RHEINISCHE FRIEDRICH – WILHELMS – UNIVERSITÄT BONN

Faculty of Agriculture

M A S T E R T H E S I S

As part of the Master programme

AGRICULTURAL AND FOOD ECONOMICS

Submitted in partial fulfilment of the requirements for the degree of

„Master of Science“

ECONOMIC ANALYSIS OF INTEGRATED VEGETABLE AND POULTRY PRODUCTION SYSTEMS IN THE BABATI DISTRICT OF TANZANIA

Submitted by:

Habiyaremye Naphtal

2915687

Submitted on: 13th February 2018

First examiner: Prof. Dr. Thomas Heckelei

Second examiner: Dr. Justus Ochieng

ABSTRACT

Attaining food security remains a global challenge as the supply of sufficient quantity and nutritious food is threatened partly due to climate change, high cost of production and rapid growing population. Recently, vegetables and poultry production have attracted attention both from the scientific and policy making communities for their contribution to food security as well as the opportunities they offer in improving the livelihood of smallholder farmers. Despite the efforts made, the profitability of vegetable-poultry (V-P) integration system is yet well-known, particularly in Tanzania. This study therefore, employed the Gross Margin (GM) analysis to evaluate the profitability of V-P integration and logit model to determine factors influencing adoption of V-P integration farming system using a cross-sectional data collected from 250 households in Babati District, Tanzania. The findings show that vegetable-poultry integration is more profitable than vegetable farming alone and the profitability increases as the flock size increases. Moreover, for smallholder farmers to make significant profits from V-P production system, they should keep at least 18 chickens per household. The decision to integrate V-P production systems is influenced by gender, education level and marital status of the head of the household, household size, off-farm income, land owned, total income received by the household, and awareness of V-P integration benefits. The policy implication is that scaling up promotion of the vegetable poultry production practices and adoption of new farming technologies are essential for efficient utilization of available resources and increase the profitability of V-P integration system. This can be done through farmers' capacity building, increased provision of trainings and extension services which contribute in transforming the rural farming from subsistence to profit-oriented farming.

Key words: Vegetable-poultry integration, profitability, Gross Margin, logit model.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ACKNOWLEDGEMENT

I would like to begin by sincerely thanking my supervisor, Dr. Justus Ochieng of World Vegetable Center, Eastern and Southern Africa, Arusha, Tanzania for the marvelous opportunity to work on the Africa RISING project and his support and guidance throughout my stay in Tanzania. Secondly, my sincere gratitude goes to Mr. Bisrat Haile of University of Bonn for his supervision and ideas from the research proposal till the end of this thesis. I am thankful to Prof. Dr. Thomas Heckelei for his comments and suggestions during the seminar in Agricultural and Development Policy and in his office.

I sincerely acknowledge the BEAF/GIZ for financially supporting this study and my stay at WorldVeg, Arusha, Tanzania. It would not have been possible to conduct this study without their support. I acknowledge the entire staff members of WorldVeg who were so friendly and made my stay there awesome. Special thanks to Dr. Fischer Gundula, Mr. Philipo Joseph and Mr. Marwa Joseph for their support in questionnaire preparation and data collection process. I appreciate all the staff of the AFECO program and lectures from whom I gained more knowledge and new skills. My special thanks to all AFECO classmates of 2015/2016 particularly Martin-Paul Tabee-Ojong JR. for his helpful discussions and ideas in this thesis and the entire program. I am so grateful to my friend Mashauri Muliro who not only made me know the AFECO program but also contributed to this study as well as to the majority of my courses.

My brother Kalekwa cannot go unmentioned. I thank him for investing in my education and sponsoring my studies in Germany. I will always be grateful for him and what he has done for me and strive to do until I become the person he wants me to be in society. My words cannot explain my gratitude to my Fiancée Michelle and my daughter Adrielle for their love and encouragements especially when things were not going as planned, they were always there to cheer me up.

Above all, I bring honor and glory to the Almighty God for his love, protection and strengths which kept me going until I could finish this program. It was not an easy journey, "*Yet in all these things we are more than conquerors through Him who loved us*" (Romans 8:37, NKJV)

DEDICATION

Dedicated to my loving Mum Mukankwaya Bernadette for her special care, especially when I lost my Dad at the age 7.

LIST OF ACRONYMS

CBO	Community Based Organization
CGIAR	Consultative Group on International Agricultural Research
FAO	Food and Agriculture Organization of United Nations
GDP	Gross Domestic product
GM	Gross Margin
IFAD	International Fund for Agricultural Development
IFS	Integrated Farming System
IFSNAR	Integrated Food Security and Nutrition Assessment Report
IHSN	International Housing Survey Network
IPCC	International panel on Climate Change
NI	Net Income
NRC	National Research Council
NSCA	National Sample Census of Agriculture
POGRBC	Poultry One Guide to Raising Backyard Chickens
RUM	Random Utility Maximization
SACCO	Saving and Credit Cooperative Organization
SSA	Sab-Saharan Africa
TALIRI	Tanzania Livestock Research Institute
TC	Total Cost
TDHS-MIS	Tanzania Demographic and Health Survey and Malaria Indicator Survey
TNNS	Tanzania National Nutrition Survey
TR	Total Revenue
TSH	Tanzanian Shilling
TVC	Total Variable Cost
USAID	United States Agency for International Development
USD	United States Dollar
V-P	Vegetable-poultry
WB	World Bank
WFP	World Food Programme
WHO	World Health Organization

1. INTRODUCTION

Attaining food security remains a global challenge for both the developing and developed countries; however, the difference lies in the degree of severity and the share of the population affected (Chagomoka et al., 2016; Mwaniki, 2006). Despite the recent progress attained in areas such as nutrition and agricultural technology, close to 800 million people, generally from the developing countries, are still chronically undernourished and food insecure (FAO et al., 2014). The 2016 Global Hunger Index report shows that one in four children under five years of age is stunted while wasting affects eight percent of these children worldwide (Von Grebmer et al., 2016).

Sub-Saharan Africa (SSA), by virtue of relying on rain-fed farming, is more vulnerable to recurrent drought, storms and flood events (IPCC, 2014; Rose, 2015). Livestock and fishery are other important agricultural components which are also affected by climate change. This has a wide ramification that extend to famine, malnutrition and death in many developing nations. Tanzania has been affected by malnutrition as well as the rest of SSA. A quarter of world undernourished people amounting to 214 million live in SSA (FAO et al., 2014) which means that, 23.8% of total SSA population is undernourished (FAO et al., 2014). Around 34.7% of children under five, and 5.5% of women aged between 15 and 49 years are considered to be underweight in Tanzania (TNNS, 2014) while 58% and 45% suffer from iron deficiency anaemia respectively (TDHS-MIS, 2016).

In Tanzania, agriculture does not only contribute significantly to the National Gross Domestic Product (GDP) but it also serves as a mean to address famine as it is the primary source of livelihoods to the majority of poorer households. Tanzanian agricultural sector grew at 4.4% per year and this contributed to yearly GDP growth of 6.6% between 1998 and 2007 (Pauw & Thurlow, 2011). The World Bank report of 2015 shows that, agriculture alone contributes 31% of the total GDP (WB, 2015) and 66.9% of the total employment in Tanzania (WB, 2014). However, the sector is confronted with many constraints such as increased population, market fluctuation due to cost of production, supply and demand among others. Consequently, there is a need to transform this sector as the country strives to be food secure and attain the second Sustainable Development Goal of zero hunger.

1.1 Vegetable Production

Many poor farmers around the world have been diversifying into horticultural crops and this has led to a faster production growth of vegetable and fruit crops worldwide (Lumpkin et al., 2005). The dramatic increase in quantity of vegetables and fruits traded worldwide has steered the trade of horticultural crops, approaching around 21% of total exports from developing countries (Weinberger & Lumpkin, 2005). Available evidence shows that, vegetable consumption contributes to households‘ nutritional intake by providing additional nutrients such as vitamins, proteins and minerals (Beattie et al., 2005; Kamga et al., 2013). Moreover a daily intake of 400g of vegetables combined with fruits could stop many chronic diseases, strokes and cancers (Beattie et al., 2005; FAO & WHO, 2005). Ochieng et al. (2017), found that, increased consumption of traditional African vegetables has a positive and significant effect of dietary diversity on children under five years and women aged between 15 and 35 years in northern part of Tanzania. Furthermore, Afari-Sefa et al. (2012) and Weinberger and Lumpkin (2007) argue that vegetables improve smallholder farmers' livelihoods, contribute a lot to their food security and enrich their nutritional status. The recent consideration to vegetable production is not only from their nutritional importance but also their economic contribution. Vegetable farming is described as a valued economic activity that provides income to farmers and offers employment opportunity mostly to women and young people in poor rural areas (Everaarts et al., 2015; Weinberger & Lumpkin, 2005, p. 20).

Different international organizations such as World Health Organization (WHO), Food and Agriculture Organization of the United Nations (FAO), and Consultative Group on International Agricultural Research (CGIAR) have recognized the role that horticulture plays in poverty alleviation and decreasing the health disparity in Tanzania (Lumpkin et al., 2005). Vegetables in particular have received considerable attention and are generally produced by smallholder farmers who own about two hectares of land (Marble & Fritschel, 2014; Weinberger, 2004). For instance, out of 8.8 million ha of used land in Tanzania, around 115,000 ha were allocated to vegetable production and a total of 635,000 tonnes of vegetables were produced in the year 2007/2008 (NSCA, 2008).

Despite a high and an increasing demand for vegetables, most areas of Tanzania have been experiencing a low productivity, partly linked to factors such as diseases and pests, unavailability

or high price of quality seed, and lack of appropriate control measures (Lazaro et al., 2017; Rajendran et al., 2017; Weinberger, 2004). This low productivity combined with high production cost from other input costs incurred by farmers such as labour, manure and chemical fertilizer costs, reduce the profitability of vegetable farming.

The low profitability underscores the need of practical innovative systems of production in order to increase yield and stimulate productivity of vegetables, serving as an indispensable means to improve smallholder farmer's livelihoods (Rajendran et al., 2015). It is argued that, the adoption of new technologies that increase farm production and income is essential to ensure food and nutrition security and sustained economic growth of smallholder farmers, who are arguably underutilizing resources (Hayami & Ruttan, 1971; Kuznets, 1966; Msuya, 2008; Schultz, 1964). Besides technology adoption, production growth can also be attained by using available resources efficiently (Nishimizu & Page, 1982; Rajendran et al., 2015).

1.2 Poultry production

In the past, the poultry farming was not regarded as a significant business that one should invest in, however, due to its fast monetary revenue, it has gained much attention in livestock sector (Amos, 2006; Tijjani et al, 2012). The poultry farming is now being transformed into business opportunity that generates numerous benefits such as production of eggs, manure, as well as broiler and hatchery to smallholder farmers (Amos, 2006). Besides, poultry products such as eggs and meat do not only generate income but also contribute highly to nutritional needs of human beings (Folorunsho & Onibi, 2005). In 2014, the total world population of chickens was estimated to be around 21.4 billion, 1 billion of ducks, 460 millions of turkeys, and 32 millions of pigeons and other birds (FAO, 2014b). Poultry production in rural areas is regarded as a cherished asset to local societies due to their share in poverty alleviation, provision of food, and their role in supporting gender equality (Guèye, 2000).

For a long time, the marginalized and remote rural villages of Africa have been keeping poultry as a source of income and mainly involving women as they decide on most of household expenditures particularly food consumption (Aklilu et al., 2007; Guèye, 2000, 2005). Furthermore, Guèye (2000) and Sonaiya (1990) established that over 80% of rural population in Africa keep poultry.

They also established that indigenous chickens known as 'local' or 'family' account up to 80% of the total poultry flock in the continent.

The 2007/2008 National Sample Census of Agriculture (NSCA) in Tanzania reports that out of the households keeping livestock, at least 66% raise chicken, while the total population of chickens and ducks was about 36 million and 1.3 million respectively in 2014 (FAO, 2014a; WB, 2013). Indigenous chickens dominate the poultry enterprise, representing over 90% and make up almost the entire poultry meat and eggs consumed in rural areas and close to a quarter in urban areas of Tanzania (Zootechnica, 2016).

Furthermore, the demand for animal proteins is expected to increase in Tanzania due to population growth, expected to rise from the current 53,47 million to137 million by the year 2050 (Brentrup et al., 2016). This anticipated rise in demand for animal products will be met through improved poultry production and management interventions (Delgado et al., 2001; Ochieng et al., 2012). However, despite the central role that the poultry plays, its potential in Tanzania is not till now fully explored (Goromela et al., 2007; Marwa et al., 2016; Mutayoba et al., 2012). The Tanzania Livestock Research Institute (TALIRI) establishes that the poultry sector contributes about 3 percent of the GDP derived from agriculture, equivalent to 1% of the total national GDP (TALIRI, 2015). It is even argued that if the sector is managed effectively and efficiently, its contribution to the national economy could be higher (Marwa et al., 2016; Minga et al., 1996) . Hence, improving the productivity of poultry is vital for eliminating poverty, improving food security and enhancing the wellbeing of rural communities and in the process helping the country to meet its Sustainable Development Goals (SDGs) obligations.

1.3 Problem statement

For the past three decades, most of African countries have been implementing institutional, macroeconomic and sectorial reforms to stimulate economic growth, promote food security, and reduce poverty (Dessy et al., 2006; WB, 2007). These low income countries have been relying on agriculture for their development, cognizant of the role the sector plays in addressing both food security and poverty alleviation. However, a transformation of the agricultural production system from subsistence to a commercial and more productive system is essential if the sector is to continue to be the engine of economic growth.

The agricultural sector in Tanzania is greatly dominated by smallholder farmers who hold on average two hectares of land per household and produce close to 75% of the total agricultural production (Salami et al., 2010, p. 11). The majority of Tanzanian poor people are living in rural areas. Despite the agricultural progress that Tanzania has made in the recent years, the sector's growth is yet to achieve food security or address poverty adequately particularly in the rural areas (WB, 2008). It is argued that the country has great agricultural potential to respond to the anticipated need, but this potential is underutilized (Bekunda, 2014; Ngunga & Lukuyu, 2016). Based on the above, it becomes important to fully optimize the agricultural sector in order to respond to the foreseen food demand and to cushion the livelihood of the millions rural poor farmers through various sustainable intensive agricultural initiatives or technologies.

The Africa Research in Sustainable Intensification for the Next Generation (Africa RISING), is one of such initiatives implemented in Babati District, Manyara Region, in Northeast Tanzania. In 2010, Babati District was reported along with other 27 Districts to have a high level of poverty and poor nutritional status in Tanzania (IFSNAR, 2010). This raised a number of programs in Babati that promoted production and consumption of nutritious food. Africa RISING, which is United States Agency for International Development (USAID) funded program seeks to provide options that contribute to rural poverty alleviation and improve the nutrition standards and the general wellbeing of rural farmers by increasing vegetable and rural poultry production in the District of Babati in Tanzania. One of the initiatives within the program is to promote integration of vegetable and poultry production systems. Vegetable-poultry integration system is viewed as an alternative to the conventional farming system, through which poultry is integrated into vegetables farming with the aim of increasing their productivity and household consumption. Within this integration, vegetables are fed to poultry while poultry manure is applied in vegetable farming.

Notwithstanding the above, no specific study has been conducted to economically assess the profitability of integrated vegetable-poultry production system under the Africa RISING and similar kind of initiatives in the region. This is one of the gaps that this study seeks to fill. It is only when the economic analysis of such integrated production system is carried that its viability can be evaluated and recommendations on its adoption drawn and scaled out in other regions in SSA to address poverty, food and nutrition challenges, particularly, among people living in rural areas.

1.4 Research objectives

The main objective of this study is to economically analyse the integrated vegetable-poultry production systems in the Babati District of Tanzania. The specific objectives of the study are:

- To characterize integrators and non-integrators of vegetable-poultry production systems
- To evaluate the economic benefits of the integrated vegetable-poultry production systems
- To determine the factors that influence the decision to integrate vegetable-poultry production systems

1.5 Structure of the thesis

This thesis consists of seven chapters including the above introduction. The remaining chapters are as follows: Chapter two is the literature review which involves the previous studies on integrated farming systems, profitability of integrated vegetable-poultry production systems and the nutritional benefits of vegetable-poultry integration. The third chapter discusses the theoretical framework emphasizing on the theory behind the integration decision and the model specification. Chapter four represents the methodology employed to tackle the objectives of the study which includes the gross margin calculations and econometric approaches used. Chapter five is describes the data and the description of variables used while displaying descriptive summary statistics of some important variables and chapter six presents the results and the discussions. Finally, chapter seven presents the conclusion and draws policy recommendations based on the findings of the study.

2. LITERATURE REVIEW

In this chapter, different integrated farming systems (IFSs), their benefits and sustainability are discussed in detail. The chapter also expounds on profitability and nutritional benefits of the integrated vegetable-poultry production system. Various existing literatures and empirical evidences on profitability of integrated farming systems are outlined in this chapter.

2.1 Integrated farming systems (IFSs)

The integrated farming System (IFS) is defined a judicious arrangements of two or more farming systems that are interconnected in production process and promotes an active recycling of residue for proper management of existing resources (Baishya et al., 2014; Bhuiya et al., 2016; Nath et al., 2016). IFS has been deliberated among the best effective ways of enhancing land productivity, alleviating smallholder farmers' poverty through maximum utilization of resources (Bhuiya et al., 2016; Byerlee et al., 1982). The main idea of IFS is that resource combination and diversification can improve the productivity on resource-poor farms (Devendra & Thomas, 2002; Halwart et al., 2006; Prein, 2002; Smyth & Dumanski, 1993). Different IFS studies have been done in several developing countries and their results confirm that, synergies among farm production systems rise the overall farm productivity (Alsagoff et al., 1990; Berg, 2002; Dalsgaard & Oficial, 1997; Frei & Becker, 2005; Pant et al., 2005), hence its appeal mostly in developing countries.

IFS is a method that focuses on a preferred interlinked, inter-reliant and interconnected systems of crops and animals or any other related farming systems that lead to a systematic and efficient use of resources (Gill et al., 2009; Nath et al., 2016). Moreover, an IFS will safeguard the existing natural resources to achieve a sustainable profitability and reinforce the nutritional security if there is a complementarity of its components (Nath et al., 2016). Therefore, An IFS can be conveniently hypothesized as a third farming system that is the most beneficial both economically and environmentally because it is in the middle of high and lower harvests from conventional and organic farming respectively (El Titi, 1992, p. 34; Morris & Winter, 1999).

The integrated farming system (IFS) has been proposed by different scholars as one of the promising ways to cushion households against climate and market fluctuation shocks, arguing that it reduces the cost of production, creates jobs and generates more income; altogether improving the overall food security and the nutritional status of the agricultural-dependent households (Alam

et al., 2009; Dashora & Singh, 2014; Guèye, 2000, 2005). For instance, empirical evidences of various integrated farming systems involving fishery, poultry, livestock and crop in Bangladesh (Akteruzzaman, 2006; Akteruzzaman et al., 2012; Alam et al., 2009) and fishery, poultry and vegetable farming in India (Dashora & Singh, 2014) have demonstrated that the integrated system has resulted into economic gains for households. The Bangladesh case-study has further established that the profits for households that have adopted the integrated farming system was the highest compared to households practicing conventional farming systems. This reaffirms Alam et al. (2009)'s economic viability standpoint that contends that the approach rises the revenue for households adopting the technology and generates more animal protein for the rural community at large.

Further empirical evidences on rice production in different rainfed districts in India confirm that, IFS has a higher net return than conventional farming (Nath et al., 2016). For instance, the IFSs of rice-early, tomato-early, cauliflower-paddy, straw-mushroom-poultry and vermi-compost pit gave a net return of about seven-fold of traditional farming per hectare in Odisha district (Paradkar et al., 2010). Taking the case of Chhattisgarh district as an example, the IFS of rice-two-bullocks-one cow-one buffalo-ten goats-ten poultry-ten ducks produced a net return of around four-fold of traditional farming per 1.5 acre and increased labour from 165 to 365 man days per year (Ramrao et al., 2006). In this integration, animals consumed the fodder and straw and in turn provided manure and this improved the soil fertility and the productivity of animals. In both cases, IFS was economically profitable, increased employment and provided food and nutrition security to households.

Diversified production systems such as crop–livestock integration seem to be an exciting pathway towards agricultural development in developing countries which are generally constrained by volatility of market prices for both inputs and outputs and exposed to climate change related extreme weather events (Lemaire et al., 2014). It is clearly evident that agricultural systems that adopt such integration enjoy numerous benefits partly due to the fact that crop residues are the main source of livestock feed while animals provide the cultivation power and manure as fertilizers which lead to a significant reduction in costs of production while ecological system is preserved (Herrero et al., 2013; Herrero et al., 2010; Nath et al., 2016). The crop-livestock synergy does not only contribute to food security and household income but also plays a vital role in reducing

unemployment and in poverty alleviation (Baishya et al., 2014; Gupta et al., 2012; Nath et al., 2016; Robinson et al., 2011). Despite the benefits emanating from integration of different farming systems and their sustainability, little contributions have been made to advance this practice in a holistic manner.

2.2 Sustainability of integrated farming systems

Globally, food production has increased significantly in the last 50 years, partly as a result of agricultural intensification led by mechanization, high application of chemicals and synthetic fertilizers together with an expansion of land area for production of crops and livestock (Alves et al., 2017; Bowler, 1992). Albeit, around 805 million people all over the world are still undernourished and food insecure (FAO et al., 2014; Godfray et al., 2010; WB, 2007). This poses even a deeper intersecting challenges considering that the world population is projected to reach 9.1 billion by 2050, which in essence, will require a considerable increase in the food production (Abel et al., 2016; Godfray et al., 2010). Consequently, the future demand for food, meat, fish and dairy will increase the existing pressures on land and water leaving serious negative effects on natural resource and the environment at large, unless the current production systems are modified to improve the yield potentials (Alves et al., 2017; Assessment, 2005; Godfray et al., 2010). Therefore, a sustainable intensification is indispensable to meet the future food demands while decreasing the environmental negative effects (Baulcombe et al., 2009; Godfray et al., 2010; Thornton & Herrero, 2015).

The IFS is considered as a panacea to achieve sustainable intensification (Godfray et al., 2010; Nath et al., 2016). It is distinctive from traditional farming, in the sense that sustainable production and safeguard of biodiversity are at the core of its goals (Morris & Winter, 1999). Sustainable farming on its own entails using available resources within the limitations of the earth's ability to replace them, inferring that any nonrenewable input-dependent farming system is unsustainable (Brundtland, 1987; Godfray et al., 2010). IFS promotes the use of organic fertilizers and this can produce a range of ecological benefits such as biological pest regulations, preservation of natural capita and improvement of soil quality (Holland et al., 1994; Martin et al., 2016; Moraine et al., 2017). We explore further the benefits of the IFS within the context of the vegetable-poultry integration.

2.3 Vegetable-poultry integration

The world remains at risk of food insecurity as the available resources for food production continue to be scarce, raising the challenges of food insecurity and malnutrition due to unhealthy diets and insufficient food (Galhena et al., 2013). Several strategies are required to adequately address these issues. Improved community health awareness and promotion of different nutritious diets from both the vegetables and animal product sources to complement the staple food is one of the strategies that can significantly contribute to food security. For example, more benefits are derived when vegetable farming is associated with poultry in an integrated farming approach, a position strongly supported by Akteruzzaman et al. (2012), arguing that there are more returns for investment when poultry is integrated with vegetable farming. The integration provides an opportunity to enhance both systems whereby vegetable provides feeds to poultry while poultry supplies the needed mineral to vegetables[1] (Adekiya & Agbede, 2016; Hochmuth et al., 2009; Malone et al., 1992; Swidiq et al., 2011). The manure derived from poultry is an important organic fertilizer for vegetable and relatively cheaper compared to chemical fertilizers. Hochmuth et al. (2009) assert that the waste from poultry speeds up the mineralization process, improves the soil structure and moisture holding capacity, therefore improving soil fertility and subsequently increasing farm profitability.

Figure 1 below demonstrates the elements of vegetable-poultry integration and their interactions within this farming system.

[1] The mineral from poultry manure are mainly nitrogen (N= 2.94%), Phosphoric Acid (P2O5=3.22%) and Potassium Oxide (K2O=2.03%) which represent a significant percentage of common commercial fertilizers (Malone, Sims, & Gedamu, 1992)

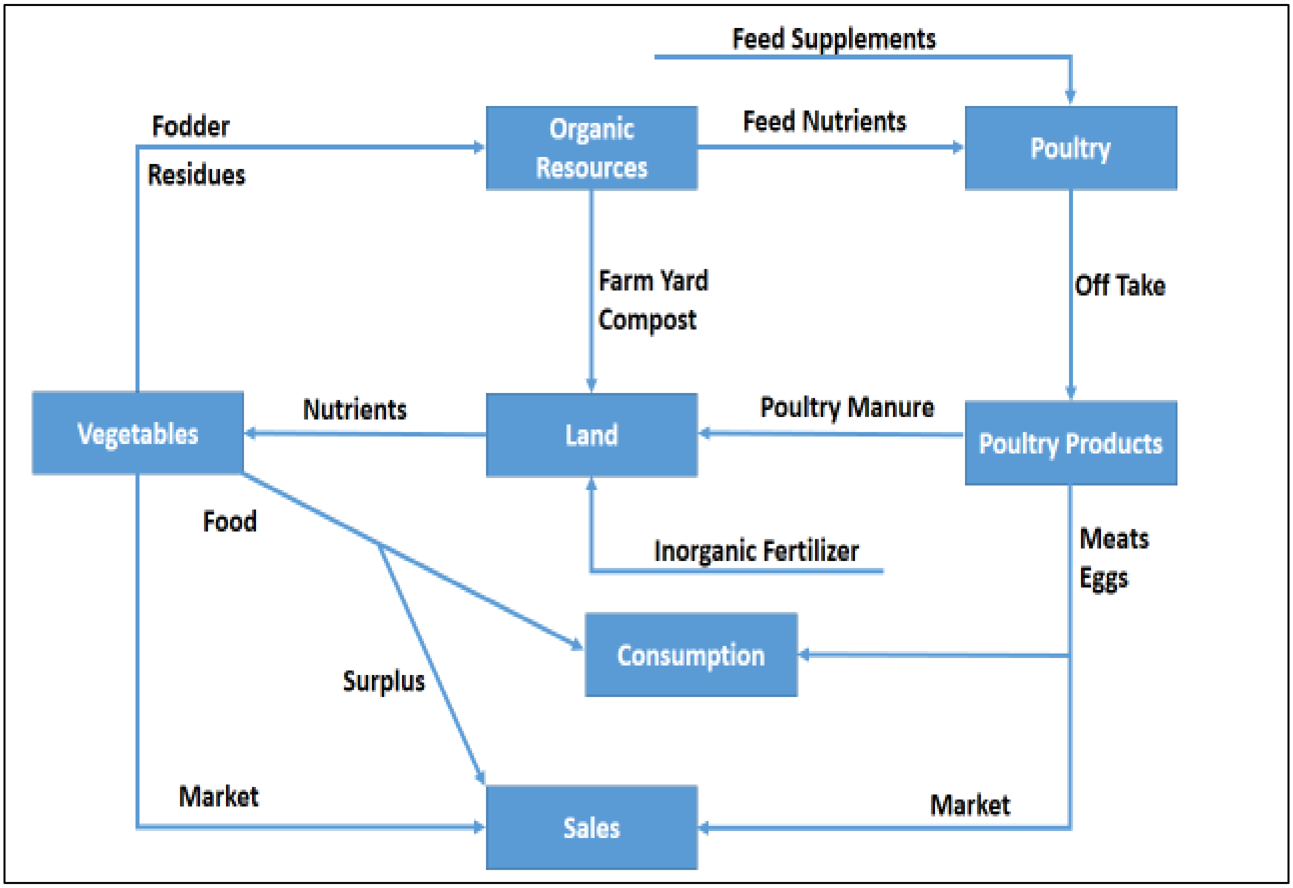

Figure 1. Schematic representation of the elements of vegetable-poultry integration system

Source : Own illustration adapted from (Thorne, 1998, p. 2).

From Figure 1, there are three key interfaces in vegetable-poultry integration system that make the integration successful. These include vegetable-poultry, poultry-land and land-vegetables interactions. The vegetables produced are consumed at the household level and the surpluses are taken to market which generate income to the household. The other part of vegetables as fodder or residues constitute partly to organic resources that are feed to poultry together with non-vegetable feed supplements. The feed from vegetables are rich in nutrients such as vitamins that contribute to the productivity of poultry. The organic resources that are not used as feed are decomposed and used in land as compost or farmyard manure. In turn, poultry generates a range of products such as meat and eggs that are either consumed or sold in the market for cash. Furthermore, poultry produces the manure that improve the soil quality for vegetable growth and this increases the vegetable yield. As an end result, the farmer is able to recycle the resources within this integration and attain the household food security and income generation.

2.3.1 Profitability of vegetable-poultry production system

Vegetable production provides an opportunity to enhance productivity and increase smallholders' income (Ali, 2000; Chand, 1996; Joshi et al., 2003). Weinberger and Lumpkin (2007) argue that vegetables are more profitable than cereals crops while Joshi et al., (2006) in India contend that the net profit of radish and eggplant ranged between Rs 5591/ha and Rs 12094/ha respectively while that of maize and paddy ranged from Rs 2519/ha to Rs 10384/ha. Furthermore, the set of vegetables in Bangladesh, Cambodia, Laos, Niger, North Vietnam, Philippines, and South Vietnam gave a net return on area and labor inputs that is higher than that of rice with the exception of the output value per Labor Day in the Philippines[2] (See Table 1 below).

Table 1. Vegetable farming: Profitability indicators as a ratio to rice

Output value	**Output value per ha**	**Output value per labor day**	**Sources**
Bangladesh	13.8	2.1	(Ali & Hau, 2001)
Cambodia	9.4	1.9	(Ali, 2002)
Laos	8.7	3.7	(Siphandouang et al., 2002)
Niger	3.3	1.6	(Chohin-Kuper et al., 1999)
North Vietnam	14.2	2.3	(Ali, 2002)
Philippines	1.3	0.7	(Weinberger & Lumpkin, 2007)
South Vietnam	9.6	1.9	(Ali, 2002)

Source: Adapted from Weinberger and Lumpkin (2007)

On the other hand, poultry production is regarded as an investment opportunity that offers a quick and high profits to rural poor farmers (Epprechtet al., 2007; Sonaiya, 2007). Smallholder farmers can generate more revenue from the sales of poultry products that are not consumed by the household members. For instance, Oladeebo and Ambe-Lamidi (2007) estimated the profitability of poultry farming among youth farmers in Nigeria using net income, gross margin, and gross return per naira invested. Their findings revealed that, based on all the three indicators, poultry production is profitable and worthy to venture in.

[2] The ratio of vegetables to cereals was used to measure the profitability. The ratio greater than 1 implies that vegetables were more profitable than cereals, else the opposite.

The vegetables and poultry farming systems have the potential of generating more revenue, however, they are facing a number of challenges such as low yields and high cost of productions. If these two farming systems were to be produced in an efficient way, their productivity would be more than the actual. From the cost of production standpoint, labor and fertilizer costs are the main costs incurred during vegetable production while feeds alone occupy over 60% of total variable costs in the process of poultry farming (Dutta et al., 2013; Huong et al., 2013; Ike & Ugwumba, 2011; Masuku & Xaba, 2013; Tijjani et al., 2012). Vegetables provides vitamins to poultry that increases their productivity and poultry manure is an organic fertilizer to vegetables that increases vegetable yield (Adekiya & Agbede, 2016; NRC, 1984, p. 6). Therefore, the integration of vegetable-poultry production systems results into reduction of poultry feed cost and reduces the costs of fertilizers.

2.3.2 Nutritional benefits of vegetable-poultry production systems

Apart from monetary benefits derived from reduced production costs and increased yield, the integrated vegetable-poultry production systems offer other benefits such as food and nutrition security through consumption of vegetables, meat and eggs at household level (Dessie et al., 2003; Mengesha et al., 2008; Ochieng et al., 2017; Ochieng et al., 2012). The consumption of Vegetables contributes to nutritional intake in many rural households through provision of vitamins, proteins and minerals and subsequently increasing the people's immunity against many chronic and acute diseases (Beattie et al., 2005; FAO & WHO, 2005; Kamga et al., 2013; Ochieng et al., 2017).

Similarly, chicken products are cost-effective source of protein to humans and their higher nutrient concentration enables them to play a vital role of complimenting staple food (Kitalyi, 1998; Memon et al., 2009). For instance, eggs and chicken meat are considered as important food for improving the nutritional needs of malnourished children under 5 years in many parts of the developing world mainly in Africa's rural communities (Rosegrant & Cline, 2003). Similarly, Pica-Ciamarra and Dhawan (2009) argue that, improved health can be attained if poultry products are easily available and consumed in rural households. However, Bett et al. (2013) contend that poultry products are inexpensive source of animal proteins for households, a position that may not be true in many rural households in Africa due to high level of poverty and low level of nutritional awareness, therefore, vegetable-poultry integration can be the best possible way of accessing these nutritious products to rural farmers.

3. THEORETICAL FRAMEWORK

This section discusses the theoretical model used in this study. The study used the non-separable agricultural household model which is supported by the random utility maximization theory. Different studies applied this model in the presence of imperfect markets to shape the household decision making process. The second part of this chapter discusses the model specification.

3.1 Integration decision

Smallholder farmers in Tanzania as well as in other developing countries are concurrently involved in production activity and consumption decisions. Asymmetric information, high unemployment rate, high transaction costs and poverty in most of developing countries result into market failures that leave smallholder farmers in rural areas faced with imperfect input, output and credit markets (Asfaw et al., 2012). In these conditions, the non-separable household model becomes of high relevance where the decisions regarding consumption and production cannot be made separately (Sadoulet & De Janvry, 1995). The non-separable household model offers an appropriate framework for evaluating household behavior facing the imperfect markets (Asfaw et al., 2012; De Janvry et al., 1991; Singh et al., 1986). The household production models founded on utility maximization that is subject to a set of budget and production constraints, have been the basic instruments to analyze the farm households and therefore serving as an integration decision tool (Chiappori, 1997).

Households are endowed with human, fiscal, social, and natural resources that are influenced by external factors which create constraints to their productivity. A change in technology applied and their distribution impact the preferences, predictions and views of farmers toward several varieties and inputs used in production. As a result, the decisions on resource allocation to numerous inputs, investment, and crop choice will be formed. Therefore, this would affect their consumption, production, sales of quantity produced from different crops and consequently their income. This implies that, vegetable-poultry integration may not only affect vegetables and poultry sectors but it may encourage modifications in farming patterns and ways to allocate resources to diverse usage. Hence, choices and decisions made by households establish their behavioral results which also will influence their consumption as well as their well-being.

The utility of a household is assumed to be maximized depending on the consumption (c_i), production (q_i), sales (s_i), purchases (d_i), and amount of input used (x_l) in the process of producing each product *i* (where *i* = 1, 2, . . . N) using different inputs *l* (where *l* = 1, 2, . . . M). The household produces agricultural commodities (q_i) using different inputs (x_l) such as land, labor, capital, etc. However, the optimization occurs in the presence of various constraints. Therefore, the household maximizes utility (3.1) subject to income (3.2), the product balance (3.3), production technology (3.4) and non-negativity (3.5) constraints.

$$\underset{q_i, c_i, s_i, d_i, x_l}{\text{Max}} \; U(c, z_u) \tag{3.1}$$

Subject to

$$\sum_{i=1}^{N} p_i^m (s_i - d_i) - \sum_{l=1}^{M} p_l \, x_l + I \geq 0 \tag{3.2}$$

$$q_i - c_i - s_i - x_l + d_i + E_i \geq 0, \;\; \text{for} \;\; i = 1, \ldots . N \tag{3.3}$$

$$H\left(q, x; z_q\right) \geq 0 \tag{3.4}$$

$$q_i, \; c_i, \; s_i, \; d_i, \; x_l \geq 0 \tag{3.5}$$

Where p_i^m represents the market price, I is the income from non-farming activities, E_i is the endowment of good *i*, H indicates the household's production technology and z_u denotes the vectors of demographic household while z_q is production characteristics. The income constraint (3.2) implies that the household's expenses on purchases should not exceed the revenues from crop sales plus other income from non-farming activities that is received by the household. The product balance (3.3) states that the quantity produced, purchased and endowed should be more than or equal to the quantity consumed, used as input and sold in the market for each product *i*. The production technology constraint (3.4) relates to a well-behaved conversion function that transform all inputs to outputs. The last non-negativity constraint (3.5) implies that quantity produced, sold, consumed, purchased and inputs used for commodity *i*, cannot be negative. These quantities are either positive or zero.

It is important to note that the utility maximization discussed above holds only when there are no transaction costs incurred by households. However, transaction costs play a vital role in shaping the farmers' stand point towards the production and market (Alene et al., 2008; Bellemare & Barrett, 2006; Key et al., 2000; Larochelle & Alwang, 2015). Households may be sellers or buyers

of either inputs or for consumption. Therefore, the transaction costs may increase the price gap between buyers and sellers and consequently, this influences the farmer's production and market decisions (De Janvry et al., 1991; Key et al., 2000). Therefore, household's behaviors of either producing a particular crop or not can partly be explained based on the differences in transaction costs and accessibility of facilities that lessen them.

To incorporate the transaction costs in the liquidity constraint, assume a household that is facing transaction costs $\Gamma_i^c\,(z_u,\ A,\ G,\ I)$ on quantity purchased and sold of commodity i. These costs comprise either one or both the variable (Γ_i^v) and fixed costs (Γ_i^f)and may be depending on farm characteristics (z_u), farm assets and resources (A), institutional and access related (G) as well as income from non-farming activities (I). The income constraint (3.2) containing transaction costs is therefore amended down as:

$$\sum_i \left[s_i\,(p_i^m - \Gamma_i^v\,\delta_i^s) - \Gamma_i^f\,\delta_i^s + d_i\left(p_i^m + \Gamma_i^v\,\delta_i^d\right) - \Gamma_i^f\,\delta_i^d \right] - \sum_l^M p_l\,x_l + I \geq 0 \qquad (3.6)$$

Where δ_i^s takes a value of 1 for a selling and 0 for an autarkic household while δ_i^d equals 1 for a purchasing household and 0 otherwise. This constraint implies that there is a difference in market prices between buyers and sellers, which constitutes the transaction, whereby the seller gets a lower price while the buyer pays higher than the market value for the same commodity.

In this study, we laid emphasis on the production decisions that is the decision to integrate poultry into vegetable farming.

The farmer's decision to integrate poultry into vegetable farming system is regarded as a binary choice because of the dichotomous nature of the dependent variable, which is to integrate or not to integrate. Observing integration through the lens of optimization by lucid agents, households integrate if integration is perceived to be profitable and is a choice that is actually affordable for them to make as it is for adoption studies (De Janvry et al., 2010). Following the same context of adoption decisions as discussed by Ali and Abdulai (2010) and De Janvry et al. (2010), the integration decision can be modeled in a random utility model (RUM). In this RUM, the utility from each alternative is supposed to be a linear function of individual characteristics that are observable plus an additive error term (Verbeek & Leuven, 2000). RUM assumes that decision makers make their decisions by choosing alternative opportunities that maximize their expected

utility. Furthermore, decision makers are presumed to recognize the opportunities that meet their utility. In the context of vegetable farming enterprise and integrated vegetable-poultry system, the farming system that maximizes a farm household's utility given the embedded constraints will be chosen. Given resource endowment and entitlement, the observed preferences are also assumed to be based on farmers' implicit cost and benefit prospect of the alternative farming system. Consequently, farmers are likely to disclose their preference based on their objectives.

Households normally assess the expected utility from new farming practices such as vegetable-poultry integration that can be represented as $U_i^*(\pi)$ where π is the net farm income. A utility maximizing farmer *i* chooses to integrate vegetable-poultry only if the random utility of integrating is greater than that of not integrating; that is, $U_I^*(\pi) > U_N^*(\pi)$ or $U_I^*(\pi) - U_N^*(\pi) > 0$. Since the utilities are not observable, they can be defined by a latent variable U_i^* that can be related to a group of socio-economic, institutional and access related variables (x_i). Therefore, by following the adoption studies by Asfaw et al. (2012), Feleke and Zegeye (2006), and Kohansal and Firoozzare (2013), the integration can be modelled in a random utility framework as:

$$U_i^* = \beta X_i + u_i \qquad i = 1, 2, \dots, N \qquad (3.7)$$

Where X_i is a vector of explanatory variables, β is a vector of parameters to be estimated and u_i is a random error term. When the choice of the farmer is known, the observable pattern of vegetable-poultry integration can be presented by a dummy variable (y_i) whereby the observed values of y_i are related to y^* as:

$$y_i = \begin{cases} 1 & if \ \ U_I^*(\pi) > U_N^*(\pi) \\ 0 & otherwise \end{cases} \qquad (3.8)$$

3.2 Model specification

The model specification under consideration in this study is grounded on the theoretical framework discussed above. The dependent variable of this study was the household decision to integrate poultry into vegetable farming and was tackled using a set of independent variables which were selected based on the theory and various theoretical and empirical literatures (Akter et al., 2012; Asfaw et al., 2012; Feleke & Zegeye, 2006; Ghimire et al., 2015; Mariano et al., 2012; Namwata et al., 2010). Therefore, the vegetable-poultry integration variable was framed as a function of

household characteristics, farm assets and resource ownership, institutional and access related, farm characteristics and information variables as well as agro-climatic zone.

Household characteristics in this study include gender, marital status, age, level of education of the head of the household, as well as the size of the household. Most of these variables were expected to have a positive relationship with vegetable-poultry integration. The agricultural sector in developing countries rely mostly on household labor. It is therefore expected that the married head of the household with a bigger household size has a more available labor source. Furthermore, the larger the size of the household, the more the demand of food quantity for consumption is anticipated, hence, households would allocate their resources to a more income and food generating farming practice to meet their demand. Likewise, a more educated head of household has better skills and access to information and therefore, he/she is in a better position to evaluate the relevance of vegetable-poultry integration. The exact relationship of age of household head on integration decision is unclear, in that younger farmers are generally innovative and risk takers but they may lack the farming experience. Similarly, the effect of gender of household head is ambiguous. This ambiguity emanates from the fact that male headed households are more expected to integrate than female headed households due to their superior farming capacity and access to land, while on the other side, women in developing countries are considered to be more involved in vegetables and poultry sectors than men and this can make female headed households to positively influence the vegetable-poultry integration. Therefore, the ultimate effect of gender and age is an empirical question (Asfaw et al., 2012).

In conditions of input output market failures, households' production is affected by its level of wealth or poverty. Due to lack of modern capital in rural Tanzania, farm assets and resource ownership variables used in this study include land size owned, off-farm income and total income received by household to capture the effect of resource endowment. Land area is decreasing in Tanzania due to population growth and the density is projected to increase further by the year 2050 (Brentrup et al., 2016). It is expected that the size of the land owned by the household will positively influence the integration whereby households with lager land holding may allocate a portion of their land to vegetables and poultry. Off-farm income was expected to influence vegetable-poultry integration in a positive way by providing the needed vegetable-poultry initial investment. It was also expected that total income will positively influence the integration as

wealthier farmers are in a position to easily encounter the starting capital compared to poor farmers.

All institutional and access related variables were expected to have a positive relationship with vegetable-poultry integration. In this category, variables like access to extension services and credit along with attending vegetable-poultry integration trainings were considered in this study. The farmers who have access to extension services as well as those who attended vegetable-poultry integration trainings were more likely to integrate. This is the same case for farmers who have access to credit as lack of starting capital is regarded as a serious challenge in adoption of new technologies. Access to credit is expected to positively influence borrowing and investments in integration.

Farm characteristics and information variables were expected to influence vegetable-poultry integration positively. For instance, access to information is likely to reduce uncertainty about the new farming practices. Thus, households who have knowledge and are aware of benefits from vegetable-poultry integration are expected to integrate. Similarly, vegetable farm size is expected to positively influence integration. This is because, the bigger the size of land allocated to vegetables, the more the manure is needed which can stimulate the farmer to integrate poultry for manure production.

Therefore, the underlying model for household decision to integrate poultry into vegetable farming can be specified as follows;

$$V - Pint_i = f(gend_i, mstat_i, hhsiz_i, edlev_i, age_i, lansiz_i, offinc_i, totinc_i, cred_i, trainatt_i, ext_i, benawar_i, vegarea_i, acz_i, u_i) \qquad (3.9)$$

Where;

$V - Pint_i$: is the household i[th] decision to integrate vegetables and poultry which takes the value 1 if the household integrates and 0 otherwise.

$gend_i$: is gender of household head

$mstat_i$: is the marital status of the household head

$hhsiz_i$: is the total number of household members

$edlev_i$: is the education level of household head in terms of years

age_i: is the age of household head in years

$lansiz_i$: is the area of land owned by the household in terms of hectares

$offinc_i$: is dummy for presence of off-farm income which takes the value 1 if the household has an off-farm income and 0 otherwise

$totinc_i$: is the household total income in terms of Tsh

$cred_i$: is a dummy for access to credit for agricultural activities and takes the value 1 if the household has access to credit and 0 otherwise

$trainatt_i$: is a dummy for training attendance which takes the value 1 if the household attended a V-P integration training and 0 otherwise

ext_i: is dummy for accessing extension services and takes the value 1 if the household received extension services

$benawar_i$: is a dummy for benefit awareness which takes the value 1 if the farmer was aware of vegetable-poultry integration profits and 0 otherwise

$vegarea_i$: is vegetable farm size which is the land allocated to vegetables in terms of hectares

acz_i: regional dummy (village)

u_i: is random error term associated with vegetable-poultry integration.

4. METHODOLOGY

In this chapter, the methodology used to tackle the objectives of this study are discussed. The gross margin (GM) analysis that was used to calculate the profitability and econometric approach used to examine factors influencing the decision to integrate vegetables-poultry production systems are explained.

4.1 Gross Margin (GM) calculations

The study sought to economically compare the benefits obtained from the integrated vegetable-poultry production system with the vegetable production system alone with the view to assess the economic profitability. To evaluate the economic benefits of integrated vegetable-poultry production systems, the Gross Margin (GM) analysis was used. The GM is preferred because it allows for easy enterprise selection, establishment of net farm income and it is useful in subsistence enterprises with small fixed income (Odoemenem & Otanwa, 2011).

The GM method has been used in previous studies from various disciplines including vegetables and poultry, to determine the profitability of a proposed technology (Akter et al., 2012; Ayieko et al., 2014; Etuah et al., 2013; Lazaro et al., 2017). It is represented by the formula:

$$GM = TR - TVC \qquad (4.1)$$

$$NI = TR - TC \qquad (4.2)$$

$$TR = PQ \qquad (4.3)$$

$$TC = TVC + TFC \qquad (4.4)$$

Where:

- Gross Margin (GM) is the difference between total revenue and total variable cost
- Net Income (NI) is deduction of total cost from total revenue
- TR is the product of output price and quantity of output produced
- Total cost (TC) is the sum of total variable cost (TVC) and total fixed cost (TFC)

In computing the cost of vegetable-poultry inputs, this study considered the prevailing market price for purchased inputs and the same price was considered for household self-supplied inputs. The cost of land allocated to vegetables was estimated and constituted the fixed cost of vegetable

production for both integrators and non-integrators. On the other hand, the fixed cost of poultry production for integrators comprised of the poultry housing depreciation costs. To calculate the profitability of both systems, the GM of vegetable production and NI were calculated for both integrators and non-integrators while that of poultry production was calculated for integrators only. Lastly, the GM and NI of integrated system were computed and the difference in both groups was calculated for comparison purposes. “The higher the GM, the greater profitable the system” criteria was used to determine the farming system that is more profitable.

4.2 Econometric approach

The dependent variable which is the decision to integrate poultry into vegetable farming is dichotomous in nature and is taking the value 0 or 1. To examine the determinants of this integration, the construction of binary model which comprises the factors that influence the household’s decision making is essential. Using a linear regression model to explain this variable is inappropriate; hence, the call for alternative models such as the logit and probit that can model discrete and continuous variables and take care of estimation and interpretation of their parameters (Verbeek, 2008). The two models give the same results but logit model was chosen for this study as it allows the prediction of the probability of a farmer to integrate vegetable-poultry production systems and its asymptotic characteristics limits the predicted probabilities between zero and one. The study selected the maximum likelihood as the common estimation method since our data was from individual household observations.

4.2.1 The Logit model

The logit model is based on the logistic cumulative distribution function, thus its results are not sensitive to the distribution sample elements when estimated by maximum likelihood (Aldrich & Nelson, 1984). Vegetable-poultry integration is based on a particular threshold which depends on certain socio-economic factors. Based on the utility theory, farmers will integrate if the critical threshold value is met while there is no integration below the threshold. The utility difference between integrators and non-integrators depends on profitability generated from integration and other household characteristics. Hence, for each household i, the difference in utility between integrating and non-integrating households can be obtained which depends on the observed characteristics $(x_i)$and unobserved characteristics (u_i). On the assumption of the linear additive

relationship, we present unobserved utility difference (y_i^*) which is referred to as a latent variable and represented as:

$$y_i^* = x_i'\beta + u_i \quad (4.5)$$

Where x_i' represents the vector of independent variables explaining the integration decision, β is the vector of parameter estimates, and u_i is the error term which is assumed to be independent and distributed as $u_i \sim NID\ (0, 1)$.

Therefore, we observe:

$y_i = 1$ (integration) if $y_i^* > 0$ and

$y_i = 0$ (no integration) otherwise

Consequently, the probability of integrating vegetable-poultry is represented as:

$$pr\ \{y_i = 1\} = pr\ \{x_i'\beta + u_i > 0\} = pr\ \{-u_i \leq x_i'\beta\} = F(x_i'\beta) \quad (4.6)$$

Where F denotes the cumulative distribution function (CDF) and should be in the interval [0 1]. If F is chosen to be the standard distribution function, then;

$$F(x_i'\beta) = \int_{-\infty}^{x_i'\beta} \frac{1}{\sqrt{2\pi}} \exp\left\{-\frac{1}{2}t^2\right\} dt \quad (4.7)$$

Which leads to the standard logistic distribution function, given by:

$$F(x_i'\beta) = \frac{e^{x_i'\beta}}{1+e^{x_i'\beta}} \quad (4.8)$$

4.2.2 Likelihood function

Equation (4.8) represents a binary choice model estimating the probability of integrating vegetable-poultry (y_i) as a function of explanatory variables (x_i'). The farm household decides whether to integrate vegetable and poultry or not. Using the binary logit model, it is represented as follows:

$$pro(y_i = 1|x_i', \beta) = F(x_i'\beta) = \frac{e^{x_i'\beta}}{1+e^{x_i'\beta}} \quad (4.9)$$

$$pro(y_i = 0|x_i', \beta) = 1 - F(x_i'\beta) = 1 - \frac{e^{x_i'\beta}}{1+e^{x_i'\beta}} = \frac{1}{1+e^{x_i'\beta}} \quad (4.10)$$

Where y_i is the response for the i^{th} household. This means that $y_i = 1$ for a vegetable-poultry integrating household and $y_i = 0$ for non-integrating household. F is the standard normal cumulative distribution function, x_i' a vector of explanatory variables determining integration, and β is a vector of parameter estimates. Hence, the full distribution of F is:

$$f(y_i|x_i') = [F(x_i'\beta)]^{[y_i=1]}[1 - F(x_i'\beta)]^{[y_i=0]} \quad (4.11)$$

4.2.3 Marginal effects

The direct interpretation of coefficients of the estimates from the logit model above is not possible except their signs only. Therefore, a post-estimation analysis was undertaken to enable us to estimate the change in probability of integrating vegetable-poultry as a result of a unit change in a specific explanatory variable and that is referred to as marginal effects. The marginal effects are therefore computed by the partial derivative of the probability that $y_i = 1$ with respect to a continuous explanatory variable (x_i) and for dummy variables by calculating the implied probabilities for the two likelihoods, holding all other explanatory variable constant. It can be shown as:

$$\frac{\partial p(y_i=1|x_i')}{\partial x_i} = \beta_i F(x_i'\beta) \quad (4.12)$$

If x_i is a continuous variable and

$$\frac{\Delta p(y_i=1|x_i')}{\Delta x_i} = F(x_i'\beta^1) - \beta_i F(x_i'\beta^0) \quad (4.13)$$

If x_i is a dummy variable

Where $x_i'\beta^1 = x_1\beta_1 + \cdots + x_{i-1}\beta_{i-1} + 1.\beta_i$ and $x_i'\beta^0 = x_1\beta_1 + \cdots + x_{i-1}\beta_{i-1} + 0.\beta_i$

The margins commands were used in stata to calculate the APEs and delta method for the standard errors.

4 DATA AND VARIABLE DESCRIPTION

This chapter discussses the study area, sampling techniques used, the data types, variables and the source of data survey that addressed important aspects such as household characteristics, farm assets and resources, institutional characteristics, vegetable and poultry production activities, as well as costs and benefits arising from vegetable-poultry integration.

5.1 Study area

The research took place in the District of Babati, Manyara region in Tanzania, covering a surface area of 5609 km^2 out of it, 4969 km^2 is the total land area while the remaining 640 km^2 is covered by water (Mangesho et al., 2013). The potential land available for agriculture in babati District is about 134,187 ha but only 120,000 ha is used for cultivation while 212,100 ha is under livestock keeping (Mangesho et al., 2013). Löfstrand (2005) estimates that around 31,775 ha and 142,500 ha are forests and parks&game reserves respectively. The district of Babati is mainly rural “with about 90% of its population that rely on agriculture and livestock as main source of their livelihood” (Ngunga & Lukuyu, 2016, p. 1). The Tanzania Population and Housing Census of 2012 shows that, Babati District had a total population of 405,500 out of which 77% were in rural and 23% were in urban areas (IHSN, 2012).

The District of Babati is divided into four major divisions (namely the division of Babati, Gorowa, Mbugwe and Bashnet), 21 wards and 96 villages (Mangesho et al., 2013). This study was conducted in five villages where Africa RISING is operational, namely; Bermi, Galapo, Matufa, Seloto, and Shaurimoyo (see Figure. 2).

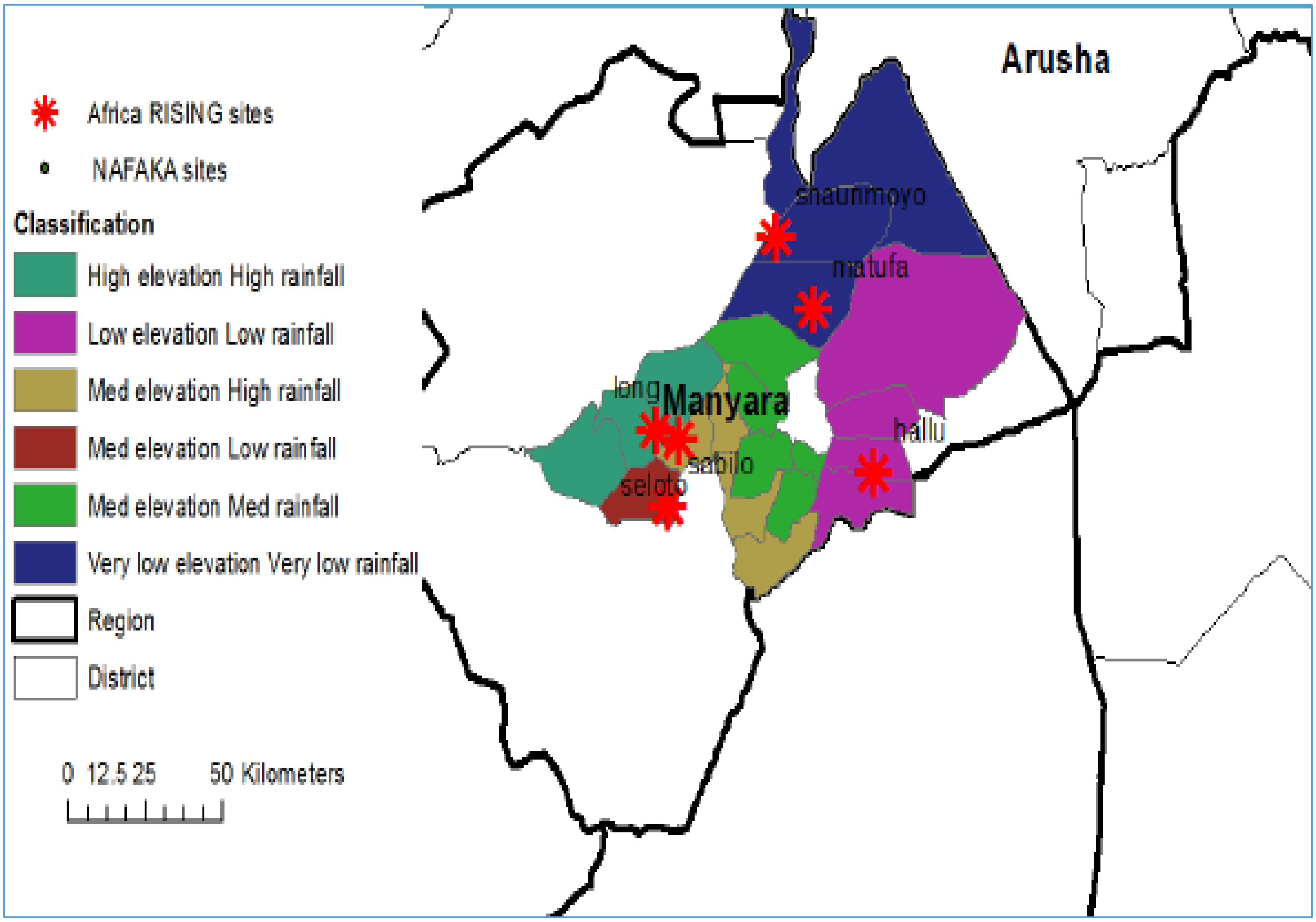

Figure 2. Map of the study area (Bekunda et al., 2014)

5.2 Sampling design and techniques

A multi-stage sampling procedure was used in this study. The first stage involved choosing Babati District in Manyara, is due to the pre-determined sites based on the Africa RISING Eastern and Southern Africa projects sites. The second stage was the selection of five villages out of total villages in Babati District. The five listed villages are the only villages in Babati that work with World Vegetable Center, Eastern and Sourthen Africa region. The third stage was a random sampling of households (both integrators and non-integrators).

The sample size was determined by the following proportionate to size sampling approach using the formula (Kothari, 2004; Smith et al., 2005):

$$\boldsymbol{n} = \frac{z^2 pq}{e^2} \qquad (1)$$

Where; n = sample size; Z= confidence level; p = proportion of the population, q = 1-p and e= margin of error.

The proportion of population of interest is not known with certainty. However, previous studies indicate that over 80% of rural population in Africa keep poultry (Guèye, 2000; Sonaiya, 1990); therefore, p = 0.8 and q = 0.2. A margin of error of 5% which is assumed to sufficiently remove 95% bias in sampling was used (Smith et al., 2005). A confidence level of 95% that gives a z-score of 1.96 was used in this study hence the sample size of 246 which was aproximated to 250 household farmers.

5.3 Data type

As mentioned above, this study is based on the household survey conducted in June 2017 covering households from five villages in Babati District. The data was collected as part of the partneship arrangement between the BEAF/GIZ[3] and World Vegetable Center, Eastern and Sourthen Africa region[4] under the framework of the Africa RISING program in Tanzania. Four experienced enumerators were recruited and trained to support in data collection process. Tablets were used for real-time data collection through surveyCTO (Survey platform for electronic data-collection based on Open Data Kit) and the semi-structured questionnaires were filled by both integrators and non-integrators of vegetable-poultry production systems.

The questionnaire developed captured various information on household characteristics, land ownership, land allocated to vegetables, source of income and ownership of poultry. Furthermore, data on inputs used in both systems that include labor, manures, chemical fertilizers and other variables such as productions, consumptions, and sales were collected. The prices of input and output were also documented together with costs and benefits of both farming systems. Data on the reasons for integrating or not integrating and institutional characteristics such as credit and extension service accessibility were also collected. The data was cleaned, coded and analyzed

[3] BEAF/GIZ funded my stay at WorldVeg for a period of six months
[4] WorldVeg funded the entire data collection costs

using Stata14. Based on the detailed data collected, the assessment and analysis of integration decisions was made possible and enabled to respond to the objectives of this study.

In this study, integrators are regarded as farmers who are producing vegetables, feeding vegetables to poultry, applying poultry manure into vegetable garden and own at least five adult birds. On the other hand, non-integrators are described as vegetable producers that may own less than five adult birds or none. The treshold number of birds was selected based on the quantity of manure that can be produced. Poultry One Guide to Raising Backyard Chickens establish that, the manure produced by five to ten chickens is enough to fertlize the vegetable garden as one chicken can produce around 45 pounds of manure annually (POGRBC, 1999). Furthermore, the Tanzania Livestock Research Institute (TALIRI) reports that, on average households in Tanzania own five to twenty birds per household (TALIRI, 2015); hence the minimum number of five birds was chosen to describe integrators.

5.4 Variable description

The variables included in this study were classified into categories such as production characteristics, household characteristics, farm asset and resource ownership, institutional and access related, farm characteristics and information variables. The Table 2 below shows the summary statistics of the entire data of continuous variables while Table 3 displays frequencies and percentages of indicator variables. In addition, the dummies representing Bermi, Galapo, Matufa, seloto, and Shaurimoyo villages were created and added as explanatory variables since agro-climatic conditions may influence profitability and integration decision.

Table 2.Summary statistics of continuous variables (N=250)

Variables	Mean	Min	Max	SD
Household size (number)	5.208	1	12	2.101
Household head education (years)	7.032	0	16	2.660
Age of household head (years)	47.388	19	98	12.937
Dependency ratio[5] (number)	0.397	0	1	0.218
Land owned by the household (in hectares)	1.198	0	6.172	1.176

[5] The dependency ratio in this study is the sum of household members who are below 15 years of age and above 64 years divided by total number of household members

Off-farm income (in Tsh)	110,913.3	0	3,000,000	279163.8
Total household income (in Tsh)	346,464.1	20,000	3,160,000	345945.6
GM from V-P integration (in Tsh)	392,566.6	-457,962.5	4,905,000	801325.2
Vegetable farm size (in hectares)	0.0902	0.0008	0.607	0.083
Quantity harvested (in Kg)	866.096	4	6750	1299.594
Household yield (in Kg/ha)	9,399.946	98.842	99,171.54	11188.36
Number of poultry birds owned	9.46	0	200	15.576

Source: Own calculation based on the survey data collected

Table 3. Summary statistics of indicator variables (N= 250)

	Yes (1)		**No (0)**	
Variables	**Frequency**	**Percentage (%)**	**Frequency**	**Percentage (%)**
V-P integration (=1 if integrate)	140	56	110	44
Gender (=1 if head of household is Male)	210	84	40	16
Marital status (=1 if HH head is married)	193	77.2	57	22.8
Off-farm income (=1 if access)	105	42	145	58
Access to credit (=1 if access)	52	20.8	198	79.2
Getting extension service (=1 if access)	169	67.6	81	32.4
Attending V-P training (=1 if attended)	120	48	130	52
Awareness of V-P benefits (=1 if aware)	229	91.6	21	8.4
Own poultry (=1 if own)	185	74	65	26
Bermi (=1 if the farmer is from Bermi)	50	20	200	80
Galapo (=1 if the farmer is from Galapo)	51	20.4	199	79.6
Matufa (=1 if the farmer is from Matufa)	50	20	200	80
Seloto (=1 if the farmer is from Seloto)	49	19.6	201	80.6
Shaurimoyo (=1 if from Shaurimoyo)	50	20	200	80

Source: Own calculation based on the survey data collected

5.4.1 Vegetable-poultry production characteristics

The dependent variable (vegetable-poultry integration) was a dummy variable that took the value of 1 if the household was integrating and 0 otherwise. The sample size of 250 farm households (see section 5.2) was considered of which 56% represented the households that are integrating vegetable-poultry production systems. The quantity of vegetables produced was reported in different local units, however, it was converted into kilogram using the conversion unit provided in the survey and was found to be 866.096 Kg on average. The land area allocated to vegetables averaged 0.0902 ha, giving an average yield of 9,399.95 Kg/ha. The number of poultry owned ranged between 0 and 200 whereby 74% of all households own at least one bird leading to an average flock size of around 9 birds per household.

5.4.2 Household characteristic variables

The household characteristic variables include a number of characteristics that are important in farming decision making. The survey indicates that 84% of households are male headed households and 77.2% of the head of the households are married with an average age of 47.4 years which ranges from 19 to 98 years. This implies that vegetable farming is attractive to both young and old. The education level of the head of household was measured as the number of years spent in formal schooling and ranges between 0 and 16 years with an average of 7 years, inferring that many farmers know to read and write since they attended at least the primary school which generally takes 7 years in Tanzania. The average household size is around 5 with a household dependency ratio of nearly 0.4.

5.4.3 Farm assets and resource ownership variables

Having an off-farm income is a dummy variable which took the value of 1 if any member of the household had income from wage/salary or any business activity during the survey period. The total sample household shows that 42% of household had an extra income that is not from farming activities. The amount of off-farm income earned as well as the total household income which is the amount the household possesses from all sources were reported in Tanzanian Shillings (Tsh[6]). The average off-farm income was Tsh 110,913.3 per household indicating that they are engaged

[6] Tsh (Tanzanian shilling) is the Tanzanian currency; 1USD= Tsh 2239.9 in December, 2017

in other income generating activities accounting close to a third of total household income (Tsh 346,464.1). The average households' farm land size is about 1.2 hectares which is small compared to the national average land holding of 2 hectares per household, an indication that land is scarce in Babati District.

5.4.4 Institutional and access related variables

All the institutional variables in this study were dummies that seek to know if farmers were getting extension services, participating into vegetable-poultry trainings and if they had access to farming credit. Extension facilities provide rural households with information on input and output markets as well as new farming technologies. This variable took the value 1 if the household was receiving any extension service. From the household sample, 67.6% of households are getting extension services from different organizations mainly WorldVeg and ILRI as well as village agricultural extensionists. This infers that these organizations and extensionists are contributing to community capacity building. For instance, close to half of the households (48%) attended vegetables-poultry trainings that were mostly organized by WorldVeg, IITA, and ILRI within the framework of Africa RISING project. From credit accessibility standpoint, the survey showed that only 20.8% of sample households had access to farming credits implying that either credit providers are probably few in the area or farmers do not meet the borrowing requirements set by lenders.

5.4.5 Farm characteristic and information variables

The average vegetable farm size is 0.0902 ha which is small compared to average land owned of about 1.2 ha. This means that, vegetable farming is not the main agricultural activity in Babati District. Awareness of the benefits of the vegetable-poultry integration variable attempted to establish if farmers knew the benefits derived from this farming approach. It was used as a dummy variable that took value 1 if farmers were aware of these benefits. Close to 91.6% of households were aware of different benefits of vegetable-poultry integration. The most common benefits were income generation, manure availability and improved food and nutritional security to the household. Despite such broad knowledge of the benefits, only 56% of the sample population are integrators. This implies that some other factors might be hindering the adoption of vegetable-poultry production systems.

5 RESULTS AND DISCUSSIONS

This chapter discusses the main findings of the research. It specifically looks at the characterization of integrators and non-integrators of vegetable-poultry, the profitability from vegetable-poultry integration as well as key integration determinants.

6.2 Characterization of integrators and non-integrators of vegetable-poultry production systems

The analysis of descriptive information is used to characterize vegetable-poultry integrators and non-integrators. The means of household's socio-economic and farm characteristic variables were used to compare integrators and non-integrators. The independent t-test was performed to test the difference in means of variables between integrators and non-integrators and their level of significance. Figure 3 below presents the main vegetables produced in the study area by both integrators and non-integrators.

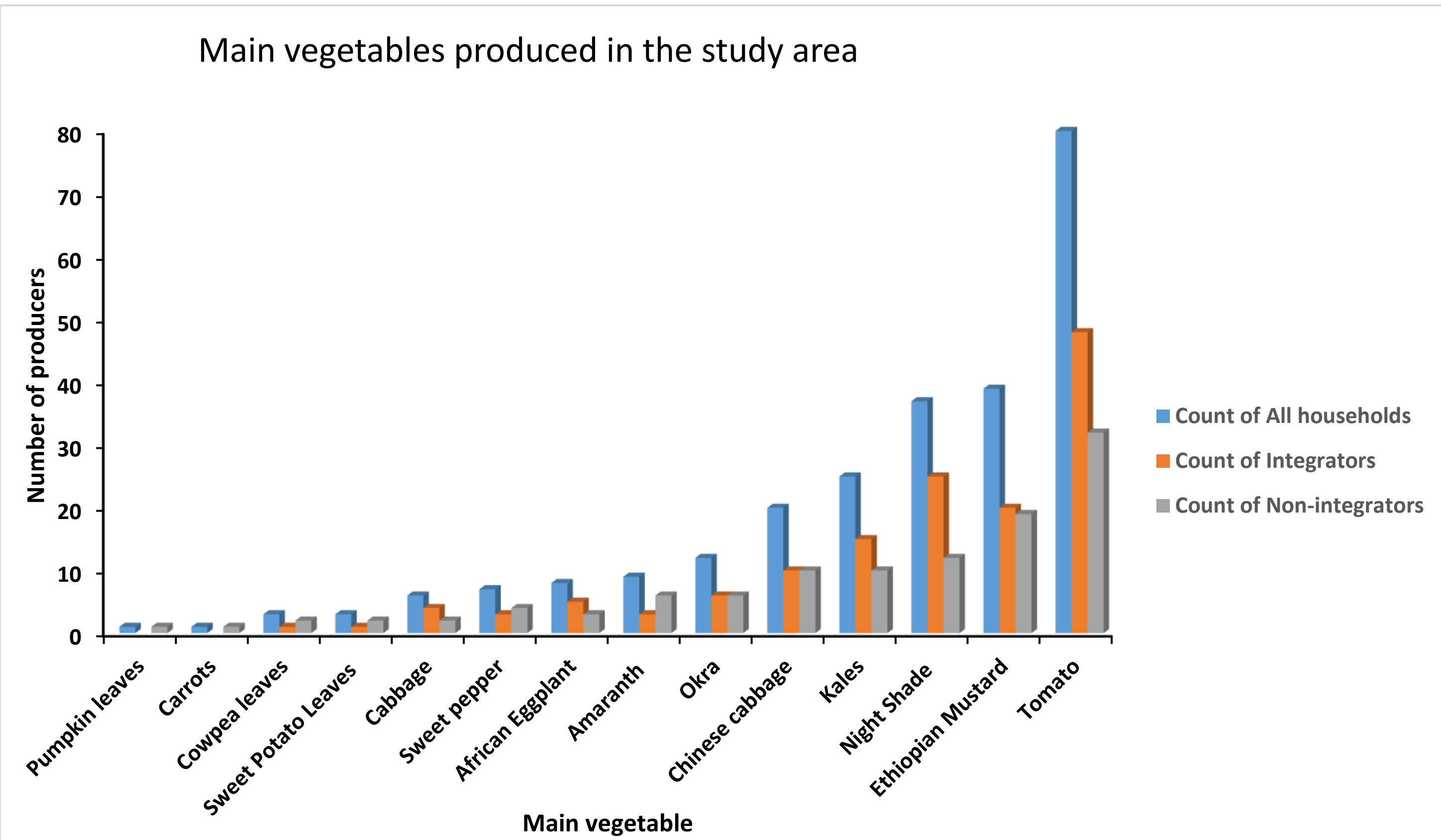

Figure 3. Main vegetables produced in Babati District by integration

Source: own calculation based on the data collected

There are 14 main types of vegetables produced in Babati District as seen in Figure 3. Most of these vegetables were produced for both household consumption and commercialization. Tomatoes were the most produced vegetables in the area followed by Ethiopian mustard, night shade, kales and Chinese cabbage respectively. The majority of farmers were engaged into tomato production probably due to their high profits generation and high consumption as they are ingredients in most of recipes. Integrators seem to produce tomatoes and night shade more than non-integrators while the latter dominate in amaranth and sweet pepper. However, based on unequal number of integrators and non-integrators, we cannot decide the specialization of each group or differences based on vegetables produced.

Table 4 displays the comparison of integrators and non-integrators based on their vegetable input use and vegetable productions. Table 5 presents their comparison based on profitability, access related, socio-economic and farm asset characteristics.

Table 4. Vegetable input use and production quantity by V-P integration (N=250)

Variables	**Non-integrators (1) (N=110)**		**Integrators (2) (N=140)**		**t-test (1-2)**
	Mean	**SD**	**Mean**	**SD**	
Vegetable farm size (ha)	0.092	0 .094	0.089	0.074	0.215
Seed cost (Tsh)	6357.445	8715.065	7008.421	9383.885	-0.562
Nursery management cost (Tsh)	7063.873	11237.240	8817.864	20324.340	-0.813
Compost quantity (Kg)	757.316	1500.923	927.856	2951.732	-0.459
Poultry manure quantity (Kg)	32.750	45.177	81.794	150.142	-0.643
Pesticide cost (in Tsh)	10778.790	11656.690	10374.510	12623	0.260
Total labor used (labor day)	19.148	17.891	24.153	20.548	-1.960 *
Production quantity (Kg)	827.738	1231.736	896.235	1354.147	-0.413
Yield (Kg/ha)	7903.232	7517.613	10575.940	13295.090	-1.885 *

Note: * denote the level of significance of difference in means at 10%

Source: own calculation based on the data collected

Means comparison based on vegetable inputs have shown no significant differences between integrators and non-integrators with the exception of labor input. Non-integrators have allocated

slightly higher land area to vegetable farming and are having higher pesticide costs than integrators. However, the t-test results show that their differences are not significant at any level. This is the same case for other input variables such as seed, nursery management costs, quantity of compost and poultry manure where the mean of integrators is higher than that of non-integrators though insignificant. The only input that shows a significant difference in means is labor employed in vegetable production. The total labor used in vegetable farming from sowing seeds to selling of harvests was reported in labor days. On average, the seasonal labor days of integrators were 24.05 which is higher than 19.15 of non-integrators and was significant at 10%; indicating that integrators are providing more employment opportunities than non-integrators.

The average quantity of vegetable harvested by integrators was about 896.2 Kg, which is higher compared to 827.7 Kg for non-integrator, though the difference was not significant. On the other side, integrators have a higher vegetable yield compared to non-integrators as they produce more on a smaller land area. On average, the seasonal vegetable production yield was close to 10,576 Kg and 7,903 Kg per hectare for integrators and non-integrators respectively and the difference is significant at 10% confidence level. This implies that, integrators would get more and significant returns than non-integrators if they were both farming vegetables at the same land scale.

Table 5. Characteristics of vegetable-poultry integrators and non-integrators (N=250)

Variables	**Non-integrators (1) (N=110)**		**Integrators (2) (N=140)**		**t-test (1-2)**
	Mean	**SD**	**Mean**	**SD**	
Gender of household head (dummy)	0.845	0.363	0.836	0.372	0.208
Marital status of HH head (dummy)	0.691	0.464	0.836	0.372	-2.739 ***
Household size (number)	4.745	2.304	5.571	1.855	-3.139 ***
Dependency ratio	0.364	0 .231	0 .423	0 .205	-2.131 **
Education of household head (years)	6.654	2.758	7.329	2.551	-2.001 **
Age of household head (years)	46.373	14.691	48.186	11.362	-1.101
Land owned (ha)	0 .916	0 .866	1.420	1.334	-3.436 ***
Off-farm income (dummy)	0 .464	0 .501	0 .386	0 .489	1.238
Total income (Tsh)	280,006.1	250113	398,681.2	398862.5	-2.727 **

Credit (dummy)	0.191	0 .395	0 .221	0.417	-0.588
Extension (dummy)	0 .6	0 .492	0 .736	0.442	-2.290 **
Attending V-P training (dummy)	0 .391	0 .491	0 .550	0 .499	-2.521 **
Awareness of V-P benefits	0 .854	0 .354	0 .964	0 .186	-3.154 ***

Note: *****, **, *** denote the level of significance of difference in means at 1%, 5%, 10% respectively.
Source: own calculation based on the data collected

From the above table, vegetable-poultry integrators are significantly distinguishable from non-integrators in terms of some household characteristics such as household size, dependency ratio, marital status and education level of household head. For instance, on average, integrators are married, have a bigger household size as well as a higher dependency ratio than non-integrators. The differences in marital status and household size are significant at 1% while dependency ratio differs at 5% significance level. Similarly, integrators' group is headed by a relatively educated household heads with a significant difference of 5% significance level. On average, integrators' household head has 7.3 years of formal schooling compared to 6.6 years of non-integrators. This may imply that households headed by educated farmer may have higher skills and better ability to access information that can positively influence vegetable-poultry integration.

Land holding and total income earned by farmers significantly distinguish integrators from non-integrators. For instance, the average land owned by integrators is 1.42 hectares compared to 0.916 hectares of non-integrators; a difference that is significant at 1% significance level. Moreover, integrators earn on average a total income of Tsh 398,681 which is significantly higher than that of non-integrators (Tsh 280,006) at 5% significance interval. Likewise, integrators' group is considerably distinct from non-integrators with respect to both attending vegetable-poultry trainings and access to extension programs and their mean differences are significant at 5% level. Around 55% of sample household integrators and 39.1% of non-integrators had attended at least one vegetable-poultry training. Likewise, integrators appear to get better access to extension services as 73.6% of them get these services compared to 60% of non-integrators. On the other hand, most of sample households seem to be aware of benefits from vegetable-poultry integration as 96.4% of integrators and 85.4% of non-integrators are aware of these benefits. Still, the means of benefits awareness differ significantly at 1% significance level.

Integrators are not significantly distinguishable from non-integrators based on the gender and age of the head of household. From the gender of the head of household standpoint, about 83.6% of integrators are headed by males compared to 84.5% of non-integrators. Also, the two groups are not significantly distinguishable based on whether they earn any income from off-farm activities or not as only 46.4% of non-integrators and 48.9% of integrators get off-farm income. The survey also revealed that farming credit accessibility is a challenge as only 22.1% of integrators and 19.1% of non-integrators have access to farming credit; an undistinguishable difference between the two groups. The main credit providers in the study area were microfinance institutions, co-operatives, SACCOs and informal money lenders. Farmers expressed various reasons of not accessing credit and all were related to high interest rate which was 10.6% per year on average together with lack of collaterals and fear of bankruptcy.

6.3 Profitability of vegetable-poultry integration

The Gross Margin (GM) analysis was used to calculate the profitability of vegetable-poultry integration. At first, the vegetable GM was computed for both integrators and non-integrators followed by poultry GM for integrators' group only, and lastly the vegetable-poultry integration GM was calculated and all were measured in Tanzanian Shilling (Tsh). In addition, the Net Income (NI) was also calculated to ascertain the profitability even when fixed costs are involved.

6.3.1 The profitability of vegetable production

The total variable cost (TVC) of vegetables was composed of a set of various cost components namely; seed and transplanting, nursery management, compost, poultry manure, fertilizer, pesticide, and labour costs. The highest costs incurred in vegetable production process are mostly labour, compost and pesticides costs. The poultry manure cost was the lowest incurred by non-integrators while integrators were using the self-produced poultry manure. From the results, as explained in Figure 4 below, there is no big difference in costs incurred by integrators and non-integrators, with the exception of the labour and compost costs whereby the former was found to be higher for integrators and the latter was higher for non-integrators.

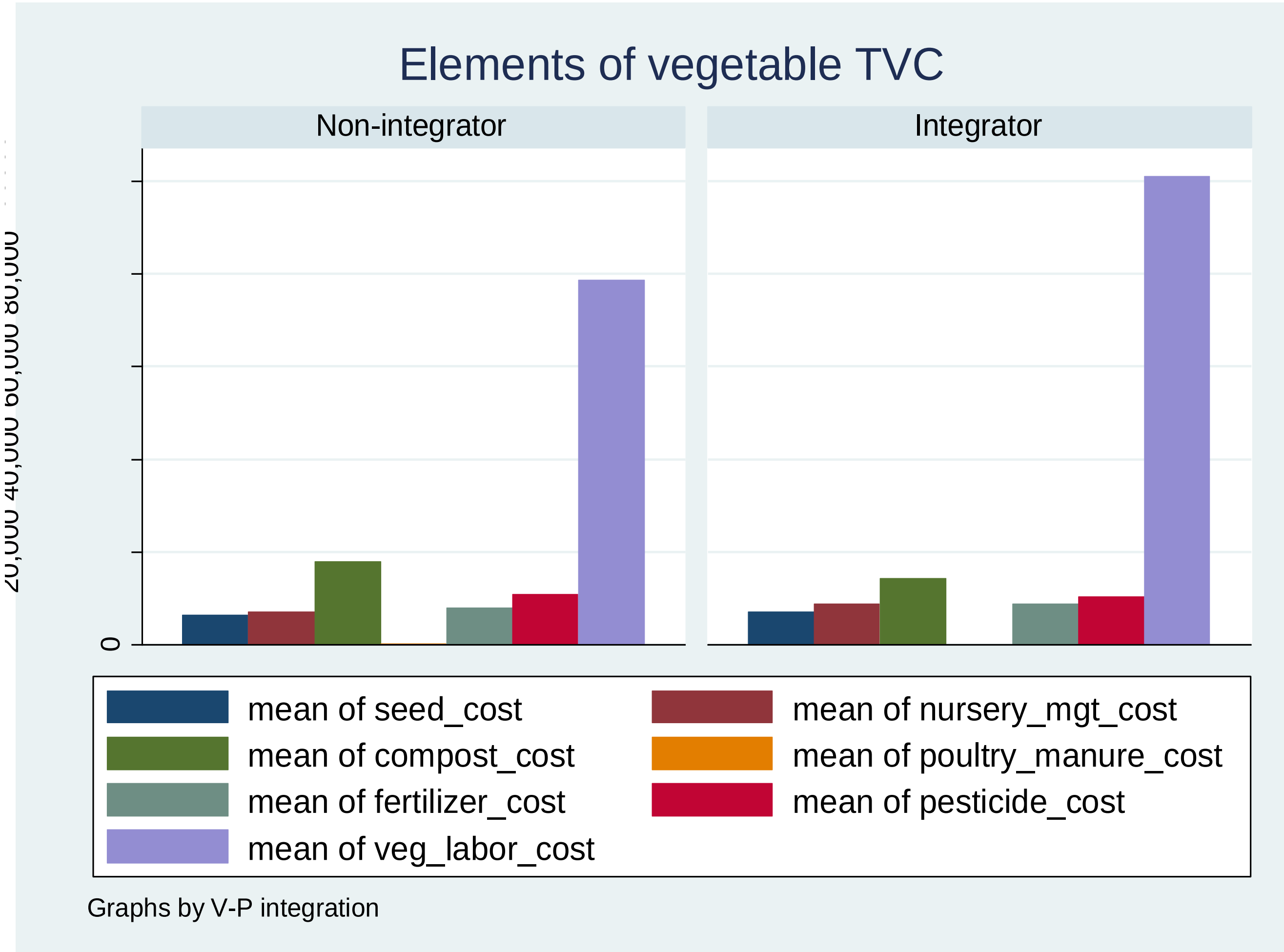

Figure 4. Elements of vegetable TVC by integration

Source: own calculation based on the data collected

The fixed cost comprised the cost of land allocated to vegetable farming which was estimated based on the farmers' reported cost of renting one hectare of land with water for irrigation. Vegetable total revenue was the income from selling vegetables. Table 6 presents the average costs and revenues of vegetable production for both vegetable-poultry integrators and non-integrators. The vegetable GM and NI were calculated per household (using the land area allocated to vegetables) and per hectare of vegetable farming for a season of six months.

Table 6. Average costs and revenues from vegetable production (N=250)

Variables (in Tsh)	Non-integrators (Mean)	Integrators (Mean)
Vegetable area (in hectares)	0 .0915	0 .0892
Total variable cost (TVC)	128,886.90	150,374.60
TVC/ha/season	2,976,474	2,887,161
Fixed cost (FC)	38,295.56	34,714.04
FC/ha/season	411,803	387,034.20
Total cost (TC)	167,182.50	185,088.60
TC/ha/season	3,388,277	3,274,195
Total revenue (TR)	456,352.90	478,201.20
TR/ha/season	3,934,881	4,851,837
Gross margin (GM)/season/household	327,466	327,826.60
GM/ha/season	958,406.80	1,964,676
Net Income (NI)/season/household	289,170.50	293,112.60
NI/ha/season	546,603.80	1,577,642

Source: own calculation based on the data collected

Vegetable TVC per household[7] was slightly higher for integrators (Tsh 150,374.6) compared to non-integrators (Tsh 128,886.9), however, the seasonal TVC per hectare (Tsh, 2,976,474) for non-integrators was comparatively higher than that of integrators (Tsh 2,887,161). Similarly, non-integrators had a higher fixed cost making them to incur a higher total cost per hectare than integrators. The seasonal total revenue (TR) that was computed as the product of vegetable price per kilogram and quantity of vegetable produced in kilograms was found to be Tsh 478,201 for integrators compared to Tsh 456,353 for non-integrators. Therefore, the difference in seasonal TR becomes bigger per hectare and increases proportionally according to the land area allocated to vegetables.

Given the above average total variable costs, fixed costs and average total revenues for vegetables, the seasonal GM per household was slightly higher for integrators than non-integrators. The vegetable GM per hectare is also higher for integrators (Tsh 1,964,676) compared to that of non-

[7] TVC per household was Calculated based on land each household allocated to vegetables

integrators (Tsh 958,407). Correspondingly, integrators enjoyed higher seasonal Net Income (NI) per hectare of Tsh 1,577,642 compared to Tsh 546,604 for non-integrators. Consequently, based on GM and NI results, vegetable production is beneficial for both groups, however, the average seasonal integrators' GM per hectare is more than that of non-integrators by about Tsh 1,006,269; implying that integrators are getting more benefits from vegetables than non-integrators.

6.3.2 Profitability of Poultry production

The profitability of poultry production was computed for integrators only by virtue of being the only group keeping poultry. The poultry total variable cost for this study comprised the costs of parent stock (initial chicks or chickens), feeds and feed preparation, medication and vaccinations, as well as labour costs. The highest poultry cost was the feeding cost which occupies about 60.6% of TVC followed by the parent stock cost (17%), medicine (13%) and labour costs (9.4%) respectively. These findings reaffirm findings in similar studies whereby the feed costs constitute the biggest proportion of the total cost of poultry production (Dutta et al., 2013; Ike & Ugwumba, 2011; Tijjani et al., 2012). This implies that feeding is very germane in any poultry production as it affects the poultry yield. Figure 5 displays the elements of TVC and the percentage share occupied by each cost in poultry TVC.

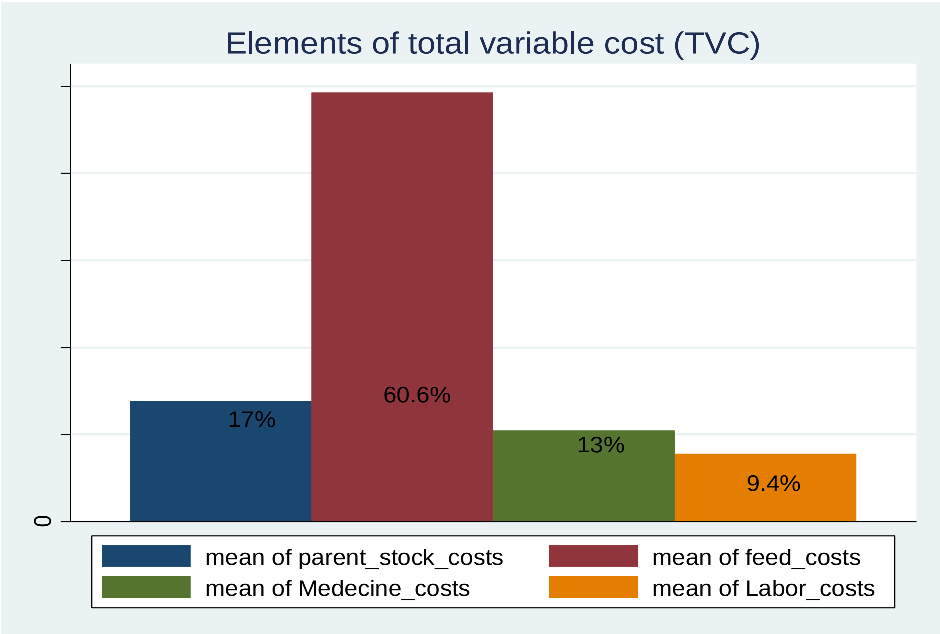

Figure 5. Share of each cost in poultry TVC

Source: own calculation based on the data collected

The fixed cost of poultry production is comprised of poultry housing depreciation cost that was calculated using the straight line depreciation method. This study applied the depreciation rate of 10% per annum on poultry housing, as previously used in different poultry studies to calculate the gross margin (Ayieko et al., 2014; Dutta et al., 2013; Matthews & Sumner, 2014). The poultry total revenue was computed by summing up the revenue from poultry and egg sales as well as the estimated cost of manure generated. Table 7 below presents the average costs and revenues of poultry production for vegetable-poultry integrators. All variables were calculated on a seasonal basis of six month period of time.

Table 7. Average costs and revenues of poultry production (N=140)

Variables (in Tsh)	**Integrators (Mean)**
Flock size (number)	15.75
Total variable cost (TVC)/season	72,592.46
TVC/bird/season	5,767.71
Fixed cost FC (10% Housing depreciation)/season	5,901.23
FC/bird/season	504.18
Total cost (TC) /season	78,493.70
TC/bird/season	6,271.89
Total revenue (TR) /season	188,482.90
TR/bird/season	15,272.36
Gross margin(GM) /season/household	115,890.50
GM/bird/season	9,504.66
Net Income (NI) /season/household	109,989.20

NI/bird/season	9,000.47

Source: own calculation based on the data collected

On average, an integrating household owns close to 16 birds and the seasonal poultry TVC is Tsh 72,592 indicating an average seasonal TVC per bird of Tsh 5,768. Furthermore, poultry seasonal FC amounts to Tsh 5,901 giving an average seasonal FC of Tsh 504 per bird. The average seasonal poultry TR is nearly Tsh 188,483 which means that an integrating household gets an average seasonal TR of Tsh 15,272 per bird. As a result, the seasonal poultry GM and NI per household are Tsh 115,890 and Tsh 109,989 respectively and one bird can generate a GM of Tsh 9,505 and a NI of Tsh 9,000 per season implying that poultry farming is profitable.

6.3.3 The profitability of integrated vegetable-poultry productions

The profitability of vegetable-poultry production systems was computed by summing up the GM from vegetable production and the GM from poultry production. This study calculated the vegetable-poultry GM for five different scenarios. The first scenario was the seasonal vegetable-poultry GM per household which was computed as a sum of seasonal vegetable GM per household and the seasonal poultry GM per household. In the second scenario, we computed the vegetable-poultry GM by summing up the vegetable GM per household and poultry GM from a flock size of 16 birds. The number of birds was chosen as the mean size of poultry owned by integrators in the study area. Scenario three was the sum of vegetable GM per household and poultry GM from flock size of 20 birds. This number was chosen based on TALIRI report that on average, households in Tanzania own between five to twenty flock size per household (TALIRI, 2015).

The fourth scenario presented the vegetable-poultry integration from vegetable GM per hectare and poultry GM from a flock size of 100 birds. In this scenario, the vegetable GM from one hectare was computed assuming equal land size allocated to vegetables by both groups and we performed different simulations to find the minimum number of birds (100) that can generate a significant difference in their GM. The last scenario presented vegetable-poultry GM per hectare and poultry GM from a flock size of 200 birds which was the maximum number of birds owned in the sample. In all the five scenarios, the t-test was used to test the significance in means of GMs' differences between integrators and non-integrators. See Table 8 below.

Table 8. Profitability of V-P integration (N=250)

Variables (in Tsh)	Non-integrators (1) N=110	Integrators (2) N=140	t-test (1-2)
V-P GM per household (scenario 1)	327,466	443,717.1	-1.139
V-P GM per household/16 birds (scenario 2)	327,466	479,901.1	-1.482
V-P GM per household/20 birds (scenario 3)	327,466	517,919.7	-1.832 *
V-P GM per hectare/100 birds (scenario 4)	958,406.8	2,915,142	-1.923 *
V-P GM per hectare/200 birds (scenario 5)	958,406.8	3,865,607	-2.804 ***

Note: *****, *** denote the level of significance of difference in means at 1% and 10% respectively
Source: own calculation based on the data collected

In all the five scenarios above, integrators have higher GM compared to non-integrators. This was expected as integrators get extra revenue from the poultry aspect of integration that is not earned by non-integrators. However, it is important to note that, the GM differences between the two groups are significant in three of the five scenarios. Scenario 1 and 2 do not significantly distinguish the profits earned by households from both groups while Scenario 3 shows that the integrating households get higher GM and the difference is significant at 10% significance level. This implies that an integrating household with poultry flock size of 20 birds and above will significantly get higher profits in the study area since the profitability is proportional to the poultry flock size. Likewise, Scenarios 4 and 5 show that integrators can get much benefits as their GMs differences are significant at 10% and 1% significance levels respectively compared to non-integrators.

The results above arose the interest of seeking to know the minimum number of birds per household and per hectare that an integrating household should keep to get a significant difference in GM compared to non-integrator in the study area. We performed again different simulations and we found that, the threshold number of birds that an integrating household should keep to get a significant higher profit than non-integrator is 18 birds. Furthermore, 71 birds per hectare of land

allocated to vegetables should be kept by integrators to get the profit that is significantly higher than that of non-integrators (see Table A1 in Appendix). The vegetable GM per household together with poultry GM from 18 birds gave Tsh 327,466 for non-integrators and Tsh 498,910 for integrators and the difference was significant at 10% significant level. Similarly, the vegetable GM per hectare together with poultry GM from 71 birds generated Tsh 2,639,507 for integrators and Tsh 958,407 for non-integrators which are significantly different at 10% level.

6.4 Factors influencing the probability to integrate vegetable-poultry production systems

In this section, the results of binary logit model are discussed as delineated in chapter four. The estimated maximum likelihood results are presented in Table A2 in Appendix. The chi-squared test statistic of the model is significant at 1% level implying the combined significance of vegetable-poultry integration variables. Furthermore, the results show that household profiles such as the household size, the level of education of the head of the household, and marital status of the household head are related to higher probability of integration. Equally, ownership of land, total income, and awareness of benefits are also positively linked to vegetable-poultry integration. However, the gender of the head of household and having an off-harm income are negatively related to the probability of vegetable-poultry integration. All remaining explanatory variables are non-significant but have expected signs, apart from having access to credit and vegetable farm size which contrasted their hypothesized effects (see model specification in section 3.2).

Lastly, the quantitative impact of each factor that influence vegetable-poultry integration was determined by calculating the marginal effect of each explanatory variable on the probability of integrating vegetable-poultry. By using the margin command and delta method approach in stata, the coefficients of average marginal effects as well as the standard errors were estimated. The results of this model are shown in Table 9 below.

Table 9. Logit model - Factors influencing the probability of V-P integration in Babati District

Variables	**Marginal effects**	**Std.error**	**Z values**
Gender of household head (=1 if head of household is male)	-0.285 **	0.119	-2.390
Marital status of household head (=1 if married, 0 otherwise)	0.238 **	0.106	2.250
Household size (number)	0.027 *	0.015	1.790
Education level of household head (years)	0.019 *	0.011	1.670
Age of household head (years)	-0.001	0.003	-0.350
Land owned (ha)	0.092 ***	0.032	2.880
Off-farm income (=1 if the household gets off-farm income)	-0.163 ***	0.060	-2.730
Total income (Tsh)	2.66E-07 **	1.11E-07	2.39
Credit (=1 if access to credit)	-0.014	0.071	-0.20
Attending V-P training (=1 if attended V-P training)	0.077	0.062	1.230
Extension (=1 if access to extension services)	0.023	0.065	0.360
Awareness of V-P benefits (=1 if aware of V-P benefits)	0.237 **	0.109	2.180
Vegetable farm size (land size allocated to vegetables in ha)	-0.370	0.355	-1.040
Bermi (=1 if farmer is from Bermi)	0.053	0.095	0.560
Galapo (=1 if farmer is from Galapo)	-0.169 *	0.089	-1.890
Matufa (=1 if farmer is from Matufa)	-0.058	0.091	-0.640
Shaurimoyo (=1 if farmer is from Shaurimoyo)	0.083	0.095	0.870

Note: *****, **,*** denote the level of significance of difference in means at 1%, 5% and 10% respectively
Source: own calculation based on the data collected

The results show that the household characteristic variables that significantly influence the probability of integrating vegetable-poultry are gender, marital status, and education level of the household head and the household size. The gender of the head of the household is negatively related to the probability of integrating poultry into vegetable farming. The probability of integration decreases by 28.5% if the household is headed by a male ($p<0.05$). This is probably as a result of women being more involved into poultry activities than men since the poultry is regarded as the sector for women in developing countries. This finding is supported by previous studies by Bravo-Baumann (2000) and Devendra and Chantalakhana (2002) who established that poultry production is a field of women mostly in developing countries. Furthermore, Branckaert and Gueye (1999) assert that around 70% of poultry in SSA is owned by women.

The marital status of the head of the household was found to influence the vegetable-poultry integration as anticipated. The probability of integrating poultry into vegetables increases by 23.8% if the head of the household is married ($p<0.05$). The married farmers were more likely to integrate because of required quantity of food that is increased as a result of marriage. Namwata et al. (2010) and Voh et al. (2001) affirm the positive relationship of marriage and adoption of improved agricultural technologies in Tanzania and Nigeria.

Expectedly, "*ceteris paribus*", each additional household member increases the probability of integrating poultry into vegetables by 2.7% which is marginally significant at 10% significance level. This is most likely due to its effect on household food demand for consumption or availability of family labor; since vegetable-poultry integration may be one way to meet the increased food consumption or a result of increased labor force in the household. Likewise, the higher the level of education of farmers, the higher their capacity to process information and to adopt appropriate technologies to cope with farming constraints. This finding is consistent with earlier literatures which considered education as a substitute for access to information and placed the more educated farmers in a position to evaluate the importance of new technologies faster (Ghimire et al., 2015; Kassie et al., 2011; Schultz, 1975). The estimated marginal effects of this variable indicate that, an increase in formal education level by one year increases the probability of integrating vegetable-poultry by 1.9 % ($p<0.1$).

All farm assets and resource ownership variables were expected to influence the adoption of integrated vegetable-poultry production systems. However, the estimates show mixed results. For example, farmers who own a bigger land size are more likely to integrate vegetable-poultry than those who have smaller land. One hectare increases in land owned by the household in the study area increases the probability of integrating vegetable-poultry by 9.2% ($p<0.01$). This is arguably due to land demand for vegetable-poultry integration. Most rural farmers dedicate a large portion of their land to the production of staple food crops. Therefore, farmers with large areas of land can diversify their production by allocating an additional portion of the land to the integration of both farming systems, a choice that is not available to farmers who possess a small area of land (Kassie et al., 2011; Mariano et al., 2012; Mendola, 2007). This presents a serious challenge to vegetable-poultry integration promoters in Babati District for the reason that the majority of farm households are small scale farmers who hold an average of about 1.2 hectares of land.

Unexpectedly, this study reveals that having an off-farm income source negatively influenced the decision to integrate vegetable with poultry ($p<0.01$). The results show that, the probability of integrating vegetable with poultry decreases by 16.3% if the farmer has an off-farm income source. This is probably because most of off-farm income might have been spent on family purchases and other farming systems rather than on investment in vegetable-poultry integration. Furthermore, the availability of off-farm income may reduce the consideration (or value) that households give to vegetable-poultry integration as they rely on the other source of income. The main off-farm income generating activities in the study area were small businesses such as shops run by households' members in several village centers and at market places and salaries from regular jobs mostly primary teachers and nurses. Since these two activities require much time and may generate more income than vegetable-poultry integration, farmers may choose to concentrate and spend much of their time on them than being involved in integration. However, the total income that a given household gets is positively related to the vegetable-poultry integration ($p<0.05$) but with a very low marginal effect. This result is similar to previous findings by Franzel (1999) who asserted that farmers with high income are less risk averse and more likely to venture into new farming practices and they are in a position to meet the initial integration investment . Furthermore, Namwata et al. (2010) found that increased household income increases the likelihood of adopting new agricultural technology for Irish potatoes in Tanzania.

Awareness of vegetable-poultry integration benefits positively influenced the decision to adopt this integrated system ($p<0.05$). The likelihood of integrating poultry into vegetable increases nearly by 23.7% if the farmer is aware of the benefits derived from integration. This implies that, if households know that the benefits from integration are more than those from vegetable farming alone, they are more likely to integrate both farming systems. This is consistent with (Abara & Singh, 1993) who established that, small scale farmers are more likely to adopt new farming practices if returns from conventional and the alternative farming practices are significantly different.

Lastly, the households from Galapo village are less likely to integrate vegetable with poultry production compared to households from other villages. The probability of integrating vegetable-poultry decreases by 1.7% if the household is from Galapo village ($p<0.1$). This is partly due to the Newcastle disease known as “Kideri or Mdondo” in Swahili, which has no treatment once the chickens are infected. Many households in this village reported this disease as the main reason for not keeping poultry.

6 CONCLUSION AND POLICY IMPLICATIONS

Different studies show that, despite a high and an increasing demand for vegetables, most areas of Tanzania have been experiencing a low productivity, partly linked to unavailability or high price of quality seed, and lack of appropriate control measures. The combination of low productivity with high production costs such as labour, manure and chemical fertilizer costs, reduce the profitability of vegetable farming. Furthermore, previous studies have highlighted the role of poultry sector in Tanzanian economy and its potentials in improving the food security and enhancing the wellbeing of rural communities. However, they argued that if the sector is managed effectively its contribution to the national economy could be higher.

The low profitability underscores the need of practical innovative systems of production in order to increase yield and stimulate productivity of vegetables, serving as an indispensable mean to improve smallholder farmer’s livelihoods. Therefore, this study argued that integrating poultry into vegetable production may be one of such innovative systems that increase profitability of both farming systems. The proposed integration of poultry into vegetable production system under the Africa RISING is viewed as an alternative to the conventional farming system, through which poultry is integrated into vegetable farming with the aim of increasing their productivity and household consumption in the District of Babati.

This study used the gross margin analysis (GM) to calculate the profitability of integrated vegetable-poultry production systems in the Babati District of Tanzania. The study also employed the logit model to examine the factors influencing the decision to integrate vegetable-poultry production systems in the study area. The study was based on a cross-sectional data conducted in June 2017 covering households from five villages in Babati District. The total sample of 250 households out of which 140 were integrators and 110 non-integrators of vegetable-poultry production systems was used.

The results from descriptive analysis reveal that, integrators of vegetable-poultry production systems are differentiated to non-integrators in terms of land holding, education level and marital status of household head, extension services they get, total income, vegetable yield, and labor usage. Integrators have a bigger land size allowing them to diversify into different farming activities and are wealthier than non-integrators as their income is higher. Moreover, they are more

educated and get more vegetable-poultry related extension services than non-integrators which facilitate their access to information on new farming skills and practices. Integrators have greater vegetable yield implying that they are more efficient in vegetable production than non-integrators. Furthermore, the majority of integrators are married compared to non-integrators and are contributing more to unemployment reduction in the study area as they employ more people in the process of integrating vegetable-poultry production systems.

The gross GM results show that both vegetable and poultry farming systems are profitable when produced independently. Nonetheless, the profitability from an integration of both farming systems can be much higher compared to that of vegetable production alone due to resource cycling in the process of production. Based on GM per household, the study finds no significant differences in profits obtained by integrators and non-integrators due to small flock size owned by integrators (16 birds per household). However, after conducting different simulations, the study concluded that, if an integrating household would have at least a flock size of 18 birds, its profitability would be more significant than that of non-integrating household. In addition, this study also established that, the flock size of 71 birds integrated to one hectare of vegetable farming will produce the profits to integrators that are significantly higher than that of non-integrators. Based on the findings, the study therefore concludes that, integration of vegetable-poultry is more profitable than vegetable production alone, however, the flock size owned matters as the profitability increases depending on the flock size.

Further results reveal that, decision to adopt the integrated vegetable-poultry production system is influenced by education level of household head, indicating that educated famers are more likely to integrate as education is regarded as a proxy to information. Other factors which considerably influenced the decision to integrate vegetable-poultry production systems include gender and marital status of the household head, household size, land owned, total income, and awareness of benefits from integration. Female headed households are more likely to adopt vegetable-poultry integration system because poultry activities are mostly linked to females than males in developing countries. The study also finds that, households with off-farm income sources are less likely to integrate vegetables with poultry because they concentrate more on those off-farm income generating activities for their livelihood.

7.2 Policy implications

Table 10. Key findings and policy implications

Key findings	Policy implications
Vegetable-poultry farming is more profitable than vegetables only and profitability increases with the increase in the flock size.	• Promotion of the existing vegetable –poultry farming practices • Intensify poultry sector by increasing the number of birds/flock size • Decrease production costs through improved technology adoption such as good agricultural practices in vegetable farming.
Education increases integration	Promotion of informal education and capacity building and training through: • Farmer field schools • Farmer associations/groups • Community based organizations (CBOs).
Land holding increases integration	Using the available land efficiently through promotion of initiatives aiming at increasing productivity such as: • Availability and affordability of improved seed and poultry breed • Improved technology within the integration
More female household heads adopted V-P integration and made more profit margins.	• Give females more access to land and resources • Empower women so that they contribute in household decision making process • Support in creation of women cooperatives and groups through which they get trainings and capacity building
Households with off farm income access are less likely to adopt integration	• Improve technology and markets to make farming beneficial • Further research to understand how farmers invest their off-farm incomes into agriculture
Awareness of the benefits of V-P integration increases its adoption by farmers	• Provide more vegetable-poultry extension services and trainings to promote the practice.

Table 10 above summarizes the recommendations from the study findings. The study finds that vegetable-poultry integration is more profitable than vegetable farming alone and the profitability increases as the flock size increases. For smallholder farmers to make significant profits from vegetable-poultry production system, they should keep at least 18 chickens. Therefore, stakeholders should promote the existing production practices to enable the use of the available resources efficiently and intensify the poultry sector as the flock size determines the magnitude of profits. This will assist in reducing the cost of production, increasing yield, and consequently increased. The study recommends the promotion of farmers' education and capacity building through village community based organizations (CBOs), field schools, and cooperatives to improve their knowledge on new technologies that increase their profits. Given the present small land holding and the pressure on land due to population increase in Tanzania, the study suggests promotion of initiatives aiming at increasing farm productivity. The improved technology within integration together with availability and affordability of improved vegetable seeds and poultry breeds may play a role in increasing the output and produce the maximum possible in the available land.

Furthermore, the study suggests policy measures that empower women so that they can contribute to household decision making and get access to more land and other productive resources. Moreover, the creation and empowerment of women cooperatives and groups as well as providing more trainings that target women are needed. These will serve as capacity building which will increase their level of education and access to information. Since farmers do not reinvest off-farm incomes in vegetable-poultry production systems, there is a need to sensitize them to revert this behaviour and begin to invest such incomes in this integration. This can be achieved by transforming the agricultural system from subsistence to commercial through targeting farm technologies and improved markets which may attract more rural households into profit-oriented farm production. Consequently, this study recommends further research on rural technology adoption and input-output markets to ascertain the earning potentials of vegetable-poultry integration. Lastly, the study recommends the sensitization of the communities about the benefits of vegetable-poultry integration through trainings and more extension services.

REFERENCES

Abara, I. O., & Singh, S. (1993). Ethics and biases in technology adoption: The small-firm argument. *Technological Forecasting and Social Change, 43*(3-4), 289-300.

Abel, G. J., Barakat, B., Samir, K., & Lutz, W. (2016). Meeting the Sustainable Development Goals leads to lower world population growth. *Proceedings of the National Academy of Sciences, 113*(50), 14294-14299.

Adekiya, A., & Agbede, T. (2016). Effect of methods and time of poultry manure application on soil and leaf nutrient concentrations, growth and fruit yield of tomato (Lycopersicon esculentum Mill). *Journal of the Saudi Society of Agricultural Sciences*.

Afari-Sefa, V., Dagnoko, S., Endres, T., Tenkouano, A., Kumar, S., & Gniffke, P. A. (2012). Tools and approaches for vegetable cultivar and technology transfer in West Africa: A case study of new hot pepper variety dissemination in Mali. *Journal of Agricultural Extension and Rural Development, 4*(15), 410-416.

Aklilu, H., Almekinders, C., Udo, H., & Van der Zijpp, A. (2007). Village poultry consumption and marketing in relation to gender, religious festivals and market access. *Tropical Animal Health and Production, 39*(3), 165-177.

Akter, S., Islam, M., & Rahman, M. (2012). An economic analysis of winter vegetables production in some selected areas of Narsingdi district. *Journal of the Bangladesh Agricultural University, 9*(2), 241-246.

Akteruzzaman, M. (2006). Impact Evaluation of Fish Farmer Group under Greater Noakhali Aquaculture Extension Project (GNAEP). *Final Report, DANIDA Bangladesh*.

Akteruzzaman, M., Parvin, T., & Islam, S. (2012). Improvement of integrated farming systems for maximizing income and food security in Noakhali region.

Alam, M. R., Ali, M. A., Hossain, M. A., Molla, M., & Islam, F. (2009). Integrated approach of pond based farming systems for sustainable production and income generation. *Bangladesh Journal of Agricultural Research, 34*(4), 577-584.

Aldrich, J. H., & Nelson, F. D. (1984). *Linear probability, logit, and probit models* (Vol. 45): Sage.

Alene, A. D., Manyong, V., Omanya, G., Mignouna, H., Bokanga, M., & Odhiambo, G. (2008). Smallholder market participation under transactions costs: Maize supply and fertilizer demand in Kenya. *Food policy, 33*(4), 318-328.

Ali, A., & Abdulai, A. (2010). The adoption of genetically modified cotton and poverty reduction in Pakistan. *Journal of Agricultural Economics, 61*(1), 175-192.

Ali, M. (2000). Dynamics of vegetable production, distribution and consumption in Asia.

Ali, M. (2002). *The Vegetable Sector in Indochina Countries: Farm and household perspectives on poverty alleviation*: Asian vegetable research and development center (AVRDC). Asian regional center (ARC).

Ali, M., & Hau, V. T. B. (2001). *Vegetables in Bangladesh: economic and nutritional impact of new varieties and technologies*: Asian vegetable research and development center (AVRDC).

Alsagoff, S. A. K., Clonts, H. A., & Jolly, C. M. (1990). An integrated poultry, multi-species aquaculture for Malaysian rice farmers: a mixed integer programming approach. *Agricultural Systems, 32*(3), 207-231.

Alves, B. J., Madari, B. E., & Boddey, R. M. (2017). Integrated crop–livestock–forestry systems: prospects for a sustainable agricultural intensification: Springer.

Amos, T. (2006). Analysis of backyard poultry production in Ondo State, Nigeria. *International Journal of Poultry Science, 5*(3), 247-250.

Asfaw, S., Shiferaw, B., Simtowe, F., & Lipper, L. (2012). Impact of modern agricultural technologies on smallholder welfare: Evidence from Tanzania and Ethiopia. *Food policy, 37*(3), 283-295.

Assessment, M. E. (2005). Ecosystems and human well-being: wetlands and water. *World resources institute, Washington, DC, 5*.

Ayieko, D. M., Bett, E. K., & Kabuage, L. W. (2014). Profitability of Indigenous Chicken: The Case of Producers in Makueni County, Kenya. *Journal of Economics and Sustainable Development, 5*(11).

Baishya, A., Hazarika, J., Gogoi, B., Borah, M., Bora, A., Rajbongshi, A., . . . Hazarika, J. (2014). *Integrated Farming System–The Answer to Livelihood Security?* Paper presented at the Conference Organizing Committee.

Baulcombe, D., Crute, I., Davies, B., Dunwell, J., Gale, M., Jones, J., . . . Toulmin, C. (2009). *Reaping the benefits: science and the sustainable intensification of global agriculture*: The Royal Society.

Beattie, J., Crozier, A., & Duthie, G. G. (2005). Potential health benefits of berries. *Current Nutrition & Food Science, 1*(1), 71-86.

Bekunda, M. (2014). Research in Sustainable Intensification in the sub-humid maize-based cropping systems of Babati: Providing alternative integrated technologies to improve food security and income. From http://africa-rising.wikispaces.com/file/view/BabatiProposal2014-16(2).docx. Retrieved on 2nd March, 2017

Bekunda, M., Kihara, J., Kizito, F., Makumbi, D., Lukuyu, B., Beed, F., . . . Afari-Sefa. (2014). Research in Sustainable Intensification in the sub-humid maize-based cropping systems of Babati: Testing performance of integrated past year best-bet Component technologies. From https://africa-rising.wikispaces.com/file/view/Babati+workplan+Final+March+11.pdf. Retrieved on 2nd March 2017

Bellemare, M. F., & Barrett, C. B. (2006). An ordered Tobit model of market participation: Evidence from Kenya and Ethiopia. *American Journal of Agricultural Economics, 88*(2), 324-337.

Berg, H. (2002). Rice monoculture and integrated rice-fish farming in the Mekong Delta, Vietnam—economic and ecological considerations. *Ecological Economics, 41*(1), 95-107.

Bett, H. K., Peters, K.-J., Nwankwo, U., & Bokelmann, W. (2013). Estimating consumer preferences and willingness to pay for the underutilised indigenous chicken products. *Food policy, 41*, 218-225.

Bhuiya, M., Karim, M., & Hossain, S. (2016). Study on integrated farming systems model development. *Journal of the Bangladesh Agricultural University, 12*(2), 325-336.

Bowler, I. R. (1992). The industrialization of agriculture. *The geography of agriculture in developed market economies*, 7-31.

Branckaert, R., & Gueye, E. (1999). "FAO's programme for support to family poultry production." *the Proceedings of the Workshop on" Poultry as a Tool in Proverty Eradication and Promotion of Gender Equality".< http://www. husdyr. kvl. dk/htm/php/tune99/24_Branckaert. htm*. 1999.

Bravo-Baumann, H. (2000). *Gender and livestock: capitalisation of experiences on livestock projects and gender*: Direktion für Entwicklung und Zusammenarbeit DEZA.

Brentrup, F., Lammel, J., Plassmann, K., & Schroeder, D. (2016). Sustainability of Intensification of Smallholder Maize Production in Tanzania *Climate Change and Multi-Dimensional Sustainability in African Agriculture* (pp. 127-148): Springer.

Brundtland, G. H. (1987). *Report of the World Commission on environment and development:" our common future."*: United Nations.

Byerlee, D., Harrington, L., & Winkelmann, D. L. (1982). Farming systems research: Issues in research strategy and technology design. *American Journal of Agricultural Economics, 64*(5), 897-904.

Chagomoka, T., Unger, S., Drescher, A., Glaser, R., Marschner, B., & Schlesinger, J. (2016). Food coping strategies in northern Ghana. A socio-spatial analysis along the urban–rural continuum. *Agriculture & Food Security, 5*(1), 1.

Chand, R. (1996). Diversification through high value crops in western Himalayan region: evidence from Himachal Pradesh. *Indian Journal of Agricultural Economics, 51*(4), 652.

Chiappori, P.-A. (1997). Introducing household production in collective models of labor supply. *Journal of Political Economy, 105*(1), 191-209.

Chohin-Kuper, A., Kelly, V., & Mariko, D. (1999). Le maraîchage dans la zone de l'Office du Niger au Mali—Quelle évolution après la dévaluation du fcfa? *Bamako. May*.

Conan, A., Goutard, F. L., Sorn, S., & Vong, S. (2012). Biosecurity measures for backyard poultry in developing countries: a systematic review. *BMC veterinary research, 8*(1), 240.

Dalsgaard, J., & Oficial, R. (1997). A quantitative approach for assessing the productive performance and ecological contributions of smallholder farms. *Agricultural Systems, 55*(4), 503-533.

Dashora, L. N., & Singh, H. (2014). Integrated Farming System-Need of Today. *International Journal of Applied Life Sciences and Engineering (IJALSE), 1* (1), 28-37.

De Janvry, A., Dustan, A., & Sadoulet, E. (2010). Recent advances in impact analysis methods for ex-post impact assessments of agricultural technology: options for the CGIAR. *Unpublished working paper, University of California-Berkeley*.

De Janvry, A., Fafchamps, M., & Sadoulet, E. (1991). Peasant household behaviour with missing markets: some paradoxes explained. *The Economic Journal, 101*(409), 1400-1417.

Delgado, C. L., Rosegrant, M. W., & Meijer, S. (2001). *Livestock to 2020: The revolution continues.* Paper presented at the annual meetings of the International Agricultural Trade Research Consortium (IATRC), Auckland, New Zealand.

Dessie, T., Tadesse, M., Yami, A., & Peters, K. (2003). Village chicken production systems in Ethiopia: 1. Flock characteristics and performance.

Dessy, S., Ewoudou, J., & Ouellet, I. (2006). Understanding the persistent low performance of African Agriculture.

Devendra, C., & Chantalakhana, C. (2002). Animals, poor people and food insecurity: opportunities for improved livelihoods through efficient natural resource management. *Outlook on agriculture, 31*(3), 161-175.

Devendra, C., & Thomas, D. (2002). Crop–animal interactions in mixed farming systems in Asia. *Agricultural Systems, 71*(1), 27-40.

Dutta, R. K., Islam, M. S., & Kabir, M. A. (2013). Production performance of indigenous chicken (Gallus domesticus L.) in some selected Areas of Rajshahi, Bangladesh. *American Journal of Experimental Agriculture, 3*(2), 308.

El Titi, A. (1992). Integrated farming: an ecological farming approach in European agriculture. *Outlook on agriculture, 21*(1), 33-39.

Epprecht, M., Vinh, L., Otte, J., & Roland-Holst, D. (2007). Poultry and poverty in vietnam. *HPAI Research Brief*(1).

Etuah, S., Nurah, G. K., & Ohene-Yankyera, A. (2013). Profitability and Constraints of Broiler Production: Empirical Evidence from Ashanti Region of Ghana. *Journal of Business & Economics, 5*(2), 228.

Everaarts, A. P., de Putter, H., & Maerere, A. (2015). Profitability, labour input, fertilizer application and crop protection in vegetable production in the Arusha region, Tanzania: PPO AGV.

FAO. (2014a). *FAOSTAT* :Chickens and Ducks population in Tanzania. http://www.fao.org/faostat/en/#data/QA *Retrieved on 26th. Nov. 2017*.

FAO. (2014b). FAOSTAT: World Statistics of Chickens, Ducks, Turkeys and Pigeons. *http://www.fao.org/faostat/en/#data/QA, Retrieved on 26th Nov. 2017*.

FAO, IFAD, & WFP. (2014). The State of Food Insecurity in the World 2014: Strengthening the Enabling Environment for Food Security and Nutrition. *Food and Agricultural Organization of the United Nations, Rome.*

FAO, & WHO. (2005). *Fruit and vegetables for health: report of a Joint FAO/WHO Workshop, 1-3 September, 2004, Kobe, Japan.* Paper presented at the Fruit and vegetables for health: Report of a Joint FAO/WHO Workshop, 1-3 September, 2004, Kobe, Japan.

Feleke, S., & Zegeye, T. (2006). Adoption of improved maize varieties in Southern Ethiopia: Factors and strategy options. *Food policy, 31*(5), 442-457.

Folorunsho, O., & Onibi, G. (2005). *Assessment of the nutritional quality of eviscerated waste from selected chicken types.* Paper presented at the 2005. Proceedings of the 1st Annual Conference on Developments in Agriculture and Biological Sciences. 27th April.

Franzel, S. (1999). Socioeconomic factors affecting the adoption potential of improved tree fallows in Africa. *Agroforestry systems, 47*(1), 305-321.

Frei, M., & Becker, K. (2005). *Integrated rice-fish culture: Coupled production saves resources.* Paper presented at the Natural Resources Forum.

Galhena, D. H., Freed, R., & Maredia, K. M. (2013). Home gardens: a promising approach to enhance household food security and wellbeing. *Agriculture & Food Security, 2*(1), 8.

Ghimire, R., Wen-chi, H., & Shrestha, R. B. (2015). Factors affecting adoption of improved rice varieties among rural farm households in Central Nepal. *Rice Science, 22*(1), 35-43.

Gill, M., Singh, J., & Gangwar, K. (2009). Integrated farming system and agriculture sustainability. *Indian Journal of Agronomy, 54*(2), 128-139.

Godfray, H. C. J., Beddington, J. R., Crute, I. R., Haddad, L., Lawrence, D., Muir, J. F., . . . Toulmin, C. (2010). Food security: the challenge of feeding 9 billion people. *Science, 327*(5967), 812-818.

Goromela, E., Kwakkel, R., Verstegen, M., & Katule, A. (2007). Identification, characterisation and composition of scavengeable feed resources for rural poultry production in Central Tanzania. *African Journal of Agricultural Research, 2*(8), 380-393.

Guèye, E. (2000). The role of family poultry in poverty alleviation, food security and the promotion of gender equality in rural Africa. *Outlook on agriculture, 29*(2), 129-136.

Guèye, E. (2005). Gender aspects in family poultry management systems in developing countries. *World's Poultry Science Journal, 61*(01), 39-46.

Gupta, V., Rai, P. K., & Risam, K. (2012). Integrated crop-livestock farming systems: A strategy for resource conservation and environmental sustainability. *Indian Research Journal of Extension Education, Special Issue, 2*, 49-54.

Halwart, M., Bartley, D., Burlingame, B., Funge-Smith, S., & James, D. (2006). FAO Regional Technical Expert Workshop on aquatic biodiversity, its nutritional composition, and human consumption in rice-based systems. *Journal of Food Composition and Analysis, 19*(6), 752-755.

Hayami, Y., & Ruttan, V. W. (1971). *Agricultural development: an international perspective*: Baltimore, Md/London: The Johns Hopkins Press.

Herrero, M., Havlik, P., Valin, H., Notenbaert, A., Rufino, M., Thornton, P., . . . Obersteiner, M. (2013). Global livestock systems: biomass use, production, feed efficiencies and greenhouse gas emissions. *Proceedings of the National Academy of Sciences of the United States of America.(In review)*.

Herrero, M., Thornton, P. K., Notenbaert, A. M., Wood, S., Msangi, S., Freeman, H., . . . van de Steeg, J. (2010). Smart investments in sustainable food production: revisiting mixed crop-livestock systems. *Science, 327*(5967), 822-825.

Hochmuth, G., Hochmuth, R., & Mylavarapu, R. (2009). Using composted poultry manure (litter) in mulched vegetable production. *Teknik Rapor*.

Holland, J., Frampton, G., Cilgi, T., & Wratten, S. (1994). Arable acronyms analysed–a review of integrated arable farming systems research in Western Europe. *Annals of applied biology, 125*(2), 399-438.

Huong, P. T. T., Everaarts, A., Neeteson, J., & Struik, P. (2013). Vegetable production in the Red River Delta of Vietnam. I. Opportunities and constraints. *NJAS-Wageningen Journal of Life Sciences, 67*, 27-36.

IFSNAR. (2010). Integrated Food Security and Nutrition Assessment Report of the 2009/10 Main (Masika/Msimu) Season for the Market Year 2010/2011. From http://www.ipcinfo.org/fileadmin/user_upload/ipcinfo/docs/1_IPC_TZA_Nutrition%20Assessement_10_10_Report.pdf Retrieved on 26th Nov. 2017

IHSN. (2012). Tanzania: Population and Housing Census 2012. From http://catalog.ihsn.org/index.php/catalog/4618 Retrieved on 26th Nov. 2017

Ike, P., & Ugwumba, C. (2011). Profitability of small scale broiler production in Onitsha North local government area of Anambra State, Nigeria. *International Journal of Poultry Science, 10*(2), 106-109.

IPCC. (2014). *Climate Change 2014–Impacts, Adaptation and Vulnerability: Regional Aspects*: Cambridge University Press.

Joshi, P., Gulati, A., Birthal, P., & Tewari, L. (2003). Agricultural Diversification in South Asia: Patterns. *Determinants, and Policy Implications, Washington, DC: Food Policy Research Institute*.

Joshi, P., Joshi, L., & Birthal, P. S. (2006). Diversification and its impact on smallholders: Evidence from a study on vegetable production. *Agricultural Economics Research Review, 19*(2), 219-236.

Kamga, R. T., Kouamé, C., Atangana, A., Chagomoka, T., & Ndango, R. (2013). Nutritional evaluation of five African indigenous vegetables. *Journal of Horticultural Research, 21*(1), 99-106.

Kassie, M., Shiferaw, B., & Muricho, G. (2011). Agricultural technology, crop income, and poverty alleviation in Uganda. *World development, 39*(10), 1784-1795.

Key, N., Sadoulet, E., & Janvry, A. D. (2000). Transactions costs and agricultural household supply response. *American Journal of Agricultural Economics, 82*(2), 245-259.

Kitalyi, A. J. (1998). *Village chicken production systems in rural Africa: Household food security and gender issues*: Food & Agriculture Org.

Kohansal, M. R., & Firoozzare, A. (2013). Applying multinomial logit model for determining socio-economic factors affecting major choice of consumers in food purchasing: The case of Mashhad. *Journal of Agricultural Science and Technology, 15*, 1307-1317.

Kothari, C. R. (2004). *Research methodology: Methods and techniques*: New Age International.

Kuznets, S. (1966). Modern Economic GrowthYale University Press. *New Haven, CT*.

Larochelle, C., & Alwang, J. (2015). Explaining marketing strategies among Bolivian potato farmers. *Quarterly Journal of International Agriculture, 54*(3), 285-308.

Lazaro, V., Rajendran, S., Afari-Sefa, V., & Kazuzuru, B. (2017). Analysis of Good Agricultural Practices in an Integrated Maize-based Farming System. *International Journal of Vegetable Science*(just-accepted).

Lemaire, G., Franzluebbers, A., de Faccio Carvalho, P. C., & Dedieu, B. (2014). Integrated crop–livestock systems: Strategies to achieve synergy between agricultural production and environmental quality. *Agriculture, Ecosystems & Environment, 190*, 4-8.

Löfstrand, F. (2005). *Conservation agriculture in Babati District, Tanzania.* slu.

Lumpkin, T., Weinberger, K., & Moore, S. (2005). Increasing income through fruit and vegetable production opportunities and challenges.

Malone, G., Sims, T., & Gedamu, N. (1992). Quantity and quality of poultry manure produced under current management programs. Final report to the Delaware Department of Natural Resources and Environmental Control and Delmarva Poultry Industry, Inc., University of Delaware. *Research and Education Center, Georgetown, Delaware*.

Mangesho, W., Loina, R., Diyu, J., Urassa, V., & Lukuyu, B. A. (2013). Report of a feed assessment in Babati District, Tanzania.

Marble, A., & Fritschel, H. (2014). 2013 Global Food Policy Report, International Food Policy Research Institute. *2013 Global Food Policy Report, International Food Policy Research Institute.*

Mariano, M. J., Villano, R., & Fleming, E. (2012). Factors influencing farmers' adoption of modern rice technologies and good management practices in the Philippines. *Agricultural Systems, 110*, 41-53.

Martin, G., Moraine, M., Ryschawy, J., Magne, M.-A., Asai, M., Sarthou, J.-P., . . . Therond, O. (2016). Crop–livestock integration beyond the farm level: a review. *Agronomy for sustainable development, 36*(3), 53.

Marwa, L., Lukuyu, B., Mbaga, S., Mutayoba, S., & Bekunda, M. (2016). Characterization of local chicken production and management systems in Babati, Tanzania.

Masuku, M. B., & Xaba, B. (2013). Factors affecting the productivity and profitability of vegetables production in Swaziland. *Journal of Agricultural Studies, 1*(2), 37-52.

Matthews, W., & Sumner, D. (2014). Effects of housing system on the costs of commercial egg production. *Poultry science, 94*(3), 552-557.

Memon, A., Malah, M., Rajput, N., Memon, A., Leghari, I., & Soomro, A. (2009). Consumption and cooking patterns of chicken meat in Hyderabad district. *Pakistan Journal of Nutrition, 8*(4), 327-331.

Mendola, M. (2007). Agricultural technology adoption and poverty reduction: A propensity-score matching analysis for rural Bangladesh. *Food policy, 32*(3), 372-393.

Mengesha, M., Tamir, B., & Tadelle, D. (2008). Socio-economical contribution and labor allocation of village chicken production of Jamma district, South Wollo, Ethiopia. *Livestock Research for Rural Development, 20*(10), 2008.

Minga, U., Katule, A., Yongolo, M., & Mwanjala, T. (1996). *The rural chicken industry in Tanzania: Does it make economic sense?* Paper presented at the Proceedings of the 7 th Tanzania Veterinary Association Scientific Conference. Arusha International Conference Centre Dec 3.

Moraine, M., Duru, M., & Therond, O. (2017). A social-ecological framework for analyzing and designing integrated crop–livestock systems from farm to territory levels. *Renewable Agriculture and Food Systems, 32*(1), 43-56.

Morris, C., & Winter, M. (1999). Integrated farming systems: the third way for European agriculture? *Land Use Policy, 16*(4), 193-205.

Msami, H. (2000). *Studies on the structure and problems of family poultry production in Tanzania.* Paper presented at the Characteristics and parameters of family poultry production in Africa, Proceedings of the Research coordination meeting of IAEA, held in Morogoro, Tanzania in.

Msuya, E. E. (2008). Reconstructing agro-biotechnologies in Tanzania: smallholder farmers perspective. *Reconstructing biotechnologies*, 283.

Mutayoba, S., Katule, A., Minga, U., Mtambo, M., & Olsen, J. E. (2012). The effect of supplementation on the performance of free range local chickens in Tanzania. *Livestock Research for Rural Development, 24*(5).

Mwalusanya, N., Katule, A., Mutayoba, S., Mtambo, M., Olsen, J., & Minga, U. (2002). Productivity of local chickens under village management conditions. *Tropical Animal Health and Production, 34*(5), 405-416.

Mwaniki, A. (2006). Achieving food security in Africa: Challenges and issues. *UN Office of the Special Advisor on Africa (OSAA)* http://www. *un. org/africa/osaa/reports/Achieving% 20Food% 20Security% 20in% 20Africa-Challenges% 20and% 20Issues. pdf (Last accessed on May 9, 2010)*.

Namwata, B. M., Lwelamira, J., & Mzirai, O. (2010). Adoption of improved agricultural technologies for Irish potatoes (Solanum tuberosum) among farmers in Mbeya Rural district, Tanzania: A case of Ilungu ward. *Journal of Animal & Plant Sciences, 8*(1), 927-935.

Nath, S. K., De, H., & Mohapatra, B. (2016). Integrated farming system: is it a panacea for the resource-poor farm families of rainfed ecosystem? *Current Science, 110*(6), 969.

Ngunga, D., & Lukuyu, B. A. (2016). Report of a livestock feed assessment in Babati District, Tanzania. From https://cgspace.cgiar.org/bitstream/handle/10568/76496/AR_feast_babati_jul2016.pdf?sequence=1&isAllowed=y. Retrieved 2nd March, 2017

Nishimizu, M., & Page, J. M. (1982). Total factor productivity growth, technological progress and technical efficiency change: dimensions of productivity change in Yugoslavia, 1965-78. *The Economic Journal, 92*(368), 920-936.

NRC. (1984). *National Research Council : Nutrient requirements of poultry- Subcommittee on Poultry Nutrition*: National Academies.

NSCA. (2008). NATIONAL SAMPLE CENSUS OF AGRICULTURE. From http://www.kilimo.go.tz/uploads/Crops_National_Report_(2008).pdf. Retrieved on 26th Nov. 2017

Ochieng, J., Afari-Sefa, V., Karanja, D., Kessy, R., Rajendran, S., & Samali, S. (2017). How promoting consumption of traditional African vegetables affects household nutrition security in Tanzania. *Renewable Agriculture and Food Systems*, 1-11.

Ochieng, J., Owuor, G., & Bebe, B. O. (2012). Determinants of adoption of management interventions in indigenous chicken production in Kenya. *African Journal of Agricultural and Resource Economics, 7*(1), 39-50.

Odoemenem, I., & Otanwa, L. (2011). Economic analysis of cassava production in Benue State, Nigeria. *Current Research Journal of Social Sciences, 3*(5), 406-411.

Oladeebo, J., & Ambe-Lamidi, A. (2007). Profitability, input elasticities and economic efficiency of poultry production among youth farmers in Osun State, Nigeria. *International Journal of Poultry Science, 6*(12), 994-998.

Pant, J., Demaine, H., & Edwards, P. (2005). Bio-resource flow in integrated agriculture–aquaculture systems in a tropical monsoonal climate: a case study in Northeast Thailand. *Agricultural Systems, 83*(2), 203-219.

Paradkar, V., Tiwari, D., & Reddy, R. (2010). *Response of baby corn to integrated nutrient management in: Extend Summaries.* Paper presented at the XIX National symposium on Resource Management Approaches Towards Livelihood Security, organized by Indian Society of Agronomy at University of Agricultural Sciences Bengaluru India.

Pauw, K., & Thurlow, J. (2011). Agricultural growth, poverty, and nutrition in Tanzania. *Food policy, 36*(6), 795-804.

Pica-Ciamarra, U., & Dhawan, M. (2009). A Rapid Rural Appraisal of the Family-Based Poultry Distribution Scheme of West Bengal, India. *Pro-Poor Livestock Policy Initiative (PPLPI) Research Report (FAO)*.

POGRBC. (1999). Your Guide to World of Chickens: Using Your Chickens' Manure as Vegetable Garden Fertilizer. http://poultryone.com/gardens-and-misc/chickenmanure-html. Retrieved on 6th June 2017

Prein, M. (2002). Integration of aquaculture into crop–animal systems in Asia. *Agricultural Systems, 71*(1), 127-146.

Rajendran, S., Afari-Sefa, V., Karanja, D. K., Musebe, R., Romney, D., Makaranga, M. A., . . . Kessy, R. F. (2015). Technical efficiency of traditional African vegetable production: A case study of smallholders in Tanzania. *Journal of Development and Agricultural Economics, 7*(3), 92-99.

Rajendran, S., Kimenye, L. N., & McEwan, M. (2017). Strategies for the development of the sweetpotato early generation seed sector in eastern and southern Africa. *Open Agriculture, 2*(1), 236-243.

Ramrao, W., Tiwari, S., & Singh, P. (2006). Crop-livestock integrated farming system for the Marginal farmers in rain fed regions of Chhattisgarh in Central India. *Livestock Research for Rural Development, 18*(7), 23-30.

Robinson, T. P., Thornton, P. K., Franceschini, G., Kruska, R., Chiozza, F., Notenbaert, A. M. O., . . . Fritz, S. (2011). *Global livestock production systems*: FAO and ILRI.

Rose, R. M. (2015). The Impact of Climate Change on Human Security in the Sahel Region of Africa. *Donnish Journal of African Studies and Dev, 1*(2), 009-014.

Rosegrant, M. W., & Cline, S. A. (2003). Global food security: challenges and policies. *Science, 302*(5652), 1917-1919.

Sadoulet, E., & De Janvry, A. (1995). *Quantitative development policy analysis* (Vol. 5): Johns Hopkins University Press Baltimore.

Salami, A., Kamara, A. B., & Brixiova, