LAND USE ALLOCATION BETWEEN FORESTRY PLANTATIONS AND FOOD CROP PRODUCTION IN SELECTED VILLAGES IN MUFINDI DISTRICT, TANZANIA

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A THESIS SUBMITTED IN FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY OF SOKOINE UNIVERSITY OF AGRICULTURE. MOROGORO, TANZANIA.

2021

EXTENDED ABSTRACT

The increasing population and income have raised the demand for timber and other wood products, hence opening a new economic opportunity in addition to the production of food crops by smallholder farmers in Mufindi District and the Southern Highlands of Tanzania in general. Farmers require information on the optimal land allocation for various farm enterprises to make the best use of their land. However, such information is missing in the study area. Therefore, the determination of optimum land use allocation between tree plantations and food crops is vital for increased earnings, food security, and improved livelihoods of smallholder farmers. Worldwide, studies have mainly focused on optimization problems involving annual food crops only, while in reality, there are farmers allocating land to both food crops and forestry plantations, and that, there is limited knowledge on the optimal land allocation for farmers in the study area who allocate their land to both food crops and forestry. This study, therefore, aimed to establish the optimal land-use allocation between forestry plantations and production of food crops in selected villages in Mufindi District, and was guided by three objectives; (i) identifying the food crops/tree plantation combination that maximizes smallholder farm profit; (ii) exploring the determinants of land use allocation decision in food crops-tree production; and (iii) assessment of food security status by Smallholder Famers' in selected Villages in Mufindi District. A multistage sampling technique was adopted in the sampling process. The first stage involved the selection of three divisions from the District based on their potential in food crops and tree production. It was followed by a purposive selection of eight villages both potential in food crops/tree growing in each division, and finally, a random sampling technique was used to select 413 households. A multi-period profit maximization programming model was used to analyze the study objective one; while objective two was analyzed by using fractional multinomial logit model (FMNL), and the Households Food

Access Scale approach (HFIAS) was used in the analysis of the third objective. Major results showed that a farmer can maximize profit by allocating 1.81 and 1.74 acres to round potatoes and pine trees respectively, to generate a maximum profit of 13 592 440.53 while also allocating about 0.57 and 0.35 acres for maize and beans respectively to meet family food requirements. Moreover, the results showed that capital and land are binding in the study area. Results from fractional multinomial logit showed that sex, land size, awareness of land use policy, access to market information, and availability of labour play an important role in determining land allocation decisions to tree production, fallow, and food crops. On average households tended to allocate 4.28 acres to tree plantations, 3.57 acres to food crops, and 0.39 acres to fallow Moreover, overall results on food security as measured by Household Food Insecurity Access Scale (HFIAS) showed that 23% of all households were food secure, 9.7% mildly food insecure, 59.8% moderately food insecure and 7.5% severely food insecure. From the study results, it can be generally concluded that farmers can maximize farm profit by allocating 1.74 acres to pine trees and 1.81 acres to round potatoes while also allocating 0.57 and 0.35 acres to maize and beans to meet subsistence households' consumption. Also, land size, access to agricultural market information on output prices, awareness of land use policy; and availability of farm labour are the major determinants of land allocation decisions. Moreover, income from tree plantations was found to contribute a big portion to the household income than other sources. However, as income from tree plantations becomes available after several years, production of both food crops and tree plantations is essential for ensured food security at both the household and national levels. Hence the study recommends that farmers should acquire more land either through purchasing or hiring to allocate more on trees and round potatoes for increased income and profit and hence improved household food security. Also, the creation of more off-farm activities from the forestry farming sector, to absorb

the excess labour. This, in turn, increases income hence improving household food security and better living. From the government's perspective, the government should provide low-interest credits to enable farmers to invest more hence increased income and improved households’ food security; also, the government should improve its agricultural information system through the use of agricultural extension agents and media. This in turn will enhance more land allocation to trees and round potatoes.

DECLARATION

I, Haji Sauth Ng'elenge, do hereby declare to the Senate of the Sokoine University of Agriculture that this thesis is my original work, done within the period of registration and that it has neither been submitted nor concurrently being submitted to any other institution.

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ACKNOWLEDGEMENTS

I would like to give many thanks to the Almighty God for giving me the power to pursue my Ph.D. studies at the Sokoine University of Agriculture.

I also thank the Management of Jordan University College (JUCo), especially Professor Betram B. Mapunda (The Principal) and Prof. Daniel Mkude for granting me some financial assistance and study opportunity to pursue my Ph.D. studies.

My sincere appreciation goes to Dr. Damas Philip and Prof. Fredy T Kilima, for supervising my study and for encouraging me throughout my course of study. I appreciate and acknowledge AERC for granting me funds for data collection. Special thanks to my wife Grace Haji Chaligha and the entire family for encouragement, tolerance, and prayer during the entire period of my study.

Also, special thanks go to the following staff in the School of Agricultural Economics and Business Studies (SAEBS); Dr. Daniel Ndyetabula (Head of Department of Agricultural Economics and Agribusiness) and all other Staffs in the School, for their constructive comments and guidance during seminar presentations.

DEDICATION

This work is dedicated to my fellows and relatives who contributed immensely through

prayers, hence the success of my Ph.D. studies.

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LIST OF ABBREVIATIONS AND SYMBOLS

BoT Bank of Tanzania

AERC African Economic Research Consortium

FANTA	Food and Nutrition Technical Assistance
FAO	Food and Agricultural Organization
FDT	Forestry Development Trust
FMNL	Fractional Multinomial Logit
GDP	Gross Domestic Product
HFIA	Household Food Insecurity Access
HFIAS	Household Food Insecurity Access Scale
HLPE	High-Level Panel of Experts on Food Security and Nutrition
JUCo	Jordan University College
LP	Linear Programming
ML	Maximum Likelihood
MoCU	Moshi Co-operative University
NBS	National Bureau of Statistics
PFP	Plantation Forestry Programme
RHS	Right Hand Side
SAEBS	School of Agricultural Economics and Business Studies
Tshs	Tanzanian Shillings
UNCTAD	United Nations Conference on Trade and Development
URT	United Republic of Tanzania
USAID	United States Agency for International Development

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background Information

Land-use allocation to different uses has currently gained particular interest among researchers (Liu *et al*. 2016; Adjimoti, 2018; Allen and James, 2014; Ndhlove, 2010; Mwaura and Adong, 2016 and Mponela *et al*., 2011). The major reason behind the growing interest is that land allocation to various use should aim at maximizing social, economic, and ecological benefits to decision-makers including farm households (Liu *et al.,* 2016 and Hettig *et al.,* 2016). The new and fast-growing tree plantations sector which has been reported to be competing for agricultural land with food crops (FDT, 2015) is a major concern on how the land can be allocated in a way that can maximize the benefits at both household and national level in terms of food security and income. Moreover, the involvement of smallholder farmers in this sector has recently attracted special interest (Arvola *et al.,* 2019; Kakuru *et al*. 2014; Matthies and Karimov, 2014; and Meijer *et al*. 2015); the major reason could be that smallholder farmers are the major players in this allocation, and they are the major producers of food in the country.

Factors underlying land-use allocations emanate from the increasing demand for land due to increased human activities such as the expansion of tree plantations, agriculture, and increasing population hence the demand for more habitat areas, and other ecological uses. For example, FAO (2011) reported that global tree plantations have expanded by 48.1 percent between 1990 and 2010 while during the same period plantations in Africa expanded by 32.1 percent. Moreover, it has been reported that Africa accounts for about 17 percent of the global forest area and that forecasts show Africa to be the global hub of tree plantations in the next decade (Markus, 2012). The expansion of tree plantations in locations other than East Asia has been reported to be driven by both smallholders and corporations (FAO, 2011; Sikor, 2012).

While tree planting is promoted in Tanzania, it is more pronounced in the Southern highlands with Mufindi District in the Iringa region being a pioneer in this activity (PFP, 2016). Tree plantations in Mufindi increased by 168.3 percent between 2008 and 2016 (*Ibid*.). The increase is associated with the conversion of some arable land to tree plantations (FDT, 2015). However, the amount of land converted from food crops to trees has not yet been quantified. While many are involved in the activity, smallholder farmers have been the dominant actors who account for 52.72% of the planted trees followed by government agencies (26.72%) and private companies (20.56%) (Indufor, 2011). Therefore, in Mufindi District, a household with access to land may allocate it to food crop production, tree plantations, and fallow as a means of nourishing soil fertility. However, little is known on how farmers allocate land at their disposal between food crops and trees, which may have important ramifications on food security and income.

1.2 Problem Statement

Allocation of land by farmers to both tree plantations and food crops is vital for their livelihoods, as tree plantations provide income to farmers in the long run (after 10 years) while food production is crucial to ensure food security and regular income for farmers in the short-run as they wait for earnings from trees (Liu *et al.,* 2016 and Hettig *et al.*, 2016). Farmers in Mufindi District have been allocating land to several food crops and tree plantations (FDT, 2015; Indufor, 2011; PFP, 2016 and Ngaga, 2011) but little is known concerning firstly, whether the land use allocation is optimum hence allowing the farmers to maximize profit from the crop/tree combination; secondly, what determines land use allocation decision between food crops and tree production and; thirdly, the extent to which tree plantations affect household's food security.

The National Land Policy (URT, 1997) and the draft of the National Land Policy of Tanzania (URT, 2016), all state the importance of land use plans for poverty reduction. The National Agricultural Policy (URT, 2013), also identifies that the pace of land use planning and management is slow and that, there are growing environmental concerns and land use conflicts between various sectors, farming, and forests inclusive. The policy also states that agricultural land will be identified and set aside for agricultural use. According to the report by the National Land Use Planning Commission on strategy for addressing land use challenges in Tanzania (URT, 2017), sustainable use of land is vital for economic development, food security, and poverty reduction. Thus, objective land use plans are reported to have increase productivity of land and related natural resources. Given the above, the government of Tanzania instituted a mechanism that requires land-use plans at the village level showing allocation of land for various uses. However, such plans are not based on a thorough analysis of household-specific factors underlying land allocation decisions and how the combined use impacts profit levels and food security.

Studies on land use allocation Johansson and Azar, (2006); Mugabe *et al.,* (2014); Igwe *et al., (*2015); Chukwuigwe *et al.*, (2006); Igwe and Onyenweaku, (2013) and Drafor *et al*. (2013) have focussed mainly on land use allocation to annual food crops, but have paid little attention to an optimum combination involving both food crops and forest plantations. A most recent study involving optimum allocation between food crops and trees was done in Kenya by Alexandra and Scott (2016), however, they used self-regenerating trees such as grevillea which is different from Pine trees that once harvested can only be re-planted.

Also, several studies have been conducted to investigate the determinants of land use allocation (Mwaura and Adong, (2016); Adjimoti, (2018); Allen, (2014); Gebresilassie and Bekele, (2015); Yigezu *et al.* (2018); Ndhlove, (2010); Alam *et al*. (2016); Amare *et al*. (2018); Jianhong *et al.* 2013; Nguyen *et al*. (2017) and Grise and Kuishreshtha, (2016). However, the studies have focused on land use allocation to individual crops rather than production categories. This poses difficulties in modeling intercropped crops such as cereals and legumes (Adjimoti, 2018), hence a need to understand determinants of land use allocation decision to production category rather than individual crops.

Optimality in land allocation between food crops and tree plantations is the way to enhanced profit maximization from the allocation, improved food security, and success of poverty reduction initiatives in the country. In Tanzania, there is a paucity of information about optimal land use allocations between food crops and tree plantations and their determinants. Hence it is not understood whether farmers are maximizing benefits from their land allocation decisions. This study helps to cover this gap. The findings of this study provide to the government a working tool that helps create awareness to smallholder farmers on how they can optimally allocate land between food crops and tree plantations to maximize their earnings and hence improve their livelihoods. Secondly, it informs the government on the status of household food security as a result of tree plantations expansion, and thirdly, it provides useful information for formulating and enforcing policy action geared towards improving land use allocation in Tanzania.

1.3 Research Objectives

1.3.1 Overall objective

The Overall objective of this study is to determine the optimum land use allocation between timber trees and food crops for increased earnings, food security, and improved livelihoods of smallholder farmers.

1.3.2 Specific Objectives

The specific objectives of this study were;

i. To establish an optimum food crops/tree combination that maximizes smallholder farm profit in the villages.

ii. To explore the determinants of land use allocation decision in food crops-tree production in the villages.

iii. To assess the influence of the current land allocation on households' food security in the villages.

1.3.3 Research question

i. What are the optimum food crops/tree combinations that maximize smallholder farm profit in the villages?

ii. What is the effect of tree plantations expansion on household food security in the villages?

1.3.4 Research hypotheses

Ho: Land use allocation decision to food crops-tree production and fallow is not determined by households' sex, age, education, Household size, Land size, land use Policy, access to market information, labour, and Income.

1.4 Justification of the Study

The purpose of this study was to determine the optimum land use allocation between timber trees and food crops for increased earnings, food security, and improved livelihoods of smallholder farmers. While studies on agricultural land allocation have been done in the previous (Mugabe *et al.,* (2014); Igwe *et al., (*2015); Igwe and Onyenweaku, (2013) and Drafor *et al*. (2013), there is a paucity of knowledge on optimum land allocation involving food crops production and tree plantations, a practice common in the study area.

Mufindi district has faced increased expansion of forest plantations, a situation that involves some conversion of agricultural to forestry (FDT, 2015). Income from forestry becomes available after ten years of tree maturity, while food is needed on daily basis. Hence there is a need for finding an optimal land allocation that maximizes farmers' welfare in terms of food security and income.

The results from this study have the potential of raising awareness to both government, researchers, and farmers. To the government, this study can potentially provide useful information to guide land-use policies formulation and plans to ensure food security in the country. Furthermore, the study will enhance farmers’ understanding of how best they can allocate their land resources in a way that can maximize profit while ensuring households’ food security. The findings of this study will enable researchers to use the knowledge as a reference for further research.

1.5 Theoretical Framework

Based on the objectives, this study was guided by two models and one theory, namely; Multi-Period Profit Maximization Model, The Agricultural Household Model, and the Entitlement Approach for Food Security theory (explained in detail in chapters two, three, and four of this study).

1.6 Conceptual Framework of the study

The conceptual framework of the study (Figure 1), depicts that, farm households allocate land at their disposal to food crops production, tree plantations, and fallow. The major aim of this allocation is to earn income both in the short run and long run from both food crops and trees. Land allocation decisions to these enterprises are however determined by factors such as sex, gender, education level, household size, land size of the household, awareness of land use policy, access to market information, labour, and household income. The optimum combination between food crops and trees is seen as a strategy to ensure that, households maximize profit and ensure food security at the household level. Therefore, farmers have to decide on how many acres of land have to be allocated to each food crop/tree they produce to maximize profit subject to other resource constraints such as labour and working capital. Discounted Multi-period profit maximization programming model is suitable in reaching an optimum combination between food crops/trees given their production constraints. The multi-period production involving the comparison of revenue from annual food crops and perennial trees should be estimated.

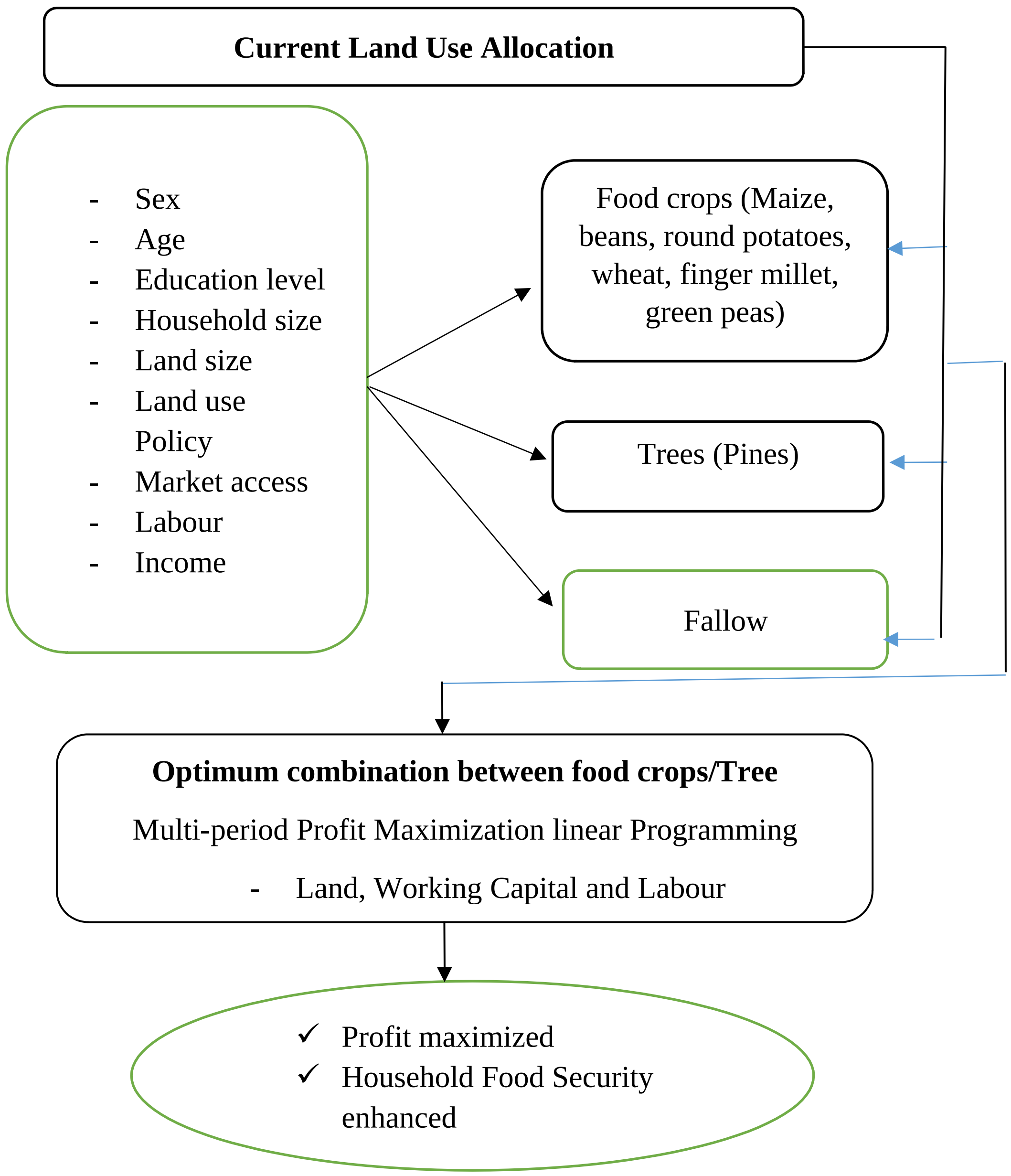

Figure 1.1: Conceptual framework showing land use allocation and its dynamics

Source: Researcher conceptualization

1.7 Organization of the study

This thesis is organized into five chapters. Chapter one is an introduction, in which the context of the study, problem statement, justification of the study, the theoretical background of the study, and study objectives have been presented. Chapter two is about manuscript one which covers the first objective focusing on finding out the optimum food crops/tree combination that maximizes smallholder farm profit; Chapter three presents publishable manuscript from the second objective aimed at exploring the determinants of land use allocation decision in food crops-tree production; Chapter four presents the third publishable manuscript geared towards investigating the influence of tree plantations expansion on household food security. A final section covers chapter five which summarizes, concludes, and provides recommendations of the study.

References

Adjimoti, G. (2018). Analysis of cropland allocation in rural areas Benin: A Fractional multinomial approach. *Cogent Food & Agriculture*, 4(1).

