

**ECONOMIC VALUE OF USING AFRICAN WEAVER ANTS AS BIOLOGICAL
CONTROL IN FRUIT PRODUCTION AND EXPORT IN TANZANIA**

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**PUBLISHABLE MANUSCRIPT PAPERS SUBMITTED IN COMPLETE
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EXTENDED ABSTRACT

Food consumer demands are increasing for safe crop production systems because of ecological and health risks of pesticides. African weaver ants are alternative to pesticides to promote production and facilitate export. An experiment was conducted to test the weaver ants (with and without feeding) in 2012/13 and 2013/14 seasons and was compared with insecticides and no-pest control. A qualitative survey on export problems was conducted in 2013/14 buying season. The objective was to investigate the economic value of using African weaver ants as biological control agent in both production and export. The methods of analysis were partial budgeting techniques involving Marginal Rate of Return (MRR) and measures of return on investments namely: Net Present Value (NPV), Benefit Cost Ratio (BCR) and Internal Rate of Return (IRR). Export problems were interpreted from the perspective of institutional theory. Results shows that switching from insecticides to African weaver ants in cashew led to positive net change in benefits of 8731 TZS/tree in 2012/13 and 13 903 TZS/tree in 2013/14 seasons. Higher MRR values was obtained when switching from no-pest control to African weaver ants without feeding at 235% in 2012/13 and at 405% in 2013/14 seasons. It ranked first for all decision criteria used (NPV at TZS 66 926 per tree, BCR at 2.5:1 and IRR at 57%). In mango, switching from insecticides to African weaver ant without feeding gave positive net change in benefits by 8957 TZS/tree in 2012/13 and 20 736 TZS/tree in 2013/14 seasons. The MRR were higher at 509% in 2012/13 and at 743% in 2013/14 seasons when switching from no-pest control to African weaver ants without feeding. Conflicting results were noted when ranking feasibility. African weaver ants without feeding was superior for NPV at TZS 66 926 per tree. The use of African weaver ants without feeding in both orchards and was recommended. It facilitates to capture organic markets of cashew and mango products from Tanzania to the target export market in Europe such as meeting export product quality, insufficient volumes of products.

DECLARATION

I, **William Juma George**, do hereby declare to the Senate of Sokoine University of Agriculture that this dissertation is my own original work done within the period of registration and that it has neither been submitted nor being concurrently submitted in any other institution.

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The above declaration is confirmed



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DEDICATION

This thesis is dedicated to my beloved mother, Theresia Mpanduji and my father, Juma George who showed me that education is the most important gift that parents can provide to their children and motivated me to participate in rural community development activities.

TABLE OF CONTENTS

EXTENDED ABSTRACT.....	ii
DECLARATION.....	iii
COPYRIGHT	iv
ACKNOWLEDGEMENTS	v
DEDICATION.....	vi
TABLE OF CONTENTS	vii
LIST OF TABLES	xii
LIST OF FIGURES	xiii
LIST OF PLATES	xiv
LIST OF ABBREVIATIONS	xv
CHAPTER ONE	1
1.0 GENERAL INTRODUCTION.....	1
1.1 Cashew and Mango Production in Tanzania	1
1.2 Economic Importance of Insect Pests	2
1.3 Alternative Control Measures of Insect Pests.....	6
1.4 Objectives	9
1.4.1 Overall objective.....	9
1.4.2 Specific objectives	9
1.5 Hypothesis of the Study	9
1.6 Research Questions.....	9
1.6 Organization of the Report	11
1.7 References.....	11

CHAPTER TWO	17
2.0 PARTIAL BUDGETING ANALYSIS OF DIFFERENT STRATEGIES FOR MANAGEMENT OF INSECT PESTS IN CASHEW AND MANGO ORCHARDS IN TANZANIA	17
2.1 Abstract.....	17
2.2 Introduction.....	18
2.3 Materials and Methods.....	20
2.3.1 Descriptions of study areas.....	20
2.3.2 Experimental treatments	20
2.3.3 Data.....	22
2.3.4 Statistical and economic analyses.....	23
2.4 Results.....	24
2.4.1 Costs and benefit analysis in cashew.....	24
2.4.2 Costs and returns analysis in mango.....	25
2.4.3 Partial budgeting.....	27
2.4.4 Marginal analysis.....	30
2.5 Discussions	31
2.5.1 Costs and returns analysis.....	31
2.5.2 Partial budgeting.....	33
2.5.3 Marginal analysis.....	34
2.6 Conclusions.....	34
2.7 Acknowledgements.....	35
2.8 References.....	35

CHAPTER THREE	39
3.0 BENEFIT-COST ANALYSIS OF ALTERNATIVE INSECT PESTS MANagements IN CASHEW AND MANGO ORCHARDS IN TANZANIA	39
3.1 Abstract.....	39
3.2 Introduction.....	40
3.3 Materials and Methods.....	42
3.3.1 Descriptions of study areas.....	42
3.3.2 Experimental treatments.....	43
3.3.3 Data used in the financial analysis.....	44
3.3.4 Benefit cost analysis.....	46
3.3.5 Data analysis.....	50
3.4 Results.....	50
3.4.1 Costs and returns analysis.....	50
3.4.2 Feasibility analysis.....	52
3.4.3 Sensitivity analysis results.....	54
3.5 Discussions.....	56
3.5.1 Costs and benefits analysis.....	56
3.5.2 Financial analysis.....	58
3.5.3 Sensitivity Analysis (SA).....	60
3.6 Conclusions.....	60
3.7 Acknowledgements.....	60
3.8 References.....	61

CHAPTER FOUR.....	66
4.0 INVESTIGATION OF EXPORT BARRIERS FOR CASHEW AND MANGO PRODUCTS FROM TANZANIA TO EUROPE	66
4.1 Abstract.....	66
4.2 Introduction.....	67
4.3 Theoretical Framework.....	69
4.3 Methodology.....	73
4.3.1 Study areas.....	73
4.3.2 Research design.....	73
4.3.3 Sample selection.....	73
4.3.4 Data collection.....	75
4.3.5 Data analysis.....	76
4.4 Results and discussions.....	76
4.4 Value chains and actors.....	76
4.4.1 Cashew value chains.....	77
4.4.1.2 Mango value chains.....	82
4.2 Analysis of barriers towards Market Access to Europe.....	84
4.2.1 Regulatory institutions.....	84
4.2.2 Normative institutions.....	86
4.2.3 Cognitive institutions.....	87
4.2.4 Barriers not explained by pillars of institutions.....	88
4.2.4.1 Insufficient quantities of products for export.....	88
4.2.4.2 Inadequate information.....	89
4.5 Conclusions.....	90
Acknowledgement.....	91
References.....	92

CHAPTER FIVE	100
5.0 GENERAL CONCLUSIONS	100
APPENDICES	102

LIST OF TABLES

Table 1: RCN production and export data from 2004/05 to 2011/12 cropping season	2
Table 2: Comparisons of cost and revenues in TZS/tree between treatments in cashew	25
Table 3: Comparison of cost and revenue in TZS/tree between treatments in mango	27
Table 4: Partial budget (TZS/tree) of African weaver ants on cashew in two seasons.....	28
Table 5: Partial budget (TZS/tree) of African weaver ants on mango in two seasons.....	29
Table 6: Dominance and marginal rate of return analysis in cashew orchard.....	30
Table 7: Dominance and marginal rate of return analysis in mango orchard.....	31
Table 8: Comparisons of variable costs (TZS/Kg) and Benefits (TZS/tree) for each treatment in cashew orchards	51
Table 9: Comparisons of variable costs (TZS/Kg) and Benefits (TZS/tree) for each treatment in mango orchards	52
Table 10: NPV (TZS/tree), BCR and IRR (%) analyses of treatments in cashew and mango production	53
Table 11: Summary of financial indicators under sensitivity analysis for each treatment.....	56
Table 12: Export earnings of cashew in selected cropping season.....	67
Table 13: Distribution of key informants per sub sector	75

LIST OF FIGURES

Figure 1: Research questions forming manuscripts..... 10

Figure 2. The analytical framework 70

Figure 3: Tanzanian cashew export value chain and actors 78

Figure 4: Marketing of raw cashew nuts through WRS in Tanzania 79

Figure 5: Tanzanian mango export value chain and actors 83

LIST OF PLATES

Plate 1: Major insect pests in cashew and mango of economic importance in Tanzania ..	3
Plate 2: External and internal damage symptoms on cashew and mango	4
Plate 3: Insecticides spray in cashew orchard at experimental plot at NARI	5
Plate 4: African and Asian weaver ants (<i>Oecophylla spp</i>)	7
Plate 5: Activities during implementation of weaver ant technology in both orchards....	8

LIST OF ABBREVIATIONS

AMAGRO	Association of Mango Growers
ANOVA	Analysis of Variance
AU	Aarhus University
BCA	Benefit Cost Analysis
BCR	Benefit Cost Ratio
CBT	Cashew Board of Tanzania
CIMMYT	International Maize and Wheat Improvement Centre
DAEA	Department of Agricultural Economics and Agribusiness
DANIDA	Danish International Development Agency
DBA	Department of Business Administration,
DFC	DANIDA Fellowship Centre
DCSP	Department of Crop Science and Production
EC	Emulsifiable Concentrates
FAO	Food and Agriculture Organization
FAOSTAT	Food and Agriculture Organization Statistics
HACCP	Hazard Analysis Control Point
IPM	Integrated Pest Management
IRR	Internal Rate of Return
ISO	International Organization for Standardization
JMP	John's Macintosh Program
KENFAP	Kenya National Federation of Agricultural Producers
MDB	Marketing Development Bureau

MMA	Match Maker Associates
MPRL	Maximum Pesticides Residual Levels
MRR	Marginal Rate of Return
MSE	Medium Scale Enterprises
NARI	Naliendele Agricultural Research Institute
NPV	Net Present Value
PMD	Powdery Mildew Disease
SUA	Sokoine University of Agriculture
TANEXA	Tanzania Exporters Association
TIC	Trade Information Centre
TZS	Tanzanian shillings
UAE	United Arab Emirates
UNIDO	United Nations International Development Organization
URT	United Republic of Tanzania
USITC	United States International Trade Commission
WRS	Warehouse Receipt System

CHAPTER ONE

1.0 GENERAL INTRODUCTION

1.1 Cashew and Mango Production in Tanzania

Nut and fruit production is continually gaining recognition as a major income generating activity for both small and large-scale farmers in Tanzania, creating job opportunities and improving diet by providing essential micronutrients and vitamins (MMA, 2010; UNIDO, 2011; Kilama, 2013). Of the many nuts and tropical fruits grown in Tanzania, this study focuses on cashew (*Anacardium occidentale*) and mango (*Mangifera indica*) because they are major candidates for both local and export markets in the country. Over the last ten years, cashew is important export crop in Tanzania, following tobacco, coffee and cotton (FAOSTAT, 2011). On the other hand, mango has emerged as Tanzania's third most important fruit in terms of acreage, total volume of production and export after bananas and pineapples according to a value chain analysis conducted in 2009 (MMA, 2010). In Tanzania, production of cashew and mango are differentiated as traditional or market-oriented (commercial) cultivation where the latter developed based on locally adapted and newly imported cultivars (MMA, 2010; NARI, 2010).

Africa's cashew and mango production is considered to be below its potential as a result of the ever increasing production costs and the reduction of the quality and quantity of marketable produce (Snodgrass and Sebstad, 2005). A number of biotic and abiotic constraints contribute to this situation. The current study focused on biotic constraints such as heavy infestations by a range of insect pests (Mwatawala *et al.*, 2009; NARI, 2010). The major abiotic constraints focused in this study include limited access to markets of cashew and mango products to Europe (Van Melle *et al.*, 2007; ICIPE, 2009; Serem, 2010). A very smaller fraction of the national production of both crops are

exported to other markets in Europe like Netherlands, United Kingdom, Belgium, Germany and France (FAOSTAT, 2011). Unreliable supplies of quality nuts and fruits mainly due to pest infestation hamper competitiveness in these export markets (Varela *et al.*, 2006; FAO, 2009; Serem, 2010; Fitzpatrick, 2012). Most of the Tanzanian raw cashew nut crop, that is about 85% is exported to India as Raw Cashew Nuts (RCN) and only a small portion, which is 15%, is processed internally for local consumptions (FAO, 2012). Table 1 summarizes production and export data of raw cashew nuts from 2004/05 to 2011/12 cropping seasons.

Table 1: RCN production and export data from 2004/05 to 2011/12 cropping season

Cropping season (year)	Production (metric tons)	Export (metric tons)	% exported as raw	% processed internally
2004/05	71,918.33	70,667.07	98.26	1.74
2005/06	77,446.38	66,708.00	86.13	13.87
2006/07	92,573.19	69,259.30	74.82	25.18
2007/08	99,106.72	75,887.90	76.57	23.43
2008/09	79,068.79	64,334.55	81.37	18.63
2009/10	75,366.66	63,043.83	83.65	16.35
2010/11	121,134.97	112,374.00	92.77	7.23
2011/12	158,714.09	127,138.99	80.11	19.89

Source: FAO, 2012

1.2 Economic Importance of Insect Pests

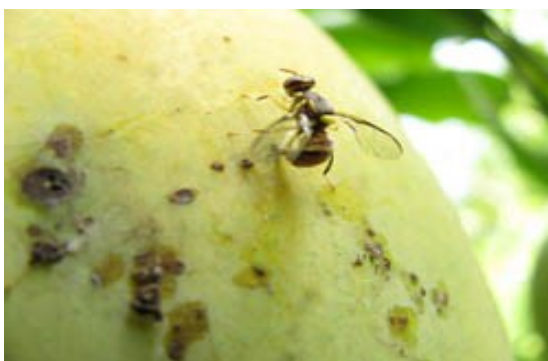
In Tanzania, two potentially serious pests in cashew sub-sector are the mirids (*Helopeltis anacardii*) and coreid bug (*Pseudotheraptus wayi*) (NARI, 2010). Mango on the other hand is susceptible to fruit flies particularly the *Bactrocera invades* and the mango seed weevil (*Sternochetus mangiferae*) (Ekesi *et al.*, 2007; Mulungu *et al.*, 2008; Mwatawala *et al.*, 2009). The major insect pests in both cashew and mango orchards are shown in plate 1.



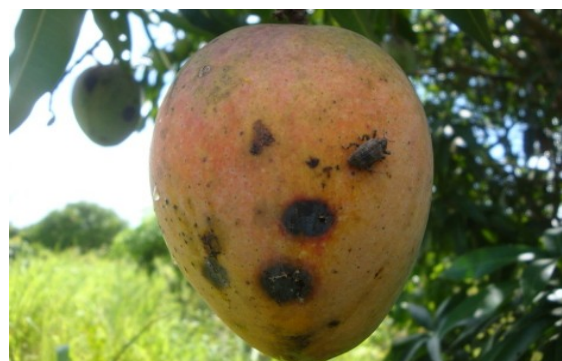
Cashew mosquito bugs (*Helopeltis anacardii*)



Coreid bugs (*Pseudotheraptus wayi*) in cashew



Fruit flies (*Bactrocera invades*) in mango



Mango seed weevil (*Sternochetus mangiferae*)

Plate 1: Major insect pests in cashew and mango of economic importance in Tanzania

These pests, attack leaf and floral flushing shoots and cause early abortion of young developing nuts and fruits and substantial loss of yield (Azam-Ali and Judge, 2006). Their wide distribution, fast proliferation and polyphagous nature (feeding on multiple host crops) make it difficult to control (MMA, 2008; NARI, 2010; Nguyen, 2010; Peng *et al.*, 2010). They threaten the production and marketability of nuts and fruits by reducing their yield and quality. These losses have been estimated to cause annual economic losses of more than USD 183 million and USD 54 million of revenue in cashew and mango respectively (FAOSTAT, 2010). Internal and external damage caused by these pests is shown in Plate 2.



Insect pests damages of cashew both external and internal of the nuts



Insect pests damages of mango both external and internal of the fruits

Plate 2: External and internal damage symptoms on cashew and mango

In some cashew and mango-based farming systems, current agricultural practices don't involve pest control methods. That is the tree crops are left untreated which results in decline in yields and quality due to insect pests which in turn causes significant economic loss (NARI, 2010; Gudila *et al.*, 2013). Other smallholder farmers rely on synthetic pesticides spray for most of their pest management (Christian *et al.*, 2011; Peng and Christian, 2014) (Plate 3). However, the increased use of pesticides for pest control has led to the rise of production costs due to the high costs of insecticides, equipment and labour during application (Alam, *et al.*, 2003; Baral *et al.*, 2006). Dependence on broad spectrum pesticides often resulted in pest resistance and environmental pollution (Christian *et al.*, 2008). Other drawbacks include the reduction of natural enemies and pollinators and pose health risks to human and their animals (Peng and Christian, 2006;

Christian *et al.*, 2011). However, smallholder farmers continue to rely on insecticides because cost-effective and environment friendly alternative control measures are not available to them (Varela *et al.*, 2006). Farmers also try to use stronger pesticide concentrations and mix several pesticides together to ‘enhance’ their effectiveness in their orchards (Gitonga, 2009).



Spraying of lambda cyhalothrin (Karate[®]) in 2013/14 cropping season at NARI, Mtwara

Plate 3: Insecticides spray in cashew orchard at experimental plot at NARI

The control of these pests at the destructive larval stage is difficult because insecticides in form of dust or sprays cannot reach them (Peng *et al.*, 2010). In the absence of natural enemies as biological control agents, insect pest populations are menace such that sometimes, damage is high (Peng *at al.*, 2010). This curtails the expansion of international trade, triggering huge economic losses that deprive producers of massive

revenues (Van Melle *et al.*, 2007). Most countries in Sub-Saharan Africa have been banned from exporting their cashews and mangoes to markets in the EU and the United States of America (Lux *et al.*, 2003; Ndiaye *et al.*, 2008; Vayssieres, 2009). Smallholder farmers are seeking alternative technologies the use of weaver ants (*Oecophylla spp*) that reduce production costs and/or increase yields and quality, compatible to organic certification to tap high value markets in Europe and ultimately increase profits.

1.3 Alternative Control Measures of Insect Pests

The use of Asian weaver ants, *Oecophylla smaragdina* (green ants) as biological control agents in Asia, South Pacific Islands and Northern Territory of Australia has been found to be superior to pesticides in insect pest control (Peng *et al.*, 2010). More than 50 insect pest species belonging to 18 families are effectively controlled by *Oecophylla* in eight tropical tree crops and some forest trees (Peng and Christian, 2009). They reduce infestation through: predation of adult insect pests, predation of third-stage larvae and the repulsive effect of “pheromones” left by the weaver ants on nuts and fruits so that insect pests are discouraged from laying eggs in them (Adandonon *et al.*, 2009). However, little is known about the economic benefits of using African weaver ants, *Oecophylla longinoda* (red ants) in both production and export. A collaborative project on improving cashew and mango using African weaver ants (*Oecophylla longinoda*) was conducted in Mtwara and Coast regions by Aarhus University (AU), Denmark and Sokoine University of Agriculture (SUA) in Tanzania. The African and Asian weaver ants are shown in Plate 4.



African weaver ant (*O longinoda*), the red ant and its queen protected by workers



Asian weaver ant, the green ant

Plate 4: African and Asian weaver ants (*Oecophylla spp*)

African weaver ant as biological control agent was tested and managed (Appendix 1) in Tanzanian environment for sound insect pest control that would contribute to the success of the cashew and mango industry for the rapidly expanding domestic and attractive organic export market in Europe, where food sanitation and safety guidelines are very strict (Van Melle *et al.*, 2007). During implementation of this technology, other trees with weaver ants were supplied with food such as sugar solution and water to see if it could enhance ant population, predation efficiency and translate into economic benefits. The activities conducted during implementation (transplanting) of weaver ants in both orchards and their predation to insect pests are shown in Plate 5.



(i) Determine colonies boundary by placing a nest containing ant workers adjacent other tree with ants. The ants of different colonies fighting each other



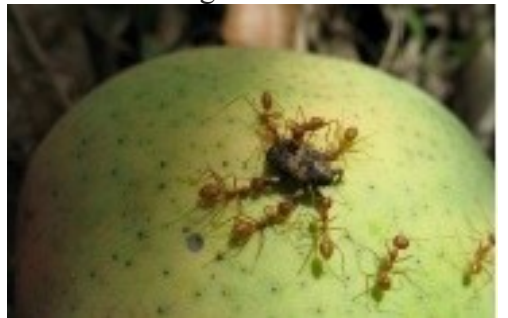
(ii) Harvesting ant nests using picking pole and collecting ant of the same colony using plastic bags for transplanting.



(iii) Hanging the plastic bags in the tree to release workers and the queen and immediately they make new nets



(iv) Connecting tree of the same colonies using a rope (4mm) to increase territory in the canopy and feeding the ants



African weaver ants predated insect pests in cashew and mango orchards

Plate 5: Activities during implementation of weaver ant technology in both orchards at NARI, Mtwara and Mlandizi mango farm at Kibaha

Therefore, this study analyzed the net change in benefits and financial feasibility before smallholder farmers make decision to switch from conventional practices to *O. longinoda* for enhancing export markets in Europe through better yields and quality cashew and mango products in Tanzania.

1.4 Objectives

1.4.1 Overall objective

This research investigated the economic benefits of using African weaver ants as a biological control of insect pests and its implications to export markets in Europe.

1.4.2 Specific objectives

The specific objectives are subdivided as follows;

- (i) To estimate the effect on net benefit of changing from chemical insecticides and no-control to African weaver ants as biological control;
- (ii) To analyze the financial efficiency of African weaver ants, insecticides and no-control in cashew and mango orchards;
- (iii) To identify export problems that cashew and mango exporters and smallholder farmers encounter in export of their products from Tanzania to Europe;

1.5 Hypothesis of the Study

The study in the field experiment was guided by one hypothesis that there is no significant difference in the yields between *O. longinoda* and conventional agricultural practices.

1.6 Research Questions

In order to investigate the economic benefits of using *O. longinoda* as biological control of insect pests in cashew and mango orchards and its implications in export, the thesis sets up three key research questions.

- (i) How does the costs and benefits of African weaver ants technology compare to the average cost and benefits of chemical insecticides and no-control?

- (ii) What is the relative financial benefit of African weaver ants as biological control agent compared to chemical insecticides and control?
- (iii) What are the significant export problems encountered by exporters, marketers and smallholder farmers in relation to export of cashew and mango products from Tanzania to Europe?

The relation between the research questions and the three manuscript papers is illustrated in Figure 1.

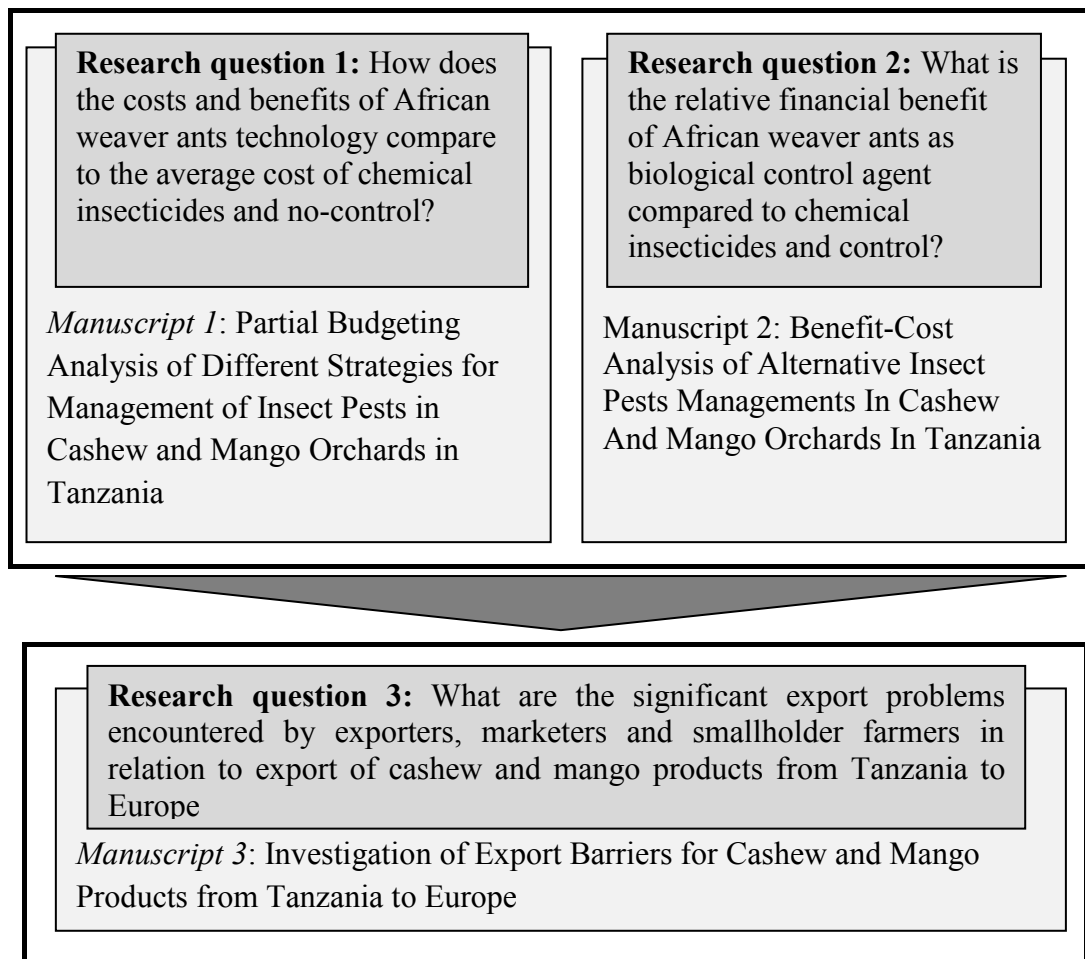


Figure 1: Research questions forming manuscripts

1.6 Organization of the Report

The remainder of the Thesis is structured as follows: Chapter two presents the *first manuscript paper* that aims at answering **research question 1**. The purpose of the paper was to document the effects on net benefit when switching from either insecticides or no-pest control to African weaver ants against insect pests in cashew and mango orchards in Tanzania. It is followed by the *second manuscript paper* in chapter three which further aims at answering **research question 2**. The main aim of the paper was to investigate the financial feasibility of using African weaver ants to provide information that help smallholder farmers making decision on appropriate alternative insect pest management in Tanzania. Key informants' view on the export problems of cashew and mango products from Tanzania to Europe are the main focus of *manuscript paper 3* and answers **research question 3** presented in chapter four. This is a survey adopting qualitative approach that identifies key export problems and suggestions to reduce their strength in order to tap high value markets in Europe. Finally, the general conclusion is provided that summarize arguments for the Thesis.

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CHAPTER TWO

2.0 PARTIAL BUDGETING ANALYSIS OF DIFFERENT STRATEGIES FOR MANAGEMENT OF INSECT PESTS IN CASHEW AND MANGO ORCHARDS IN TANZANIA

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2.1 Abstract

Before changing from one production method to another, farmers need to consider costs and incomes resulting from the change. This study estimated the effects on net benefit of switching from conventional Tanzanian growing practices (spraying of chemical pesticides and non-pest control) to the use of African weaver ants (*Oecophylla longinoda*) to control pests in cashew and mango. Yield data from one cashew and one mango plantation covering two cropping seasons were used in an economic analysis. The use of chemical pesticides and the use of weaver ants resulted in higher yields compared

to the non-control treatment. Lower input costs in weaver ant treatments, though, resulted in higher economic returns than the use of chemical insecticides in both seasons and crops. In all cases weaver ant treatments also produced higher returns than non-control treatments, despite their higher costs. Switching to African weaver ants without feeding was feasible due to positive net change in benefits in both crops. In cashew the average net benefit for the two seasons was 94% higher when using ants compared to non-control and 112% higher than in the chemical treatment. The corresponding values in mango were 117% and 63% respectively. Marginal Rate of Return (MRR) was highest for African weaver ants without feeding in cashew at 235% in 2012/13 and 405% in 2013/14 seasons. Similarly, MRR was highest for weaver ant without feeding in mango at 509% in 2012/13 and 743% in 2013/14 seasons. In conclusion, the use of African weaver ants without feeding was consistently the most economically feasible management strategy to be used in Tanzanian cashew and mango pest management.

Key words: Biological control, net benefit, marginal rate of return, cashew, mango

Contribution/ Originality:

This study documents the effects on net benefit when switching from conventional agricultural practices to African weaver ants against insect pests in cashew and mango orchards in Tanzania.

2.2 Introduction

Cashew and mango represent an important source of income for smallholder farmers in Tanzania (Marketing Development Bureau (MDB), 2010). High yields and quality nuts/fruits are essential to ensure a price premium (Ekesi *et al.*, 2007; Marketing Marker Associates (MMA), 2011). Insect pests are one of the main factors responsible for low

yield and quality (Mulungu *et al.*, 2008). Major insect pests in cashew orchards are cashew mosquito bugs (*Helopeltis anacardii*) and coconut bugs (*Pseudotheraptus wayi*) (NARI, 2010). In mango orchards, the major insect pests are mango seed weevil (*Sternochetus mangiferae*) and fruit flies particularly *Bactrocera invadens* (Mwatawala *et al.*, 2009). To combat these pests smallholder farmers often rely on chemical pesticides, but these are expensive and potentially damaging to human health and the environment (Christian *et al.*, 2008).

This challenging situation invites attention from entomologists to concentrate their attention on integrated pest management (IPM) for the production of cashew and mango using weaver ants (*Oecophylla spp*) as biological control agents (Peng *et al.*, 2010). Previous studies have mainly focused on South East Asia and Australia when using Asian weaver ants (*Oecophylla smaragdina*) for biocontrol; so far only limited research has addressed the feasibility of using African weaver ants (*Oecophylla longinoda*) for pest control in Tanzania.

Substituting conventional insecticides with Asian weaver ant biocontrol in cashew orchards in Northern Territory Australia led to increased net benefits of 71% over three seasons due to improved nut yields and quality combined with lower costs (Peng *et al.*, 2004). Similarly in mango orchards net benefits increased by 73% over three seasons due to higher fruit quality and lower costs (Peng *et al.*, 2005). In Thai and Vietnamese citrus plantations net benefits increased between 15 and 47%, respectively, when substituting chemical pesticides with Asian weaver ants, whereas a 125% negative net gain were associated to the use of weaver ants in a Thai mango plantation due to labour intensive of feeding the sugar solution (Offenberg *et al.*, 2013). In the present study we analyzed the

economic feasibility of adopting African weaver ants, *O. longinoda* as biocontrol agents in cashew and mango orchards in Tanzania.

2.3 Materials and Methods

2.3.1 Descriptions of study areas

The study was conducted at two experimental sites in 2012/13 and 2013/14 cropping seasons. The two sites are predominantly cashew and mango growing areas in Tanzania. The first experiment in a cashew orchard was conducted at Naliendele Agricultural Research Institute (NARI) (10°22'S and 40°10'E) in Mtwara Region, Southern Zone of Tanzania at an altitude of 120 m above sea level. The area receives a mean annual rainfall of about 1160 mm (unimodal) which falls mainly between November and April. The mango orchard was based at Mlandizi village (6°46'0"S, 38°55'0"E) in Kibaha District, Eastern Tanzania and at an altitude of 73 m above sea level. It receives an average annual rainfall of 1023 mm mainly between November and May.

2.3.2 Experimental treatments

In the cashew and mango orchard four different treatments were compared: (i) a chemical treatment where chemical pesticides were used to control insect pests and diseases (chemical), (ii) an ant treatment where weaver ants were used for biocontrol (WANF), (iii) an ant treatment where weaver ants supplied with food were used for biocontrol (WAF), and (iv) a control treatment where no control measures against pests were applied (control). Seventy two trees of similar age and appearance were allocated to each treatment in both crops using a randomized block design with three replicates. In the chemical treatment in cashew, to control insect pests, Karate® 5% EC was applied at a rate of 0.005 litres per tree four to five times per season using a motorized backpack sprayer (M 225-20 Motor-Rückensprüherät). The first round was applied at the

beginning of leaf flush with additional rounds being applied during flowering and ending at about mid-nut development. To control for Powdery Mildew Disease (PMD), Bayfidan EC 250 g active ingredient was applied at a rate of 0.015 litres per tree once in every three weeks making a total of four rounds. To further prevent PMD to establish five rounds of Sulphur dust were applied at a rate of 0.25 kg per tree at 14-days intervals during panicle emergence and continuing throughout the flowering period. The chemical spraying regime used in cashew was based on the recommendations given by Naliendele Agricultural Research Institute with mandate in cashew (NARI, 2010).

In the mango plantation Powershot (200ml; 10 ml/tree) and Dudumida (30g packets; one gram/tree) were sprayed three times and once every three weeks, to control sucking and chewing pests. Fungicides were applied every second week, four times: Vegimax (125 ml packet) was applied at a rate of one ml/tree, Potassium Nitrate (500 g) at 15 g/tree and Megasin (500 g) at 10 g/tree. This spraying regime was based on the recommendations given by the Association of Mango Growers in Tanzania (AMAGRO).

In the weaver ant treatments in both crops weaver ant colonies collected from neighboring villages were transplanted onto plantation trees so that each colony occupied with nine trees with eight colonies per treatment. In the treatment where ants were provided food, weaver ants were fed eight times per season (two times per month in four months) with a one kilogram of 30% sugar solution, one litre of water and two kilogram of fish meat. The weaver ant feeding treatment was not included in the mango orchard during the first cropping season because competing *Pheidole megacephala* ants were abundant in the plantation. Feeding may attract these ants which may result in the eradication of the weaver ant colonies as *P. megacephala* is able to kill weaver ants and

destroy their colonies (Seguni, 2011). Sulphur spraying regimens identical to the chemical treatment were used in both weaver ant treatments to control PMD.

To study the extra costs and returns associated to pest protection, no control measures was used against insect pests on the trees in the control treatment, however, fungicides were applied as in the other treatments. Sulfur sprayings were needed as PMD is believed to destroy the harvest if not controlled.

2.3.3 Data

Yields: in cashew the physiologically ripe raw nuts that had dropped to the orchard floor were collected each day separately for each tree (Appendix 2). Collection of the nuts started in late August and ended in November in each cropping season. After the harvest the mass of raw nuts collected from each tree was summed and converted into kernel mass before being compared between treatments. This conversion factor is the average of two different methods (high out turn and low out turn) (UNIDO, 2011). In mango the number of fruits per tree was obtained by counting all fruits on each tree (Appendix 3). Fruits were counted on 18 December and 20 December in 2012 and 2013, respectively. The methods used for the field work in the cashew and mango plantations and the yields used in the present study derives from Nassor *et al.*, 2015, where additional details can be found.

Costs and benefits: the costs associated to each treatment were based on the inputs needed to manage each treatment (Appendix 4). In the weaver ant treatments, transplantation of weaver ant colonies covers the labor involved in identifying ant colonies and transporting them into the plantation. Plastic bags refer to the bags that were used to carry the ant nests that were transplanted into the plantation. Nylon rope was used

to connect trees within ant colonies to ease their migration between trees. Plastic bottles were used to feed the ants with water and test tubes used as sugar solution feeders.

Transport costs cover all the transport in relation to the management of the treatment. Wage rates, transport costs and prices on equipment were obtained from local markets. To obtain the average costs per tree for each treatment the total cost was calculated and divided by the number of trees ($N = 72$ tree per treatment). Selling prices of cashew kernels and mango fruits were based on the price that smallholders could obtain by selling their produce to local farmer cooperatives. The average price used in the analysis was obtained by interviewing 12 representatives from five farmer cooperatives (Namkuku Primary Cooperative, Mtwara District; Nanganga and Mpowora Primary Cooperative, Masasi District; Umoja Primary Cooperative Society, Tandahimba District; Jitegemee Primary Cooperative Society, Mkuranga District; Mwendapole Primary Cooperative, Kibaha District). In cashew there was a realized premium price on organically produced nuts which were used in the weaver ant and control treatments as these methods are compatible with organic certification. This premium price was given by the Masasi Cooperative for organically grown nuts which were subsequently exported to Netherlands. In mango there was not yet an established market for organic products. In this case the premium price for organic produce used in the analyses was based on what farmer cooperatives expected to be able to achieve via collective action.

2.3.4 Statistical and economic analyses

Analysis of variance was used to test the effect of treatments on yields for each season and for each crop. The partial budgeting technique was used to analyze the net change in benefits when switching from conventional practices to African weaver ant treatments. It was used to analyze the change from conventional agricultural practices to weaver ants

by considering the costs that varies. In this analysis the aspects considered were reduced cost and income, as well as additional cost. Reduced operational costs were due to reduced amount and frequency of insecticides spray applied. Added revenue included the revenue gained from yield increase and added expenses were increased cost for labour for harvesting, transplanting and feeding of weaver ants. We compared and tabulated the gains (benefits) and losses (costs) per tree when switching to weaver ants. The decision to adopt African weaver ants was based on the Benefit-Cost equation. A positive difference indicates the change is profitable (Kay *et al.*, 2008).

To compare the additional costs that varied with the benefits, marginal analysis involving dominance analysis was used. The Marginal Rate of Return (MRR) for each cost un dominated treatments were calculated as the marginal net benefits (i.e. the change in net benefits between treatments) divided by the marginal costs (i.e. change in costs), expressed in percentage. Recommendations were made based on the comparisons of the rates of return between treatments to the minimum rate of return acceptable to farmers from 50% to 100% (CIMMYT, 1988). Hence, any treatment that has MRR above 100% is considered worthy investment by farmers.

2.4 Results

2.4.1 Costs and benefit analysis in cashew

In both seasons total costs were highest in the chemical treatment followed by weaver ants with and without feeding and with the lowest costs in the control treatment. The use of weaver ants reduced total variable costs by 19% and 22% in the first and second season, respectively, compared to the use of chemical pesticides, and the use of ants increased costs by 37% and 24% in the two seasons, compared to the control group. Table 2 reveals that there is significantly different in the yields between the chemical

insecticides, WAF and WANF treatments and the control treatment. The differences in costs between treatments and the lower selling price of nuts from the chemical treatment generated the highest net benefit in WAF, followed by WANF, control and chemical treatments in the first season, whereas the net benefit in the second season was higher in the chemical as compared to the control treatment and both of these treatments were lower than the ant treatments.

Table 2: Comparisons of cost and revenues in TZS/tree between treatments in cashew

Costs/Yield components	2012/13 season				2013/14 season			
	WANF	WAF	Chem	Control	WANF	WAF	Chem	Control
Total variable cost (TZS tree ⁻¹)	12092	14273	15008	8857	13695	15352	17505	11042
Average yield (Kg/tree)	1.03 ^a	1.03 ^a	0.98 ^a	0.65 ^b	1.20 ^a	1.32 ^a	1.21 ^a	0.73 ^b
Average prices (TZS/Kg)	28500	28500	23000	28500	28500	28500	23000	28500
Gross benefit (TZS/tree)	29355	29355	22540	18525	34200	37620	27830	20805
Net benefit (TZS/tree)	17263	15082	7532	9668	20505	22268	10325	9763

Notes: Levels not connected by the same letter are significantly different at $P < 0.05$

2.4.2 Costs and returns analysis in mango

Table 3 presents the total variable cost, number of mango fruits per tree, gross and net benefits for each treatment. Similar to cashew, total variable cost was highest in the

chemical treatment in both seasons followed by the use of weaver ants and with lowest costs in the control treatment. Compared to the control treatment, the use of ants (WANF) and chemicals increased costs by 23 and 206%, respectively, in the first season, and by 14 and 207% in the second season. In both years the average number of mango fruits was significantly different in the yields between the chemical, WAF, WANF treatments and the control treatment.

Based on the interviews with farmer organizations the average selling price of a mango fruit would be expected to increase from 880 TZS to 1100 if a market for organic mangoes could be established. In the first season the differences in costs and selling prices generated the highest net benefits in the WANF treatment, followed by the control treatment and lastly a low benefit of only 818 TZS in the chemical treatment. In the second year, higher yields increased the net benefit in the chemical treatment where it exceeded the control treatment but still with higher benefits in the ant treatments. The use of ants (WANF) increased the net benefit by 66% compared to the control treatment in the first season and by 103% in the second. Due to low yields in the first season in combination with high costs in the chemical treatment the net benefit in WANF was more than 11 times higher than in the chemical treatment, whereas, in the second year with much higher yields, WANF produced a 33% increased net benefit.

If average net benefits for the two seasons are compared between treatments the use of ants in cashew increased the net benefit by 94% as compared to the control where it increased by 112% compared to the chemical treatment. In mango, ants increased the benefit by 117% compared to the control and by 63% compared to the chemical treatment. It follows therefore, that the use of chemical pesticides as compared to the control decreased net incomes by eight percent in cashew, while it led to an increase of

33% in mango. In the second year the net benefits for both crops were slightly higher in the treatments where ants were fed compared to the unfed ants. However, it should be noted that this difference was based on a non-significant difference in yields between the two treatments. Therefore, the observed differences in net benefits should not be considered statistically significant.

Table 3: Comparison of cost and revenue in TZS/tree between treatments in mango

Costs/Yield	Year 2012/13			Year 2013/14			
	WANF	Chem	Control	WANF	WAF	Chem	Control
Total variable							
costs (TZS/tree)	3905	9742	3183	4044	5583	10920	3562
Average yield							
(fruits/tree)	12 ^a	12 ^a	8 ^b	68 ^a	71 ^a	73 ^a	35 ^b
Prices							
(TZS/fruit)	1100	880	1100	1100	1100	880	1100
Gross benefit							
(TZS/tree)	13200	10560	8800	74800	78100	64240	38500
Net benefit							
(TZS/tree)	9295	818	5617	70756	72517	53320	34938

Notes: Levels not connected by the same letter are significantly different at $P < 0.05$

2.4.3 Partial budgeting

For cashew, partial budget analyses show that switching from insecticides to African weaver ants led to a positive net change in benefits of 8731 TZS/tree in the 2012/13 season and 13 903 TZS/tree in the 2013/14 season. Similarly, a positive net change in

benefits by 9991 TZS/tree in the 2012/13 season and 16 622 TZS/tree in the 2013/14 season was obtained when switching from untreated control treatment to African weaver ants (Table 4).

Table 4: Partial budget (TZS/tree) of African weaver ants on cashew in two seasons

Cropping seasons	2012/13		2013/14	
Proposed change	Switch from chemical to ants	Switch from control to ants	Switch from chemical to ants	Switch from control to ants
I. Incremental Benefits				
From Weaver Ants				
i. Added benefits	6815	10830	9790	16815
ii. Reduced Costs	3815	0	4306	0
Total incremental				
Benefits (i+ii) = B	9630	10830	14096	16815
II. Incremental Costs				
Rom Weaver Ants				
iii. Reduced benefits	0	0	0	0
iv. Added costs	899	839	193	193
Total incremental				
Detriments (iii+iv) = D	899	839	193	193
Net change in benefits				
(B - D)	8731	9991	13903	16622

Source: Experimental data, 2012/13 & 2013/14 cropping seasons

Partial budgeting analyses for mango show that switching from insecticides to African weaver ant without feeding gave positive net change in benefits by 8957 TZS/tree in the

2012/13 season and 20 736 TZS/tree in the 2013/14 season. Also, a positive net change in benefits by 3918 TZS/tree in the 2012/13 season and 39 118 TZS/tree in the 2013/14 season was obtained when switching from untreated control treatment to African weaver ants (Table 5).

Table 5: Partial budget (TZS/tree) of African weaver ants on mango in two seasons

Years/seasons	2012/13		2013/14	
Proposed change	Switch from chemical to ants	Switch from control to ants	Switch from chemical to ants	Switch from control to ants
I. INCREMENTAL BENEFITS				
FROM ANTS				
i. Added benefits	2640	4400	13860	39600
ii. Reduced Costs	7059	0	7618	0
Total incremental Benefits (i+ii) = B	9699	4400	21478	39600
II. INCREMENTAL COSTS				
FROM ANTS				
iii. Reduced benefits	0	0	0	0
iv. Added costs	742	482	742	482
Total incremental Detriments (iii+iv) = D	742	482	742	482
Net change in benefits (B – D)	8957	3918	20736	39118

Source: Experimental data, 2012/13 & 2013/14 cropping seasons

2.4.4 Marginal analysis

Chemical insecticides and African weaver ants with feeding were cost dominated treatment in cashew orchard (Table 6) and therefore not subjected to marginal analysis. Switching from the baseline (untreated control) to African weaver ants without feeding gave the MRR values at 235% in the 2012/13 season and was highest in 2013/14 season at 405%. The lowest MRR values were recorded when switching from untreated control to African weaver ants with feeding at 290% in the 2013/14 cropping season.

Table 6: Dominance and marginal rate of return analysis in cashew orchard

Seasons	Treatments	Total costs	Net benefits	Dominance	Marginal rate of return (%)
2012/13	Control	8857	9668		
	WANF	12092	17263	Un dominated	235 > 100 recommended
	WAF	14273	15082	Dominated	
	Insecticides	15008	7532	Dominated	
2013/14	Control	11042	9763		
	WANF	13695	20505	Un dominated	405 > 100 recommended
	WAF	15352	22268	Un dominated	290 > 100 recommended
	Insecticides	17506	10325	Dominated	

Source: Experimental data, 2012/13 and 2013/14 cropping seasons at NARI, Mtwara

Similarly, chemical insecticides generated low net benefits at higher costs in the mango orchard in both cropping seasons (Table 7) and were not considered in marginal analysis. The MRR value at 509% was recorded in the 2012/13 cropping season when switching from the baseline (untreated control) to African weaver ants without feeding. The highest

MRR value at 743% was recorded in the 2013/14 season when switching from the baseline (untreated control) to African weaver ants without feeding. Lowest MRR value at 186% in the 2013/14 cropping season was recorded when switching from untreated control to African weaver ants with feeding.

Table 7: Dominance and marginal rate of return analysis in mango orchard

Cropping Seasons	Treatments	Total costs	Net benefits	Dominance	Marginal rate of return (%)
2012/13	Control	3183	5617		
	WANF	3905	9295	Un dominated	509 > 100 recommended
	WAF	-	-	-	
	Insecticides	9742	818	Dominated	
2013/14	Control	3562	34938		
	WANF	4044	70756	Un dominated	743 > 100 recommended
	WAF	5583	72517	Un dominated	186 > 100 recommended
	Insecticides	10920	533319	Dominated	

Source: Experimental data, 2012/13 and 2013/14 cropping seasons at Mlandizi village

2.5 Discussions

2.5.1 Costs and returns analysis

This study showed that the two methods based on weaver ant biocontrol were superior to chemical and control treatments in terms of net benefits. Ant treatments consistently

showed higher net benefits than the two other treatments as they both benefitted from a fruitful combination of high yields and selling prices and at the same time showed lower costs than the chemical treatments. On the other hand, the extra investment in the feeding of ants compared to unfed ants did not translate into significantly higher yields and net benefits. Therefore, the use of ants without feeding is recommended as the best practise to increase farmer's net gains. Also the net benefits in the control treatments, despite low yields in these treatments, in some cases, exceed the chemical treatments, again due to lower costs and higher selling prizes. This was especially pronounced in mango in the first season where the net benefit in the chemical treatment was very low. This low benefit was the result of the high investment in chemicals in combination with low yields that year, which drastically reduced the margin between income and costs. This result illustrate that treatments with high costs are economically risky in crops with variable yields. In the following year with several-fold higher yields, the net benefit in the chemical treatment increased considerably and to an extent where it exceeded the control treatment.

The higher yields in weaver ant and chemical treatments compared to the control treatments shows that both ant and chemical pesticides efficiently protected both crops. This positive effect was attributed to efficient control of several insect pests in the two crops. The non-significant difference in yields between the ant and chemical treatments showed that these two techniques were equally effective in their control of prevalent pests. These issues are discussed further by Nassor *et al.* (2015) in the study that provided the yield estimates used in the current economic analyses.

The high costs associated to the chemical treatments were partly a result of the simultaneous use of several pesticides in both crops and four to five sprayings per season.

If these recommended extensive sprayings are needed to obtain adequate pest control, the results of the present study suggest that this investment is not matched with adequate incomes and therefore should be avoided. It may be considered if fewer chemicals or spraying applications would suffice.

Increased yields and net incomes associated with the weaver ant technology compared to alternative control methods comply with previous studies. Peng *et al.* (2004) and Peng and Christian (2005) found that the use of *O. smaragdina* increased net incomes with 71 and 73% compared to chemical pesticide treatments in cashew and mango, respectively, over a three year period. These increases were based on lower costs and higher quality of the harvest in both cases as well as a higher yield in the case of cashew. Higher cashew yields associated with the use of *O. Longinoda* has also been observed by Dwomoh *et al* (2009) in Ghana, where weaver ants increased yields more than four-fold as compared to control treatments but showed no significant difference as compared to chemical treatments. In this case no analyses were conducted on net benefits. Offenberg *et al.* (2013) also found that *O. smaragdina* was able to increase net incomes with 47% in Vietnamese citrus plantations as compared to chemical treatments. In this case because of high costs associated with the use of chemicals, as there was no significant difference in yields.

2.5.2 Partial budgeting

The benefit-cost equation yielded positive net changes in benefits when switching from either chemical insecticides or control to African weaver ants. This implies that the incremental benefits in farming with African weaver ants exceed the incremental costs and suggests that using African weaver ants is an economically feasible management practice. Evans (2005) pointed out that if a technology is relatively new, requiring some

new skills, higher benefits associated with less costs may be appropriate to a farmer to change or shift from his/her old technology.

2.5.3 Marginal analysis

Switching from untreated control (baseline) to African weaver ant with and without feeding increased farmers' returns, Marginal Rate of Return (MRR). Both gave MRR above 100% which is typically considered a minimum rate of return acceptable to smallholder farmers to change from one technology to another (CIMMYT, 1998). This implies that for every Tanzanian shilling invested in African weaver ant with and without feeding, farmers recover their one Tanzanian shilling plus an additional shilling as benefit thus making the use of African weaver ants an attractive option. Farmers who are keen on high profit margin are recommended to adopt African weaver ant without feeding as this gave highest MRR in the analysis. This finding is in line with the study by Das *et al.* (2010) who claimed that rational farmers adopt a new innovation that has a comparatively higher MRR.

2.6 Conclusions

Agricultural growth requires continuous improvement of crop production technology at the farm level. The objective of partial budget was to recommend insect pests management practice that is economically superior and socially acceptable to smallholder farmers. The proposed technological change in this study was from conventional practices to African weaver ants as biological control agent in cashew and mango orchards. Partial budget results indicated positive net change in benefit when switching from conventional practices to African weaver ants. Switching from untreated control to African weaver ant without feeding resulted into highest and above 100% MRR, and was recommended.

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Tanzania's cashew value chain: A diagnostic. United nations industrial development organization (UNIDO). Vienna, Austria. pp: 235.

CHAPTER THREE

3.0 BENEFIT-COST ANALYSIS OF ALTERNATIVE INSECT PESTS MANagements IN CASHEW AND MANGO ORCHARDS IN TANZANIA

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3.1 Abstract

This study was conducted to determine the financial feasibility of African weaver ants (*Oecophylla longinoda*) as biological control agents in cashew and mango orchards. It was compared to chemical insecticides and control based on the experimental data in 2012/13 and 2013/14 cropping seasons. Three important discounted financial indicators were used in the study, they are the Net Present Value (NPV), Benefit-Cost Ratio (BCR) and Internal Rate of Return (IRR). Three scenarios concerning the increase of costs and benefits were used. The results of the study showed that all indicators for financial

feasibility analysis were positive and accepted in each treatment. In cashew, African weaver ant without feeding indicated highest NPV (TZS 32 640), BCR (2.5:1) and IRR (57%). In mango, conflicting results were observed in feasibility ranking. But African weaver ants without feeding gave highest acceptable NPV of TZS 66 926. The three scenarios showed that setting much higher costs and benefits at five percent the NPV for African weaver ant was highest than other treatments. The findings of this study suggest that African weaver ant without feeding are financially feasible to be adopted and was recommended.

Key words: *Anacardium occidentale*, biological control; economic analysis, *Mangifera indica*, *Oecophylla longinoda*

Contribution/Originality:

This study is one of very few studies which have investigated the financial feasibility of using African weaver ants (*Oecophylla longinoda*) to provide information that helps smallholder farmers making decision on appropriate alternative insect pest management in Tanzanian cashew and mango.

3.2 Introduction

Cashew (*Anacardium occidentale*) and mango (*Mangifera indica* L.) are the most important tree crops widely grown in the Southern and Eastern Tanzania (NARI, 2010; Marketing Marker Associates (MMA), 2011). The most important cashew and mango growing regions are Mtwara and Coast. The crops are produced in Tanzania both for export and local markets and contribute as a source of income to smallholder farmers (USITC, 2007; United Republic of Tanzania (URT), 2012). However, the presence of numerous insect pest species causes low yields and quality at farm level.

Cashew is attacked by sucking insect pests such as cashew mosquito bugs (*Helopeltis anacardii*) and coconut bugs (*Pseudotheraptus wayi*) (NARI, 2010). Insect pests for mango are seed weevil (*Sternochetus mangiferae*) and fruit flies particularly *Bactrocera invadens* (Mwatawala *et al.*, 2009). Control of these pests is crucial to sustainable production of cashew and mango.

Although there are several insecticides available that can control the various pests afflicting cashew and mango in Tanzania, they are often too expensive for poor resource farmers and can result in food contamination or environment pollution (Christian *et al.*, 2008). Integrated Pest Management (IPM) has been used in different regions around the world to reduce both dependence on insecticides and yield reductions due to insect pests damage (Van Melle and Cuc, 2000; Peng *et al.*, 2010). The IPM model such as the use of Asian weaver ants (*Oecophylla smaragdina*) have mainly focused on South East Asia and Australia, and that it is so far limited research has addressed the financial feasibility of using African weaver ants (*Oecophylla longinoda*) for insect pest control in Tanzania.

Studies in the Northern territory of Australia indicated that substituting conventional insecticides with Asian weaver ant biocontrol in cashew orchards led to increased net benefits of 71% over three seasons due to improved nut yields and quality combined with lower costs (Peng *et al.*, 2004). Similarly in mango orchards net benefits increased by 73% over three seasons due to higher fruit quality and lower costs (Peng *et al.*, 2005). In Thai and Vietnamese citrus plantations net benefits increased with 15% and 47%, respectively, when substituting chemical pesticides with Asian weaver ants, whereas a 125% negative net gain were associated to the use of weaver ants in a Thai mango plantation (Offenberg *et al.*, 2013). McConnachie *et al.* (2003) revealed positive benefit-cost ratios of biocontrol ranging from 1.9:1 to 53:1 arising from saving in control costs in

South Africa as a whole. A study by Alene *et al.* (2007) estimated benefit-cost ratio for biocontrol for management of mango mealy bug varied between 200:1 to 740:1 with the discounted value of benefits amounting to a NPV of USD 1.7 million for Nigeria, USD 3.8 million for Ghana and USD 7 million for Benin. Therefore, the objective of this study is to analyze the financial feasibility of adopting African weaver ants, *O. longinoda* as biocontrol against insect pests in cashew and mango orchards in Mtwara and Coast regions of Tanzania. Results of this study provide information to help smallholder farmers in other parts of the country who want to venture into weaver ants in understanding the costs and return issues.

3.3 Materials and Methods

3.3.1 Descriptions of study areas

The study was conducted at two experimental sites in 2012/13 and 2013/14 cropping seasons. The two sites are predominantly cashew and mango growing areas in Tanzania with good population of weaver ants. The first experiment on cashew orchard was conducted at Naliendele Agricultural Research Institute (NARI) in Mtwara Region, Southern Zone of Tanzania. The experimental site is located at 10°22'S, 40°10'E and at an altitude of 120 m above sea level. The area receives a mean annual rainfall of about 1160mm (unimodal), which falls between November and April. The second experiment was on mango orchard based at Mlandizi village in Kibaha District, Eastern Zone of Tanzania. Its geographical coordinates are 6°46'0"S, 38°55'0"E and at an altitude of 73m above sea level. It receives average annual rainfall of 1023 mm between November and May.

3.3.2 Experimental treatments

In the cashew and mango orchards, four different treatments were compared: (i) in the first treatment, a chemical pesticide was used to control pests (chemical), (ii) in the second treatment, weaver ants without feeding were used for biocontrol (WANF), (iii) in the third treatment, weaver ants supplied with food were used for biocontrol (WAF), and (iv) a control treatment where no control measures against insect pests were applied (control). A total of 72 trees of similar age and appearance were allocated to each treatment in both crops in a randomized block design with three replicates. Karate ® 5%EC was applied in the chemical treatment at a concentration of 0.005 litres per cashew tree four to five times per season. The motorized backpack sprayer (M 225-20 Motor-Rückensprühgerät) was used for spraying. The first round was applied at the beginning of leaf flush with additional rounds being applied during flowering and ending at about mid-nut development. Bayfidan, EC 250 g active ingredient was applied at a concentration of 0.015 litres per tree once in every three weeks making a total of four rounds as insecticide for control of powdery mildew diseases (PMD). Also five rounds of Sulphur dust against PMD at the concentration of 0.25 kg per tree were applied at 14-days intervals during panicle emergence and continuing throughout the flowering period making five rounds per season (NARI, 2010). Chemical insecticide treatment used to control sucking and chewing pests in mango orchards were used once every three weeks. Their application concentration was as follows: Powershot (200 ml) was applied 10 ml/tree trees three rounds, Dudumida (30 g packets) was applied 1g/tree trees three rounds. Fungicides were applied once every two weeks at a rate as follows: Vegimax (125ml packet) was applied one milliliters per tree trees four rounds, Potassium Nitrate (500g) was applied 15g per tree trees applied four rounds and Megasin (500g) was applied 10g/tree trees applied four rounds (AMAGRO 2011, un published report).

In the weaver ant treatments in both crops, weaver ant colonies were collected from neighboring villages and transplanted onto plantation trees so that each colony occupied nine trees with eight colonies per treatment. In the treatment where ants were provided food, weaver ants were fed eight times per season (two times per month in four months) with a 1kg of 30% sugar solution, 1litre of water and 2kg of fish meat. The weaver ant feeding treatment was not included in the mango orchard during the first cropping season because competing *Pheidole megacephala* ants were abundant in the plantation this year. Feeding might have attracted these ants, which could have resulted in the eradication of the weaver ant colonies, as *P. megacephala* is able to kill weaver ant colonies (Seguni, 2011). Sulphur spraying regimens identical to the chemical treatment were used in both weaver ant treatments to control PMD.

To study the extra costs and returns associated to pest protection, no control measure was used against pests on the trees in the control treatment, except for sulfur sprayings that were applied as in the other treatments. Sulfur sprayings were needed, as PMD is believed to destroy the harvest if not controlled by Sulfur.

3.3.3 Data used in the financial analysis

Yields

In cashew the physiologically ripe raw nuts that had dropped to the orchard floor were collected every second day separately for each tree (Appendix 2). Collection of the nuts started in late August and ended in November in each cropping season. After the harvest the mass of raw nuts collected from each tree was summed and converted into kernel mass before being compared between treatments. To convert raw nut mass into kernel mass, the raw nut mass was multiplied by 0.245. This conversion factor is the average of two different methods (high out turn and low out turn) (UNIDO, 2011). In mango the

number of fruits per tree (Appendix 3) was obtained by counting all fruits on each tree on the day before the commercial mango harvesters were collecting all fruits in the plantation. Mango fruits were counted on 18 December and 20 December in 2012 and 2013, respectively.

Costs and benefits

The costs associated to each treatment were based on the inputs needed to manage each treatment (Appendix 4). Wage rates, transport costs and prices on equipment were obtained from local markets. The total variable costs were estimated as the product of total quantity of inputs/labour used and market prices. To obtain the average costs per tree for each treatment, the total cost was divided by the number of trees ($N = 72$ trees). Selling prices of cashew kernels and mango fruits were based on the price that smallholders could obtain by selling their produce to local farmer cooperatives. The average price used in the analysis was obtained by interviewing 12 representatives from five farmer cooperatives (Namkuku Primary Cooperative, Mtwara District; Nanganga and Mpowora Primary Cooperative, Masasi District; Umoja Primary Cooperative Society, Tandahimba District; Jitegemee Primary Cooperative Society, Mkuranga District; Mwendapole Primary Cooperative, Kibaha District). In cashew there was a realized premium price on organically produced nuts, which were used in the weaver ant and control treatments as these methods are compatible with organic certification. This premium price was given by the Masasi Cooperative for organically grown nuts, which were subsequently exported to the Netherlands. For mango there was not yet established market for organic products. In this case the premium price for organic produce used in the analyses was based on what farmer cooperatives expected to be able to achieve via collective action. The gross benefit per tree was calculated by multiplying average yields per tree and price (organic vs. conventional prices).

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3.3.4 Benefit cost analysis

A financial benefit cost analysis (BCA) was used to estimate the costs involved and benefits accrued in the management of insect pests in cashew and mango orchards. The BCA is a popular quantitative method used to discount the costs and benefits of alternative investments to a common time period. The two major ways of conducting a BCA are financial and economic analysis. A financial BCA is made from the perspective

of the person; group or unit directly involved in the project, for example a farm (Gittinger, 1982). Only the expenses that will be made by the farm and the benefits that will accrue to the farm (externalities not included) are taken into account in a financial analysis (ICRA, 2009). An economic BCA takes the broader perspective of the society. In calculating prices, the main difference between a financial and economic BCA is that while the former uses market prices, the later uses shadow prices. A financial BCA was carried out from the farmers' perspective of the costs incurred and benefits accrued from managing the insect pests in both orchards.

There are different B-C evaluation criteria such as net present value (NPV), benefit-cost ratio (BCR), internal rate of return (IRR), Pay Back Periods (PBP), etc. For the purposes of comparison, the NPV, BCR and IRR are the financial indicators used in the study. Future flows of costs and benefits were discounted at 10% for a period of two cropping seasons to obtain their present values. The discount rate was considered as the opportunity cost of capital in Tanzania as proposed by the World Bank. The NPV was calculated from (Equation 1) adopted from Shively (2000).

$$NPV = \left[\frac{GB_1}{(1+r)^1} + \frac{GB_2}{(1+r)^2} \right] - \left[\frac{TVC_1}{(1+r)^1} + \frac{TVC_2}{(1+r)^2} \right] \dots \dots \dots (1)$$

Where, GB =Gross benefit in each season, TVC = Total variable costs, **1 and 2** = Number of seasons and r =discount rate. The treatment is financially feasible if the calculated NPV is positive (greater than zero) and highest when discounted at the opportunity cost of capital (Gittinger, 1982; Poudel *et al.*, 2009).

Benefit-cost ratio (BCR) is the ratio of discounted value of gross benefits (present value of benefit) to discounted value of variable costs (present value of costs). The Equation 2 adopted from Cellini and Kee (2010); Shively (2000) was used.

$$BCR = \left[\frac{GB_1}{(1+r)^1} + \frac{GB_2}{(1+r)^2} \right] \div \left[\frac{TVC_1}{(1+r)^1} + \frac{TVC_2}{(1+r)^2} \right] \dots\dots\dots (2)$$

Where, *GB* =Gross benefit in each cropping season, *TVC* = Total variable costs in each season, *1 and 2* =Number of seasons and *r* = discount rate. The investment is said to be financially feasible when the BCR is one or greater than one (Gittinger, 1982; and Poudel *et al.*, 2009).

The Internal Rate of Return (IRR) is the rate of return that sets the NPV of benefits minus costs to zero. It provides the answer in percentages (relative measure of investments). According to Shively (2000), IRR is that discount rate ‘i’ (Equation 3) such that:

$$\left[\frac{GB_1}{(1+i)^1} + \frac{GB_2}{(1+i)^2} \right] - \left[\frac{TVC_1}{(1+i)^1} + \frac{TVC_2}{(1+i)^2} \right] = 0 \dots\dots\dots (3)$$

That is, the *NPV* = 0 and *BCR* = 1.0. Where: *GB* =Gross benefit in each cropping season, *TVC* = Total variable costs in each season, *1 and 2* =Number of seasons and *i* =interest (discount) rate. A treatment is financially feasible for investment when the IRR is higher than the opportunity cost of capital (Gittinger, 1982; Poudel *et al.*, 2009).

Sensitivity analysis (SA): Several different uncertain parameters should be considered before recommending an alternative. The benefit cost analysis does not capture potential

changes in factors that alter the feasibility of technologies (does not determine risk factors and uncertainties). A sensitivity analysis was used to determine the risk factors of the activity. Prices may change in the market and this affects the returns the farmers receive and costs may also change. What would happen given a certain percent increase in the price of yields (benefit) level and a certain percent increment of the market price of the inputs for the implementation of each option (cost). The financial feasibility of treatments under changed circumstances was ascertained through changes in NPV, BCR and IRR, assuming changes in total costs and gross benefits for three distinct scenarios: a 5% increase in costs without corresponding increase in benefits (SA1), a 5% increase in benefits without corresponding increase in costs (SA2) and a 5% increase in both costs and benefits (SA3).

Choice of discount rate: The discount rate used in calculating a project's worth is very crucial. The discount rate determines the value today of an amount received or paid out in the future. In most developing countries, it is assumed to be somewhere between 8% and 18% in real terms. For this study, future flows of costs and benefits were discounted at 10% for a period of two cropping seasons to obtain their present values between the treatments as proposed by the World Bank. Nkang *et al.* (2007) used the NPV and BCR to analyze the investment in cocoa production in Nigeria. The study examined costs and returns in cocoa production in Cross River State in the context of three identified management systems of cocoa production in the area, namely owner-managed, lease-managed and sharecrop managed systems. The results show that cocoa production is a profitable business irrespective of the management system employed, since all of them had positive NPVs at a 10% discount rate.

3.3.5 Data analysis

Microsoft Excel and John's Macintosh Program (JMP) version 10.0 computer packages were used to manage and analyze data. The BCA was used to compare the costs and benefits of managing insect pests for the four treatments studied.

3.4 Results

3.4.1 Costs and returns analysis

Table 8 shows a summary of variable costs and returns used in financial analysis for each treatment in cashew and mango orchards. In both seasons total costs were highest in the chemical treatment followed by weaver ants with and without feeding and with the lowest costs in the control treatment. Yields in both cashew and mango were not significantly different between the chemical, WAF and WANF treatments but these treatments were all significantly higher than the control. The use of weaver ants (WANF) in cashew reduced total variable costs by 19% and 22% in the first and second season, respectively, as compared to the use of chemical pesticides, and the use of ants increased costs by 37% and 24% in the two seasons, compared to the control group. Compared to the control treatment in mango, the use of ants (WANF) and chemicals increased costs by 23% and 206% respectively, in the first season, and by 14% and 207% in the second season.

Table 8: Comparisons of variable costs (TZS/Kg) and Benefits (TZS/tree) for each treatment in cashew orchards

Treatment	Seasons	Cashew kernels			
		Costs	Yields (Kg/tree)	Price (TZS/Kg)	Benefit
WAF	2012/13	14273	1.03	28500	29355
	2013/14	15352	1.32	28500	37620
WANF	2012/13	12092	1.03	28500	29355
	2013/14	13695	1.20	28500	34200
CHE	2012/13	15008	0.98	23000	22540
	2013/14	17505	1.21	23000	27830
Untreated	2012/13	8857	0.65	28500	18525
	2013/14	11042	0.73	28500	20805

Source: Experimental data

In cashew (Table 8), the differences in costs between treatments and the lower selling price of nuts from the chemical treatment generated the highest net benefit in WAF, followed by WANF, control and chemical treatments in the first season, where as the net benefit in the second season was higher in the chemical compared to the control treatment and both of these treatments lower than the ant treatments.

While in mango (Table 9), the differences in costs and selling prices in the first season generated the highest net benefits in the WANF treatment, followed by the control treatment and lastly low benefit of only TZS 818 in the chemical treatment.

Table 9: Comparisons of variable costs (TZS/Kg) and Benefits (TZS/tree) for each treatment in mango orchards

Treatments	Seasons	Costs	Yields (pcs/tree)	Prices (TZS/pc)	Benefits (TZS/tree)
WAF	2012/13	14273	-	-	-
	2013/14	15352	71	1100	78100
WANF	2012/13	12092	12	1100	13200
	2013/14	13695	68	1100	74800
CHE	2012/13	15008	12	880	10560
	2013/14	17505	73	880	64240
Untreated	2012/13	8857	8	1100	8800
	2013/14	11042	35	1100	38500

Source: Experimental data

3.4.2 Feasibility analysis

A perusal of Table 10 shows the results of data analysis for the three financial indicators. The NPV, BCR and IRR worked out to be greater than zero, greater than one and greater than the discount rate (10%) for all treatments in both orchards.

Table 10: NPV (TZS/tree), BCR and IRR (%) analyses of treatments in cashew and mango production

Orchards	Particulars	Treatments			
		WAF	WANF	CHE	Untreated
Cashew	Present Value of Benefits	57777	54951	43491	34035
	Present Value of Cost	25663	22311	28111	17177
	Net present value	32114	32640	15380	16858
	Benefit-Cost Ratio	2.3:1	2.5:1	1.5:1	2.0:1
	Internal rate of return	49	57	24	41
	Raking based on NPV	2	1	4	3
	Raking based on BCR	2	1	4	3
	Ranking based on IRR	2	1	4	3
Mango	Present Value of Benefits	64546	73818	62691	39818
	Present Value of Cost	5583	6892	17918	5837
	Net present value	59931	66926	44773	33981
	Benefit-Cost Ratio	14.0:1	10.7:1	3.5:1	6.8:1
	Internal rate of return	274	174	72	132
	Raking based on NPV	2	1	3	4
	Raking based on BCR	1	2	4	3
	Ranking based on IRR	1	2	4	3

Notes: Discount rate = 10%

In cashew orchard, all the decision criteria used was highest for African weaver ants without feeding than other treatments. On per tree basis, NPV for African weaver ant without feeding was TZS 32 640 while African weaver ants with feeding was the second with NPV of TZS 32 114 and control third with NPV of TZS16 858. The NPV for chemical insecticides was lowest at TZS 15 380. The BCR was found to be highest for African weaver ants without feeding at 2.5:1, followed by 2.3:1 for African weaver ants with feeding, 2.0:1 for untreated control and 1.5:1 for chemical insecticides. The IRR was highest for African weaver ants without feeding untreated control (57%), followed by weaver ant with feeding (49%) and untreated control (41%). Chemical insecticides recorded the lowest IRR at 24%.

NPV for African weaver ants without feeding recorded highest at TZS 66 926 per tree, African weaver ants with feeding recorded the second highest at TZS 59 931 and chemical insecticides ranked third at TZS 44 773. Untreated control recorded the lowest NPV at TZS 33 981. The conflicting results (opposite order) between NPV, CBR and IRR were noted when ranking feasibility of the treatments. The BCR for African weaver ants with feeding was highest at 14.0:1 despite the lowest NPV when compared to African weaver ants without feeding, which ranked second with BCR at 11.7:1. Control ranked third with BCR of 6.8:1 and fourth for chemical insecticides with BCR of 3.5:1. Similar trend was observed when ranking based on IRR (274% for African weaver ants with feeding, 174% for African weaver ants without feeding 132% for control and 72% for chemical insecticides).

3.4.3 Sensitivity analysis results

Table 11 shows the results of data analysis according to the assumed scenarios, SA-1, SA-2 and SA-3 in cashew and mango orchards. The analysis showed that all the financial

indicators used in the study were slightly lower than those in the existing scenario if there is an increase of five per cent in the costs and the benefits remaining the same (SA-1). All the treatments enjoy astonishingly higher level of NPV, BCR and IRR when costs remained the same and there is an increase of five per cent in benefits (SA-2). The NPVs were found to be slightly higher than the existing values where five percent increase was made in both costs and benefits (SA-3) but the BCR and IRR remained the same as those were found in the existing scenario.

Table 11: Summary of financial indicators under sensitivity analysis for each treatment

Treatments	SA	Cashew orchard			Mango orchard		
		NPV (TZS)	BCR	IRR (%)	NPV (TZS)	BCR	IRR (%)
WAF	SA-1	30831	2.1:1	46	59701	13.3:1	265
	SA-2	35003	2.4:1	53	63159	14.7:1	283
	SA-3	33720	2.3:1	49	62928	14.0:1	274
WANF	SA-1	31524	2.3:1	54	66581	10.2:1	169
	SA-2	35387	2.6:1	61	70617	11.2:1	180
	SA-3	34272	2.5:1	57	70272	10.7:1	174
Insecticides	SA-1	13975	1.4:1	21	43878	3.3:1	69
	SA-2	17555	1.6:1	27	47012	3.5:1	72
	SA-3	16149	1.5:1	24	47012	3.5:1	72
Control	SA-1	15999	1.9:1	38	33689	6.5:1	127
	SA-2	18559	2.1:1	45	35972	7.2:1	132
	SA-3	17701	2.0:1	41	35680	6.8:1	132

Source: Experimental data

Notes: SA-1: Five percentage increases in cost, benefit unchanged

SA-2: Five percentage increase in benefits, cost unchanged

SA-3: Five percentage increase in both cost and benefit

3.5 Discussions

3.5.1 Costs and benefits analysis

This study showed that the two methods based on weaver ant biocontrol were superior to chemical and control treatments in terms of net benefits. Ant treatments consistently showed higher net benefits than the two other treatments as they both benefitted from a

fruitful combination of high yields and selling prizes and at the same time showed lower costs than the chemical treatments. On the other hand, the extra investment in the feeding of ants compared to unfed ants did not translate into significantly higher yields and net benefits. Therefore, the use of ants without feeding is recommended as a best practise to increase farmer's net gains. Also the net benefits in the control treatments, despite low yields in these treatments, in some cases, exceed the chemical treatments, again due to lower costs and higher selling prices. This was especially pronounced in mango in the first season where the net benefit in the chemical treatment was low. This low benefit was the result of the high investment in chemicals in combination with low yields that year, which drastically reduced the margin between income and costs. This result illustrates that treatments with high costs are economically risky in crops with variable yields. In the following year with several-fold higher yields, the net benefit in the chemical treatment increased considerably and to an extent where it exceeded the control treatment.

The higher yields in weaver ant and chemical treatments compared to the control treatments shows that both ant and chemical pesticides efficiently protected both crops. This positive effect was attributed to efficient control of several insect pests in the two crops. The non-significant difference in yields between the ant and chemical treatments showed that these two techniques were equally effective in their control of prevalent pests. These issues are discussed further by Nassor *et al.* (2015) in the study that provided the yield estimates used in the current economic analyses. The high costs associated to the chemical treatments were partly a result of the simultaneous use of several pesticides in both crops and four to five sprayings per season.

Increased yields and net incomes associated to the weaver ant technology compared to alternative control methods concur with previous studies. Peng *et al.* (2004) and Peng and Christian (2005) found that the use of *O. smaragdina* increased net incomes with 71% and 73% compared to chemical pesticide treatments in cashew and mango, respectively, over a three year period. These increases were based on lower costs and higher quality of the harvest in both cases as well as a higher yield in the case of cashew. Higher cashew yields associated to the use of *O. Longinoda* has also been observed by Dwomoh *et al.* (2009) in Ghana, where weaver ants increased yields more than four-fold compared to control treatments but showed no significant difference compared to chemical treatments. In this case no analyses were conducted on net benefits. Lastly, Offenberg *et al.* (2013) found that *O. smaragdina* was able to increase net incomes with 47% in Vietnamese citrus plantations compared to chemical treatments. In this case because of high costs associated to the use of chemicals, as there was no significant difference in yields. In contrast, the same study found that *O. smaragdina* was unable to protect Thai mango adequately as net benefits in this case was 125% lower in the ant treatment compared to trees protected with chemical pesticides due to failed fruit set in the ant trees.

3.5.2 Financial analysis

Benefits and costs do not serve as true yardsticks for making a decision to go for investing in cashew and mango production. This is due to the fact that costs incurred and benefits are not comparable without discounting such costs and benefits. For this purpose, three techniques i.e. Net Present Value (NPV), Benefit Cost Ratio (BCR) and Internal Rate of Return (IRR) were used for comparisons. There were differences in feasibility ranking of the treatments in cashew and mango orchards.

In the cashew orchard, all the decision criteria were highest for African weaver ants without feeding. The NPV was positive and highest for African weaver ants without feeding indicating that the discounted worth of benefits was greater than discounted worth of cost streams. This suggests African without feeding was feasible for adoption. The results are in line with that of Bokonon-Ganta *et al.* (2002) in Benin reported the discounted value of benefits of biological control of mango mealy bug generated higher net benefits which demonstrated the success of the option. Similar results have also been reported by McConnachie *et al.* (2003) in South Africa. Low cost for African weaver ants without feeding compared to chemical insecticides proved advantageous to give the highest BCR. These results compare well to Zeddies *et al.* (2000) and Norgaard (1988) who recorded benefit-cost ratio of 199:1 and 149:1 respectively when biological control was applied against cassava mealybug. Bokonon-Ganta *et al.* (2002) in Benin found biological control effective against mango mealybug with benefit-cost ratio estimated at 145:1. Van Den Berg (2010) found highly cost effective biological control of the spiny blackfly in Switzerland with a benefit-cost ratio of 199:1. The highest IRR for African weaver ant without feeding in cashew and for African weaver ant with feeding compared to conventional practices indicating the worthiness of investments.

In the mango orchard, none of the four treatments studied was observed to hold the best position for all decision criteria used (opposite order). The conflicting results might be due to differing cash inflow. Farmers need to decide one treatment to adopt and invest in. This was resolved by considering NPV indicator and ignoring the values of BCR and IRR because NPV is an absolute value as compared to other indicators. African weaver ants without feeding returned highest NPV implying that weaver ants without feeding is financially feasible due to high value added from its implementation. Jacobs (2007)

reported that for conflicting results between NPV, BCR and IRR should rely on NPV to take decisions on the basis of ranking more than one technology.

3.5.3 Sensitivity Analysis (SA)

Sensitivity analysis indicated that the treatments can improve their positions if benefits are increased at five percent. In addition, increase only in benefits and not in the costs, would lead the treatments to astonishing returns.

3.6 Conclusions

The study analyzed the financial feasibility of African weaver ants (*Oecophylla longinoda*) as biological control agents in cashew and mango orchards compared to conventional practices. The experimental data supported the research questions indicating that African weaver ant without feeding is financially feasible technology. The results also agree with previous studies as indicated in this study. It is in this backdrop that the comparative analysis of the costs and benefits of the insect pest management used and the dissemination of the findings are of great importance to the farmers, researchers and policy makers for better yields and high quality nuts and fruits. There are some limitations in this study where the data is limited to two crops. Ideas for future experiment would be to implement in other tree crops to increase the validity of the study.

3.7 Acknowledgements

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CHAPTER FOUR

4.0 INVESTIGATION OF EXPORT BARRIERS FOR CASHEW AND MANGO PRODUCTS FROM TANZANIA TO EUROPE

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4.1 Abstract

This study explores the barriers that value chain actors face when they export cashew and mango products to Europe. Using purposive and snowball sampling procedures, a total of 32 informants were recruited. Data were collected through personal in-depth interviews and analyzed using thematic coding and interpretation based on an institutional theory perspective. Results show that growers cannot produce sufficient quantities of high-quality fruits for export. Other barriers include costly and lengthy process of certification, insufficient volumes, lack of market research and unfavourable exchange rates. The findings have important implications for policy and further research.

Keywords: Export barriers, institutions perspective, supply chain, Tanzania, Europe

4.2 Introduction

Cashew (*Anacardium occidentale*) and mango (*Mangifera indica*) are high value crops in Tanzania and ideal for export (Niyibigira *et al.*, 2004; Mulungu *et al.*, 2008; Cashew Board of Tanzania (CBT), 2010). Both sub-sectors are major players in ensuring household income and food security for smallholder farmers in Tanzania (Match Maker Associates (MMA), 2008; United Republic of Tanzania (URT), 2010). Available data showed that the cashew sub-sector (Table 12) earned the country USD 75 million in the 2005/2006 cropping season (TIC, 2005), USD 70 million in the 2008/2009 cropping season (UNIDO, 2011; FAOSTAT, 2011) and USD 140 million in the 2010/2011 cropping season (CBT, 2010).

Table 12: Export earnings of cashew in selected cropping season

Cropping season (year)	Production (metric tons)	Export (tons)	% exported as raw	Earnings in USD Million
2005/06	77,446.38	66,708.00	86.13	75
2007/08	99,106.72	75,887.90	76.57	70
2010/11	121,134.97	112,374.00	92.77	140

Sources: CBT (2010), FAOSTAT (2011), TIC (2005), UNIDO (2011).

According to Fitzpatrick (2012), 85% of the total cashew output is exported raw (primarily to India) and 15% is processed and consumed on the domestic market. Match Maker Associates (MMA, 2008) reported that the mango fruits can be processed into dry mango, mango pickle, mango jelly, or can be eaten cooked. Currently, processing of Tanzanian mango for export is less developed (MMA, 2008).

While globalization has provided business opportunities to entrepreneurs in various countries, targeting a new market with new agricultural products is not without difficulty (Okpara, 2011). It comes with its own set of marketing challenges that represent barriers to export that can make it difficult to enter a particular market (Anders, 2009) and to take advantage of the new opportunities provided by trade liberalization (Killick *et al*, 2000). This study focuses on the problems exporters and other key players in the Tanzanian cashew and mango value chain encounter when they strive to gain access to potential European markets which offer premium prices for organic products such as Denmark and Germany.

Previous studies that have attracted considerable interest in the Tanzanian cashew and mango sub-sectors are policy and taxes in the industry (DAiPesa, 2004), value chain diagnostic (MMA, 2008; UNIDO, 2011) and regulations (Fitzpatrick, 2012). Finally, a comparative study on the Tanzanian and Vietnamese cashew (Kilama, 2013), which contended the existence of a ‘thin market’ (few buyers and sellers) in the Tanzanian cashew nut industry, has since compelled an interventionist approach. Thus, the Government has introduced a Warehouse Receipt System (WRS) in an attempt to control failure of the crop’s market. However, none of these studies have focused on export marketing.

The motivation for this study is to contribute to the literature that explores export barriers perceived by farmers and exporters and to provide useful insights that can aid policymakers design appropriate strategies to promote export trade from Tanzania to Europe. Institutional theory was used to identify and analyze barriers to exports from Tanzania to Europe. This theoretical approach is relevant for this study because it can be used to understand challenges in a developing economy, especially issues of how the

institutional context promotes or inhibits exporting (Scott, 1995). Therefore, the objective of this study is to investigate export problems that cashew and mango exporters, marketers and smallholder farmers encounter in export of their products from Tanzania to Europe. Choosing Tanzania for the purpose of this study is because the country is among the most important producers in Africa of cashew and mango. Currently, exports are so low and high-value markets in Europe are not reached directly by Tanzanian exporters.

4.3 Theoretical Framework

This study addresses the question of how the institutional context affects organizations' or groups of people's access to export markets. Institutional theory provides a useful theoretical lens for analyzing how different organizations and groups conform to the rules and norms of the environment in which they operate (Brunton *et al.*, 2010).

North (1990; 1991) has been the most notable scholar of the economic strand of institutional theory and was the first to propose that formal (political, legal and economic systems and including constitutions, laws, regulations, property rights) and informal institutions (sanctions, taboos, customs and traditions) combine to constrain the choices available to individuals and organizations.

The importance of institutions in shaping firm behavior has been asserted and emphasized by both economists and sociologists. While North (1991) represents the economic version of institutional theory, Scott (1995) represents the sociological version

and defines institutions as cognitive, normative, and regulative structures and activities that provide stability and meaning to social behavior (Figure 1).

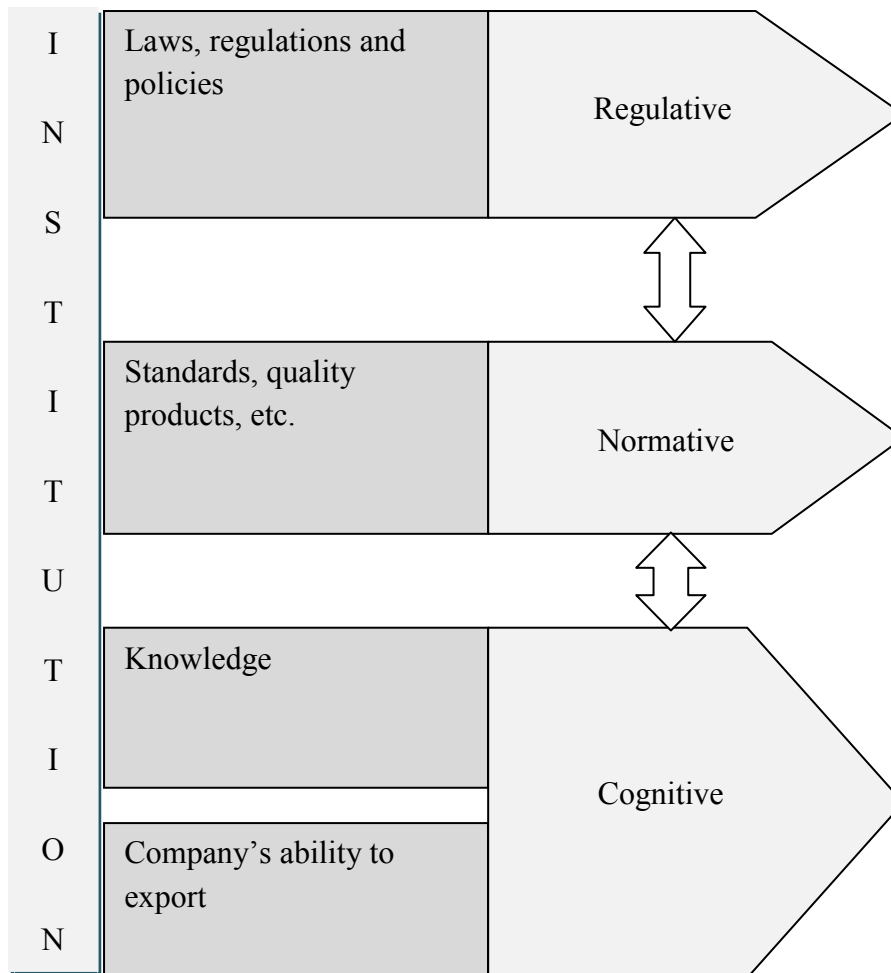


Figure 1: The analytical framework
Source: adapted from Scot (1995)

Figure 2. The analytical framework

According to Scott (2008:54), the regulatory pillar defines what organizations and individuals “may or may not do” (where “may” implies permission). Regulations and policies can constrain value chain actors by setting trade barriers for production materials and production technology by limiting information flows, imposing unfavorable taxes and by denying infrastructural investments that would benefit value chains. For example,

Van Melle *et al.* (2007) in Benin and Bizpro (2005) in Ukraine identified inadequate infrastructure as restricting smallholder farmers in dealing with requisite product quality standards.

The normative pillar defines what actors should or should not do. It comprises values of what is appropriate and norms about how to conduct business abroad, for example in the form of minimum standards that are deemed to apply beyond national borders (Scott, 2007 in Brunton *et al.*, 2010). Lemeilleur (2011) noted that exports from Peru to United States (US) and Europe need to respect the Maximum Pesticide Residual Levels (MPRL) for European markets. At plant level, the Hazard Analysis Critical Control Points (HACCP) is essential and GLOBALGAP has been becoming a de facto standard at the production level since 2007, and organic certification and ISO 22000 has spread (Ghafoor, 2010; Bignebat *et al.*, 2011).

The cognitive pillar defines what “is or is not true” and what “can or cannot be done” (where “can” implies ability). It is about the rules that specify what types of actor are allowed to exist and what procedures they can follow. The cognitive pillar comprises cultural assumptions of “the way we do things”, that is, organizations should look and behave like other types of organizations.

Institutional theory research suggests that firms are influenced by the institutional environment when making market entry decisions, as the institutional environment of the host country constitutes the “rules of the game” by which firms participate in the particular market (North, 1991). The influence of institutions on the choice of markets is

confirmed by Yiu and Makino (2002). With regard to market selection, Whitelock and Jobber (2004) found that the four factors that most significantly influence the decision of whether or not to enter a country are good market information, unsympathetic government attitude, political similarity and market attractiveness. The first three of these factors can be interpreted as institutionally based factors, indicating that the institutional environment of the host country also strongly influences market selection.

The application of institutional theory has thus proven helpful to marketing research. Institutional theory has played a major role in helping to explain the forces that shape entrepreneurial success (Peng, 2006). In a review of literature employing institutional theory for understanding the status of the field, Bruton *et al.* (2010) found that though institutional theory has proven highly useful, its use has reached a point that suggests a need to establish a clearer understanding of its wide-ranging implications for marketing research. In this context, institutional theory can be used to understand marketing challenges in a developing economy, especially, the issue of how the institutional context promotes or inhibits firms from entering export markets.

4.3 Methodology

4.3.1 Study areas

The study was conducted in the Dar es Salaam and Mtwara regions of Tanzania; the commercial/business cities, industrial and transportation centers of the country. According to Mnenwa and Maliti (2005), the two regions have a large number of Small and Medium Enterprises (SMEs) and SME support institutions and are major production development areas for exportable cashew and mango cultivars

4.3.2 Research design

This study used a cross-sectional design to interview individuals and firms at the same point of time. The study mainly relies on the primary sources of information from different stakeholders such as smallholder farmers, marketers and exporters. The use of qualitative techniques in the context of exploration was considered appropriate, as the variables investigated were unknown and it was important to obtain rich data. The interviewees provided responses using their own terms and with their own words. It is valuable in generating an understanding of a particular situation (Merriam, 2009).

4.3.3 Sample selection

A purposive sampling technique was used because this study required interviewees who have experience dealing with cashew and mango production and exporting. The Tanzania Exporters Association (TANEXA) was the main information sources for preparing the list of key informants. Based on the possible initial list of interviewees, more respondents were added into the list by using a snowball sampling procedure. Miller *et al.* (2011) argued that using snowball sampling is more suitable and effective than many other non-random sampling techniques and can provide detailed information and characterizations

of unknown population when conducted carefully. In the end, 32 key informants were selected and participated in face-to-face in-depth interviews: 18 smallholder farmers (six drawn from each sub sector and six from both), eight marketers (three from each sub sector and two from both comprising primary collector, brokers and wholesalers) and six exporters (two from each sub sector and two from both) who are actively engaged in export activities (Table 13).

Table 13: Distribution of key informants per sub sector

Key informants	Number of key informants			Total
	Cashew	Mango	Both (cashew and mango)	
Smallholders	6	6	6	18
Marketers	3	3	2	8
Exporters	2	2	2	6
				32

4.3.4 Data collection

The study covered the period from June 2013 to May 2014. The data collection process took longer than anticipated due to the busy schedule of potential informants, particularly marketers and exporters. There was a need to wait their appointment as suggested by the targeted markets and exporters selected for discussions. This was not the case for smallholder farmers both cashew and mango. Semi-structured, personal in-depth interviews were adopted as the main way to generate data. An interview guide was used to capture stories from growers, marketers and export managers, which allowed follow-up questions. Interviewees expressed a wish to remain unnamed, and the information is therefore reported anonymously. Various topics were covered during interviews including cashew and mango export chains and key players in each sub-sector, specific functions of each player and the barriers they encounter when trying to export to Europe. Possibilities to improve cashew and mango exports in the future also were covered during interviews. The questions were open-ended, because this research involved a small sample such smallholder, marketers and exporters and it allowed key informant freedom to convey their experiences and views. Interviewing stopped when no significant additional insights generated from additional interviews.

4.3.5 Data analysis

Interviews were transcribed and transcripts were analyzed by focusing on themes (thematic analysis) and meanings of the text. Patterns and commonalities in responses from interviewees were identified and coded. Coding included reviewing interviewee responses and giving label names to parts that appear to be theoretically significant. This allowed for easy data analysis and the identification of common themes. The coded data were then complemented with the notes from the interviewer's observations as well as informal talk. Empirical data were analyzed from the perspective of the institutional theory developed by Scott (1995).

4.4 Results and discussions

This research aimed at getting qualitative information about the barriers that cashew and mango chain actors face when try to export from Tanzania to Europe.. Significant and relevant topics are highlighted through respondents' verbatim quotes. All opinions from respondents represent various possibilities to improve cashew and mango export in the future. Rather than find the average or representative view, an effort was made to uncover different views. Also, varying results were anticipated due to differing experiences of the respondents.

4.4 Value chains and actors

In order to better understand the institutional environment behind cashew and mango markets, this section presents the structures of Tanzanian cashew and mango export chains.

4.4.1 Cashew value chains

In the cashew sub-sector, the current marketing of raw cashew in Tanzania is through the Warehouse Receipt System (WRS)). The WRS is a collective action that strives to ensure that smallholder farmers participate directly in the export market. It presents the current value chain of cashew in Tanzania and the actors involved in the chains (Figure 3.

The current marketing of cashew is legally under the licensed warehouse receipt system. Other selling options such as free buyers in the open market and the door-to-door market are prohibited by the government. The flow of raw cashew from the farmers is unidirectional and is channeled through Primary Cooperatives (PCs). In order to sell in the WRS, about 20 - 30 farmers must go together to form a primary cooperative society (PCs). Currently there are about 400 PCs covering major cashew growing areas in Tanzania. The PCs on behalf of the member farmers provide inputs (mainly pesticides) and procure supplies in bulk (e.g. farm equipment, fertilizers, sprayers, and gunny bags). The cooperative buys raw cashew nuts from its members, who in return receive a first payment; the cooperatives usually require a credit to pay out these payments. The PCs sell the raw cashew nuts to buyers via the warehouse system. In return they receive a produce cess (deducted at the product level). They use part of the fees earned for service from the produce cess to construct storage facilities at farm level and eventually provide other services such as savings and revolving credit products for cashew inputs, and even investment in common assets such as irrigation schemes, to their members.

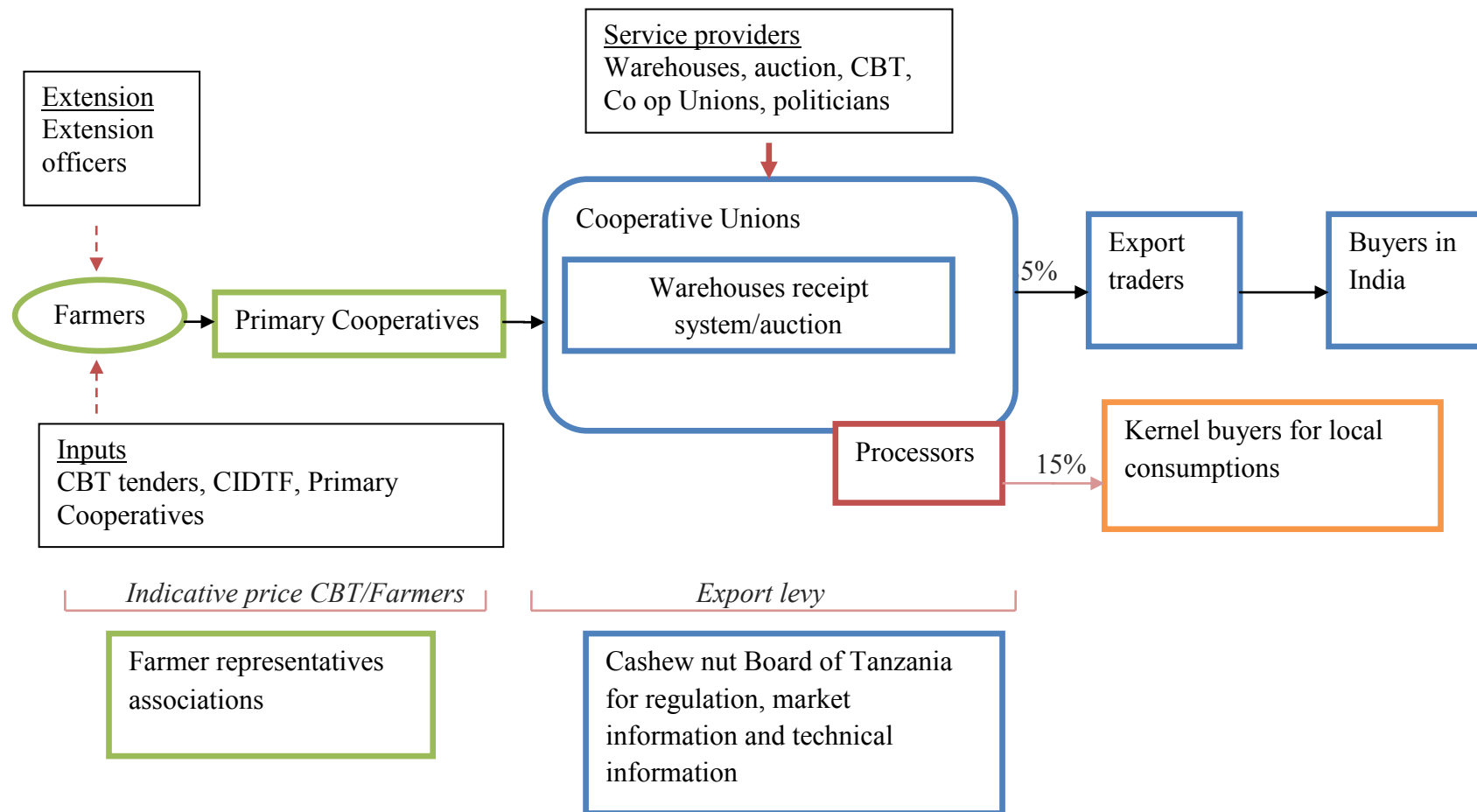


Figure 3: Tanzanian cashew export value chain and actors

Figure 4, illustrates how the WRS was operating in Tanzania during the fieldwork period. The arrows in the top left-hand box show how cashew move from the farmer to the primary society and then to the cooperative society before being auctioned off to exporters and processors.

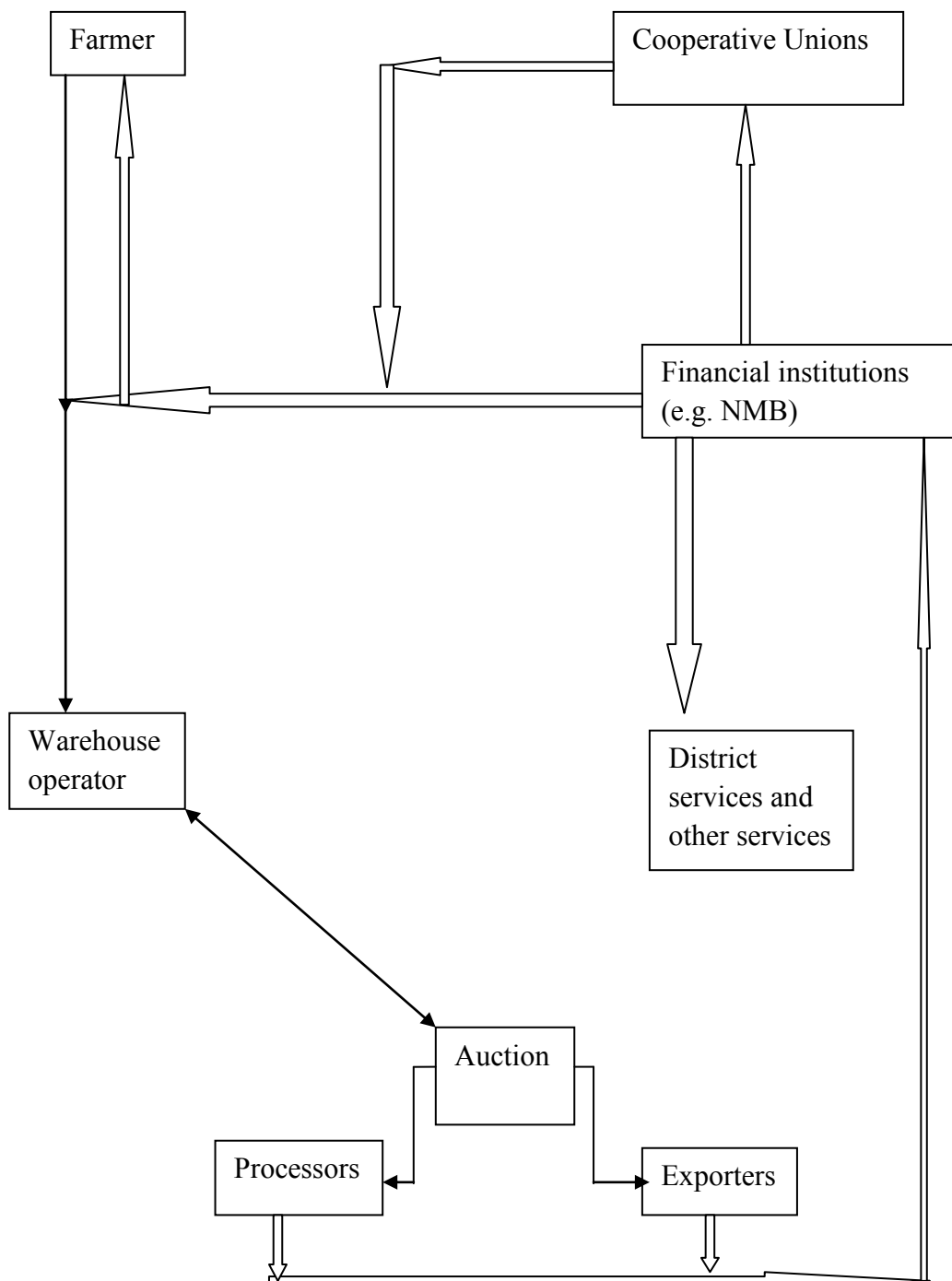


Figure 4: Marketing of raw cashew nuts through WRS in Tanzania

Flow of raw cashew nuts

Flow of money

At the same time, other services are provided by the PCs. For instance, provision of inputs, buying of raw cashew nuts from its members, collecting and transporting of cashews and storing them in licensed warehouses, money transfer and warehouse maintenance. In the right-hand corner, the movement of money to and from the bank is shown. Initially, the primary societies apply for loans from banks to pay their farmers for their cashew before auction. Once the loans have been approved, the cooperative unions are responsible for assisting the primary societies by supplying them with money whenever necessary. Farmers are paid a proportion of the indicative price per kilogram determined based on the production cost per cashew tree. The indicative price is the preliminary estimate of the bid and offer price announced by cashew board of Tanzania each cropping season. It is used by buyers to evaluate their trading strategies. For example, during 2014/2015 cropping season the indicative price for cashew nuts was TZS 1000 per kilogram. It is normally paid 70% of the price as an advance, using money obtained from banks (bank loans) before cashew nuts are sold to traders and the remaining part of the price (30%) is paid after auction. Smallholder farmers are paid a bonus in cases when the cashew nuts are sold above the indicative price announced by Cashew Board of Tanzania (CBT). During the discussions with farmers they complained that the computations of the bonus are not clear from CBT. Mashindano *et al.* (2011) reported that farmers retain the receipt and, after sale at the auction by the warehouse management several months later, farmers are given the bonus by deducting costs of storage, interest, transport and administration. This is in line with CBT (2012) and Nkonya and Barreiro (2013) who both reported that if auction prices are above expectations, farmers are paid an additional price bonus.

Various processes take place in the warehouse area. First, the vehicles from the primary societies are weighed and a sample is taken for scientific grading to determine the quality

of the batch. The cashew are arranged in the order in which they arrived at the warehouse and a Cashew Board of Tanzania (CBT) quality certification is issued noting the batch's weight and grade. The warehouse officer then produces a receipt for the bank and a copy for the primary society.

At the warehouse where the auction takes place, the cashew sacks are organized by the primary society. A raw cashew sales catalogue with the grades of batches for the different primary societies is provided for the bidders who write down the prices for a batch and put them in an auction box. The auction is then conducted under CUs and CBT and the winning (highest) bidder takes the warehouse receipt to the bank to arrange for payment. After having paid, the bidder is provided with a permit and a levy for transporting the product, and then returns the original warehouse receipt that was used to pay for the batch at the bank. Given proof of payment from the bank, the warehouse manager provides the winning bidder with a release warrant. Bids must be high enough to cover any unforeseen additional costs associated with production. If they are too low, the auction is suspended and there is no winner. The minimum bid allowed is for 50 tons. After the auction, farmers receive a second payment that covers the full price indicated and if it is high enough, a third payment in terms of a bonus is also provided as commented by respondents;

“Multiple bidders are required to ensure competition among bidders (traders) in order to guarantee a good price. Currently, bids are deposited to a tender locked box placed at CBT and they are given half a day to deposit their bids before they are opened on the same day”.

This is contrary to the past where bidders were given five days to deposit their bids, farmers and exporters said.

Buyers of raw cashew nuts comprise both domestic and international traders; the latter mainly from India and operating through local and multi-national companies. These traders are licensed for purchase and export of cashew nuts. The number of traders per season has been fluctuating with only 22 buyers being regular in the market. This might contribute to the fact that auctions are not advertised in the newspapers. Instead phone calls are used to alert existing buyers in the cashew market and thus not attracting new buyers. This finding is supported by UNIDO (2011), which found that power of exporters in African countries is limited by the concentration of purchasers in India who purchases raw cashew nuts.

4.4.1.2 Mango value chains

Contrary to cashew nut value chains, the mango products currently flows via three alternative supply chains from farm to various end market consumers (Figure 5).

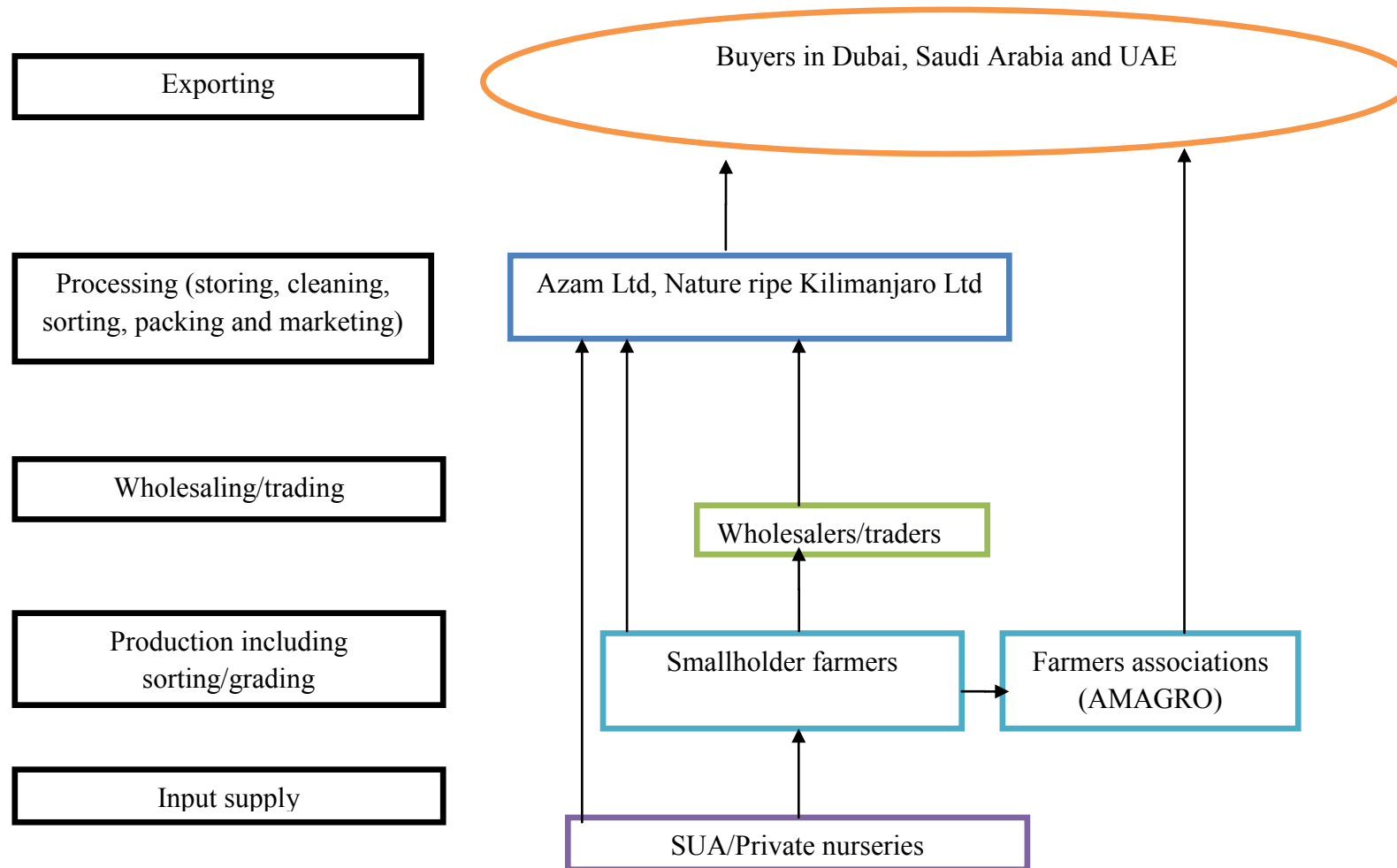


Figure 5: Tanzanian mango export value chain and actors

The export channel is mostly driven by Nature ripe Kilimanjaro LTD and a few other actors exporting low volumes. There are four potential exporters selling within the region (Eastern-Southern Africa) or to the Middle East. Exported volumes have been low due to limited production and the prevalence of pests and diseases. None of the Tanzanian mango is exported to Europe, although there is interest from the Netherlands and Turkey to invest in Tanzania and provide post-harvesting training and support agribusiness knowledge at grower level. These results are supported by Deligonul *et al.* (2011), who argue that normative and regulative institutions such as offering education and training to ensure suppliers along the value chains to be familiar with norms and value in the business environment.

4.2 Analysis of barriers towards Market Access to Europe

Exporters and farmers have strong intentions for exporting cashew and mango products to Europe, but they are faced with barriers that hinder to access to these markets. Below, the findings are categorized according the three pillars of the theoretical framework (regulatory, normative and cognitive institutions) and other barriers not explained by any of the three pillars of institutions.

4.2.1 Regulatory institutions

Actors in the value chains face restrictive regulations. In order to export to Europe, farmers, marketers and exporters said that they need to undertake certification tests and have to supply the certificate (permit) during the trade process according to strict European retailers. Delays of inspection by authorities in providing certification cause huge transactions costs. Due to this complication, potential exporters lose time and money and thus abandon their intention to enter European markets. These results are related to the regulative institutions with regard to the established business regulations

and rules. A sense of this problem is reflected by the following comment from marketers and exporters and farmers;

“Fruits and nuts could not be exported to Europe according to their regulation, certification and other procedures. Perhaps, we need to comply with quality standards” (both exporters and marketers said).

“Currently we don’t have cold room facilities for fresh mango and we are not enabled for these facilities” mango farmers said.

The findings echo Adda and Hinson (2006), who pointed out that poor administration of laws relating to the issuance of licenses and permits, unequal access to public services and resources, and delays in the delivery of public services impede efforts at making access to European markets easier for the farmers.

4.2.2 Normative institutions

Another barrier under normative institutions is the need to comply with the standards which are necessary requirements in Europe. This constitutes a further challenge related to farm level (production stage). The lack of standards might be attributed to the current production technology adopted by smallholder farmers such as frequent use of chemical insecticides as an immediate solution against major insect pests in orchard managements. It was further discussed that to export to European markets should consider production of marketable varieties and appealing appearance (free from damages). The damage caused by insect pests and disease infestations reduce quality levels and thus quantities suitable for export to Europe (Nassor et al, 2015). Infestation of mango fruits by insect pests such as fruit fly was reported as major export problems. For the moment, penetration to the EU market is impossible for Tanzanian cashew and mango products due to environmental concerns because smallholder farmers rely on chemical insecticides as an immediate solution against insect pests in both cashew and mango orchards.

Interviewees who are connected with export to Middle Eastern countries such as Dubai, Saudi Arabia and UAE aluded that the importance of quality in these countries is different compared to Europe markets. While specific quality such as free from insect pests and diseases was deemed important for exports to Europe, quality seems less as important Middle East market

The Middle East and Indian markets accept the raw nuts and fresh mango fruits from Tanzania with lower standards, hence exporters resort to these markets. This is not possible for buyers in the European markets with the current quality who insists on norms and standards to avoid food risks. Stringent market conditions in the importing

countries are a strain on the exporter. According to Ghafoor (2010) and Bignebat *et al.* (2011), supermarkets in Europe select suppliers based on certification (GLOBAL GAP, HACCP). Without using Integrated Pest Management (IPM) technologies and required standards, there is no chance Tanzanian cashew and mango can be exported to Europe. These are normative institutions in the sphere of technical regulations.

These findings confirm North (1990) description of institutions as “rules of the game” in a society, which organizations or groups need to comply with in order to gain legitimacy. Nadvi *et al.* (2004), Jaffee and Henson (2005) and Ghafoor (2010) all argued that global standards and requirements restrict market access of developing countries’ suppliers. Evolution of multiple standards resulting to increased compliance costs has been a stumbling block for many exporters in accessing new markets (SIDA, 2007; TAHA, 2010).

4.2.3 Cognitive institutions

The loss in value of the Tanzanian shillings in relation to US Dollar and other currencies erases the profit margin in business. The rates of currency are always fluctuating, thus exporters face currency exchange risks. This situation in one way or another coupled with high export tax of raw products imposed by the government does constrain exporters to achieve the level of profit margin they planned and therefore limit them to expand their operations. This makes difficult of doing business in Tanzania for exporters as it is explained:

“Prices are always fluctuating caused by high loss in value of Tanzania shillings compared to other currencies in Europe and it is not sure to give profits. We don’t want to take that kind of risk perhaps”.

4.2.4 Barriers not explained by pillars of institutions

4.2.4.1 Insufficient quantities of products for export

The analysis suggests that insufficient volumes of both cashew and mango products from Tanzania is a significant barrier to exports to Europe. This problem is related to value addition at processing stage. Fitzpatrick (2012) revealed that cashew processing in Tanzania is minimal, with only 15% being processed for local consumption and 85% exported raw to mainly India where they are exported to Europe at high profit margin. Similarly, mango can be processed in many ways and used for many forms of products but Tanzania has only so far developed a few of them. This might be attributed to insufficient plant capacity, organizations for processing, and no dedicated cargo flight from Tanzania (TAHA, 2010). Some European markets such as Netherlands (cashew kernels) and Turkey (mango fruits) recently started to show interest to buy cashew and mango products from Tanzania under the condition that smallholder farmers adopt and use organic production techniques during production. During the discussion with smallholder farmers, they said that they will be trained on the use of organic production before they export the products to these markets. Currently, a few farmer groups in the Masasi District in the Mtwara region have adopted the use of African weaver ants as biological control agents against insect pests. They expected to enjoy premium price but the problem is that low quantity of organic cashew products is produced to meet the demand of buyers in these countries. These markets are controlled by big retail chains which require large quantities. Based on the current situation, Tanzanian exporters have no chance to export to Europe.

4.2.4.2 Inadequate information

Exporters in the cashew and mango chains indicated that there is inadequate information and knowledge of the European markets. This is caused by lack of market research efforts with regards to the real needs of the retailers in Europe. Innovation relies on bringing together different types of research and utilizing this knowledge to design new products. Without a market research focus, firm risk falling behind competitors in innovative new products and it is impossible to do business with potential European buyers. Tanzania is facing competition from other countries like India, Pakistan, Brazil and Mexico that take advantage of the available information and knowledge of European markets. This suggests that information gaps remain critical challenges even in the current era of extensive information availability. These results are supported by Beleska and Glaister (2011) and Bari (2008), who both found that there is a lack of research done by exporting firms before entering in the new markets and encounter problems in analyzing the foreign market.

Also, the results clearly show that farmers are in a situation of information asymmetry that puts them in a disadvantaged position, which is used by other supply chain actors, i.e. exporters and marketers, to exploit them. These actors need to be educated that, for the better performance of their individual businesses they need to share information to all members in the chain in order to enhance access to export market in Europe based on the requirements including quality and quantity of the produce. This will assist the chain to get better deals in terms of price at the international market and therefore be competent as suppliers. The findings of this study conform to Singh (2002), who found that when supply chain members strive to achieve the overall supply chain objective, market information sharing enhance competitiveness in the foreign markets.

4.5 Conclusions

The study investigated barriers faced by Tanzanian cashew and mango value chain actors when they try to export to Europe. In pursuing this objective, the study identified important barriers experienced or perceived by actors in the value chains. The barriers identified in the current study namely, insufficient quality in the nuts and fruits production tier due to insect pests. Other barriers include: costly and lengthy process of certification and insufficient volumes produced, little effort on market research and unfavourable shilling-US Dollar exchange rates. The findings from the analysis clearly support the three pillars of institutional theory such as costly and lengthy process of certification explained under regulative institutions, insufficient quality standards of products explained under normative institutions while the loss in value of Tanzania shillings relative to international currency such as dollar was explained under cognitive institutions on export intention to Europe. However, insufficient quantities of products for export and inadequate information were not explained by these pillars.

Several implications can be drawn from the findings. Based on the findings, policy makers should understand and focus on specific institutional barriers and policy interventions required to enhance export of cashew and mango to tap higher value markets in Europe. Similarly, while several business-support institutions exist in Tanzania, the lack of export knowledge and information to value chain actors is still a major problem.

The findings have important implications for exporters. They should be aware that venturing into overseas markets is not trouble free, because different kinds of barriers stand on their way. Hence, adequate preparation and efforts to minimize the barriers are needed. In the context of this study, exporters, marketers and farmers should be aware of

the certification process, standards imposed by European retailers, export market knowledge and information, insufficient volumes of exportable products could impede export activities.

Finally, the findings in the present study should be interpreted in the light of two limitations. One, the cross sectional nature of the study's design poses challenges to the validity of results. A longitudinal design is more appropriate for solving this problem. Two, the findings are based on the primary data collected from chain actors in cashew and mango sub-sectors. This research can also be done in other sub-sectors in Tanzania. Both the contributions and limitations of this research merit attention and provide directions for future work. Further research is needed to extend the generalizability of the framework presented in this paper. A logical next step would be to adopt the same model and increase the sample size to increase the validity of the study. Another intriguing avenue for future research is to investigate export barriers from other sub-sectors in Tanzania.

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CHAPTER FIVE

5.0 GENERAL CONCLUSIONS

This research was conducted to investigate the economic benefits of using African weaver ants in nuts and fruit production and export. It was designed to specifically assess the feasibility of weaver ants compared with conventional practices to manage insect pests in cashew and mango orchards. It also explored the export problems hindering cashew and mango chain actors to export their products from Tanzania to Europe.

The results were presented in three chapters: the first chapter deals with partial budgeting to estimate the financial consequences of a change when cashew and mango farmers decide to switch from conventional practices to weaver ants. Switching from either chemical insecticides or no-pest control to weaver ants without feeding gave positive and higher net change in benefits. Furthermore, MRR for switching from no-pest control to weaver ants without feeding was highest suggesting that it was feasible to be adopted by cashew and mango smallholder farmers. The second chapter deals with benefit cost analysis using discounting approach to reduce the net benefits which accrued in two cropping seasons to a present value. The weaver ants without feeding recorded highest Net Present Value (NPV) indicating that it financially feasible to be adopted by smallholder farmers in both crops under study. The last chapter deals with marketing challenges that represent export problems of cashew and mango products from Tanzania to Europe. It was observed that insufficient volumes and low quality were the major barriers to both sub-sectors which hinder smallholder farmers and other value chain actors to tap high value markets in Europe.

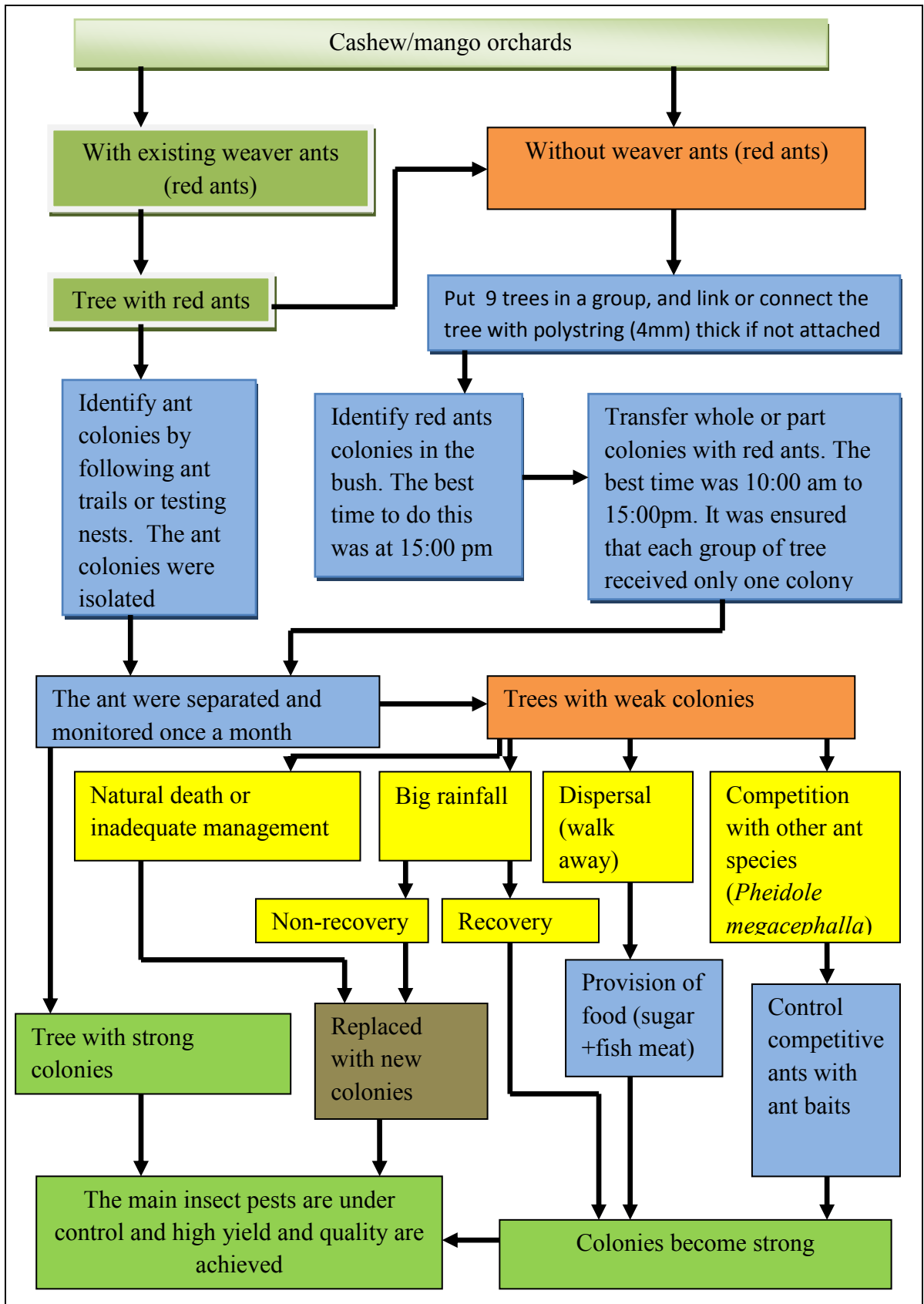
The findings from this study served to promote weaver ant awareness to cashew and mango smallholder farmers and increase their knowledge for easy adoption. Farmers should make proper selection of appropriate insect pest alternatives with desirable socioeconomic considerations, such as higher benefits associated with less costs of implementation, with no adverse effects to the environment and consumers at the markets. Weaver ants are a desirable technology that protected crops and led to higher net benefits resulted from increased yields, improved quality and premium organic prices that smallholder farmer enjoyed from exporting cashew to big retailers in Netherlands. The technology is compatible with organic certification and can be used to reduce or eliminates the need for synthetic chemicals; hence fulfill organic food production in Tanzania.

Switching from insecticides to African weaver ant without feeding was recommended for adoption by smallholder farmers in cashew and mango. Hence, adequate preparations and efforts to minimize the barriers are needed by smallholder farmers through adoption of weaver ants to manage insect pests in their orchards.

The experimental trials and surveys were limited to only two crops (cashew and mango) and cross sectional design respectively. Ideas for future experiment and surveys would be to implement in other tree crops and increase the sample size to increase the validity of the study. A longitudinal design is more appropriate for solving the problem of cross sectional design adopted in the current study.

APPENDICES

Appendix 1: A flowchart of weaver ant colony management in cashew and mango orchards



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Appendix 5: Interview Guide on Export Barriers during Focus Group Discussions

1. Introduction:

My name is William J. George; I represent Sokoine University of Agriculture in Morogoro, Tanzania. Currently, I am conducting research focuses on access to export markets in cashew and/or mango products. The objective of the study is to identify marketing challenges that represents barriers impeding exports from Tanzania to Europe. The following is interview guide, rather than a questionnaire to be used to prompt and guide this discussion. I encouraged you (exporters, farmers and marketers) to engage in the discussion. The result of the discussion is for research purposes only. The length of the discussion ranged from 60 - 90 minutes per group. Would you agree to answer the questions?

2. Export information

- (a) How long does your group have been in this business?
- (b) Which product/s do/es you export to Europe?
- (c) Which new products are you willing to export?
- (d) Distribution network: from where do you get cashew and mangoes?
- (e) To which country/ies do you export or want to export these products?

3. The topics of the interview

3.1 Processes of regulation & representational practices (The overall market conditions)

- a. How will you describe the market for cashew/mango?
 - Organic and traditional
 - Raw and processed products
 - General development in the market
 - Premium prices
 - Local market and the EU market
- b. How do you expect the market for organic cashew/mango to develop in the next five years?
 - Why?
 - New entrants/ withdrawing of competitors?
- c. How would you describe the marketing channel for mango and cashew?
 - Different types of channels
 - Channel members (*main actors*)
- d. What are the responsibilities for each actor in the marketing channel?
 - Channel function/channel flow
- e. What is the role of the organization in the marketing channel
 - What is the firm specialize with

- f. How do you add value to cashew/mangos along the supply chain?
 - g. What are the main challenges for adding value for mango/cashew nuts?
 - h. Problems of exporting: What are the major problems are you facing in exporting to European countries? Start your comment from the point of efforts of getting an order, receiving it, through the production process, facing the customs, entering the market and consumption.
 - i. How do you strive to overcome these problems/challenges?
 - j. What kind of support does the government or other organizations provide to the mango and cashew sector?
 - To whom and why?
 - Do you think that there is sufficient support?
 - Suggestions for improvements?
- 3.2 Processes of validating combines with normalizing practices (Give a new introduction for the following questions)
- a. How do you access market information?
 - Information about private standards
 - Are there any trade associations that influence?
 - b. How can you change the mango/cashew industry?
 - How do you influence other stakeholders?
 - Are there any trade associations that influence?
- 3.3 Processes of habitualizing combined with exchange practices (the competitor situation and how they do business on a daily business)
- a. Who do you consider to be your main competitors in the cashew and mango sector?
 - Countries
 - Between producers/ exporters/ retailers
 - Criteria they compete on
 - What are the strengths/ weaknesses of the competitors?
 - Marketing activities of the competitors?
 - Competitors prices
 - b. How do you react to your competitors activities?
 - Mimic the behavior and activities of the main competitor?
 - Description of a concrete situation
 - c. How will you expect your main competitors will react to your activities?
 - Why?
 - Description of a concrete situation
 - d. Can you describe a typical exchange situation?

- e. How do prior decisions affect your current and future actions?
 - f. Which methods do you use to communicate with others actors in the marketing channel?
 - g. How would you describe the collaboration in the marketing channel?
 - Types of collaboration
 - Level of collaboration
 - What are the criteria that you use for choosing a business partner?
 - Challenges with collaboration
 - Sharing of information
 - Level of trust
 - h. How would you describe the relationships with your business partners?
 - Loyalty level
 - Difference in the relationship to different business partners
 - Difference between short and long-term relationships
 - Use of legal contract
 - Power position
 - i. Can you describe the process for starting up a relationship with a new business partner?
 - How do you form a contact with a new business partner?
 - Description of a concrete example
 - j. How would you describe the transaction process between you and your business partners?
 - How many actors are involved in the exchange process?
 - Terms of agreement (advanced payment)
 - Product exchange (including transporting and storage)
 - Price setting
 - k. Do you perform any marketing activities for selling mango and cashew?
 - Support from other actors in the marketing channel?
 - Education for performing marketing activities?
 - Identification of segments that are especially interested in organic mango and cashew from Africa
4. Your suggestions will be very valuable for cashew and mango exporting in future. What is the future of export of this product? Can it be improved?
5. (Wrap up)
- (i) Are there other issues that are really important if I want to understand the cashew and mango industry?
 - (ii) Is there anyone that you think can give me a different perspective?

Thank you for taking the time to participate in the FGDs!