSP compared to traditional variety and the production of SP tubers using local variety was lower compared to the production using improved variety. The differences are accounted by the fact that improved variety is free from virus which enhances it production while tradition variety mostly suffers from virus infestation.

Table 6: Comparison of tubers and vines production (kg) between VFSP and local variety per hectare

Statistics	Tradition variety		VFSP variety	
	Tubers	Vines	Tubers	Vines
Mean	871.21	59.9	1 284.71	90.17
Maximum	1080.00	77.00	3 333.33	743.77
Minimum	476.00	33.00	300.00	4.83
Standard deviation	59.72	5.95	483.90	86.46

4.4 Productivity and Production of VFSP Among Zones

Table 7 presents productivity for sweet potato using certified virus free per hectare across the zones. The overall average yield of SP production across zones was 1.7 ton/ha, which is well far below the potential yield of sweet potato of 15 tons/ha. Across zones, average sweet potato production was higher in the Lake Zone with 3.3 tons/ha with a mean production of 1.3 ton/ha. In the Coastal zone the production was slightly lower than lake zone with 2.2 tons/ha and mean production of 1.3 ton/ha. The difference in production between the two agro-ecological zones could be attributed to number of reasons including LVZ sweet potato being among of the main source of food.

Despite the use of certified virus free materials the yield depends on many factors including GAP. In the surveyed areas, farmers acknowledged that not using fertilizers do not contribute to low production inspite of using improved certified PLM.

Table 7: Yield production VFSP tubers (Yield in ton/ha)

Statistics	Lake Zone	Coastal Zone	Overall
Mean	1 309.44	1 249.75	1 702.79
Minimum	300.00	300.00	300.00
Maximum	3 333.33	2 222.22	3 703.70
Standard deviation	461.42	497.69	493.10

4.5 Productivity and VFSP Vines Among Zones

In the two zones the common method of packaging planting material for sale is bundles that contains about 50-60 vine cuttings of about 15-20 cm. The result shows that the mean production of virus free vines per farmers in the Lake Zone was 133.34 kg/ha and coastal zones was 227.65 kg/ha (Table 8)**.** This indicates that both vine production and productivity is higher in Lake Zone compared to Coastal Zones. This is attributed to the fact that LVZ sweet potato is used as staple food which increases the demand of vines each season compared to coastal zone.

Table 8: Yield production of VFSP vine (Kg/ha)

Statistics	Lake Zone	Coastal Zone
Yield of vine multiplication		
Mean	133.34	276.65
Minimum	10.68	15.91
Maximum	512.82	2 447.98
Standard deviation	92.40	398.82

4.6 Comparison of Cost and Benefit Between VFSP and Local Variety Tubers and Vines

The comparison of cost used in the production and benefit obtained in TZS between VFSP and local variety tubers and vines per hectare were shown in table 9. Cost is relatively higher in VFSP vine production compared to production of vines using traditional variety. The difference is attributed to the fact that producer of vines using improved variety are required to buy certified vines while traditional variety does not need that. Cost of production of sweet potato tubers is lower using improved variety compared to tradition variety. In the case of benefit, VFSP seems to have positive net benefit for both variety but it is relatively higher in improved variety than traditional variety which attracts more producers to invest in production of VFSP vine.

Table 9: Comparison of cost and benefit in (TZS/ha) between VFSP and local variety tubers and vines

Statistics	**Tradition variety**		**VFSP variety**	
	Tubers	**Vines**	**Tubers**	**Vines**
Description per ha				
Cost	298 370	124 300	276 115.63	124 023.80
Benefit	608 148	215 000	962 509.41	325 433.25
Net benefit	309 778	90 700	686 393.78	201 409.45

4.7 Costs and Benefits of VFSP Vine Multiplication

The study findings showed that, overall in the Lake Victoria Zone cost of vine multiplication was TZS 114 850, benefit was TZS 333 937 with the net benefit of TZS 219 086, while in Coastal zone cost of vine multiplication was TZS 145 043, with benefit of TZS 305 949 and net benefit of TZS 160 905 (Table 10). The findings demonstrate that vine multiplication is profitable due to its positive benefit in both zones. However,

majority of farmers still use traditional method where vine cuttings are mostly sold in bundles of different sizes. Lack of standard measure for marketing the vines limits the level of profitability.

The formal seed delivery system mostly practiced by research centres and private tissue culture laboratories, each sweet potato vine of pre-basic grade is sold at the unit of sale 60-70 TZS. In these study areas the improved VFSP materials are sold in bundles as in traditional system. This is one of the market strategies to gradually transform farmers from traditional to official seed system to first let the farmers access VFSP cheaply and see the benefit and finally adopt the formal system because farmers will have already realised the benefit of using improved VFSP.

Table 10: Cost and benefit of VFSP vine multiplication (TZS/ha)

Statistics	Lake Zone	Coastal Zone
Description per ha		
Cost	114 850	145 042
Benefit	333 937	305 949
Net benefit	219 086	160 905

4.8 Average Costs and Benefits per hectare Associated in VFSP Vine Multiplication

The results revealed that the average cost in vine multiplication in the Lake Zone was 116 848 TZS/ha, minimum cost of production was TZS 50 000 and maximum cost of production was 250 000 TZS/ha while average and net benefit were TZS 339 745 and TZS 222 897 respectively (Table 11). Also in average, minimum and maximum cost of vine multiplication in Coastal Zone was TZS 150 000, TZS 30 000 and TZS 280 000 respectively while the average benefit was 312 450 TZS/ha and net benefit was 164 325 TZS/ha. This is attributed to a reason that in LVZ the demand of vine is high relative to

large area which is used in production, and the number of farmers engaged in sweet potato production is relatively high compared to Coastal Zone. This is because sweet potato is a staple food in LVZ, thus accelerates its production and boosts the need of vines.

Table 11: Average costs and benefits in VFSP vine multiplication (TZS/ha)

Statistics	Cost	Benefit	Net Benefit
Lake Zone			
Average	116 848	339 745	222 897
Minimum	50 000	67 500	7 500
Maximum	250 000	600 000	450 000
Standard deviation	25 152	107 851	100 286
Coastal Zone			
Average	150 000	312 450	164 325
Minimum	30 000	40 000	36 000
Maximum	280 000	1 000 000	880 000
Standard deviation	31 823	250 495	210 624

4.9 Average Costs and Benefit in VFSP Vine Multiplication among Regions

Our findings indicated that, the average cost was higher in Pwani region followed by Dar es Salaam both in Coastal zone, and Kagera region in LVZ, while the least cost was in Mwanza (Table 12). The differences are due to the fact that Pwani and Dar es Salaam are within the commercial city (Dar es Salaam) where demand for sweet potato is high hence fetching good price. This creates more demand for certified VFSP vines to boost production needed to serve this market demand.

Table 12: Average cost and benefit in VFSP vine multiplication (TZS/ha) across regions

Statistics	Pwani	Dar-es-Salaam	Mwanza	Kagera
	n = 30	n = 12	n = 44	n = 47
Yield in bags	249.51	133.61	207.92	291.60
Benefit				
Average	330 133	241 954	336 454	348 617
Minimum	40 000	52 000	67 500	120 000
Maximum	1 000 000	6 600 000	600 000	600 000
Standard deviation	266 821	195 798	114 196	101 845
Cost				
Average	150 167	134 545	104 090	130 000
Minimum	50 000	30 000	50 000	50 000
Maximum	280 000	270 000	160 000	250 000
Standard deviation	72 021	56 725	31 011	43 564

1 bag = 50kg

4.10 Comparison of Cost and Benefit in the Production of SP Vine Using Virus Free and Local Variety

Table 13 presents the comparison of cost used in the production of VFSP and local potato vines in the open space and screen house and benefit obtained per hectare. Cost was relatively higher in vine production using screen house compared to open space and benefit normally takes 5 years to repay investment cost used since it was expected to be TZS 600 000 each season while screen house cost estimated to TZS 3 000 000. The production of SP vine using local variety was lower compared to VFSP vine. In the case of benefit VFSP seems to have positive net benefit for both ways. The differences are accounted by the fact in the production of VFSP vine in a screened house consume higher cost compared to production in the open space while cost of production of vine using

local variety is lower than using virus free since in virus free variety farmers are supposed to buy the prepared and registered vine from research centres but local variety does not.

Table 13: Comparison of cost and benefit in the production of VFSP and local vine

Statistics	**Improved variety**		**Local variety**
	Open field	**Screen house**	
Cost	112 760	600 000	73 000
Benefit	387 760	812 000	238 000
Net benefit	275 000	212 000	165 000

4.11 Cost and Benefit in VFSP based Tuber Production

The findings show that the use of certified virus free vines for production of sweet potato tubers generated positive net benefit in both zones. In the LVZ, the average net benefit of TZS 1 029 718 was generated with an investment cost of TZS 254 948 in a production per hectare while in Coastal zone TZS 847 042 was accrued from TZS 312 483 investment in production (Table 14). The results demonstrated that using certified planting materials, benefitted sweet potato farmers. This was manifested by the positive net benefit in both zones, which indicates that adopting certified virus free planting materials is profitable option. Findings in this work agrees with those of Fuglie *et al*. (2016) "who recorded net benefit using virus free planting materials in Shandong province in China.

Table 14: Costs and benefits (TZS/ha) in VFSP tuber production

Statistics	**Lake Zone**	**Coastal Zone**
Cost	254 948	312 483
Revenue	1 284 666	1 159 525
Net benefit	1 029 718	847 042

4.12 Average Cost and Benefit Associated in Tuber Production Using VFSP Vines ha^{-1}

The results showed that the production costs of sweet potato using certified planting materials in LVZ ranged from 64 000 TZS/ha to 986 000 TZS/ha with an average cost of 312 913 TZS/ha. The average revenue and net benefit was 1 576 745 TZS/ha and 1 263 833 TZS/ha respectively (Table 15). The multiplication cost in Coastal zone was slightly higher than LVZ, ranging from 64 000 TZS/ha to 1 011 000 TZS/ha with an average cost of 315 503 TZS/ha. Similarly, the average revenue of 1 000 000 TZS/ha and net benefit of 595 000 TZS/ha accrued in Coastal zone was significantly lower (P-value 0.000116) than of LVZ. The positive net benefit of multiplication and selling of certified virus free SP in both agro-ecological zones indicates that the business is beneficial to the small holder farmers.

Table 15: Average cost and benefit in VFSP tuber production in TZS ha-1

Statistics	Cost	Benefit	Net benefit
Lake Zone			
Mean	312 913	1 576 745	1 263 833
Minimum	64 000	250 000	68 000
Maximum	986 000	8 000 000	7 634 000
Standard deviation	27 445	130 651	503 004
Coastal Zone			
Mean	315 503	1 000 000	595 000
Minimum	64 000	250 000	68 000
Maximum	1 011 000	5 000 000	4 144 000
Standard deviation	26 859	658 280	443 899

4.13 Average Cost and Benefit in VFSP Tubers Production Across Regions

The study revealed that average cost used in production of SP tubers using certified VFSP vines per ha in each regions is almost similar (Table 16). However, maximum cost used in production was high in Kagera and Dar es Salaam, while the lowest cost of production was in Mwanza (Table 16). The benefit per ha was positive in all the regions, with more benefit per ha realised in Mwanza and Kagera regions, both in LVZ. The reason of this difference is that despite the evident benefit obtained from using VFSP vines, their productivity goes together with adoption of good agronomical practices recommended for sweet potato cultivation.

Table 16: Average cost and benefit in SP tuber production using VFSP vines between regions (TZS/ha)

Statistics	Pwani	Dar-es-Salaam	Mwanza	Kagera
Cost				
Average	306 733	319 844	311 064	319 902
Maximum	504 000	1 011 000	856 000	986 000
Standard deviation	91 310	200 931	125 695	118 657
Benefit				
Average	886 686	931 729	931 780	996 134
Maximum	1 720 000	1 550 667	2 952 889	2 895 111
Standard deviation	446 322	340 042	489 820	513 612

4.14 Comparison of Cost and Benefit Between Virus Free and Local Variety Sweet Potato Tubers Production Across Two Zones

The Table 17 presents the comparison of cost used in the production of sweet potato using virus free and local variety and benefit obtained per hectare across two zones. Cost was relatively higher in Coastal zone compared to LVZ. The production of SP using local variety was lower in the LVZ compared to the cost used to produce VFSP while in the Coastal Zone the cost used in the production of local variety was higher. In the case of benefit of VFSP seems to have higher net benefit compared to local variety in both Zones. The differences are attributed by the fact that, in the production of VFSP other costs are not incurred since it does not require insecticides and since the VFSP is an improved variety its yield is higher compared to local variety.

Table 17: Comparison of cost and benefit between VFSP and local variety tubers across two Zones

Statistics	**Lake Zone**		**Coastal Zone**	
	VFSP	**Local Variety**	**VFSP**	**Local Variety**
Description per ha				
Cost	254 948	235 782	312 483	332 173
Benefit	1 284 666	1 131 028	1 159 525	802 615
Net benefit	1 029 718	895 245	847 042	470 442

4.15 Significance Difference of Cost and Benefit in Tuber Production Using VFSP Vines ha^{-1}

This section shows the significance relationship between cost associated in production and benefits obtained. The study result indicates that there was a strongly significance relationship between cost and benefit in production of VFSP vines which was supported by probability value of (P-value) 0.000116 (Table 18). It was observed that, the costs of

production were affordable to small holder farmers, and they were lower than the benefits obtained. Thus, the production of sweet potato using certified VFSP is economically viable to the producers which lead to improvement of financial sustainability of farmer's households.

Table 18: Significance level of Cost and benefit in SP tuber production using VFSP vines

	Coefficients	Standard Error	T Stat	P-value	Lower 95%	Upper 95%
Intercept	9058.196	386.3331	23.4466	1.8274	8298.443	9817.949
Cost-Benefit	0.016579	0.004253	3.898363	0.000116	0.008216	0.024943

4.16 Costs-benefit Analysis

CBA was undertaken for the selected two Zones and two types of planting materials: certified virus free and local sweet potatoes variety. The basic assumption undertaken for CBA was that, farmers aimed at maximizing net benefits from the sweet potato production. On the basis of this assumption, farmers would prefer a sweet potato production system that has higher net present value as a criterion for decision making.

The following assumptions were adopted:

i. Sweet potato was harvested only once per season.
ii. Price used was valued at market prices of the 2018/2019 constant prices. Sweet potato vine and tubers in the study area were sold at different prices reflecting the type of vine sold and size. But all the prices were averaged to come up with one figure using farm gate prices of TZS. 1000 per Kg of sweet potato tubers and cost of certified VFSP vine was 70 TZS/vine cutting.
iii. Sweet potato production was estimated per one acre because most farmers were used to this unit of land.
iv. Discount rate used was 12% and 18% as described in the methodology chapter.

4.16.1 Results of cost benefit analysis of VFSP tuber production ha^{-1}

The analysis obtained after discounting all benefits and costs at 12 %, in both agro-ecological zones earned positive Net Present Value (Table 19). At 12 % discount rate, LVZ generated TZS. 9 157 194 per ha while in Coastal zone a total of TZS. 8 344 944 were generated per ha. In contrast, at 18 % discount rate, although NPV was still positive in both agro-ecological zones, the revenue generated from the investment was lower (TZS. 6 590 188 in LVZ) and (TZS. 5 693 821) in Coastal zone than when 12 % discount rate was applied (Table 19). The positive indication of both discount rate analysed in the two agro-ecological zones, highlights that costs can be recovered from the investment when certified seeds are used.

Cost Benefit ratio was above one for both zones, which ensure that investing in the two zones, costs would be recovered at the end of season (Table 19). Furthermore, the rate of return was below the opportunity cost of capital estimated which was 12 %. The cost benefit analysis indicates that production of sweet potatoes using certified VFSP vines in both zones are worth undertaking.

The findings in this study are in line with KARI (2019) on their project analysis based on "Cost benefit analysis of sweet potato on farm enterprises in central Uganda" their results of the CBA showed that, the production of sweet potato was financially viable with regard to commercial production of tubers, vines, storage technologies and snack production. It also pointed out that, the activity was viable since technologies require low start up capital and the products are highly demanded.

Table 19: Results of benefit costs analysis in TZS per ha^{-1}

Statistics	Lake Zone		Coastal Zone	
Rate	12 %	18 %	12 %	18 %
NPV	9 157 194	6 590 188	8 344 944	5 693 821
BCR	5.04	4.21	3.71	2.80
IRR	0.0112	0.00039	0.0102	0.00034

4.16.2 Results of cost-benefit analysis of VFSP vine multiplication

In case of certified VFSP vine multiplications, results revealed that, of the two discounting rates analysed, all benefits and costs at both agro-ecological zones earned positive Net Present Values, with 12 % earned slightly more than 18 % (Table 20).

Table 20: Results of Benefit Costs analysis in TZS ha^{-1}

Statistics	Lake Zone		Coastal Zone	
Rate	12%	18%	12%	18%
NPV	3 433 615	1 014 938	2 034 900	1 533 634
BCR	2.91	1.9	2.11	1.1
IRR	0.0042	0.0005	0.0025	0.0009

This means that costs incurred in the multiplication of certified vines can be recovered. Similar trend was observed for Cost-Benefit ratio which was above one in both agro-ecological zones, this ensures that investing in vine multiplications costs, would be recovered at the end season. The rate of return was below the opportunity cost of capital estimated at 12 %. The results based on cost benefit analysis indicate that production of certified VFSP vines in both zones is worth undertaking business.

These results match with the findings by Fuglie *et al*. (1999) on their study on "Economic Impact of Virus-Free Sweet potato Planting Material" where they highlighted that, the internal rate of return estimated to be 202 percent, with a net present value of $550 million at 10 percent discount rate.

4.16.3 Results of costs benefit analysis of local and VFSP planting materials for tuber production

The results of CBA in respect to the two planting materials namely virus free improved and local sweet potato planting materials (PLM) are shown in Table 21. The results indicated that after discounting all benefits and costs at 12 %, all the varieties earned positive Net Present Value. Since Cost Benefit ratio was above one for both PLM, an investment in all PLM costs will be recovered. The decisive factor is to suggest the variety with higher value for the calculated discounting measures; therefore the value was higher in VFSP vines.

Table 21: Results of Benefit Costs analysis calculated in TZS ha^{-1}

Statistics	**Virus free variety**		**Local variety**	
Rate	12%	18%	12%	18%
NPV	8 589 034	5 794 720	956 177	866 909
BCR	3.01	2.53	2.38	1.91
IRR	0.42	0.31	8.63	1.94

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

Descriptive statistics, cost and benefit analysis were used to analyze data collected from the study area. These analytical methods were meant to do economic analysis of virus free sweet potato production system. A binary logistic regression analysis was employed to test the statistical relationship between the probability of uptake of VFSP technology and other factors.

The results showed that actors differed with respect to age (young, middle and elder age), education levels and sex. A detailed discussion of these and other variables were found to influence participation in the VFSP production of both vines and tubers. The observed differences in yields between Lake Zone and Coastal Zone were found to have implication on economic support of Virus free PLM to the farmers.

5.1.1 Cost and benefit

The measures used to evaluate virus free sweet potatoes and vine production were NPV, CBR and IRR. The NPV was positive in both Zones, and CBR was greater than one in both zones which revealed that investing in production of sweet potatoes and vine production was worth undertaken in both Zones.

It was also established that actors in the SP seed delivery system performed differently in terms of economic benefits. Generally, production of both vines and SP using virus free was found to have economic benefits to farmers since the level of cost used was smaller compared to the benefit obtained. However, the extent of economic benefits varied

between zones in vine production as well as in SP production. The presented costs and benefits evidenced the differences in economic benefit between zones. The costs and benefits show that actors in Lake Zone obtained relatively higher benefit than those in Coastal Zone but not always the case.

The observed difference in economic benefit among farmers in the production of VFSP tubers and vines was mainly attributed to difference in production level, cost used and area cultivated. These findings revealed that, the production and net benefit achieved by the farmers were significant. Furthermore, the noted economic returns amongst actors worked against the null hypothesis which was formulated in chapter one stating that the cost and benefits of VFSP vine production by smallholder farmers is no significant and cost and benefits of sweet potato production using certified virus free PLM also is not significant.

5.1.2 Comparison between improved and local variety

The study found that both varieties had positive benefit which is worthy to invest in this sector. Although both varieties had positive benefit but yield and benefit were relatively higher to the virus free sweet potato variety compared to local variety.

5.1.3 Problems constraining production of VFSP

The present study found out that, despite the positive return to investment realized in multiplication and selling of certified VFSP planting materials, the business was highly challenged by the cheaply available inferior planting materials. It is important for the government and other development change agents and practitioners with vested interest in food security to widely promote VFSP.

Low prices for SP tubers particularly at peak harvest time were observed to be the main obstacle among smallholder farmers in expanding the production of VFSP. However, it should not be overlooked that price was the only factor limiting farmers to produce large quantity of sweet potatoes, there were other factors namely low rainfall and drought constraints, and however in some areas it was not possible to use irrigation.

5.2 Recommendations

Based on the findings of the study the following recommendations are made for increasing production of VFSP and enhancing food security and economic benefit to the smallholder farmers.

5.2.1 Training and distribution of VFSP planting materials to other regions

Since production of VFSP in the Lake and Coastal Zones is profitable, its production should be scaled out in other regions. The production of VFSP is still below the potential yield levels. The use of virus free planting material is among the strategies which help sweet potato producers to deal with the problem of diseases, it is important to intensify training on GAPs through agriculture extension agents as the way of attracting the smallholder farmers to accept sweet potatoes new variety.

5.2.2 Re-examine of VFSP production guidelines

Guidelines on production of VFSP planting material need to be revised to create conducive environment for smallholder farmers to run successful local multiplication unit. Vine Multipliers need support to meet needs of VFSP tubers growers. VFSP production training needs to cover new small holder farmers who are ignorant on the use of improved varieties.

5.2.3 Empowering producers of VFSP vine and tubers

The governments in collaboration with other stakeholders should collaborate in the development of the SP subsectors to empower VFSP producers towards enhancing their economic benefit. VFSP production for both vines and tubers should be enhanced by sound investment, training as well as planned production strategy. Furthermore a holistic approach is required for boosting VFSP production. The government subsidy program should be established to support decentralized production and distribution system of VFSP planting materials. Furthermore, since the virus free sweet potatoes seen to be profitable, the study recommend that, the virus free vines should be distributed in other zones in order for smallholder farmers to have chance of enhancing their economic stability.

5.3 Recommendation for Further Research

Based on the findings from this study, it is suggested that more empirical research should be undertaken, so as to focus on the following:

The study has just concentrated on cost-benefit analysis; further studies can be conducted on value chain assessment in VFSP production. Also the study has just concentrated on yield production; further studies can be conducted on cultural perceptions in the production VFSP in order to change product image towards enhancing economic stability to farmers.

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APPENDICES

Appendix 1: Questionnaire

SWEET POTATO PRODUCER QUESTIONNAIRE

QUESTIONNAIRE TO ASSESS THE ECONOMIC ANALYSIS OF VIRUS FREE SWEET POTATO PRODUCTION SYSTEM IN MAJOR SWEET POTATO GROWING REGION: MWANZA, PWANI AND DAR-ES SALAAM, TANZANIA

Introduce yourself by name and address

Explain to the farmer that you wish to discuss with him or her on the use of high quality virus free sweet potato planting materials and seek permission to interview him/her prior to actual interviewed. We request for your time to answer a few questions. Thank the farmer for their co-operation. Once farmer's consent granted, the details of the interviewer should also be included for accountability

Section A: Survey Identification

1. Interviewer code	
2. Date of interview	
3. Time started	
4. Time ended	
5. Name of respondent	
6. Questionnaire number	

Respondent Location

Village/Street……Ward……District……..Region……

GPS location…….Latitude……..Longitude……

Section B: Household Composition, Human and Social Capital

Please report the household composition. Note that a 'household' includes all members of a common decision making unit (usually within one residence) that are sharing income and other resources. These include dependents who are away from home. Also include workers and servants as members of the household if resident for at least six months in the household.

Please, circle the appropriate number only

	Question	**Details**
1.1	What is the sex of the head of the household?	1=M 0=F
1.2	What is the age of the head of household?	_____ (years)
1.4	What is the education level of the household head?	1= No formal education 2= Primary school 3= Secondary school 4= University 5= Other (specify):
1.7	Number of years of education of the spouse?	_____(years)
1.8	For how long have you been cultivating sweetpotato?	_____(years)
1	Age (years)	1=18-25, 2=26-33, 3=34-41, 4=42-49, 5=50=<
2	Education level	1= None 2= Primary 3= Secondary 4= Certificate 5=Diploma 6=Higher education
3	Primary occupation	1=Wage employed 3= Business 4= Crop production 5= Others…..
4	Secondary occupation	1= Employed 3= Business 4= Crop production 5= Others…..
	How long have been cultivating sweetpotato	……..……years

Household Composition

		Number. in household	**Number. working on crop production (overall)**	**Number working in sweetpotato production**	**Number working off-farm employment**
2.1	Children < 15 years				
2.2	Adult males>15 years				
2.3	Adult females>15 years				
	Total				

Notes: Adults include the household head and spouse

Source of planting materials for sweet potato production

3. How long have you been growing sweetpotato?.....

4. What type of sweet potato variety do you grow in your farm?

a) Local Varieties

b) Improved varieties

c) Improved orange flesh sweetpotato (OFSP) "***viazi lishe***"

d) Both

5. Which particular varieties did you grow last season (2018)

mention_____

6. What is your source of sweet potato planting materials?

a) Own source from previous crop

b) Purchase from fellow farmer

c) Purchase from vine multipliers

d) Another source (specify)

7. If purchased from vine multipliers how far from your field

a) Less than 10km within my village

b) More than 20 km outside my district but within the region

c) More than 100 km away from my zone

d) Other specify_____

7. How much do you purchase materials specify……..
8. How often do you change planting materials?

a) After each season start with fresh vines

b) After two seasons

c) I do not changes

9. How much are you willing to pay for cost of high quality virus free vine…… specify

Sweetpotato production (2017/2018 SEASON)

10. Which sweetpotato varieties did you grow? Please provide information on each variety in the table below

	Variety	**Area planted (Ha)**	**Production (MT)**	**Yield (MT/Ha)**
	2017 season			
1				
2				
3				
4				
5				
	Total			
	2018 season			
1				
2				
3				
4				
5				
	Total			

11. For what reason (s) do you grow these varieties? Tick appropriate response(s)

	Reasons/Attributes	**Rank (Select all that apply)**
1	Early maturity period	
2	High yielding variety	
3	Large root tubers	
4	High dry matter	
5	Sweet and palatable	
6	Big sized tuberous roots	
7	Resistant to virus	
8	Resistant to weevil	
9	Fresh market preference	
10	Drought resistant	
11	Preferred by processors for processed products	
12	Good for sale of fresh roots	
13	Other (specify):	

12. Report the cost of planting materials, fertilizer and chemicals used in production (2018 season)

Seed/planting material	**Variety**	**Quantity planted**	**Cost of seed/planting material (Shs per unit)**	**Name of fertilizer**	**Price of fertilizer (Shs per unit)**	**Total cost of agro-chemicals (shs)**	**Total cost of all other inputs (shs/Ha)**

13. What is the main source of labour used in sweet potato production?

    a) Family

    b) Hired

    c) Family and hired

14. What is the wage rate per acres for farm labor in this area?

    a) Bush clearing

    b) Cultivation

    c) Planting

    d) Weeding……

e) Harvesting ……..

15. What type of technology do you use in the farm?

a) Hand hoe

b) Animal traction

c) Tractor

16. Do you use fertilizer?

a) yes

b) No

17. If yes, describe the type of fertilizers applied, their rate and why they are used at the different field vegetable growth stages. Fill in the table below.

Stage of field vegetable growth	**Type of fertilizer/s applied**	**Application Rate**	**Reason fertilizer is used**
a. Before/or at transplanting			
b. Vegetative stage			
c. At tuberization			

18. If not using fertilizers why?

a) Not available

b) Expensive

c) Not required

d) Not easily accessible

e) Others (specify)

Section F: Pest and Disease Management

19. Do you scout for pests and diseases in your sweetpotato?

a) Yes

b) No

20. If yes, what are the major pests and diseases that affect your sweetpotato?

a) Sweetpotato weevil (Fukusi)

b) Whitefly

c) Jongoo

d) Aphids (mafuta)

e) Viral diseases

f) Other specify

21. Do you do any management after disease scouting?

a) Yes

b) No

22. If yes, what management do you practice?

……..

23. What informs your decision to practice a certain management option/s?

……

24. If the farmer uses pesticides, describe the pesticides used at the different growth stages and the target pests/diseases. Fill in the table below

Stage of crop growth	**Pest/disease problem**	**Pesticide/s applied and rate**	**Frequency of application**
a. Before/ at transplanting			
b. Vegetative stage			
c. Tuberization			
d. At maturation			

25. Which is your source of advice for production of sweet potato (GAPs) Own knowledge

a. Fellow farmers

b. Extension agent

c. Vine multipliers

d. Research centres

e. Agricultural programs-radio/Tv (e.g. Shamba shape up)

26. Any problem with marketing of your sweetpotato?.....

Appendix 2: Vine producer questionnaire

QUESTIONNAIRE TO ASSESS THE ECONOMIC ANALYSIS OF VIRUS FREE SWEET POTATO PRODUCTION SYSTEM IN MAJOR SWEET POTATO GROWING REGION: MWANZA, PWANI AND DAR-ES SALAAM, TANZANIA

Introduce yourself by name and address

Explain to the farmer that you wish to discuss with him or her on the use of high quality virus free sweetpotato planting materials and seek permission to interview him/her prior to actual interviewed. We request for your time to answer a few questions. Thank the farmer for their co-operation. Once farmer's consent granted, the details of the interviewer should also be included for accountability

Section A: Survey Identification

11. Interviewer code	
12. Date of interview	
13. Time started	
14. Time ended	
15. Name of the vine multiplier	
16. Questionnaire number	

B. Respondent Location

Village/Street……Ward……District……..Region……

GPS location…….Latitude……..Longitude……

C: Sweetpotato Vine Production

1. Do you produce vines for sale as business? Yes/No
2. Is your nursery registered by TOSCI as seed dealer (Yes/No)
3. If yes which grade of seed do you produce and sell?
    a) Prebasic seed
    b) Basic seed
    c) Certified 1
    d) Certified 2
    e) Quality declared seed (QDS)
4. If yes fill the table below (*Please fill in the following table on virus free sweet potato trading*)

Seasons	**Quantity**	**Cost**	**Quantity sold**	**Price**
2018/19				

5. Where is your source of mother stocks……
6. Do you have any contractual arrangements with buyers?
    1) Yes
    2) No
7. Who sets price of virus free sweet potato in the market
    a) Farmers
    b) Wholesalers
    c) Retailer
    d) Others (Specify)
8. What are the criteria used in setting price?
    a) Costs incurred
    b) Supply and demand situation
    c) Others specify

9. What kind of standard do you use when selling sweet potato?
    a) Per bundle
    b) Per single 30 cm vine
    c) A sack of vine
    d) By ridge
10. Does your seeds are certified by TOSCI prior to selling? (Yes/No)
    1) If yes how many times before selling
    2) No
11. How do you sell your seeds
        a) I sell them at the market
        b) On agricultural show
        c) Customers comes to my nursery
        d) I ship to them on public transport after mobile transaction
12. What is the cost of transporting one bag of sweetpotato vine from the farm to the market/your client…….?
13. Who are the major customers of your produce?
    a) Local farmers
    b) Processors
    c) Government institutions
    d) Projects/NGOs
    e) Others specify
14. What are the major constraints you experience in production of virus free sweet potato?
    a) Source of getting virus free mother stocks vines
    b) Fluctuation in price of sweet potato yield
    c) Lack of market vines

d) Drought

e) Cost of certification

f) Others (specify)……..

15. What are the factors influenced you to production of virus free sweet potato?

Rank the following factors as: 1= High, 2 = Medium 3 = Low

Factors	**Ranking**
Quantity of Yield	
Demand of high quality seed	
Training	
Cost of production is low than tubers	
Profit from selling the vines	
Encouragement for friend	
Availability of reliable mother stocks	
Experience	
Other (specify)	

D: Cost in Sweet Potato Production

16. Indicate different costs used in sweet potato vine production

Operation	**Cost/unit(acre/ha)**
Hiring land	
Cultivation	
Harrowing	
Planting	
Fertilizer	
Weeding	
Seed (buying costs + haulage cost)	
Harvesting	

12. Report the cost of planting materials, fertilizer and chemicals used in production (2018 season)

Seed/ planting material	**Variety**	**Quantity planted**	**Cost of seed/planting material (Shs per unit)**	**Name of fertilizer**	**Price of fertilizer (Shs per unit)**	**Total cost of agro-chemicals (shs)**	**Total cost of all other inputs (shs/Ha)**

17. Do you think sweetpotato seed business is the profitable venture (yes/No)

18. Please explain whatever answer……

What do you think should be done to make it more profitable business

……