Alam, S., Kowsari, M., Chowdhury, N., Islam, M., & Haque, S. (2016). Factors affecting land allocation for maize cultivars in Lalmonirhat District of Bangladesh. *Progressive Agriculture*, *27*(3), 346-354.

Alexandra, P. and Scott, M. (2016). Food Vs. Wood: Dynamic choices for Kenyan Smallholders. *Sustainable Agriculture Research* 5(1): 97-108.

Allen, M. S., and James, E. (2014). Determinants of Land Allocation in a Multi-Crop Farming System: An Application of the Fractional multinomial Logit Model to Agricultural Households in Mali. *Selected Paper prepared for presentation at the Agricultural & Applied Economics Association's 2014 AAEA Annual Meeting, Minneapolis, MN, July 28, 2014.*

Amare M., Mavrotas G and Edeh H (2018). Farmers' Crop choice decisions: Trends and determinants in Nigeria and Uganda. IFPRI Discussion Paper 01716, March 2018.

Arvola A, Malkamäki A, Penttilä J and Toppinen A (2019). Mapping the Future Market Potential of Timber from Small-Scale Tree Farmers: Perspectives from the Southern Highlands in Tanzania. Small-scale Forestry (2019) 18:189–212

Becker, G.S. (1965). A Theory of the Allocation of Time. *The Economic Approach to Human Behavior. Econ. J.* 1965:493-517.

Chukwuigwe, E. C., Oguru, E. A. A. and Igben, M. S. (2006). Revenue maximizing combination of crops Enterprises in the Bayelsa State of Nigeria: A linear Programming Application. *Ind. Jn. of Agri Econ.* 61(4).

Devereux, S (2001). "Sen's entitlement Approach: Critiques and Counter-critiques, Oxford Development Studies, 29(3): 245-263.

Drafor I, Kunze D and Sarpong D. B. (2013). Food Security: How Rural Ghanaian Households Respond to Food Shortages in Lean Season. *International Journal of* Agricultural *Management, 2(4).*

FAO, (2011). *State of the World's Forests.* Food and Agriculture Organization of the United Nations Rome. 179Pp.

Forest Development Trust (FDT), (2015). *Baseline Tree Growers Survey Report*. Uendelezaji Misitu Tanzania. Gatsby. Tanzania. 65pp.

Gebresilassie L and Bekele A, (2015). Factors determining the allocation of land for improved wheat variety by smallholder farmers of northern Ethiopia. *JDAE*. 7(3):105 – 112.

Grise J and Kuishreshtha S, (2016). Farmers' choice of Crops in Canadian Prairies under Climate Change: An Econometric Analysis. J Earth Sci Clim Change.7:332.

Hettig E, Lay J, and Sipangule K, (2016). Drivers of Households' Land-Use Decisions: A Critical Review of Micro-Level Studies in Tropical Regions. *Land* 2016, *5* (4): 32.

Igwe K.C and Onyenweaku C.E (2013). A Linear Programming Approach to Food Crops and Livestock Enterprises Planning in Aba Agricultural Zone of Abia State, Nigeria. *American Journal of Experimental Agriculture 3(2): 412-431.*

Igwe, K. C., Nwaru, J. C., Igwe, C. O. K. and Asumugha, G. N. (2015). Optimum Resource Allocation among selected smallholder root and tuber crop farmers in Abia. AJFAND 15(2).

Indufor (2011). *A Feasibility Study on Establishing a Subsidy Scheme for Commercial Plantation Forestry in Tanzania*. A Proposed Tree Farming Grant Scheme. 108pp.

Jianhong E. Mu & Bruce A. McCarl & Anne M. Wein (2013). Adaptation to climate change: Changes in farmland use and stocking rate in the U.S. Mitig Adapt Strateg Glob Change (2013) 18:713–730.

Johansson, D. J. A. and Azar, C. (2006). A scenario analysis of land competition between food and bioenergy production in the US. Climatic Change 82(3):267.

Kakuru O. V, Doreen M and Wilson M (2014) Adoption of on-farm tree planting in Kibaale District, Western Uganda. J Sustain For 33:87–98.

Liu Y, Peng J, Jiao L. (2016). A Heuristic Land-Use Allocation Model Using Patch-Level Operations and Knowledge-Informed Rules. PLoS ONE 11(6).

Markus, K. (2012). The political economy of global tree plantation expansion: A Review. *The Journal of Peasant Studies*, 41:2, 235-261.

Matthies B.D and Karimov A. A (2014). Financial drivers of land-use decisions: the case of smallholder woodlots in Amhara, Ethiopia. Land Use Policy 41:474–483.

Meijer S.S, Catacutan D, Sileshi GW, Nieuwenhuis M (2015) Tree planting by smallholder farmers in Malawi: using the theory of planned behavior to examine the relationship between attitudes and behavior. J Environ Psychol 43:1–12.

Mponela, P., Jumbe, C. B., and Mwase, W.F. (2011). Determinants and Extent of Land Allocation for Jatropha Curcas L. Cultivation among Smallholder Farmers in Malawi. Biomass and Bioenergy, 35(7): 2499 – 2505.

Mugabe, D., Chipunza, N., Mupaso, N., Munyati, V. T. and Makarudze, F. V. (2014). Estimation of optimal Land-use Allocation among Smallholder (AI) Farmer. Journal of Agricultural Science; 6(2); 2014.

Mwaura, F. M. and Adong, A. (2016). Determinants of Households' Land Allocation for Crop Production in Uganda. *Journal of Sustainable Development* 9(5).

Mwaura, F. M. and Adong, A. (2016). Determinants of Households' Land Allocation for Crop Production in Uganda. *Journal of Sustainable Development* 9(5).

Ndhlove D.E (2010). Determinants of farm households' cropland allocation and crop diversification Decisions: The role of fertilizer subsidies in Malawi. MSc. in Development and Natural Resource Economics Norwegian University of Life Sciences.77pp.

Ngaga, Y. (2011). Forest Plantations and Woodlots in Tanzania. A Platform for Stakeholders in African Forestry. African Forest Forum Working Paper Series. African. 80pp.

Ngunyen T.T., Ngunyen L.D., Lippe R.S and Grote U (2017). Determinants of Farmers' Land Use Decision Making: Comparative Evidence from Thailand and Vietnam. *World Development* 89: 199 - 213.

Private Forestry Programme, PFP (2016). Private Forestry Programme: Forest Plantation Mapping of the Southern Highlands. Final report. Iringa, Tanzania. 56Pp.

Sikor, T. (2012). Tree plantations, politics of possession, and the absence of land Grabs in Vietnam. *Journal of Peasant Studies* 39(3-4): 1077-1101.

URT (1997). The National Land Policy. Ministry of Lands and Human Settlements Development Dar Es Salaam Tanzania. Pp 49.

URT (2013). National Agricultural Policy. Ministry of Agriculture Food Security and Cooperatives. Dar es Salaam, Tanzania. Pp 47.

URT (2016). Draft National Land Policy. Ministry of Lands Housing and Human Settlements Development. Dar es Salaam, Tanzania. Pp 28.

URT (2017). Strategy for addressing land use planning challenges in Tanzania. National Land Use Planning Commission. Dar es salaam, Tanzania. Pp 65.

Yigezu A.Y., Tizale C.Y., Kassie G.T. and Hassan A (2018). Modeling land-use decisions in Production Systems involving multiple crops and varieties. African Journal of Agric Econ. 13(3): 2

CHAPTER TWO

2.0 FARM PROFIT MAXIMIZING FOOD CROPS/TREE COMBINATION IN MUFINDI DISTRICT: A MULTI-PERIOD PROGRAMMING APPROACH.

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2.1 Abstract

Finding the combination of crop and tree mix that maximizes farmer profit is vital for reduced poverty and improved living standards of farmers, however, in the study area, there is a paucity of knowledge on the optimal land allocation for farmers who allocate land to both food crops and trees. Therefore, this study aimed to determine the combination that maximizes profit from the production of food crops and trees (Pines) to improve their living standards and reduce poverty. A multi-period profit maximization programming model was used in the optimization. Results showed that a farmer can maximize profit by allocating 0.81 and 0.73 acres for round potatoes and pine trees respectively. This gives a maximum profit of 13 592 440.53 over ten years of trees maturity. Also, a farmer should allocate 0.57 and 0.35 acres for maize and beans respectively to meet food requirements. From the study findings, it can be concluded that the initial allocation done by farmers was not optimal, and therefore they were not maximizing their profits. They should however allocate their land around the optimal solution to maximize the benefits. Moreover, the study found capital and land to be binding. Therefore, this study recommends that the government promote low-interest financial support to farmers to enable them to increase their capital base and also rent more production land to increase profit. Also, farmers create off-farm activities to enable them to reduce rural unemployment in the study area.

Keywords: Multi-period Linear Programming; Net Profit; Optimization

2.2 Introduction

Optimal agricultural land use is vital for improved productivity, maximized profitability, and efficient utilization of resources (Sainio *et al.*, 2019; Hassan *et al.*, 2005). This is more thoughtful for production resources such as land which is fixed in nature while its use demand increases over time due to increased human activities; and, capital which is a scarce resource and therefore requires efficient allocation. Lucey (2002) reported that allocation of resources ensures proper utilization of limited resources to the best advantage. However, studies on optimality that could guide farmers in allocating limited production resources at their disposal for maximized benefits are rarely available and therefore not accessible to smallholder farmers who are particularly the major producers of crops in developing countries. Therefore, maximizing profits from agricultural production may not be achieved as farmers are not fully aware of how to optimize land use.

Land expansion to other uses such as mineral explorations, biofuels, conservation, urbanization, and the current expansion of tree plantations has been one of the major challenges that limit agricultural activities in Tanzania. The challenge is an outcome of inadequate implementation of the Village Land Act, 1999, and the Land-use planning Act, 2007 (Kimaro and Hieronimo, 2014). The Act among others insists on the allocation of land for various uses including cropland and forestland to facilitate efficient and orderly management of land use and empower users to make better and more productive use of their land (URT, 2007), hence profitability in the production. For decades, Smallholder farmers in Tanzania specifically in Mufindi District and the Southern highlands in general have been allocating land at their disposal to both food crops and trees (PFP, 2016; FDT, 2015). This allocation is meaningful to smallholder farmers, as food is required by households on daily basis, and food crops are also vital for the provision of income in the short run while trees provide income in the long run. However, it is not known if the food crops/trees allocation they make is optimal for ensuring that their profits are maximized.

An innovative solution for efficient allocation of their land may be finding an optimal land allocation that maximizes farmers' profit through modeling (Hassan *et al.,* 2005). Moreover, Igwe and Onyenweaku, (2013) elucidate that; modeling approach for optimal combination of agricultural enterprises has remained underdeveloped globally. In Tanzania for example smallholder farmers are prevalent and own small plots of land ranging between 0.25 – 3 acres in which multiple crops are grown. In such a situation, studies on optimal land use allocation between various crops grown by farmers could help them maximize their benefit.

There are numerous studies on crop optimization (Johansson and Azar, 2006; Mugabe *et al.*, 2014; Igwe *et al.*, 2015; Chukwuigwe *et al.*, 2006; Igwe and Onyenweaku, 2013; Drafor *et al*. 2013). These studies offer useful information on the optimization of land use. However, the focus has been on the optimum combination of annual food crop production without due consideration of the combined land for both tree plantations and food crops. The production of perennial trees is an activity that is growing fast at the global level and Tanzania in particular.

A more recent study by Alexandra and Scott (2016) in Kenya used a multi-period programming technique to find an optimum combination between food crops and trees to maximize profit. However, the study considered trees that regenerate after harvesting (grevilia and Eucalyptus) which ensures continuous revenue to farmers after planting, which is different from Pines (*Pinus Patula*)—a plantation tree grown by smallholder farmers in Tanzania. Once planted, Pines are harvested after ten years, and wanting to continue with its production must replant the trees. Therefore, this implies a different modeling approach from that of Alexander and Scott (2016) who assumed regeneration of the trees once planted. While there are scenarios where a farmer can produce only trees or food crops from which to maximize profit, this study assumes that a representative farmer in Mufindi can maximize profit from the production of both food crops (annual) and Pine trees (Perennial) as this is a common practice.

Therefore, this study aims to establish an optimal food crops/tree combination that maximizes farmer profit while meeting households' food consumption requirements. The findings from this study are useful in informing policy makers on how farmers can maximize profits from their production by allocating resources at their disposals such as land, labour, and capital efficiently.

2.3 Theoretical Framework

2.3.1 Multi-Period Profit Maximization Model

Multi-period profit maximization programming assumes that a producer aims at maximizing net profit over the time horizon through the allocation of resources that are constrained in the production process. The net profit is obtained as a sum of discounted revenue less discounted total variable costs for the entire production period. Revenue is a function of yield and prices, and costs are a function of the quantity of inputs and prices. The discounting is inevitable because revenue is realized and costs are incurred over years, and therefore, they have to be put on a common basis for comparison purposes.

As related to this study, revenue from trees becomes available after ten years while costs are incurred on yearly basis, therefore to compare the revenue and costs over years and then find an optimal combination of both annual food crops and trees, discounting of revenue and costs over ten years is necessary. To take into consideration the time preference, this study has used a current discount rate of 17 percent, the rate recommended by the central bank of Tanzania (BoT) to discount cash flows. The multi-period profit maximization model has been used in the manuscript to establish an optimal combination between food crops and trees.

Basic assumptions of the multi-period profit maximization model

i) Prices of agricultural goods and outputs per acre – the study assumes average prices over the previous five years and constant outputs throughout the production period of ten (10) years.

ii) The study assumes that each crop is grown in a pure stand.

iii) Profit maximization is confined to the following crops; maize, beans, round potatoes, wheat, green peas and finger millet (food crops), and Pine trees.

iv) Land allocation to each crop is fixed for the entire planning period.

2.4 Methodology

2.4.1 Study Location

The present study was conducted in Mufindi, a leading District in timber plantations expansion in Tanzania, based on acreage (PFP, 2016). Mufindi is one of the five District authorities of Iringa Region located 80 km South of Iringa Municipal. It is bordered by Njombe Region to the south, Mbarali District (Mbeya Region) to the West, and Iringa Rural District to the North. To the North East lies Kilolo District. In terms of location coordinates, the District lies between latitudes 8^{o}.0’ and 9^{o}.0’ south of the Equator and between longitudes 30^{o}.0’ and 36^{o}.0’ east of Greenwich. Mufindi is divided into five divisions namely Ifwagi, Kibengu, Kasanga, Malangali, and Sadani. It has 30 wards, 125 villages, and 608 hamlets. The District is mostly occupied by the forest (10 411.3 sq. km) leaving only 2 427.6 sq. km. for human settlement and other economic activities. The climatic conditions vary within the District with the first three divisions (Ifwagi, Kibengu, Kasanga) having favorable climates for timber tree plantations. According to the 2012 National census, the population was about 317,731 people of which more than 90% were engaged in agriculture, which provides more than 85% of the income.

2.4.2 Description of Smallholder Farmers and Tree Growers in Tanzania

According to National Agriculture Policy (URT, 2013), Smallholder farmers are those cultivating between 0.2 and 2.0 hectares of land, while in forestry farming, FDT (2015) report categories of tree growers as follows; smallholders (< 5 acres), medium (5 – 20 acres), and large (> 20). This study has however focused on smallholder farmers and tree growers as they are the most affected when land-use changes occur.

2.4.3 Population and Sampling

To gain a general view about production activities and tree growing, key informants comprising of Village Chairpersons, Village Executive Officer (VEO), and Ward Agricultural Extension Officer were interviewed in each selected village. Focus group discussions (FGDs) were conducted using a checklist Appendix V) to have a better understanding of community-wide activities to collect information about types and costs of inputs as well as outputs from crops and trees. Based on the geographical location of the study villages and similarities in terms of production activities, the eight villages were divided into two groups, hence two focus group discussions comprising of eight (8) members were conducted. The FGD is comprised of four village leaders and four representatives, one from each village. The members of the FGD were purposefully selected based on their knowledge and involvement in crop/tree production and crop output prices.

2.4.4 Nature and Type of Data

The study used both primary and secondary data. Secondary data entailed the collection of information on average yield for crops such as maize, beans, round potatoes, wheat, green peas, and finger millet in the Mufindi District. This information was collected from the National sample census of agriculture 2007/08, Iringa region report (URT, 2012) as farmers had not yet harvested most of the crops at the time of data collection. Thus, it was difficult for them to memorize the crop yield of previous years since they don’t keep records. Therefore, the average yield per acre measured in kilograms of various crops as reported in the national census of agriculture 2007/08, was used as a standard for Mufindi District and its villages. Moreover, primary data involved the collection of information on average crop/tree prices and production costs through the focus group discussion and key informants such as VEO and other village leaders as these are community-wide information. Moreover, acreages of trees were collected from respondents by using a structured questionnaire. Data on land allocation to various crops and/trees were collected using a structured questionnaire involving 413 randomly selected households (Table 3.1)

Resources in the linear programming model were land, labour, and working capital. The total amount of land available to the household for different allocations was computed as the maximum amount of land the household was possessing. Where household annual income obtained from different sources was used as a proxy for total working capital available for different production activities.

2.4.5 Analytical Framework

In the context of this study food crops are crops planted and harvested within a year, after which can be replanted again in the next farming season. At the household level, these crops serve dual purposes as food and a source of income. These crops include; maize, beans, round potatoes, wheat, green peas, and finger millet. Moreover, the production of pine trees is another activity undertaken by smallholder farmers, whereby once planted, harvesting can be done after ten (10) years and this is the time when revenue is realized. After harvesting the trees do not regenerate but can be replanted again. This study is only confined to Pines (*Pinus Patula*) as they are the most grown timber trees by smallholder farmers.

To compare on the same ground, the revenue from trees and that of annual food crops, a net profit from each crop is computed per acre by subtracting total variable costs from revenue which is a function of yield per acre multiplied by the farm gate price (Appendix II). Net profit is then discounted for ten (10) years using a 17% discount rate and added together to get net present value for each crop which is used in the multi-period model to find an optimal combination of food crops/trees (Appendix III).

Thus, the structure of the multi-period profit maximization programming model is as shown in equation 1 - 5:

$$Max\,\pi = \sum_{i=1}^{n}\sum_{t=1}^{T=10}\frac{P_{jt}X_{jt}}{¿¿}¿¿\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots$$

$$Max\ Profit = \sum_{i=1}^{n}\sum_{t=1}^{T=10}\frac{P_{jt}X_{jt}}{¿¿}¿¿ Max\ NPV = \sum_{i=1}^{n}\sum_{t=1}^{T=10}\frac{P_{jt}X_{jt}}{¿¿}¿¿\ldots\ldots\ldots\ldots\ldots(1)$$

Subject to:

$b_{11}X_1 + b_{12}X_2 + b_{13}X_3 + \ldots + b_{1n}X_n < c_1$ (Land constraint)…………….………...(2)

$b_{21}X_1 + b_{22}X_2 + b_{23}X_3 + \ldots + b_{2n}X_n < c_2$ (Labour constraint) ……….……………...(3)

$b_{31}X_1 + b_{32}X_2 + b_{33}X_3 + \ldots + b_{3n}X_n < c_3$ (capital constraint) ………………...(4)

$X_i \geq 0$ (Non-negativity) …………............. (5)

$\Sigma Y_{ij}X_{ij} \geq f_j$ (Subsistence consumption requirement for maize and beans)

Where: π = Net Profit to be maximized (Tshs). P_{jt} = Net profit of the j^{th} farming activity in the year *t* (Tshs/acre). X_{jt} = Acres of land devoted to the production of j^{th} crop during the survey period; r = Discount rate of capital (17%); t = the year in which the crop is cultivated (t = 1). Y_{ij} = Yield of j^{th} crop for i^{th} grower. f_j = Subsistence food requirement for maize and beans. T = the end of the year of the planning period (10). b = per acre requirement of the i^{th} resource (land, labour, capital) by the i^{th} activity during the survey period. c = Level of k^{th} resource available during the survey period. Table 2.1 shows the different types of food crops and trees produced by smallholder farmers in the study areas;

Yield obtained and profit per acre and the production requirements. Data in Table 2.1 are the inputs in the excel problem solver for the optimization process.

Table 2.1: Yield, profit per acre and the production requirements

Variables	Yield/ Acre (Kg)	Price (Tshs/kg/ Tree)	Revenue/ Acre (Tshs)	Variable Cost/Acre (Tshs)	Profit/Acre (Tshs)	Land (Acres)	Working capital (Tshs)	Labor (Man-Days /Acre)
Maize (X_1)	644	663	427 000	300 000	127 000	2.05	300 000	57
Beans (X_2)	272	1737	472 500	275 000	197 500	0.5	275 000	55
R/Potatoes (X_3)	2505	400	1 001 900	325 000	676 900	0.7	345 000	57
Wheat (X_4)	476	1400	667 000	205 000	471 900	0.22	205 000	41
Green Peas (X_5)	263	1540	405 000	180 000	225 000	0.07	180 000	55
Finger millet (X_6)	407	1400	570 000	205 000	365 000	0.03	180 000	41
Pine Trees(X_7)	650	35 000	22 750 000	270 000	22 480 000	4.28	270 000	35
Available Resources						8.25	1 330 725	714.1

Source: Field data, 2017

Objective Function

Max π = 591642.2X1+920073.5X2+3153406.34X3+2152273.2X4+1 048185X5+1 700 389X6+4 169 811X7……………………………………………………..…...….(6)

Subject to:

$2.05X1 0.8X2+0.7X3+1.13X4+0.42X5+0.46X6+4.20X7 \leq 8.25$

$2.05X1 0.8X2+0.7X3+1.13X4+0.42X5+0.46X6+4.20X7 \leq 10$

(Land constraint) ……………………….................(7)

250000X1+275000X2+345000X3+205000X4+180000X5+205000X6+

270000X7 ≤ 1330725 (working capital constraint)…………………………………..(8)

$57X1+55X2+57X3+41X4+55X5+41X6+35X7 \leq 714.1$

(Labor constraint) ……………………………… …..…….(9)

$644X1 \geq 365 (Maize - subsistence\ food\ consumption\ constraint)$……………… (10)

272X2 ≥ 96.5 (Beans - subsistence food consumption constraint) ……………….......(11)

X1- Xn $\geq 0 (Non-negativity)$………………………………………………………(12)

Solving the LP model

To find the optimal land allocation solutions that maximize the Net profit, the variables in the objective functions and constraints were entered into excel problem solver software 2010 for analysis (Adekunle & Tafamel, 2016).

2.5 Results and Discussion

2.5.1 Descriptive statistics

Descriptive statistics were computed to summarize and explain the household land resource, labour, and land allocation to various food crops and trees in the study areas.

2.5.1.1 Household's Land

The land is an important production resource from which decisions to allocate it to food crops and/trees are made. In the study areas, total land available to the household was assessed based on total land owned for the crop; land rented in for crop production, total land owned for trees, land rented in for trees, and fallowed land. Results in Table 2.1 shows that on average a household had a total land size of 8.25 acres.

Table 2.2: Household Land Resource (acres)

Land category	n	Min	Max	Mean	Std. Error	Std. Deviation
Total land owned for crop	413	0.5	15	2.92	0.10	2.01
Land rented in for crop	413	0	10	0.65	0.08	1.52
Total land owned for trees	413	0	42	3.75	0.27	5.53
Land rented in for trees	413	0	12	0.53	0.08	1.55
Total fallowed land owned	413	0	15	0.39	0.08	1.58
Total land size	413	0.5	47	8.25	0.37	7.53

2.5.1.2 Farm Labour

The amount of labour (Man-days) used in the production of each crop was calculated based on the number of man-days required to perform and complete each farm operation for each crop within eight hours, and then total man/days were added together. In the study areas, farmers were found to mostly use family labour (Table 2.3).

Table 2.3: Farm Labour (Man-days)

Labour category	Labour availability					
	Persons in the HH	Year working days	Total days	Hours/ day	Conversion factor	Total man-hours/year
Age of Males (years)						
1 - 6 years	154	0	0	0	0	0
7 - 14 years	205	52	10660	8	0.516	44004.5
Other Students	100	52	5200	8	1	41600
15 - 55 years	427	313	133651	8	1	1069208
> 55 years	64	313	20032	8	0.59	94551.0
Females						
1 - 6 years	127	0	0	0	0	0
7 - 14 years	197	52	10244	8	0.406	33272
Other Students	127	52	6604	8	0.84	44378.9
15 - 55 years	446	313	139598	8	0.84	938098.6
> 55 years	67	313	20971	8	0.562	94285.6
Total man-hours/year						2359399
Total man-days/year						294925
Household average total labour/year (man-days)						714.1

The total amount of farm labour available was computed based on the amount and type of family labour available and was found to be 714.1 man-days. On average, a household in the study area was found to have a size of 4.5 persons just above the average of 4.2 persons found in the year 2012 in the District (URT, 2013; NBS, 2013). Conversion to man-days took into consideration the age and sex of an individual.

2.5.1.3 Land allocation by crop/Trees across the village

Results in Table 2.4 show the average land allocated per different use in each village. Overall results show that, on average, households allocated about 2.05, 0.54, 0.71, 0.22, 0.07, 0.03, and 4.28 acres for maize, beans, round potatoes, wheat, green peas, finger millet, and pine trees respectively. Based on Table 2.4, households have been allocating more land to tree plantations, followed by maize which is a staple food crop.

Table 2.4: Land allocation by crop/Trees across village (acres)

	Maize	Beans	Round potato	Wheat	Green peas	Finger millet	Pine Trees
Vikula (n = 28)	2.05	0.46	0.71	0.21	0.07	0.04	4.37
Ikwega (n = 57)	2.06	0.60	0.72	0.23	0.07	0.04	4.28
Ludilo (n = 36)	2.04	0.71	0.72	0.22	0.08	0.03	4.58
Luhunga (n = 48)	2.05	0.54	0.69	0.24	0.07	0.03	4.27
Ifwagi (n = 48)	2.06	0.57	0.69	0.25	0.07	0.04	4.29
Nundwe (n = 50)	2.07	0.46	0.72	0.20	0.09	0.03	5.18
Igoda (n = 50)	2.03	0.50	0.72	0.30	0.04	0.02	3.38
Mninga (n = 96)	2.01	0.51	0.69	0.23	0.07	0.04	3.91
Average (413)	**2.05**	**0.54**	**0.71**	**0.22**	**0.07**	**0.03**	**4.28**

Results in Table 2.5 shows that the optimum combination of food crops and trees that maximizes net present value is attained when a farmer allocates 1.81 acres to round potatoes and 1.74 acres to Pine trees, while also allocating 0.57 and 0.35 acres of land for maize and beans to meet household's food demand for subsistence. Given this allocation, the maximum profit the farmer can get is Tshs 13 592 440. Moreover, Table 2.5 shows that the original land allocation made by farmers, was not optimal, and therefore was not maximizing the farmers' profit.

Table 2.5: Food crops/Tree optimum combination

The objective function and decision variables

Objective Cell (Max)			
Cell	**Name**	**Original Value**	**Final Value**
$I$10	Profit (Tshs)	12,984,700.60	13592440.53

Variable Cells

Cell	Decision variables	Original Value (Acres)	Final Value (Acres)
$B$2	Maize	2.05	0.57
$C$2	Beans	0.5	0.35
$D$2	Round potato	0.7	1.81
$E$2	Wheat	0.22	0
$F$2	Green peas	0.05	0
$G$2	Finger millet	0.05	0
$H$2	Pines Tree	4.20	1.74

Table 2.6 also shows that land and working capital constraints, are binding; implying that land and working capital are fully utilized in the final solution. The labour constraint is not binding and has a slack value of 498.5 man-days not used in the final solution. Therefore, in the study area, labour is not fully utilized in the activities considered in optimization while land and capital are binding.

Table 2.6: Constraints status in the model

Cell	Name	Cell Value	Formula	Status	Slack
$I$4	Land (Acres)	10	$I$4<=$K$4	Binding	0
$I$5	Capital (Tshs)	1330725	$I$5<=$K$5	Binding	0
$I$6	Labour (M/days)	215.46	$I$6<=$K$6	Not Binding	498.5
$I$7	Maize (Kgs)	365	$I$7>=$K$7	Binding	0
$I$8	Beans (Kgs)	96.5	$I$8>=$K$8	Binding	0
$I$9		0	$I$9>=$K$9	Binding	0

2.5.2 Sensitivity Report

The sensitivity report shows how changes in the coefficients of the objective function affect the optimal solution, and also, how changes in the constants on the right-hand side (RHS) of the constraints affect the optimal solution. The allowable increase/decrease associated with the original coefficient of a decision variable expresses the range in which the coefficient of a given decision variable in the objective function may be increased/decreased without changing the optimal solution, where all other data are fixed. The reduced cost of a given decision variable shows the rate at which the value of the objective function will worsen for each unit change in the optimized value of the decision variable with all other data held fixed.

From the sensitivity report in Table 2.7, it can be deduced that, if the objective coefficient on round potatoes is raised to Tshs 5 328 091.83, or decreased to Tshs 3 030 457.44, the optimal plan of allocating 1.81 acres of round potatoes and 1.74 acres of pine trees will be met ceteris paribus. Also, if the objective coefficient on Pine trees is raised to Tshs 18 920 438, or decreased to Tshs 3 892 371.21, the optimal plan remains constant.

Table 2.7: Model coefficients

Cell	Name	Final Value (Acres)	Reduced Cost (Tshs)	Objective Coefficient (Tshs)	Allowable Increase (Tshs)	Allowable Decrease (Tshs)
$B$2	Maize	0.57	0	591 642.2	2 412 364.3	1.00E+30
$C$2	Beans	0.35	0	920 073.5	1 706 297.8	1.00E+30
$D$2	Round potato	1.81	0	3 153 406.34	2 174 685.5	122948.9
$E$2	Wheat	0	-54 243.9	2 152 273.2	54 243.88	1.00E+30
$F$2	Green peas	0	-622 599	1 048 185	622 599.4	1.00E+30
$G$2	Finger millet	0	-193 905	1 700 389	193 905.38	1.00E+30
$H$2	Pines Tree	1.74	0	4 169 811	14 750 627	277439.79

Therefore, this means that if the net present value per acre of round potatoes varies between Tshs 5 328 091.83 and Tshs 3 030 457.44 or the net present value per acre of Pine trees varies between Tshs 18 920 438 and Tshs 3 892 371.21, the optimal production plan of using 1.81 acres for round potatoes and 1.74 acres for Pine trees under the planning period, will still be achieved, while also allocating 0.57 and 0.35 acres of land for maize and beans to meet households' food demand for subsistence. This result is in line with Mpogole and Kadigi, (2012) who reported that round potatoes in the Southern Highlands of Tanzania were profitable than other food crops. Also, Scott *et al*. (2000) reported that trees were profitable in Kenya. Moreover, results in Table 2.7 show that forcing wheat, green peas, and finger millet into the model from 0 to 1 acre, will result in reduced cost from the objective function by Tshs 54 243.9, 622 599, and 193 905 respectively.

2.5.3 Shadow Price

The shadow price of a given constraint is the rate of increase or decrease in the optimal objective function value, as the RHS of that constraint increases or decreases with all other data held fixed. Results on shadow price are presented in Table 2.8.

Table 2.8: Shadow Price

Cell	Name	Final Value	Shadow Price	Constraint R.H. Side	Allowable Increase	Allowable Decrease
$I$4	Land (Acres)	10	466 004	10	8.42	6.34
$I$5	Capital (Tshs)	1 330 725	8.19	1 330 725	2 922 984.4	54 548.98
$I$6	Labour (M/days)	215.47	0	714	1.00E+30	498.53
$I$7	Maize (Kgs)	365	-3 745.9	365	2 646.43	365
$I$8	Beans (Kgs)	96.5	-6 273.2	96.5	658.86	96.5
$I$9		0	0	0	0	1.00E+30

Results in Table 2.8 show the shadow price for the land constraint is Tshs 466 004, indicating that if the land is increased by 1 acre (in a range of 10 to 11 acres), the corresponding net present value at the optimal solution will increase by Tshs 466 004, and also will decrease by the same amount if decreased by 1 acre (from 10 to 9 acres). About working capital, results show its shadow price equal to Tshs 8.19, indicating that if working capital is increased by Tshs 1 (in a range of Tshs 1 330 725 to 1 330 726), the corresponding net present value at the optimal solution will increase by Tshs 8.19, and also will decrease by the same amount if decreased by Tshs 1 (from Tshs 1 330 725 to Tshs 1 330 724). Results also show that the shadow price for maize and beans land constraints are negative, that is -3745.91 and -6273.15 respectively. This shows that; any change by one acre in the constants on the RHS of the constraint will reduce the optimal solution by the amount equivalent to the respective shadow price. Moreover, the above changes are valid only for a range as indicated by the allowable increase and decrease columns. For example, from Table 5 as far as the RHS remains within 18.42 to 3.7 acres, the shadow price (Tshs 466 004) remains valid for land constraint, while for capital constraint, the shadow price will remain valid as far as constants in the RHS remain within the range of Tshs 4 253 709 to 789 176.

2.6 Conclusion

This study aimed to establish an optimum combination between food crops and Pine trees that maximizes farm profit, subject to land, working capital, and labour constraints available to smallholder farmers. A multi-period profit maximization model was used to determine the optimal combination. Results showed that a farmer can maximize profit by allocating between 0.72 hectares of land for round potatoes and 0.70 hectares of land for Pine trees, while also allocating 0.23 and 0.14 hectares of land for maize and beans to meet households' food demand for subsistence. From this allocation, the maximum profit the farmer can get was Tshs 13 592 440. Other crops such as wheat, finger millet, and green peas were found to have no contribution to the optimal solution. Moreover, land and working capital were found to be binding, while labour was slack. Finally, Sensitivity analysis was conducted to identify how changes in constraints can affect the optimal solution, and hence guide the decision-makers in making correct decisions. Results showed that maintaining the objective coefficient within the range of Tshs 5 328 091.83 to 3 030 457.44 for round potatoes, and Tshs 18 920 438 to 3 892 371.21 for Pine trees, ensures that the optimal plan is met. Moreover, results show that an increase or decrease by one-acre land for round potatoes is likely to increase or decrease the net present value by the shadow price (Tshs 466 004). Also, an increase or decrease in working capital by Tshs 1 is likely to increase or decrease the net present value by Tshs 8.19.

2.7 Recommendations

From the study findings, farmers are advised to combine food crops and trees within the optimal plan for maximized profit. Also, land and working capital are found to be fundamental in maximizing farmer profit; however, they are binding as opposed to labour which is found to be slack in the study area. The study, therefore, recommends that farmers be financially enabled by the government through the provision of low-interest credits to enable them to rent and also buy more land, as well as agricultural inputs for investment in round potatoes and pine trees for increased profit while producing maize and beans for subsistence food consumption. Moreover, the study recommends that farmers create off-farm activities to curb rural unemployment as a result of slack labour existing.

2.8 Acknowledgements

I would like to express my deep gratitude to Dr. Philip Damas and Professor Kilima FTM, my research supervisors, for their patient guidance, enthusiastic encouragement, and useful critiques of this research work. The author also would like to thank The African Economic Research Consortium (AERC) for sponsoring data collection, and Jordan University College (JUCO) for granting study leave for study; Finally, I wish to extend my thanks to Mufindi District and local authorities; extension agents and farmers for their help and active participation during the data collection process.

References

Adekunle S. A. & Tafamel A. E (2016). Modeling Linear Programming Problem Using Microsoft Excel Solver. *Nigeria Journal of Business Administration 12(1&2), 163-179.*

Alexandra, P. and Scott, M. (2016). Food Vs. Wood: Dynamic choices for Kenyan Smallholders. *Sustainable Agriculture Research* 5(1): 97-108.

Chukwuigwe, E. C., Oguru, E. A. A. and Igben, M. S. (2006). Revenue maximizing combination of crops Enterprises in the Bayelsa State of Nigeria: A linear Programming Application. *Ind. Jn. of Agri Econ.* 61(4).

Drafor I, Kunze D and Sarpong D. B. (2013). Food Security: How Rural Ghanaian Households Respond to Food Shortages in Lean Season. *International Journal of* Agricultural *Management, 2(4).*

FDT (2015). *Baseline Tree Growers Survey Report*. Uendelezaji Misitu Tanzania. Gatsby. Tanzania. 65pp.

Hassan I., Ahmad P., Akhter M., and Aslam M. (2005). Use of Linear Programming Model to determine the Optimum Cropping Pattern: A case of study of Punjab. Electronic. J. Environ. Agric. And Food Chem (EJEAFChe), 4(1):841 – 850.

Igwe K.C and Onyenweaku C.E (2013). A Linear Programming Approach to Food Crops and Livestock Enterprises Planning in Aba Agricultural Zone of Abia State, Nigeria. *American Journal of Experimental Agriculture 3(2): 412-431.*

Igwe, K. C., Nwaru, J. C., Igwe, C. O. K. and Asumugha, G. N. (2015). Optimum Resource Allocation among selected smallholder root and tuber crop farmers in Abia. AJFAND 15(2):2015.

Johansson, D. J. A. and Azar, C. (2006). A scenario analysis of land competition between food and bioenergy production in the US. Climatic Change 82(3):267.

Kimaro D, N and Hieronimo P (2014). Land for Agriculture in Tanzania: Challenges and Opportunities. Journal of Land and Society, 1 (1): 91-102.

Lucey, T. (2002). Quantitative Techniques. Sixth Edition ELST Edition. MPG Ltd, Bodmin, Great Britain. 558Pp.

Mpogole H and Kadigi R.M.J (2012). Round potato (Solanum tuberosum) profitability and Implications for variety selections in the Southern Highlands of Tanzania. Journal Development and Agricultural Economics Vol. 4(9): 258-267

Mugabe, D., Chipunza, N., Mupaso, N., Munyati, V. T. and Makarudze, F. V. (2014). Estimation of optimal Land-use Allocation among Smallholder (AI) Farmer. Journal of Agricultural Science; 6(2).

NBS (2013). Population and Housing Census. Ministry of Finance, Dar es Salaam, Tanzania. 264Pp.

PFP (2016). Value Chain Analysis of Plantation Wood from the Southern Highlands. Private Forestry Programme. Iringa, Tanzania. Forest Forum. Nairobi. 146pp.

Sainio, P.P; Jauhiainen L; Laurila H; Sorvali J; Honkavaara E; Wittke S; Karjalainen M; and Puttonen E (2019). Land use optimization tool for sustainable intensification of high-latitude agricultural systems. Land Use Policy, 88 (104104).

Scott G. J, Rosegrant M. W, Ringler C (2000). Roots and Tubers for the 21st Century: Trends, Projections, and Policy Options. Food, Agriculture, and the Environment Discussion, International Food Policy Research Institute. Paper No. 31.

URT (2007). Land Use Planning Act, 2007. Government Printer, Dar es salaam. 34Pp.

URT (2012). National Sample Census of Agriculture 2007/2008. Iringa Region report. 301Pp.

URT (2013). Mufindi District Socio-economic profile. Dar es Salaam, Tanzania. 184Pp

CHAPTER THREE

3.0 DETERMINANTS OF LAND ALLOCATION DECISION TO FOOD CROPS -TREE PRODUCTION IN SELECTED VILLAGES IN MUFINDI DISTRICT

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3.1 Abstract

An understanding of how farmers allocate agricultural land between food crops, trees, and fallow is vital for informed policy formulation on land use plans aiming at maximizing farmer's welfare, supporting poverty reduction initiatives, and improved food security. In the study area, there is inadequate information on what determines land use allocation between food crops and tree plantations. This study aimed at finding the determinants of land allocation decisions in food crops-tree production in the Mufindi District. The study used data collected from 413 randomly selected households. The fractional multinomial logit (FMNL) model was estimated to identify the determinants of household land allocation decisions to food crops, trees, and fallow. Results show that sex, land size, awareness of land use policy, access to market information and availability of hired labour play important roles in determining the land allocation decision. On average households allocated more land to trees (1.74 acres), followed by food crops (1.81 acres) and fallow (0.39 acres). Therefore, it can be concluded that increased household land size, awareness of land use policy, access to agricultural market information, and availability of labour are vital for enhanced land use allocation by smallholder farmers. The study, therefore, recommends that the government provide a capital base to farmers to enable them to hire or purchase more land, also it should provide education on land use policy; and improve accessibility to agricultural market information to farmers.

***Key words:* Allocation, Food Crops, fallow, Trees, Fractional Multinomial Logit**

3.2 Introduction

Determinants of land allocation decisions by farmers have received special attention among researchers and policy makers worldwide (Mwaura and Adong, 2016; Adjimoti, 2018; Allen and James, (2014); Yigezu *et al.* 2018; Grise and Kuishreshtha, 2016; Nguyen *et al*. 2017) as agriculture has impacted less on poor farmers in most developing countries (UNCTAD, (2015). One way to improve agriculture and make it work for the poor is the promotion of agricultural production that raises the smallholders’ welfare. This requires an understanding of the way they allocate land to different production activities, as well as knowing the factors that determine the allocation.

An analysis of optimal land allocation in the selected study villages in Mufindi District as presented in manuscript one of this study shows that smallholder farmers allocated about 3.62 acres of land to food crops production, 4.28 acres to tree plantations, while 0.39 were left for fallow as per details in Table 2.3 presented in the first publishable manuscript of this study. The question arising from this analysis is about how farmers make such decisions. Un-informed land allocation decisions may result in welfare loss by smallholder farmers (Liu *et al.* (2016) and Hettig *et al.* (2016) because the land is the major means of survival in rural areas and its use has important ramifications on agricultural development initiatives and food security both at a household and national level. Results from the first manuscript indicate that smallholder farmers can maximize net profit by allocating between 1.81 acres of round potatoes and 1.74 acres of trees to earn a maximum of Tshs 13 592 440, while also using 0.57 and 0.35 acres for production of maize and beans respectively to carter for household’s food requirements. The results do not require farmers to allocate land to wheat, green peas, and finger millet as allocating land to these crops will lead to loss. The results imply that profitable land use should be based on optimal allocations and greater impact can be felt when agricultural policies on land use are informed by research

An in-depth understanding of the determinants of land allocation decisions by smallholder farmers is therefore of paramount importance for informing the government on what factors govern land allocation at the household level, hence enable it to formulate agricultural and land use policies geared at enhancing agricultural development and raising the living standards of smallholder farmers.

In examining the determinants of households land use, studies have used land share allocations to individual crops as dependent variables and found that sex, age, education, household size, land size, land use policy, access to market, labour, and income determine the allocation (Mwaura and Adong, (2016); Adjimoti, (2018); Allen, (2014); Gebresilassie and Bekele, (2015); Yigezu *et al.* (2018); Ndhlove, (2010); Alam *et al*. (2016); Amare *et al*. (2018); Jianhong *et al.* 2013; Nguyen *et al*. (2017 and Grise and Kuishreshtha, (2016). However, Adjimoti, (2018) reports that it is difficult to model the allocation for crops like cereals and legumes that are intercropped. While the above studies are fundamental in explaining land allocation decisions, they have firstly focused on modeling land allocation to individual crops rather than a production system. Secondly, none of those studies have considered a scenario involving allocation between tree plantations and the production of food crops. Thirdly, none of the studies were conducted in Tanzania in general and Mufindi in particular where land-use change is happening.

Therefore, this study aimed at investigating the determinants of land use allocation in food crops-tree production in selected villages in Mufindi District, Tanzania. The study tests the hypotheses that, land share allocation decision to food crops, tree plantations, and fallow is determined by factors such as sex, age, education, household size, land size, awareness on land use policy, access to market information, availability of hired labour and income.

3.3 Theoretical Framework

The land-use allocation has been defined by Kai *et al*. (2011) as a process involving the allocation of land to different uses within a geospatial context, the aim being to maximize social, economic, and ecological benefits. The land allocation has a historical background from Thunem, (1826) who devised a theoretical model on agricultural land location and allocation. The fundamental assumption was that farmers will allocate land based on their access to the market. While the theory has good insights to explain land allocation decisions, it ignores other important attributes such as socio-economic factors that could also determine land allocation.

The agricultural household model was developed by Berker (1965). The model assumes that “agricultural households strive to maximize utility which is a function of both consumptions of agricultural goods, consumption of non-agricultural goods and leisure. Moreover, the model depicts that, the output (yield) from agricultural production is a function of several attributes such as household characteristics, land size, labour input, and perceived riskiness associated with the production of a crop.

Adjimoti (2018) presents the structural form of the agricultural household model as follows:

$Max\, U = F(C_a, C_m, C_I)$ *(Utility maximization)* ………………. (1)

S.t: $P_a(Q_a - C_a) - P_z Z - wL + Y = P_m C_m + wH$ ¿………..(2)

$Q_j = f(Z_j, a_j, L, A, X)$ *(Production constraint)*.……………….... (3)

$T = H + F + O(Time\, constraint)$ ……………….. (4)

$Ca, Cm, Q \geq 0$ *(Non negativity)* ………………………………. (5)

Where a farmer attempt to maximize his utility from the consumption of agricultural commodity (C_a), non-agricultural good (C_m), and leisure (C_l) subject to budget constraint derived as profit from agricultural production and income from off-farm activities, and secondly; production constraints such as household characteristics (Z) such as sex, age, education, household size and perceived riskiness of the crop (a), labor input (L), land size (A), and income (X). The production constraints on the other hand determine agricultural output (Q) which is estimated as land share allocation to that particular crop.

Adjimoti (2018) reported that, in agricultural production, it is difficult to estimate output, hence due to this complexity supreme supply response models have been used to model land share allocated to a particular crop as a proxy to output. Therefore, in this study, the output in the production function conceived within the agricultural household model will reflect land share to various production systems practiced by farmers.

Therefore, variables such as sex, age, education, household size, land size, land use policy, access to market information, hired labour, and household's annual income was included in the model to investigate their influence on land allocation to food crops, tree production and fallow (Equation 3).

3.4 Conceptual Framework

The conceptual framework for this study as linked to the agricultural household depicts that households strive to maximize utility from the consumption of agricultural goods. While allocating the land, their decisions are influenced by factors such as household size, sex, age, education, land size, awareness of land use policy, access to market information, availability of farm labour, and household income. On the other hand, the study is based on the fact that households grow food crops with a major aim of getting food as well as income in the short run, while income, in the long run, is obtained from tree plantations after several years. Therefore, this study aims to understand the determinants of land allocation decisions between food crops and trees production systems and fallow. Refer to Figure 1 for a general conceptual framework of the study.

3.5 Methodology

3.5.1 Description of Study Area

The study was conducted in Mufindi District, a pioneer in the country in timber plantations (PFP, 2017), as well as production of food crops. Mufindi is one of the four District authorities of Iringa Region located 80 km South of Iringa Municipal. It is bordered by Njombe Region to the south, Mbarali District (Mbeya Region) to the West, and Iringa Rural District to the North. To the North East lies Kilolo District. In terms of international identification, the District lies between latitudes 8^{o}.0’ and 9^{o}.0’ south of the Equator and between longitudes 30^{o}.0’ and 3^{o}.0’ east of Greenwich. Mufindi is divided into five divisions namely Ifwagi, Kibengu, Kasanga, Malangali, and Sadani. Agriculture is the main economic activity employing about 95% of its population (URT, 2013). Major agricultural activities practiced by smallholder farmers’ in Mufindi District include the production of food crops such as maize, beans, round potatoes, wheat, finger millet, green peas, and the growing of timber trees.

3.5.2 Research Design

This paper adopted a cross-sectional research design approach to collect data. This design was found to be more appropriate because is cost-effective and can generate useful information for descriptive purposes as well as determination of relationship among variables. Data were collected in October and November of 2017. In this study, the major focus is on a farmer possessing agricultural land from which the decision to allocate land to food crops, tree plantations production system, or fallow can be made. A farmer is a rational agent who can decide to allocate all the land to food crops, trees, and fallow or allocate a share of the land to food crops, trees, or fallow. Therefore, the unit of analysis is a household possessing agricultural land used either for the production of food crops, trees, or fallow.

3.5.3 Sampling Technique and Sample Size Estimation

The target population for this study was 4896 households in three divisions namely Ifwagi, Kibengu, and Kasanga. The major and common characteristic of all these households is that they own land and are engaged in the production of food crops as well as tree. The study adopted a multistage sampling technique involving the selection of three divisions from the district based on their potential in food and tree production, followed by a purposive selection of eight villages in each division that are potential in food crops and tree growing, and finally, a random sampling technique was used to select 413 households.

The sample size was estimated using Yamanes' sample size estimation formula for finite population (Yamane, 1967);

$$n = \frac{N}{1 + N(e2)}$$

$$n = \frac{4896}{1 + 4896(0.052)} = 370 \qquad 370+ (11.6/100*370) = 413$$

where, '*N*' is the population size and '*e*' is the level of precision desired (0.05); while '*n*' is the sample size to be estimated.

To cater for non-responses, sampling errors, and other survey problems, the sample was inflated by 11.6%. Thus, 413 households were sampled from the study villages based on the proportionality (percentage) as specified in Table 3.1. Random selection was then applied to select respondent households from each village.

Table 3.1: Sampling distribution

				Ifwagi Division		Kibengu Division		Kasanga Division	
Villages →	**Ifwagi**	**Ludilo**	**Igoda**	**Luhunga**	**Nundwe**	**Vikula**	**Mninga**	**Ikwega**	**Total**
Households	569	424	593	571	589	329	1145	676	4896
(%)	12	9	12	12	12	7	23	14	100
Sample	48	36	50	48	50	28	96	57	413

Source: **NBS (2012)**

3.5.4 Data Collection

Data used for this study are primary data collected in 2017 using a structured questionnaire administered to heads of households from eight villages in the Mufindi District, Iringa region. The eligibility of the household to be involved in sample size was the possession of land from which allocation to either food crops, trees, or fallow was made. The sampling frame of the study from which the sample size was estimated, was established through the assistance of the Village Agricultural Extension Agent.

3.5.5 Analytical Framework

To analyze land share allocation, a household is assumed to allocate all available agricultural land to either food crops, tree plantations, or fallow or to all production activities simultaneously in such a way that for whatever allocation a farmer makes, the total allocation should add up to one (1).

3.5.6 Data Analysis

Data were analyzed both descriptively and quantitatively. Descriptive analysis was conducted to summarize socio-economic variables that are continuous where statistics such as mean, standard deviation, and range were generated. An independent sample *t*-test was done to determine if there were significant differences in land use allocation across the production systems. The fractional Multinomial Logit model (FMNL) was used to estimate the determinants of land share allocation across the production systems by farm households. In using the FMNL model, the present study assumed that a farmer having a piece of land allocates the land for food crops production, trees, and fallow where all fractions add up to a unit 1. Modeling such fractional dependent variables can be conveniently done within the framework of the fractional multinomial logit (FMNL). FMNL model is mostly preferred over the ordinary multinomial logit model as FMNL is capable of modeling fractions lying between 0 and 1. The fractional multinomial logit model assumes that, $0 \leq y_{qi} \leq 1$ and $\sum_{i=1}^{l} y_{qi} = 1$, where *i* is an index that represents the activity type and q represents land share allocation to food crops, trees, and fallow. One (1) is the total of the fractions of land allocated to various uses and *yq* is the proportion of land allocated to a specified use out of the total land cultivated by a farmer. The explanatory variables are the factors that determine simultaneously land allocation decisions to the production systems. Papke and Woodridge, (1996) present the FMNL model which was also used by Ye and Pendyala (2005) as described in equation 18 below:

$$E(\log[y/(1-y)]/x) = x\beta \quad \text{......18}$$

This log-odds ratio only applies when y is strictly between 0 and 1 and is estimated using a quasi-maximum likelihood estimator as described in equation 19.

Thus, $E(log[y/(1-y)]/x) = \beta_1 + \beta_2 X_2 + \beta_3 X_3 + \dots \beta_{10} X_{10}$ ……………………………………………………………19

$= \beta_1 + \beta_2 sex + \beta 3age + \beta_4$education + β_5Household size+ β_6Land size + $\beta_7$land use Policy + β_8 access to market information + $\beta_9$labour + β_{10} Income

Table 3.2: Description of explanatory variables used in the Fractional Multinomial Logit Model

Independent Variable	Variable Definition	Measurement
Sex (X_1)	Sex of the household head (dummy)	1 if male and 0 otherwise
Age (X_2)	Age of household head in years	Continuous
Education (X_3)	Years of schooling of the household head	Continuous
Household size (X_4)	Total number of people living in the household	Continuous
Land size (X_5)	Total land owned by a household (acres)	Continuous
Policy (X_6)	Whether the household is aware of land use policy (dummy)	1 if yes and 0 otherwise
Market access (X_7)	Whether the household has access to market information (dummy)	1 if Yes and 0 otherwise
Labour availability (X_8)	Whether the household allocates land-based on available farm labour	1 if yes and 0 otherwise
Income (X_9)	Total annual household's income (Tshs)	Continuous

3.6 Results and Discussion

3.6.1 Socio-Economic Characteristics of Respondents

An assessment of the socio-economic characteristics of the respondents is of paramount importance as it gives a prediction of the response to different stimuli subjected to them. The socio-economic variable included in this study were household head sex, age, education, household size, land size, awareness of land use policy, access to market information, farm labour, and income.

Results in Table 3.3 show that respondents mainly consisted of male (77%), farmers who were not aware of land use policy (73.4%), farmers with access to market information (75.3%), and those who had easily available farm labour 71.2%). Moreover, the respondents had a mean age of 44.6 years (23 - 72 years), education level ranged between 0 – 18 years of schooling with a mean of 7.1 years (primary school levers), household size was found to range between 1 - 10 people (mean 4.5 people). This means household size is just above that reported in the national statistics (URT, 2013) which was 4.3 in Mufindi District. The land size was moreover found to range between 0.5 – 47 acres, with a mean of 8.25 acres, and the mean household’s annual income was Tshs 1 648 680 (ranging between 10 000 - 32 000 000), which was below the national average of 2,275,601. Household income is fundamental in agricultural investment; hence low income is likely to reduce land allocation to food crops/trees.

Variable	Variable category		Frequency		Percent
Sex	Male		318		77
	Female		95		23
Whether aware of land use policy	Aware		110		26.6
	Not aware		303		73.4
Whether have access to market information	Yes		311		75.3
	No		102		24.7
Labour availability	Yes		294		71.2
	No		119		28.8
	Obs	**Mean**	**Std. Dev**	**Min**	**Max**
Age	413	44.64	12.64	23	72
Education	413	7.11	2.95	0	18
Household size (Hhsize)	413	4.5	1.78	1	10
Land size (Landsize)	413	8.25	7.53	0.5	47
Income	413	1 648 680	3 124 228	10 000	32 000 000

Table 3.3: Socio-economic and demographic variables

3.6.2 Land Allocation

Table 3.4 shows that the mean land allocated to food crops by households was 3.57 acres, ranging from 0.5 to 18 acres with a standard deviation of 2.8, while the mean for trees was 4.28, ranging from 0 to 42 acres with a standard deviation of 5.9, and that of fallow was 0.39, ranging between 0 to 15 acres, and having a standard deviation of 1.44. These results imply that households in Mufindi District have generally allocated more land to tree plantations, followed by the production of food crops and fallow. The reason could be attributed to the utility in terms of profit tree growers get from tree production.

Table 3.4: Land use share allocation

Variable	n	Min	Max	Mean	Std. Dev
Food crops (Acres)	413	0.5	18	3.57	2.81
Tree plantations (Acres)	413	0	42	4.28	5.99
Fallow (Acres)	413	0	15	0.39	1.45

3.6.3 Parametric Tests for Difference in Mean Land Share allocation

Independent sample *t*-tests were performed to determine if there were significant differences in land allocation across the production, against categorical socio-economic variables such as sex, farmer's awareness of land use policy, access to market information, and availability of farm labour.

3.6.3.1 Sex

Independent sample *t*-test results indicated that there was a significant difference ($p<0.01$) in mean land allocated to tree production between male (M = 4.9, SD = 6.22) and female-headed households (M=2.2, SD = 4.64). About land allocation to fallow, results show that there was no significant difference in mean land allocated to fallow between male (M= 0.43, SD = 1.54) and female-headed households (M=0.29, SD = 1.08).

Table 3.5: Mean Land Share allocation disaggregated by sex

Land allocation category	Sex of respondent	n	Mean	Std. Dev	Std. Error Means	Mean difference
Land allocation to tree plantation (acres)	Male	317	4.92	6.22	0. 35	2.73
	Female	96	2.19	4.44	0.47	
Land allocation to fallow (acres)	Male	317	0.43	1.54	0.09	1.14
	Female	96	0.29	1.09	0.11	
Land allocation to food crops (acres)	Male	317	3.61	2.71	0.15	0.19
	Female	96	3.42	3.12	0.32	

Results in Table 3.5 also show that there was no significant difference in mean land allocated to food crop production system between male-headed households (M=3.6, SD = 2.71) and female-headed households (M=3.4, SD = 3.12), conditions; t (411) = 0.580, p = 0.563. From the results, it is suggested that male-headed households put more value on trees which is a long-term investment than female-headed households. Moreover, food production is found to be equally valued as it is required for family survival on daily basis.

3.6.3.2 Land allocation disaggregated by household's awareness of land use policy

An independent sample *t*-test was conducted to compare mean land allocation for farmers who were found to be aware of land use policy and those who were not aware.

Table 3.6: Mean land share allocation disaggregated by awareness on land use Policy

Land allocation category	Awareness to Land use Policy	n	Mean	Std. Dev	Std. Error Means	Mean difference
Land allocation to tree plantation (acres)	Yes	110	4.05	5.51	0.53	-0.32
	No	303	4.37	6.17	0.35	
Land allocation to fallow (acres)	Yes	110	0.23	0.86	0.08	-0.23
	No	303	0.46	1.61	0.09	
Land allocation to food crops (acres)	Yes	110	3.36	2.78	0.26	-0.29
	No	303	3.65	2.82	0.16	

Results show that there was no significant difference in mean land allocation to tree production by farmers who were aware of land use policy (M= 4.05, SD = 5.51), and those who were not aware of land use policy in the study area (M= 4.37, SD = 6.17) condition t(411) = -0.474, p = 0.636. Results also indicated that there was no significant difference in mean land allocation to food crops by farmers who were aware of land use policy (M=3.36, SD = 2.78) and those who were not aware (M=3.65, SD = 2.82), condition t(41) = -0.920, p = 0.358. Independent sample t-test also indicated that there were no significant difference in land allocation to fallow land by farmers who were aware of land use policy (M= 0.23, SD = 0.86) and those who were not aware (M= 0.46, SD = 1.61) condition t(356.042) = -1.835, p = 0.067. These results suggest that there is a need for more investigation in the study area to ascertain the influence of land use policy on land use allocation.

3.6.3.3 Mean land share allocation disaggregated by access to agricultural market information

Access to agricultural market information is an incentive to farmers in the allocation of land to crops assured to have a market. An independent sample t-test was conducted to identify if there were significant differences in land allocation between households who had access to agricultural market information and those who had no access.

Table 3.7: Mean land share allocation disaggregated by access to agricultural market information

Land allocation category	Access to market information	n	Mean	Std. Dev	Std. Error Means	Mean difference
Land allocation to tree plantation (acres)	Yes	311	4.73	6.15	0.35	1.81
	No	102	2.92	5.29	0.52	
Land allocation to fallow (acres)	Yes	311	0.40	1.52	0.09	-0.01
	No	102	0.40	1.20	0.12	
Land allocation to food crops (acres)	Yes	311	3.58	2.74	0.16	0.04
	No	102	3.54	3.02	0.30	

Results in Table 3.7 indicate that, there was significant difference in mean land allocation to tree production system by households who had access to agricultural market information (M = 4.73, SD = 6.15) and those who had no access agricultural market information (M = 2.92, SD = 5.29), condition t(411) = 2.671, p = 0.008. Results also indicated that, there was no significant difference in mean land allocation to food crop production system by farm households who had access to agricultural market information (M = 3.58, SD = 2.74) and those who had no access agricultural market information

(M = 3.54, SD = 3.02), condition t(411) = 0.138, p = 0.890. Moreover, results on land allocation to fallow shows that, there was no significant difference in mean land allocation to fallow by farm households who had access to agricultural market information (M = 0.39, SD = 1.52) and those who had no access agricultural market information (M = 0.40, SD = 1.19), condition t(411) = -0.034, p = 0.973. From these results, it is suggested that access to market information by farmers has a positive effect on land allocation to trees than other production activities. This could have been attributed to the high demand for timber and other wood products like poles and logs in Tanzania.

3.6.3.4 Mean land share allocation disaggregated by the availability of farm labour

Farm labour has a crucial role in agricultural production as it is the source of farm power. In this study, an independent sample t-test was conducted to investigate if there were significant differences in mean land allocation between households who had better access to farm labour and those who had not.

Results in Table 3.9 indicate that there was no significant difference in mean land allocation to a tree by households who had access to hired farm labour (M = 4.01, SD = 5.17) and those who had no access to hired farm labour (M = 4.96, SD = 7.65), condition t(163.350) = -1.244, p = 0.215.

Results also suggest that there was no significant difference in mean land allocation to food crop production by households who had better access to hired farm labour (M = 3.45, SD = 2.39) and those who had no access to hired farm labour (M = 3.86, SD = 3.65).

Table 3.8: Mean land share allocation disaggregated by the availability of farm labour

Land allocation category	Labour availability	n	Mean	Std. Dev	Std. Error Means	Mean difference
Land allocation to tree plantation (acres)	Yes	294	3.45	2.39	0.14	-0.41
	No	119	3.86	3.65	0.33	
Land allocation to fallow (acres)	Yes	294	0.34	1.32	0.08	-0.19
	No	119	0.53	1.73	0.16	
Land allocation to food crops (acres)	Yes	294	3.45	2.39	0.14	-0.41
	No	119	3.86	3.65	0.33	

Results also indicated that, there was no significant difference in mean land allocation to fallow by households who had access to hired farm labour (M = 0.344, SD = 1.32) and those who had no access to hired farm labour (M = 0.53, SD = 1.73), condition t(175.896) = -1.050, p = 0.295. This study suggests that the presence of a large family size averaged at 4.5, provides enough labour for farm operations hence less demand for labour.

3.7 Determinants of Land Share Allocation Decision

The fractional multinomial logit model results converged on a log pseudo-likelihood of -282.43098 with a Wald chi-squared of 222.79. Moreover, the chi-square result has a probability of 0.0000 meaning that it is globally highly significant. Data analysis started first with finding a maximum likelihood (ML) fit of fractional multinomial logit FMNL (Appendix 1), upon which, average marginal effects of the independent variables on land shares were calculated from the FMNL fit (Table 3.9). Food crops land share was used as a reference category as it was found to be produced by all households. Results were statistically significant at 5% and were used to explain the relationship between dependent and independent variables. Income variable was not included in the model due to the presence of outliers, hence inconsistency results.

Results in Table 3.9 show the variable sex to have a significant effect on land share allocation to trees. Female-headed households are associated with a 16.9% decrease in the relative log odds of land share allocation to tree plantations Vs food crops, while it is not significant in fallow. Results are found to be significant at $p<0.01$. The results were expected as females are mostly responsible for the production of food crops for family consumption than males, and therefore are likely to invest more in food production than in trees. These results are in line with Alexander and Scott (2016) who reported that trees cannot overturn (check if used appropriately) food crops as food is needed on daily basis by families while income from trees becomes available after several years. Villamor *et al*. (2014) also reported that males while motivated to grow trees they also incorporate food crops, while females' interest is on food production and consumption.

Table 3.9, shows that the age variable was not significant ($p<0.1$) to both tree plantations and fallow. These results are in line with Kinuthia *et al.* (2018) and Obayelu *et al*. (2014), who found that older farmers were less likely to take up crop diversification or to plant agroforestry trees and also adapt to new production practices

Table 3.9: Average marginal effects derived from the Fractional Multinomial Logit (FMNL) Model

Variable	Tree plantations land share				Fallow land share			
	dy/dx	**Std. Err.**	**z**	**P>z**	**dy/dx**	**Std. Err.**	**z**	**P>z**
SexX_1	-0.1690	0.0385	-4.39	0.000***	0.0014	0.0122	0.11	0.912
AgeX_2	-0.0021	0.0011	-1.9	0.057	0.0006	0.0003	1.88	0.060
EducatX_3	0.0042	0.0046	0.91	0.365	-0.0025	0.0014	-1.76	0.079
HhsizeX_4	-0.0121	0.0076	-1.58	0.114	0.0051	0.0024	2.19	0.029***
LandsiX_5	0.0262	0.0023	11.35	0.000***	0.0019	0.0005	3.58	0.000***
PolicyX_6	0.0617	0.0294	2.1	0.036***	-0.0071	0.0084	-0.84	0.402
MarketX_7	0.0954	0.0307	3.11	0.002***	-0.0121	0.0111	-1.1	0.273
LabourX_8	0.1164	0.0294	3.95	0.000***	0.0035	0.0075	0.47	0.636

Number of Obs = 413

Log pseudo-likelihood = -282.43098

Wald chi^2 (16) =222.79   Prob > chi^2 = 0.0000

Results presented in Table 3.9 shows that years of schooling were not statistically significant ($p>0.1$) influencing land allocation to both tree plantations and fallow. The study results are in line with Tefera and Lerra, (2016) who found that education level had no significant effect in allocating land to trees. However, it was found contradicting that of Aguilera, *et al*. (2013) who found that education level was significantly explaining land allocation decision to fallow, and gave an argument that, while fallowing is seen as a strategy to enhance soil fertility, an educated farmer may instead of fallowing; nourish the soil through the application of organic manure and inorganic fertilizers while continuing to utilize the land for crop production.

An increase in household size was found to be associated with a significant increase in land share allocated to the fallow ($P<0.05$) relative to food crops. This finding brings a new insight that requires more investigation, as it was expected that, fallow land would decrease with an increase in household size. While counter-intuitive, this could be caused by the engagement of some family members in petty and other off-farm activities created by fast-growing and commercialized tree farming, hence farmers engage in those activities to meet the daily households' requirements, leaving land fallow.

Further, results in Table 3.9 show that household land size has a statistically significant influence on land allocation decisions ($p<0.01$). A one-acre increase in household land size is associated with a 2.62% increase in the relative log odds of land share allocation to the tree against food crops. It is also, associated with a 0.19% increase in relative log odds of land share allocation to fallow versus food crops. All results are statistically significant at $p<0.01$. This means that a household having additional land is likely to allocate it to trees while bearing some for fallow as a way of replenishing soil fertility. Adjimoti (2018) also found that the share of land allocated to major food crops was significantly decreasing compared to other crops while increasing that of industrial crops. On the other hand, it is expected that, if a farmer has a large piece of land, given the resources at his/her disposal, it is possible to fallow some land.

Households' awareness of land use policy was found to be associated with a 2.94% increase in the relative log odds of land share allocation to trees versus food crops, while it is not significant for fallow land. The result is statistically significant at $p<0.05$. Thus, awareness created by various tree stakeholders including both international Companies such as Green resource and other local institutions like Southern Paper Mills, Twico, carbon credit, timber traders, and the government, are likely to contribute to increased land share to trees because of its perceived benefits. Hettig *et al.* (2016) also pointed out that global markets and focus on global cash crop markets, have created incentives for agents to switch their land use towards cash crop cultivation and for raising households' incomes. Thus, policies such as carbon credit might have resulted in a switch to allocating more land for trees.

The variable access to market information by the household was found to be associated with a 9.54% increase in the relative log odds of land share allocation to trees against food crops, while it is not significant for fallow land. Results are statistically significant at $p<0.01$. These results signal that households who have access to agricultural market information allocate 9.54% more land to timber trees than households without market information. Arvola *et al*. (2019) found that two-thirds of interviewees growing trees stated that they had already an idea of their sales strategy at the time of planting the trees. The same results were also found by Allen (2014) who reported that villages with better market access were correlated with a much higher share of secondary crops. Ahimbisibwe (2019) also reported that a household's decision to select perennial and annual crops depends on the market price of the crop. Hence households are likely to make more land allocation decisions to trees for which market is readily available than food crops.

Table 3.9 reveals the availability of farm labour to be associated with an 11.64% increase in the relative log odds of land share allocation to trees versus food crops, while it is not significant for fallow. Results are statistically significant at $p<0.01$. Based on the findings above, labour is an important variable in tree production as compared to food crop production. This could be attributed to the fact that; tree industry has created off-farm activities that attract more labour. These results are found to be related to Mponela *et al*. (2011), Coxhead and Demeke, (2004) and Perz, (2002) who reported availability of farm labour to be among the factors that influenced land allocation to various crops.

3.8 Conclusion

The purpose of this study was to investigate the determinants of land use allocation decisions in food crop/tree production in the Mufindi District. This study found that on average farmers have allocated 1.43 ha to food crops, 1.71 ha to trees, and 1.16 ha to fallow. The land allocation decision to tree production was found to be positively related to the land size of the household, awareness to land use policy, access to market information, and availability of labour; while it is negatively related to the sex of the household head with male-headed household head allocating more land trees than the female headed-household head. Fallow on the other side was found to be positively influenced by the household land size. Hence, land size, awareness of land use policy, access to market information, and availability of labour are fundamental in determining land allocation decisions between food crops production, tree farming, and fallow by smallholder farmers.

3.9 Recommendations

The study, therefore, recommends that the government should provide low-interest credits to farmers to enable them to purchase more land for enhanced allocation between food crops and trees. The government should also improve agricultural market information systems that work for smallholder farmers.

3.10 Acknowledgements

I would like to express my deep gratitude to Dr. Damas Philip and Professor Kilima FTM, my research supervisors, for their patient guidance, enthusiastic encouragement, and useful critiques of this research work. The author also would like to thank The African Economic Research Consortium (AERC) for sponsoring data collection, and Jordan University College (JUCO) for granting study leave for study; Finally, I wish to extend my thanks to Mufindi District and local authorities; extension agents and farmers for their help and active participation during the data collection process.

References

Adjimoti, G. (2018). Analysis of cropland allocation in rural areas Benin: A fractional multinomial approach. *Cogent Food & Agriculture*, *4*(1).

Aguilera, J., Motavalli, P., Valdivia, C., & Gonzales, M. A. (2013). Impacts of cultivation and fallow length on soil Carbon and Nitrogen availability in the Bolivian Andean Highland Region. Mountain Research and Development, 33(4), 391-403.

Ahimbisibwe, V., Auch, E., Groeneveld J, Tumwebaze, S, B and Berger U (2019). Drivers of Household Decision-Making on Land-Use Transformation: An Example of Woodlot Establishment in Masindi District, Uganda. Forests 10(8):619

Alexandra, P. and Scott, M. (2016). Food Vs. Wood: Dynamic choices for Kenyan Smallholders. *Sustainable Agriculture Research* 5(1): 97-108.

Alam, S., Kowsari, M., Chowdhury, N., Islam, M., & Haque, S. (2016). Factors affecting land allocation for maize cultivars in Lalmonirhat District of Bangladesh. *Progressive Agriculture*, *27*(3), 346-354.

Allen, M. S., and James, E. (2014). Determinants of Land Allocation in a Multi-Crop Farming System: An Application of the Fractional multinomial Logit Model to Agricultural Households in Mali. *Selected Paper prepared for presentation at the Agricultural & Applied Economics Association's 2014 AAEA Annual Meeting, Minneapolis, MN, July 28, 2014.*

Amare M., Mavrotas G and Edeh H (2018). Farmers' Crop choice decisions: Trends and determinants in Nigeria and Uganda. IFPRI Discussion Paper 01716, March 2018.

Askari H and Cummings J. T. (1977), Estimating Agricultural Supply Response with the Nerlove Model: A Survey, International Economic Review, 18, (2), 257-92.

Becker, G.S. (1965). A Theory of the Allocation of Time. *The Economic Approach to Human Behavior*. *Econ. J.* 1965:493-517.

Coxhead, I., and Demeke, B. (2004). Panel Data evidence on Upland Agricultural Land Use in the Philippines: Can Economic Policy Reforms Reduce Environmental Damages? Am. J. Agr. Econ, 86 (5):1354 – 2505.

FAO (2015). Global Forest Resources Assessment. Desk reference. Food and Agriculture Organization of the United Nations, Rome. 253 Pp.

Forest Development Trust (FDT) (2015). *Baseline Tree Growers Survey Report*. Uendelezaji Misitu Tanzania. Gatsby. Tanzania. 65pp.

Gebresilassie L and Bekele A (2015). Factors determining the allocation of land for improved wheat variety by smallholder farmers of northern Ethiopia. *JDAE*. 7(3):105 – 112.

Grise J and Kuishreshtha S (2016). Farmers' choice of Crops in Canadian Prairies under Climate Change: An Econometric Analysis. J Earth Sci Clim Change.7:332.

Hettig E, Lay J and Sipangule K (2016). Drivers of Households' Land-Use Decisions: A Critical Review of Micro-Level Studies in Tropical Regions. *Land* 2016, *5*(4): 32.

Jianhong E. Mu & Bruce A. McCarl & Anne M. Wein (2013). Adaptation to climate change: Changes in farmland use and stocking rate in the U.S. Mitig Adapt Strateg Glob Change (2013) 18:713–730.

Kai C, Bo H, Shaowen W, Hui L. (2011). Sustainable land use optimization using Boundary-based Fast Genetic Algorithm. Computers, Environment and Urban Systems, 36(3).

Kinuthia K, J., Inoti K, S and Nakhone L (2018). Factors Influencing Farmer's Choice of Crop Production Response Strategies to Climate Change and Variability in Narok East Sub-county, Kenya. Journal of Natural Resources and Development 2018 (8): 69-77.

Liu Y, Peng J, Jiao L. (2016). A Heuristic Land-Use Allocation Model Using Patch-Level Operations and Knowledge-Informed Rules. PLoS ONE 11(6).

Markus, K. (2012). The political economy of global tree plantation expansion: A Review. *The Journal of Peasant Studies*, 41:2, 235-261

Mponela, P., Jumbe, C. B., and Mwase, W.F. (2011). Determinants and Extent of Land Allocation for Jatropha Curcas L. Cultivation among Smallholder Farmers in Malawi. Biomass and Bioenergy, 35(7): 2499 – 2505.

Mwaura, F. M. and Adong, A. (2016). Determinants of Households' Land Allocation for Crop Production in Uganda. *Journal of Sustainable Development* 9(5).

NBS (2012). The Population and Housing Census Management and Implementation Strategy, Dar es Salaam, Tanzania.

Ndhlove (2010). Determinants of farm households' cropland allocation and crop diversification Decisions: The role of fertilizer subsidies in Malawi. MSc. in Development and Natural Resource Economics Norwegian University of Life Sciences.77pp.

Ngaga, Y. (2011). Forest Plantations and Woodlots in Tanzania. A Platform for Stakeholders in African Forestry. African Forest Forum Working Paper Series. African. 80pp.

Ngunyen T.T., Ngunyen L.D., Lippe R.S and Grote U (2017). Determinants of Farmers' Land Use Decision Making: Comparative Evidence from Thailand and Vietnam. *World Development* 89: 199 - 213.

Obayelu, O. A. Adepoju A. O, and Idowu T (2014). Factors influencing farmers' choices of adaptation to climate change in Ekiti State, Nigeria, J. Agric. Environ. Int. Develop. (JAEID), 108 (1); 3–16.

Papke, L. E., & Wooldridge, J. M. (1996). Econometric methods for fractional response variable with an application to 401 (k) plan participation rates. Journal of Applied Econometrics, 11(6): 619 – 632

Perz, S.G (2002). Household demography and land use allocation among small farms in the Brazilian Amazon. Human Ecology Review 9(2):1-16

PFP (2017). Private Forestry Programme: Forest Plantation Mapping of the Southern Highlands. Final report. Iringa, Tanzania. 56pp.

Singh, L., Squire, L. and Strauss, J. (eds) (1986). *Agricultural Household Models: Extensions, Applications, and Policy.* Johns Hopkins University Press, Baltimore, MD. 354pp.

Tefera S.A and Lerra M.D (2016). Determinants of Farmers Decision Making for Plant Eucalyptus Trees in Market District, North Willow, Ethiopia.

on Humanities and Social Sciences 6 (13); 62 – 70.

Villamor G., Noordwijk. M, V., Djanibekov, U., Javier, M, C. and Catacutan, D (2014). Gender differences in land-use decisions: Shaping multifunctional landscapes? Current Opinion in Environmental Sustainability 6(1):128-133.

UNCTAD (2015). The Least Developed Countries Report 2015; Transforming Rural Economies. United Nations, New York, and Geneva. 39 Pp.

URT (2013). Mufindi District Socio-economic profile. Dar es Salaam, Tanzania. 184Pp

Yamane, T. (1967). Statistics: An Introductory Analysis, 2nd Ed., New York: Harper and Row.

Ye, X. and R.M. Pendyala (2005). A Model of Daily Time Use Allocation Using Fractional Logit Methodology. In H.S. Mahmassani (ed.) Transportation and Traffic Theory: Flow, Dynamics, and Human Interaction. Pergamon, Elsevier Science Ltd., Oxford, UK, pp. 507-524.

Yigezu A.Y., Tizale C.Y., Kassie G.T. and Hassan A (2018). Modeling land-use decisions in Production Systems involving multiple crops and varieties. African Journal of Agric Econ. 13(3): 240 – 250.

CHAPTER FOUR

4.0 FOOD SECURITY STATUS AMONG SMALLHOLDER FARMERS IN SELECTED VILLAGES IN MUFINDI DISTRICT: A HOUSEHOLD FOOD INSECURE ACCESS SCALE APPROACH.

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4.1 Abstract

The trade-off between the expansion of tree plantation and food security is that food security can be worsened due to reduced agricultural land, however, it can also be improved through increased income from timbers, which increases households' purchasing power. In the study area, there is scanty information on whether the expansion of tree plantations has worsened or improved the food security status in the study area. This study aimed at investigating how the rapid expansion of forest plantations has influenced food security at the household level in the selected villages in the Mufindi

District. The paper used data collected from a representative sample drawn from farm households in the study area. A multi-stage sampling technique involving purposive sampling of three divisions out of five based on their potential in tree and crop production was done followed by a purposeful selection of 8 villages and finally a simple random sampling of 413 households. Findings show that farmers across villages have converted agricultural land to forestry where the overall converted land is 2.57 acres. A descriptive analysis using Household Food Insecurity Access Scale (HFIAS) was done to analyze households' food security status. Overall results showed that 24.2% of all households were food secure, 6.2% mildly food secure, 41.6% moderately food secure and 28% severely food insecure. Therefore, the study's main conclusion is that income is all that is needed to make farmers' food secure. Since in rural settings like Mufindi, households earn income from the production of food crops and trees, the study recommends enhanced production of food crops by farmers to ensure households' food security in the short run, and trees to secure them in the long run when income from trees becomes available.

Keywords: Forestry plantations, food insecurity access, entitlement approach

4.2 Introduction

Access to food is ensured when all households have enough resources to obtain food in sufficient quantity, quality, and balanced nutritious diet. This depends mainly on the amount of household's disposable income and prices of food (Bonnard *et al.*, 2002*; Jef et al.,* 2015). Changes in land use pattern such as the expansion of forestry farming coupled with conversion of agricultural land to forestry may positively improve food security through increased income from trees, or may negatively disrupt food production strategies hence affecting access to food among affected smallholder farmers, as income from trees becomes available after ten years. This means food prices may increase as a result of decreased crop acreage, hence reducing the availability of- and farmers' access to food.

Timber plantations have become an important business activity globally and in Tanzania in particular (Ngaga, 2011; PFP, 2017 and FDT, 2015 and Marcus, 2012). For example, FAO, (2011) reports that global timber plantations expanded by 48.1 percent between 1990 and 2010 while during the same period plantations in Africa expanded by 32.1 percent. This is an increase from 178.3 to 264.1 million hectares globally, and 11.66 to 15.41 million hectares in Africa during the same period (Markus, 2012). The expansion of tree plantations in locations other than East Asia has been driven by both smallholders and corporations (FAO, 2011; Sikor, 2012). Tanzania is estimated to have 290 000 ha of timber plantations, of which 85,000 ha is state-owned and 200 000 ha privately-owned plantations (Ngaga, 2011). Moreover, PFP (2017) reported that the Southern Highlands of Tanzania has a total area of 207 000 ha of forestry plantations, of which 73% are owned by individuals while 17% and 10% are owned by the Tanzanian Government and Companies respectively.

Mufindi District is a pioneer in timber plantations in Tanzania where individuals own privately–25,028 ha (46.6%), companies owned 6,845 ha (13.04%) and the government owns 20,685 (39.36%) ha (PFP (2017). This implies that timber plantations in Mufindi and the Southern Highlands of Tanzania, in general, are driven by the private sector and it has important implications for its role in food security (Vira *et al.,* 2015). Also, PFP (2017) reported that Mufindi is the leading district in Tanzania in forestry plantations which is expanding rapidly. For example, in the year 2008, only 19,586 ha of trees were planted, while by 2016, a total of 52,558 ha was planted. This is an increase of about

168.3%, in eight years, and the expansion is likely to continue due to the perceived profitability of timber trees.

According to Nuberg *et al.* (2019); HLPE, (2020) and Aju, (2014) forestry plantations should contribute to among others, access to food by households engaged in farming. Other studies, Framtiden (2012), Lyons and Westoby (2015), and Mousseau and Biggs (2014) reveal a negative influence tree plantations expansion might have on households' food security as a result of reduced cropland. Even though tree plantations are expanding rapidly in Mufindi District, to date little is known about the status of food security by smallholder farmers in the study area, as forestry farming expansion may have both positive and negative influences on households food security. Understanding the status of food security is fundamental for informed policymaking about agricultural development and food security initiatives, and forest sector development in the country.

Therefore, the study aims to assess the food security status of smallholder farmers engaged in both food and forestry farming in the Mufindi District. Specifically, the study aims at analyzing the households' food security status by using a household food insecurity access scale (HFIAS).

4.3 Theoretical Background: Entitlement Approach for Food Security

The entitlement approach for food security was developed by Amartya Sen in 1980. The approach pinpoints that, the problem of food security is not only about the food supply failure which is a Malthusian concept from population theory but is more about food access than food supply. Devereux (2001) pinpoints four types of entitlements from the theory; firstly, trade-based entitlement is the ability for people to sell or buy something for food. Secondly, the production-based entitlement refers to the ability to grow and produce food (or goods for buying food). Thirdly, own labour-based entitlement which means the action of selling the skill or lab or power for purchasing or producing food. Fourthly, inheritance and transfer-based entitlement, which refers to access to food transfer that can be provided by the government or other person and society. Food entitlements of households depend on their production, income from other off-farm activities, community support, and assets. Thus, several socioeconomic variables influence a household's access to food.

The application of this theory in this study is based on the fact that household food security depends on land that farmers are having. It is from this land that production takes place, hence any change in land use like the conversion of arable land to trees, may reduce cropland hence low food production, which eventually may result in food insecurity. On the other side, this study took into consideration that, income from trees may be used to buy food from the market; hence households may become food secure even in the state where land use is changing from food to trees. Therefore, this study assumed that farmer's decision to change the land use from food to trees is rational; however, it is not known to what extent the expansion of tree plantations has influenced household' food security. The entitlement approach for food security has been used in this manuscript to assess food security status in the study villages.

4.4 Conceptual Framework of the Study

The conceptual framework guiding this study depicts the ways households' food access can be secured or in-secured as a result of converting land for food crops to forestry. Household food security is a function of both own food production by farmers and through the market purchase of food which is determined by the amount of disposable income available. From the study areas, the current economic activity that is growing rapidly is the timber plantation which involves some conversion of cropland (FDT, 2015). While forestry farming is perceived as a profitable business, its income becomes available after ten years, hence during this period farmers depend on food crops as a source of income by selling surplus, hence stabilizing food security. Moreover, at the household level, expansion of timber plantation may improve access to food through increased income from trees, but it may also worsen food security due to reduced agricultural land especially when productivity measures are not enhanced to compensate for the reduced land.

According to entitlement to food security theory, it is the availability of income that determines households' food security (reference). Therefore, this study aims at investigating how forestry plantations expansion has influenced households' food security, assuming that peoples' income has been improved as a result of tree plantations.

4.5 Methodology

4.5.1 Description of the Study Area

This study was conducted in Mufindi District in the Iringa region, where the survey was done in 2017. The District is one of the four District authorities of the Iringa region, located 80 km South of Iringa Municipal. It is bordered by Njombe Region to the south, Mbarali District (Mbeya Region) to the West, and Iringa District to the North. To the North East lies Kilolo District. In terms of international identification, the District lies between latitudes 8^{o}.0' and 9^{o}.0' south of the Equator and between longitudes 30^{o}.0' and 36^{o}.0' east of Greenwich. Mufindi is divided into five divisions namely Ifwagi, Kibengu, Kasanga, Malangali, and Sadani. It has 28 wards, 132 villages, and 79 994 hamlets. The District is mostly occupied by forest (10 411.3 sq. km) leaving only 2 427.6 sq. km. for human activities. The climatic conditions vary within Mufindi District, with three divisions namely Ifwagi, Kibengu, and Kasanga having favorable climates for both food crops and timber plantations, and the remaining two Sadani and Malangali being hotter and not supportive to trees.

4.5.2 Research design, sampling technique, and Sample size estimation

The target population for this study was 4896 households in three divisions namely Ifwagi, Kibengu, and Kasanga. The major and common characteristic of all these households is that they own land and are engaged in food crops production as well as tree growing. A cross-sectional research design and a multistage sampling procedure were adopted in the selection of respondents. The first stage involved the selection of three divisions from the District based on the potential in food and tree production. The divisions selected were Ifwagi, Kibengu, and Kasanga. The second stage involved the purposive selection of eight villages from each division. The villages were Ifwagi, Ludilo, Igoda, Luhunga, Mninga, Ikwega, Nundwe and Vikula. The third stage involved the application of a simple random technique to select households for interview.

The sample size was estimated using Yamanes' sample size estimation formula for finite population (Yamane, 1967) as shown in the second manuscript in chapter three.

4.5.3 Data collection

Data used for this study were primary data collected in 2017 using a special food access standard questionnaire (household Food Insecurity Access Scale (HFIAS), developed by the USAID-funded Food and Nutrition Technical Assistance II Project (FANTA) in collaboration with Tufts and Cornell Universities. The questionnaire was administered to heads of households in the eight villages in Mufindi District. The questionnaire consisted of two types of questions: nine ‘occurrence’ and nine ‘frequency-of-occurrence’ questions. The household head was first asked if a given condition was experienced about food insecurity where the response was yes or no and, then he/she was asked about the observed frequency of occurrence of that condition where possible responses were rarely, sometimes, or often. The questionnaire was designed to cover a recall period of 30 days. The resulting responses can be transformed into either a continuous or categorical indicator of food security. The representative sample was drawn from households cultivating food crops and tree plantations. Moreover, the study was qualitative. Key informant interviews were held with people who had an in-depth understanding and knowledge of food/tree production. Key informants included District Agricultural Officer, Village and Ward Extension Officers as well as village leaders, teachers, and elders.

4.5.4 Analytical Framework

The analysis is based on a household possessing land from which it can grow trees or food crops for the family, and use income from food crops and other off-farm activities to buy food, while waiting for income from trees in the long run. Also, the study assumes that a farmer may convert some cropland to forestry or sell a portion of that land for tree planting but income earned both in the short run and in the long run, may enable the household to buy food from the market hence become food secure even when land for food crops is reduced.

4.6 Data Analysis

4.6.1 Household Food Insecurity Access Scale (HFIAS)

Household Food Insecurity Access Scale (HFIAS) is a method for measurement of food access by households. The method comprises a set of nine questions that have been used in several countries and appears to distinguish food insecure from food secure households across different cultural contexts (Coates *et al*., 2007). HFIAS module covers a recall period of 30 days and comprises nine "occurrence" and nine "frequency-of-occurrence" questions. The occurrence questions intend to establish if a certain food-insecure condition was experienced within 30 days (yes or no) and, if the condition was experienced, the frequency of occurrence question follows (rarely, sometimes, or often). The resulting responses were transformed into both continuous indicators called average HFIAS score, and also as categorical; food secure, mildly insecure, moderately insecure, or severely insecure.

In computing HFIAS as a continuous indicator, each of the nine occurrence questions is scored from 0 to 3, with 3 being the highest frequency of occurrence, and the score for each is added together (Coates *et al*. 2007). The total HFIAS ranges from 0 to 27, indicating the degree of insecure food access. As a categorical variable, households are categorized as food secure, mildly food insecure, moderately insecure, or severely insecure.

4.6.2 Description of Household Food Insecurity Access Scale (HFIAS)

HFIAS score (range 0 – 27) - Sum frequency-of-occurrence question response code from the standard HFIAS questionnaire (Appendix 1);

$$= \quad Q1a+Q2a+Q3a+Q4a+Q5a+Q6a+Q7a+Q8a+Q9$$

for each household.

Average HFIAS Score = $\frac{\sum of\ HFIAS\ score\ for\ all\ households}{Total\ number\ of\ households}$

HFIA category can be 1 = Food Secure, 2=Mildly Food Insecure Access, 3=moderately Food Insecure Access, 4=Severely Food Insecure Access.

HFIA category (1): 1 if [(Q1a=0 or Q1a=1) and Q2=0 and Q3=0 and Q4=0 and Q5=0 and Q6=0 and Q7=0 and Q8=0 and Q9=0]

HFIA category (2): 2 if [(Q1a=2 or Q1a=3 or Q2a=1 or Q2a=2 or Q2a=3 or Q3a=1 or Q4a=1) and Q5=0 and Q6=0 and Q7=0 and Q8=0 and Q9=0]

HFIA category (3): 3 if [(Q3a=2 or Q3a=3 or Q4a=2 or Q4a=3 or Q5a=1 or Q5a=2 or Q6a=1 or Q6a=2) and Q7=0 and Q8=0 and Q9=0]

HFIA category (4): 4 if [Q5a=3 or Q6a=3 or Q7a=1 or Q7a=2 or Q7a=3 or Q8a=1 or Q8a=2 or Q8a=3 or Q9a=1 or Q9a=2 or Q9a=3]

HFIA Prevalence = Percentage of households that fall in each food insecurity (access) category.

$$\frac{Number\ of\ households\ with\ HFIA\ category}{Total\ number\ of\ households\ with\ a\ HFIA\ category}\ x\ 100$$

The strength of this method is that it provides a simple and user-friendly approach for measuring household food insecurity, and takes into consideration that, even if crop production by households is reduced due to the land being converted to trees, still income from trees and other off-farm activities can be used to purchase food hence families remaining food secure. HFIAS has been used in several countries and appears to distinguish food insecure from food secure households across different cultural contexts such as urban and rural (Mohammadi *et al.,* 2012; Knueppel *et al.,* 2010; Gemma *et al*., 2015 and Ndobo, 2013). Also, the method is capable of detecting households' food insecurity due to decreased access to quantity and quality as a result of insufficient resources to buy food, and also it is capable of capturing the psychosocial manifestation of anxiety and uncertainty about food access (Ballard *et al.*, 2013). According to Mohammadi *et al.* (2011), HFIAS method produces accurate results because of its internal consistency, criterion validity, and reliability for analyzing household food insecurity.

4.7 Results and Discussion

4.7.1 Socio-Economic Characteristics of Respondents

The socio-economic characteristics of respondents considered in this study were the sex of the household head, age, education level, household size, and land size. Results show that male-headed households composed 77 percent while females were only 23 percent. This was expected as most of the households in the study area are male-headed., This has an important implication on forestry expansion and conversion of arable land to forestry as males are major players in forestry farming. The mean age of the households' heads was found to be 44.6 years; this is the age when people are energetic in farming and venture into long-run businesses like forestry farming. The results also showed that the average years of schooling of the household head was 7.1 years implying that most of them attained primary school education which is a common phenomenon in rural areas and that households in the selected villages are literate and can make rational decisions about investment in forestry and food production. About household size, the results show that the mean household size was 4.5 which is just above that reported mean of 4.3 for the entire District of Mufindi (URT, 2013). On the other hand, households were found to own an average of 8.25 acres of land, from which both trees and food crops are grown. Households' mean annual gross income from trees was found to be Tshs 750 215, while that of food crops was Tshs 170 167. Higher-income from trees is likely to be an incentive for tree expansion and conversion of agricultural land.

4.7.2 Conversion of Agricultural Land to Forest

To understand the direction of forestry plantations expansion by smallholder farmers in the study area, a question on whether the households had ever converted arable land to forestry was posed, and the response showed that, in all villages, arable land has been converted to forestry, however, their response varied across the villages (Table 4.1).

Table 4.1: Response on Conversion of agricultural land to forest

		Name of village								
Response		**Ifwagi**	**Igoda**	**Ikwega**	**Ludilo**	**Luhung**	**Mninga**	**Nundwe**	**Vikula**	**Total**
Yes	Count	16	21	42	17	19	19	24	22	180
	%	8.9	11.7	23.3	9.4	10.6	10.6	13.3	12.2	100
No	Count	32	29	15	19	29	77	26	6	233
	%	13.7	12.4	6.4	8.2	12.4	33	11.2	2.6	100
Total	Count	48	50	57	36	48	96	50	28	413
	%	11.6	12.1	13.8	8.7	11.6	23.2	12.1	6.8	100

The results in Table 4.1 imply that Ikwega villages had a higher number of households (23.3%) who converted agricultural land to forestry than any other village, followed by Nundwe (13.3%), Vikula (12.2%), Igoda (11.7%), Luhunga and Mninga (10.6%) each, Ludilo (9.4) and Ifwagi (8.9%). The average arable land converted to forestry for each village is shown in Table 4.2.

4.7.3 Mean Arable Land (Acres) Converted to Timber Trees

To quantify the amount of arable land that smallholder farmers converted to forestry plantations, respondents were asked about the amount of land they converted to forestry. Results in Table 4.2 show that Vikula village was leading in the conversion of arable land to forestry with a mean of 2.57 acres, followed by Ikwega (2.38 acres), Nundwe (1.96 acres), Igoda (0.92 acres), Ludilo (0.79 acres), Ifwagi (0.76 acres), Luhunga (0.58 acres) and Mninga (0.55 acres). The conversion of arable land to forestry implies household food security, as it results in reduced arable land.

Table 4.2: Mean Arable Land (acres) converted to Timber Trees

Village	Count	Mean	Std Dev	Std error	Min	Max	Sum	%
Vikula	27	2.57	2.61	0.5	0	10	69.5	14%
Ikwega	57	2.38	2.64	0.35	0	10	135.5	27%
Ludilo	36	0.79	1.07	0.17	0	4	28.5	6%
Luhunga	48	0.58	0.82	0.12	0	3	27.75	6%
Ifwagi	48	0.76	1.34	0.19	0	6	36.5	7%
Nundwe	50	1.96	2.89	0.4	0	15	98	20%
Igoda	50	0.92	1.9	0.26	0	12	46	9%
Mninga	96	0.55	1.37	0.14	0	7	52.5	11%
Overall	413	1.21	2.05	0.1	0	15	498.25	100%

From these results, one could expect that a village with a high conversion rate of agricultural land to forestry could also experience high degrees of food insecurity access, due to reduced cropland. However, according to the entitlement approach to food security, it is resources that determine a household's food security, and not food supply which is affected by the size of land cultivated.

4.7.4 Household Income

Sources of income from different activities were computed to ascertain the contribution of forestry plantations to the household's annual income. The sources of income included; sales of food crops, cash crops, other earnings from casual activities, business income, sales of livestock and products from livestock, wages and salaries, remittances, sale of forest products, and sale of other products (Table 4.3).

Table 4.3: Sources of Households Income

Descriptive Statistics						
Source of income	**N**	**Min**	**Max**	**Sum**	**Mean**	**Std. Dev**
Food crops	413	0	3 500 000	70 279 000	170 167.07	334 454.52
Cash crops	413	0	10 000 000	32 915 000	79 697.34	588 066.78
Other casual activities	413	0	17 000 000	95 277 000	230 694.92	1 010 838.28
Business	413	0	10 000 000	67 319 000	163 000.00	718 429.94
Livestock	413	0	6 000 000	29 663 000	71 823.24	331 358.84
Wages	413	0	7 500 000	54 676 000	132 708.74	514 014.17
Remittance	412	0	700 000	6 332 000	15 368.93	61 065.08
Forest products	413	0	30 000 000	309 839 000	750 215.50	2 308 725.47
Other products	413	0	5 000 000	11 500 000	27 845.04	298 762.75

From Table 4.3, it is evident that forestry plantations contributed more than any other economic activity to household's income as evidenced by a mean income of Tshs 750 215. 50, and therefore, its contribution to household food access can be noticeable when combined with other sources of income. Households with more income are likely to be more food secures than those with low income, as income increases the purchasing power of households.

4.7.5 Household Food Insecurity Access Scale (HFIAS)

Results in Table 4.4, show the mean HFIA category and the HFIAS indicator across villages in the study area. Looking at the individual village, it can be observed that, with exception of Nundwe village with a HFIA category of 3.38 (moderately food insecure access), all other villages have a HFIA category ranging between 2.4 – 2.81 meaning that, they have mild food insecure. Also, the overall HFIA category (2.73) indicates that the villages in the study area have generally mildly food insecure access. It was expected that villages with high conversion of arable land to forestry, were also expected to have a higher degree of food insecurity, however from Table 4.4, results show no direct relationship between the HFIA category and the amount of land converted to forestry in the study villages. This implies that the results are in line with the entitlement approach for food security It shows that the problem of food security is not only about the food supply failure as a result of land conversion as per this study, but is more about food access which is enhanced by the availability of resources to secure food. Therefore, while villages have converted some arable land to forestry, yet the conversion shows no direct linkages with food security status, hence it is likely that farmers use income obtained from trees and other sources to secure food. This was evidenced by the kind of off-farm activities created by forestry farming in the study area.

Table 4.4: Mean households food insecurity category (HFIA)

Village	Count	Mean	Std dev	Std Error	Min	Max	Mean arable land converted to Forestry
Vikula	28	2.64	1.3113	0.2478	1	4	2.57
Ikwega	57	2.59	1.3997	0.1854	1	4	2.38
Ludilo	36	2.78	1.1737	0.1956	1	4	0.79
Luhunga	48	2.81	1.0448	0.1508	1	4	0.58
Ifwagi	48	2.73	0.8183	0.1181	1	4	0.76
Nundwe	50	3.38	0.9452	0.1336	1	4	1.96
Igoda	50	2.8	1.0497	0.1484	1	4	0.92
Mninga	96	2.4	0.9902	0.101	1	4	0.55
Overall	413	2.73	1.1138	0.0548	1	4	2.57

4.7.6 Prevalence of Food Insecurity

Prevalence of Households Food Insecurity was computed to determine the number of households falling in each HFIA category in each village. General results in Table 4.5 shows that Vikula and Ikwega, villages with high conversion of agricultural land to forestry, had the highest number of households that are food secure than other villages with low conversion rates. However, Nundwe village is shown to have 62 percent of households being food insecure and is ranked third in land conversion with a mean of 1.96 acres. Therefore, more efforts need to be made to ascertain the major causes of this food insecurity situation.

Table 4.5: Households Food Insecurity Prevalence

	HFIAS category by village				
Village	**1 (Food Secure)**	**2 (Mildly Food Insecure access**	**3 (Moderately Food Insecure access**	**4 (Severely Food Insecure access)**	**Total**
Vikula	9 (32%)	3 (11%)	5 (18%)	11 (39%)	28 (100%)
Ikwega	23 (40%)	2 (4%)	7 (12%)	25 (44%)	57 (100%)
Ludilo	9 (25%)	2 (6%)	13 (36%)	12 (33%)	36 (100%)
Luhunga	9 (19%)	4 (8%)	22 (46%)	13 (27%)	48 (100%)
Ifwagi	7 (15%)	3 (6%)	34 (71%)	4 (8%)	48 (100%)
Nundwe	4 (8%)	4 (8%)	11 (22%)	31 (62%)	50 (100%)
Igoda	11 (22%)	0 (0%)	27 (54%)	12 (24%)	50 (100%)
Mninga	28 (29%)	8 (8%)	53 (55%)	07 (7%)	96 (100%)
Overall	100 (24.2%)	26 (6.2%)	138 (41.6%)	115 (28%)	413 (100%)

Also, the results show Ikwega besides having the highest percentage of food secure households; also had 44 percent of severe food-insecure households, followed by Vikula, Ludilo, Luhunga, Igoda, Ifwagi, and Mninga with 39, 33, 27, 24, 8, and 7 percent respectively. Generally, the overall results from the study area, show that 24.2% of all households were food secure, 6.2% were mildly food insecure, and 41.6% were moderately food insecure while 28% were severely food insecure. These results are similar to Knueppel *et al.* (2010) who found that the status of food security in Iringa rural was 20.7% food secure, 8.4% mildly food insecure, 22.8% moderately insecure and 48.1%

severely food insecure. Tumaini (2017) also found that 25.1%, 12.4%, 34.0%, and 27.8% of households in rural areas of Iringa and Morogoro were food secure, mildly insecure, moderately insecure, and severely insecure; respectively.

4.8 Conclusion

Forestry plantations expansion can have both positive and negative influences on household food security. Forest plantations expansion may involve the conversion of agricultural land hence reducing yield due to reduced cropland, while income from trees becomes available after ten years. On the other hand, income obtained from expanded forest farms, in the long run, may be used to secure households' food, while in the short run income from other sources may be used to smoothen consumption. According to the entitlement to food security approach, the problem of food security is not only about the food supply failure which may be due to land conversion but is more about food access enabled by the presence of resources (income). Households may sell forest and forest products to get income, or may intensify the little land they have, hence increased yield, also may sell their power to the forest sector hence earn income, all leading to improved food security.

Overall results showed that 24.2% of all households were food secure, 6.2% were mildly insecure, 41.6% were moderately food insecure and 28% were severely in-secure.

These findings are found to be in line with the entitlement to food security theory, that income is the major requirement for households’ food security. Therefore, households can be food secure by both producing food crops and also timber trees, from which they can get food directly and also, earn income to purchase food.

4.9 Recommendations

Therefore, based on the conclusion and the theory underpinning this study it can be recommended that households raise their income from the production of both food crops and trees to ensure households' food security in the short run and also in the long run when income from trees becomes available.

4.10 Acknowledgement

I would like to express my deep gratitude to Dr. Damas Philip and Professor Kilima FTM, my research supervisors, for their patient guidance, enthusiastic encouragement, and useful critiques of this research work. The author also would like to thank The African Economic Research Consortium (AERC) for sponsoring data collection, and Jordan University College (JUCO) for granting study leave for study; Finally, I wish to extend my thanks to Mufindi District and local authorities; extension agents and farmers for their help and active participation during the data collection process.

References

Aju P. C. (2014). The role of forestry in agriculture and food security. American Journal of Research Communication 2(6): 109-121.

Ballard, T.J., Kepple, A.W. & Cafiero, C. 2013. The food insecurity experience scale: development of a global standard for monitoring hunger worldwide. Technical Paper. Rome, FAO. 58Pp.

Bonnard P, Patricia H, Anne S, Gilles B, and James D (2002). Report of the Food Aid and Food Security Assessment: A Review of the Title II Development Food Aid Program. Washington, D.C.: FHI 360/FANTA. 158 Pp.

Coates J, Swindale A, and Bilinsky P (2007). Household Food Insecurity Access Scale (HFIAS) for Measurement of Food Access: Indicator Guide – Version 3. USAID. 34Pp.

Devereux, S (2001). "Sen's entitlement Approach: Critiques and Counter-critiques, Oxford Development Studies, 29(3): 245-263.

FAO (2011). *State of the World's Forests.* Food and Agriculture Organization of the United Nations Rome. 179Pp.

FDT (2015). *Baseline Tree Growers Survey Report.* Forestry Development Trust; Uendelezaji Misitu Tanzania. Gatsby. Tanzania. 65Pp.

Framtiden (2012). "Tree Planting Project Threatens Food Security." [http://www.framtiden.no/english/other/tree-planting-project-threatens_food security. Html] site visited on 20th July 2018.

Gemma S. C., Carmen P. R., Joy N and Javier A. B. (2015). Household Food Insecurity Access Scale (HFIAS). Nutr Hosp. 31(3):272-278.

HLPE, (2020). Food security and nutrition: building a global narrative towards 2030. A report by the High-Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security, Rome. 112Pp.

Jef L. L, Marie R, Edward A. F, Jody H, and Terri J. B (2015). Measuring the Food Access Dimension of Food Security: A Critical Review and Mapping of Indicators. Food and Nutrition Bulletin, 36(2): 167-195

Knueppel D, Demment M and Kaiser L (2010). Validation of the Household Food Insecurity Access Scale in rural Tanzania. Public Health Nutr. 13(3):360-7.

Markus, K. (2012). The political economy of global tree plantation expansion: A Review. *The Journal of Peasant Studies*, 41:2, 235-261

Mohammadi F, Nasrin O, Anahita H, Mohammad R K, Morteza A and Yadollah M (2011). Validity of an adapted Household Food Insecurity Access Scale in urban households in Iran. Public Health Nutrition 15(1):1-9

Mohammadi F, Omidvar N, Houshiar R. A, Khoshfetrat M.R, Abdollahi M, Mehrabi Y. (2012). Validity of an adapted Household Food Insecurity Access Scale in urban households in Iran. Health Nutr. 15(1):149-57.

Mousseau, F. and Biggs, S. (2014). The Darker Side of Green Plantation Forestry and Carbon Violence in Uganda; *The Case of Green Resources' Forestry- Based Carbon Markets.* The Oakland Institute. The USA. 21Pp.

Ndobo, F.P. (2013). Determining the food security status of households in a South African Township. North-West University (Vaal Triangle Campus), South Africa, Pp 7-23.

Ngaga, Y. (2011). Forest Plantations and Woodlots in Tanzania. A Platform for Stakeholders in African Forestry. African Forest Forum Working Paper Series. 80Pp.

Nuberg I. K., Shrestha K. K. and Bartlett A. G. (2019). Pathways to forest wealth in Nepal *Australian Forestry* 82 (1): 106-120.

PFP (2016). Private Forestry Programme: Forest Plantation Mapping of the Southern Highlands. Final report. Iringa, Tanzania. 56Pp.

Lyons, K. and Westoby, P. (2015). *Carbon Markets and the New 'Carbon Violence': A Case Study of Plantation Forestry in Uganda*. Conference Paper. Institute of Development Studies. Brisbane, Australia. 21Pp.

Sikor, T. (2012). Tree plantations, politics of possession, and the absence of land grab in Vietnam. *Journal of Peasant Studies* 39(3-4): 1077-1101.

Tumaini, U. J. (2017). Household food access Security along the urban-rural continuum in Morogoro and Iringa, Tanzania. Pp 29 – 45.

URT (2013). Mufindi District Socio-economic profile. Dar es Salaam, Tanzania. 184Pp

Vira, B, Wildburger, C and Mansourian, S. (2015). Forests and Food: Addressing Hunger and Nutrition across Sustainable Landscapes. Cambridge, UK. 290Pp.

Yamane, T. (1967). Statistics: An Introductory Analysis, 2nd Ed., New York: Harper and Row. 919 Pp.

CHAPTER FIVE

5.0 SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

5.1 Overview

This chapter summarizes the main findings of the study. The focus of the study is on land use allocation between forestry plantations and food crop production in selected villages in Mufindi District; where the major purpose was to determine the optimum land use allocation between timber trees and food crops for increased earnings, food security, and improved livelihoods of smallholder farmers.

The study was guided by three specific objectives which are; (i) To find out the optimum food crops/tree combinations that maximize smallholder farm profit in the villages; (ii) To explore the determinants of land use allocation decision in food crops-tree production in the villages; and (iii) To investigate the influence of the current land allocation on household food security in the villages.

5.2 Summary of the major findings and conclusions

5.2.1 Optimum food crops/tree combinations that maximize smallholder farm profit

Study findings showed that the allocation of land to food crops and forest plantation was not optimal to guarantee profit maximization. Results from the multi-period profit maximization model showed that smallholder farmers could maximize profit by allocating between 1.81 acres of round potatoes and 1.74 acres of pine trees while also allocating 0.57 and 0.35 acres to maize and beans to meet households' food demand. This allocation is optimum and smallholder farmers can get a maximum profit of Tshs 13 592 440.53. Moreover, land and working capital were found essential to enhance smallholder farmers' profitability in the study area and were find binding. Labour on the other hand was found to be slack in the study area, entailing the problem of rural unemployment.

5.2.2 Determinants of land use allocation decision in food crops-tree production

The study found that on average farmers allocated 3.57 acres to food crops, 4.28 acres to trees, and 0.39 acres to fallow. The land allocation decision to tree production was found to be positively related to the land size of the household, awareness on land use policy, access to market information, and availability of labour; while it was negatively related to the sex of the household head with male-headed household head allocating more land trees than female headed-household. Fallow was found to be positively influenced by the household land size. Hence, land size, awareness of land use policy, access to market information, and availability of labour are fundamental in determining land allocation decisions between food crops production, tree farming, and fallow by smallholder farmers.

5.2.3 Influence of the observed land allocation on household food security.

Overall results showed that 24.2% of all households were food secure, 6.2% were mildly insecure, 41.6% were moderately insecure and 28% were severely insecure. These findings are in line with the entitlement to food security theory, that income is the major requirement for households' food security. Therefore, households can be food secure by both producing food crops and also timber trees, from which they can get food directly and also, earn income to purchase food.

Generally, land use allocation between forestry plantations and food crop production that maximizes farm profit and ensure food security among smallholder farmers can be achieved by;

i) Allocating about 1.81 and 1.74 acres of pine trees and round potatoes respectively, while also allocating 0.57 and 0.35 acres to maize and beans to meet households' food demand.

ii) Acquiring more land to accommodate emerging land use; improved accessibility to market information on crop output prices; increasing farmers' awareness of land use policy; and enhanced availability of farm labour.

iii) Income from tree plantations has been shown to contribute more to the household income than other sources, however, as the overall food security status is still low, farmers should produce both food crops for ensured food security and income in the short run, while also practice growing timber trees to enable them to increase their income in the long-run which in-turn will also be used to purchase food, hence improve household's food security status.

5.3 Recommendations

5.3.1 Community level recommendations

Based on these conclusions, the farmers should consider;

i) Households' land size was found vital for enhanced land use allocation between food crops and trees, however, it was found binding. The study recommends that Farmers should acquire more land either through purchasing or hiring to allocate more on trees and round potatoes for increased income and profit and hence improved household food security.

ii) Labour in the study area was found to be slack, entailing that rural unemployment prevail. The study recommends the creation of more off-farm activities from the forestry farming sector, to absorb the excess labour. This, in turn, increases income hence improving household food security and better living.

5.3.2 Recommendations to the government

i) Working capital from farmers' perspective is of paramount importance as it enhances expanded farming investment and land use allocation. However, in the study area, working capital was found to be binding. The study recommends that the government should provide low-interest credits to enable farmers to invest more hence increased income and improved households' food security.

ii) As the access to agricultural market information was found to significantly and positively influencing land allocation, the government should improve more its agricultural information system through the use of agricultural extension agents and media. This in turn will enhance more land allocation to trees and round potatoes.

5.4 Contribution of the study to the Body of Knowledge

i) In Tanzania, studies on land use allocation are scarce and uncommon, therefore this study provides useful baseline information from which other studies can be based. It has also used available theories and models to explain how the current land allocation can be improved to enhance the profitability of smallholder farmers.

ii) The study has brought new insights of quantifying the amount of arable land converted to forestry farming by smallholder farmers, which may imply both household and national food security. Such studies were hardly available in Tanzania. Therefore, this study aimed at informing the government about the kind of land use allocation taking place in the study areas, and hence the information can be used in the formulation of land use policies and plans that can work for smallholder farmers based on the current situation.

iii) Through dissemination of the results of this study to different stakeholders, awareness will be created based on the findings, hence enable them to think on different interventions for helping farmers, and improve land use allocation that benefits both households and the nation at large.

5.5 Area for Further Research

i) This study mainly focused on Mufindi District only. Hence its results cannot be generalized in other regions such as Njombe, Mbeya, Ruvuma, and Rukwa where similar activities are taking place. It is therefore recommended that similar studies be conducted in other regions so the results can be generalized and the policymakers are informed accordingly.

ii) Also, this study recommends more specific research to be conducted on land markets by smallholders farmers and to investigate who loses and benefits in the forestry value chain.

APPENDICES

Appendix 1: ML fit of fractional multinomial logit

	Coef.	Robust Std. Err.	z	P>z	[95% Conf.	Interval]
eta_Treeplantation landshareY2						
GenderX1	-0.7440	0.1700	-4.38	0.000***	-1.0771	-0.4109
AgeX2	-0.0082	0.0048	-1.71	0.088	-0.0177	0.0012
EducationX3	0.0144	0.0201	0.72	0.474	-0.0250	0.0539
HhsizeX4	-0.0449	0.0330	-1.36	0.174	-0.1097	0.0198
LandsizeX6	0.1185	0.0102	11.67	0.000***	0.0986	0.1385
PolicydummyX7	0.2566	0.1252	2.05	0.040***	0.0112	0.5019
MarketaccessdummyX8	0.4178	0.1458	2.87	0.004***	0.1320	0.7035
LabourdummyX9	0.5385	0.1422	3.79	0.000***	0.2598	0.8172
_cons	-0.9002	0.4414	-2.04	0.041	-1.7654	-0.0350
eta_FallowunusedlandshareY3						
GenderX1	-0.2215	0.4745	-0.47	0.641	-1.1514	0.7085
AgeX2	0.0219	0.0141	1.56	0.119	-0.0056	0.0495
EducationX3	-0.0929	0.0565	-1.64	0.100	-0.2036	0.0179
HhsizeX4	0.1825	0.0972	1.88	0.061	-0.0081	0.3730
LandsizeX6	0.1156	0.0178	6.49	0.000***	0.0807	0.1505
PolicydummyX7	-0.1933	0.3809	-0.51	0.612	-0.9399	0.5533
MarketaccessdummyX8	-0.2796	0.3351	-0.83	0.404	-0.9363	0.3772
LabourdummyX9	0.3262	0.3052	1.07	0.285	-0.2720	0.9243
_cons	-4.9457	1.3682	-3.61	0.000	-7.6274	-2.2640

Appendix 2: Crop Enterprise Budget

Crop Budget	Cultivation		Sowing		Seeds	Weeding/ Pruning		Harvesting		Yield/ Acre	Per unit price	Revenue	Total Variable costs (Tshs)
	M/days	Cost/ Manday	M/days	Cost/ Manday		M/days	Cost/Md	M/days	Cost/Md	Kg/acre	(Tshs/Kg)	Tshs/acre	Tshs/acre
Maize	24	5000	10	5000	0	18	5000	8	5000	644	663	426 972	300 000
Beans	24	5000	9	5000	0	16	5000	6	5000	272	1737	472 464	275 000
Wheat	20	5000	10	5000	0	6	5000	5	5000	476	1400	666 400	205 000
Round potatoes	24	5000	11	5000	60 000	12	5000	10	5000	2505	400	1 002 000	345 000
Finger millet	20	5000	10	5000	0	6	5000	5	5000	407	1400	569 800	205 000
Green peas	21	5000	12	5000	0	13	5000	11	5000	263	1540	405 020	275 000
Pine Trees	26	5000	11	5000	65 000	5	5000	0	0	650	35000	22 750 000	270 000

Appendix 3: Discounted cash flows

		Year									
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**Total**
Maize	Costs (Tshs)	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000	
	Revenue (Tshs)	427,000	427,000	427,000	427,000	427,000	427,000	427,000	427,000	427,000	427,000	
	Net Profit (Tshs)	127,000	127,000	127,000	127,000	127,000	127,000	127,000	127,000	127,000	127,000	
	Discount (17%)	0.855	0.731	0.624	0.534	0.456	0.39	0.333	0.285	0.243	0.208	
	Present Value (Tshs)	108585	92837	79248	67818	57912	49530	42291	36195	30861	26416	591,693.00
Beans												
	Costs (Tshs)	275,000	275,000	275,000	275,000	275,000	275,000	275,000	275,000	275,000	275,000	
	Revenue (Tshs)	472,500	472,500	472,500	472,500	472,500	472,500	472,500	472,500	472,500	472,500	
	Net Profit (Tshs)	197,500	197,500	197,500	197,500	197,500	197,500	197,500	197,500	197,500	197,500	
	Discount (17%)	0.855	0.731	0.624	0.534	0.456	0.39	0.333	0.285	0.243	0.208	
	Present Value (Tshs)	168862.5	144372.5	123240	105465	90060	77025	65767.5	56287.5	47992.5	41080	920,152.50
Round potatoes												
	Costs (Tshs)	325,000	325,000	325,000	325,000	325,000	325,000	325,000	325,000	325,000	325,000	
	Revenue (Tshs)	1,001,900	1,001,900	1,001,900	1,001,900	1,001,900	1,001,900	1,001,900	1,001,900	1,001,900	1,001,900	
	Net Profit (Tshs)	676,900	676,900	676,900	676,900	676,900	676,900	676,900	676,900	676,900	676,900	
	Discount (17%)	0.855	0.731	0.624	0.534	0.456	0.39	0.333	0.285	0.243	0.208	
	Present Value (Tshs)	578749.5	494813.9	422385.6	361464.6	308666.4	263991	225407.7	192916.5	164486.7	140795.2	3,153,677.10
Wheat												
	Costs (Tshs)	205,000	205,000	205,000	205,000	205,000	205,000	205,000	205,000	205,000	205,000	2,152,458.00
	Revenue (Tshs)	667,000	667,000	667,000	667,000	667,000	667,000	667,000	667,000	667,000	667,000	

	Net Profit (Tshs)	462,000	462,000	462,000	462,000	462,000	462,000	462,000	462,000	462,000	462,000	
	Discount (17%)	0.855	0.731	0.624	0.534	0.456	0.39	0.333	0.285	0.243	0.208	
	Present Value (Tshs)	395010	337722	288288	246708	210672	180180	153846	131670	112266	96096	
Green peas												
	Costs (Tshs)	180,000	180,000	180,000	180,000	180,000	180,000	180,000	180,000	180,000	180,000	
	Revenue (Tshs)	405,000	405,000	405,000	405,000	405,000	405,000	405,000	405,000	405,000	405,000	
	Net Profit (Tshs)	225,000	225,000	225,000	225,000	225,000	225,000	225,000	225,000	225,000	225,000	
	Discount (17%)	0.855	0.731	0.624	0.534	0.456	0.39	0.333	0.285	0.243	0.208	
	Present Value (Tshs)	192375	164475	140400	120150	102600	87750	74925	64125	54675	46800	1,048,275.00
Finger millet												
	Costs (Tshs)	205,000	205,000	205,000	205,000	205,000	205,000	205,000	205,000	205,000	205,000	
	Revenue (Tshs)	570,000	570,000	570,000	570,000	570,000	570,000	570,000	570,000	570,000	570,000	
	Net Profit (Tshs)	365,000	365,000	365,000	365,000	365,000	365,000	365,000	365,000	365,000	365,000	
	Discount (17%)	0.855	0.731	0.624	0.534	0.456	0.39	0.333	0.285	0.243	0.208	
	Present Value (Tshs)	312075	266815	227760	194910	166440	142350	121545	104025	88695	75920	1,700,535.00
Pine trees												
	Costs (Tshs)	270,000	270,000	270,000	270,000	270,000	270,000	270,000	270,000	270,000	270,000	
	Revenue (Tshs)	0	0	0	0	0	0	0	0	0	22,480,000	
	Net Profit (Tshs)	-270,000	-270,000	-270,000	-270,000	-270,000	-270,000	-270,000	-270,000	-270,000	22,210,000	
	Discount (17%)	0.855	0.731	0.624	0.534	0.456	0.39	0.333	0.285	0.243	0.208	
	Present Value (Tshs)	-230850	-197370	-168480	-144180	-123120	-105300	-89910	-76950	-65610	4619680	3,417,910.00

Appendix 4: Household Questionnaire
Division (………………….) Ward (…………………) Village (…………………)

Part A: Household Characteristics
A1. Give details of the household members (including household head), living

permanently in the compound and are dependent on the household (use codes below)

Name (1st name)	Gender 1=Male 2=Female	Age (years)	Relationship to the hh head	Highest education level in years of schooling	Primary activity
1	**[…………]**	**[…………]**	**[…………]**	**[…………]**	**[…………]**
2	**[…………]**	**[…………]**	**[…………]**	**[…………]**	**[…………]**
3	**[…………]**	**[…………]**	**[…………]**	**[…………]**	**[…………]**
4	**[…………]**	**[…………]**	**[…………]**	**[…………]**	**[…………]**
5	**[…………]**	**[…………]**	**[…………]**	**[…………]**	**[…………]**
6	**[…………]**	**[…………]**	**[…………]**	**[…………]**	**[…………]**
7	**[…………]**	**[…………]**	**[…………]**	**[…………]**	**[…………]**

Codes	**Years of Schooling**	**Primary activity**
Relationship to Household Head		
1 = Household head	0 = No formal education	1 = None
2 = Wife	1 = Pre-School age	2 = Farmer
3 = Son	7 = Primary education	3 = Civil Servant
4 = Daughter	14 = Form four	4 = Employee in Private business
5 = Daughter in law	16 = Form Six	5 = Engaged in own business
6 = Son in law	18 = College education	6 = Laborer on farm
7 = Grand children	19 = Higher education	7 = Laborer on off-farm

8 = Nephew

9 = Farm employee

10 = Grant parent

11 = Sister

12 = Brother

13 = Cousin

8 = Student

9 = Others (specify)……………

5.4 Profile of crop farming activities

B1. What is the household’s major farming activity (Tick one)

1 = Production of food crops only

2 = Forestry farming only

3 = All of the above

B2. For how long have you been working for the item in B1 above?

Activity	**Experience in years**
Production of food crops only	**[…………….……]**
Forestry farming only	**[…………….……]**
All of the above	**[…………………]**

B3. Code in the box against each crop you produce

S/N	**Farming activity**	**Produce**	**Not produce**
1	Maize		
2	Beans		
3	Green peas		
4	Wheat		
5	Finger millet		
6	Tree farming		

7	Round potatoes		

B4. Please provide the following information concerning household land as per 2017

Land use category	**Land owned (total acres)**	**Land rented in (acres)**	**Land rented out (acres)**
Land for food crops			
Land for trees			
Fallow land			
Unused land but suitable for crop/tree growing			
Unused land un- suitable for crop/tree growing			

B5. Please information on land for each of the following activities since 2012

S/N	**Farming activity**	**Area (acres) allocated for each farming activity**					
		2017	**2016**	**2015**	**2014**	**2013**	**2012**
1	Maize						
2	Beans						
3	Green peas						
4	Wheat						
5	Finger millet						
6	Tree farming						
7	Round potatoes						

8	Others (mention)						

B6. What do you think is the main driver for you to allocate your land to each of the crops listed in B5 above?

S/N	Crop Type	Awareness to Agricultural/Forestry/policy (Yes = 1 No = 0)	Access to market information (Yes = 1 No = 0)	Availability of farm labour (Yes = 1 No = 0)
1	Maize			
2	Beans			
3	Green peas			
4	Wheat			
5	Finger millet			
6	Tree farming			
7	Round potatoes			
8	Others (mention)			

C: Household Food Security

C1. Has the household experienced any food shortages over the past 12 months?

Yes = 1 No = 2

C2. If the answer to C1 above is yes, what were the main reasons for the food shortage?

	Reason for food shortage	Yes = 1	No = 2
1	Decline in own farm production due to draught		
2	Expansion of tree farms into cropland		
3	Decline in own farm production because of pests and diseases		
4	Decline in own farm production because of labour constraints		
5	Increase in food prices		
6	Lack of funds to purchase food		
7	Decline in own farm production because of low agricultural inputs used		

C3. If experienced a decrease in food production, what were the strategies adopted to cope with the food shortage?

S/N	Coping strategy	Yes = 1 No = 0
1	Practicing agroforestry	
2	Selling of immature trees	
3	Using income from other sources to buy food	
4	Engagement in other non-agricultural income-generating activities	
5	Working as casual labour	
6	Others (please specify)	

C4. Have you ever converted agricultural land to forestry? Yes = 1 No = 2

C5. If yes in C4 above, how many acres have you converted up to 2017?

C6. If converted what were the reasons for that?

1 = No more idle land for tree expansion

1 = Trees are more profitable than crops

2 = The land has lost its fertility status

3 = Pressure from external household forces

C7. Assess the total production of the following crops before and after embarking on tree growing.

	Average total yield before and after embarking in tree growing	
Crop	Before- Bags (100Kgs)	After - Bags (100Kgs)
Maize		
Beans		
Wheat		
Finger millet		

C8. Household food security assessment (HFIAS Questionnaire)

No.	**Question**	**Response Options**	**Code**
1	In the past twelve months, did you worry that your household would not have enough	0 = No (skip to Q2) 1=Yes	

	food?		
1a.	How often did this happen?	1 = Rarely (once or twice in the past twelve months) 2 = Sometimes (three to ten times in the past twelve months) 3 = Often (more than ten times in the past twelve months)	
2	In the past twelve months, were you or any household member not able to eat the kinds of foods you preferred because of a lack of resources?	0 = No (skip to Q3) 1=Yes	
2a.	How often did this happen?	1 = Rarely (once or twice in the past twelve months) 2 = Sometimes (three to ten times in the past twelve months) 3 = Often (more than ten times in the past twelve months)	
3	In the past twelve months, did you or any household member have to eat a limited variety	0 = No (skip to Q4) 1 = Yes	

	of foods due to lack of resources?		
3a	How often did this happen?	1 = Rarely (once or twice in the past twelve months) 2 = Sometimes (three to ten times in the past twelve months) 3 = Often (more than ten times in the past twelve months)	
4	In the past twelve months, did you or any household member have to eat some foods that you did not want to eat because of a lack of resources to obtain other types of food?	0 = No (skip to Q5) 1 = Yes	
4a	How often did this happen?	1 = Rarely (once or twice in the past twelve months) 2 = Sometimes (three to ten times in the past twelve months) 3 = Often (more than ten times in the past twelve months)	

5	In the past twelve months, did you or any household member have to eat a smaller meal than you felt you needed because there was not enough food?	0 = No (skip to Q6) 1 = Yes	
5a	How often did this happen?	1 = Rarely (once or twice in the past twelve months) 2 = Sometimes (three to ten times in the past twelve months) 3 = Often (more than ten times in the past twelve months)	
6	In the past twelve months, did you or any other household member have to eat fewer meals in a day because there was not enough food?	0 = No (skip to Q7) 1 = Yes	
6a	How often did this happen?	1 = Rarely (once or twice in the past twelve months)	

		2 = Sometimes (three to ten times in the past twelve months) 3 = Often (more than ten times in the past twelve months)	
7	In the past twelve months, was there ever no food to eat of any kind in your household because of a lack of resources to get food?	0 = No (skip to Q8) 1 = Yes	
7a	How often did this happen?	1 = Rarely (once or twice in the past twelve months) 2 = Sometimes (three to ten times in the past twelve months) 3 = Often (more than ten times in the past twelve months)	
8	In the past twelve months, did you or any household member go to sleep at night hungry because there was not enough food?	0 = No (skip to Q9) 1 = Yes	

8a	How often did this happen?	1 = Rarely (once or twice in the past twelve months) 2 = Sometimes (three to ten times in the past twelve months) 3 = Often (more than ten times in the past twelve months)	
9	In the past twelve months, did you or any household member go a whole day and night without eating anything because there was not enough food?	0 = No (the questionnaire is finished) 1 = Yes	
9a	How often did this happen?	1 = Rarely (once or twice in the past twelve months) 2 = Sometimes (three to ten times in the past twelve months) 3 = Often (more than ten times in the past twelve months)	

5.2 **Household income**

D1. On average, what are your annual earnings from various income sources as listed below?

	Income Source	**Tshs**
1	Sale of Food Crops	
2	Sale of cash crops	
3	Other casual cash earning	
4	Business Income	
5	Sale of livestock	
6	Wages and Salaries in cash	
7	Sale of livestock products	
8	Cash remittances	
9	Sale of forest products	
10	Others (please specify)	
	Total income	

a. **E: Land characteristics**

E1. Generally, how can you describe the slope of your farmland?

1 = Flatland 2 = slightly flat 3 = Steep slope

E2. What crop do you plant in the described kind of soil above?

Land Type	**Food crops**	**Trees**
Flatland		
Slightly flat		
Steep slope		

E3. What is the general fertility level of your farmland?

1 = Very fertile 2 = moderately fertile 3 = Un-fertile

b. **Farm capital assets**

Capital asset type	**Quantity**	**Monetary Value (Tshs)**
Farm tractor		
Ox- Plough		
Oxen		

Motorcycle		
Bicycle		
Car		
Hand hoes		
Others (specify)		
Total Monetary Value		

5.3 Household working capital

G1. Kindly estimate your average monthly expenditure on the following items for your household.

	Nature of expenditure	Total expenditure (Tshs)
1	Food	
2	Education	
3	Charcoal	
4	Kerosene	
5	Electricity	
6	Medical	
7	Firewood	
8	Clothing	
9	Telephone	
10	Gas	
11	Social obligations	
12	Savings	
13	Other expenditures (specify)	
	TOTAL EXPENDITURE PER MONTH	

H1. Kindly provide information on the average yield and price of different crops as prevailed in 2017.

Crop	**Area planted (acres)**	**Yield (100kgs bags)**	**Yield/acre (00 kgs Bags)**	**Farm gate Price (Tshs/Bag)**	**Revenue (Tshs/acre)**
Maize					
Beans					
Green peas					
Round potatoes					
Wheat					
Finger millet					
Sweet potatoes					
Pine trees					
Eucalyptus					
Tea					

I1. What kind of labour do you use for your farm activities?

1 = Family labour   2 = Hired labour   3 = both family and hired labour

Thank you very much for your cooperation

Appendix 5: Questionnaire for Focus Group Discussion and Key informants

Fill in the information regarding labour use and requirements per acre.

	Agrochemical and cost requirement per acre/year for each crop												
Farm activity	**Maize**		**Bean**		**Round potato**		**Wheat**		**Green Peas**		**Finger Millet**		
	Agrochem	Cost	Agrochem	Cost	Agrochem	Cost	Agrochem	Cost	Agrochem	Cost	Agrochem		
Land preparation													
Planting													
1st Wedding													
2nd Wedding													
Fertilizer													
Pesticide													
Storage													
Total Cost													

	Labour (Man/day) and cost requirement per acre/year for each crop													
Farm activity	**Maize**		**Bean**		**Round potato**		**Wheat**		**Green Peas**		**Finger Millet**		**Pine Tree**	
	Labour	Cost	Labour	Cost	Labour	Cost	Labour	Cost	Labour	Cost	Labour	Cost	Labour	Cost
Land preparation														
Planting														
1st Wedding														
2nd Wedding														
Fertilizer Appl														
Pesticide Appl														
Harvesting														
Transportation														
Threshing														
Pruning														
Fire breaks														
Total Man-days														

Kindly provide information on the average area planted, yield, and price of different crops/Trees as prevailed in the year 2017

Crop	**Area planted (Acre)**	**Yield (100Kg/Bags)**	**Yield/Acre (Bags/Acre)**	**Farm gate Price (Tshs/Bag)**	**Revenue (Tshs/Acre)**
Maize					
Bean					
Green Peas					
Round Potatoes					
Wheat					
Finger Millet					
Pine Trees					

Appendix 6: Data Collection Permission

JAMHURI YA MUUNGANO WA TANZANIA
OFISI YA RAIS
TAWALA ZA MIKOA NA SERIKALI ZA MITAA

WILAYA YA MUFINDI
Simu Na. 2772502/ 2772052

Fax Na. 2772052

Ofisi ya Mkuu wa Wilaya
S.L.P. 100,
MAFINGA.

Kumb.Na.AB.311/366/01/161 31/10/2017

Maafisa Tarafa,
IFWAGI, KASANGA NA KIBENGU.

Maafisa Watendaji wa Kata na Vijiji,
WILAYA YA MUFINDI.

YAH: KUMTAMBULISHA KWENU HAJI SAUTH NG'ELENGE.

Kichwa cha barua chahusika sana.

Mtajwa hapo juu ni mwanafunzi wa chuo kikuu cha kilimo (SUA) ambaye anasoma shahada ya uzamivu (PHD) ya uchumi kilimo.

Namtambulisha kwenu Mwanafunzi huyu ambaye atakuwa anafanya utafiti unaohusu mabadiliko ya matumizi ya Ardhi kutoka kwenye kilimo cha chakula kwenda katika kilimo cha miti na matokeo yake. Utafiti huu unaanza 01 November, 2017 hadi 30 Disemba 2017 katika vijiji vya Ifwagi, Mwitikilwa, Mtili, Igowole na Nundwe. Hivyo mnaombwa kumpa ushirikiano wa kutosha ili atimize malengo yake.

Nakutakia kazi njema.

A.M. Bernad
KATIBU TAWALA WILAYA
MUFINDI

Nakala :- Mkuu wa Wilaya,
MUFINDI - Aione katika jalada.

:- Mkurugenzi Mtendaji (W),
MUFINDI

:- Mkurugenzi wa Mji,
S.L.P. 76,
MAFINGA

CLEARANCE PERMIT FOR CONDUCTING RESEARCH IN TANZANIA

SOKOINE UNIVERSITY OF AGRICULTURE

OFFICE OF THE VICE-CHANCELLOR
P.O. Box 3000 CHUO KIKUU, MOROGORO, TANZANIA
Phone: 255-023-2640006/7/8/9, Direct VC: 2640015; Fax: 2640021;
Email: vc@suanet.ac.tz; vc2004sua@yahoo.com

Our Ref. SUA/DRPSG/R/126/3/93

4th September, 2017

The District Administrative Secretary
P.O. Box 223 Mafinga,
MUFINDI, IRINGA

Re: UNIVERSITY STAFF, STUDENTS AND RESEARCHERS CLEARANCE

The Sokoine University of Agriculture was established by University Act Number 7 of 2005 and SUA Charter of 2007 which became operational on 1st January 2007 repealing Act Number 6 of 1984. One of the mission objectives is to generate and apply knowledge through research. For this reason the staff and researchers undertake research activities from time to time.

To facilitate the research function, the Vice-Chancellor of the Sokoine University of Agriculture (SUA) is empowered to issue research clearance to both staff, students and researchers of SUA onbehalf of the Government of Tanzania and the Tanzania Commission for Science and Technology.

The purpose of this letter is to introduce to you **Mr. Haji Sauth Ng'elenge** a bonafide **PhD(Department of Agric. Economics and Agribusiness)** student with registration number **PAC/E/2016/0001** of SUA. By this letter **Mr. Ng'elenge** has been granted clearance to conduct research in the country. The title of the research in question is **"Land use change; shifting dynamics between tree and food production system in Mufindi Tanzania".**

The period for which this permission has been granted is from **15th September, 2017 to 15th October 2017.** The research will be conducted in **Ifwagi, Mwitikilwa, Mtili, Igowelo and Nundwe in Mufundi District.**

Should some of these areas/institutions/offices be restricted, you are requested to kindly advice the researcher(s) on alternative areas/institutions/offices which could be visited. In case you may require further information on the researcher please contact me.

We thank you in advance for your cooperation and facilitation of this research activity.

Yours sincerely,

Prof. Peter R. Gillah
AG: VICE-CHANCELLOR

VICE CHANCELLOR
SOKOINE UNIVERSITY OF AGRICULTURE
P. O. Box 3000
MOROGORO, TANZANIA

Copy to:- **Mr Haji Sauth Ng'elenge - Researchers**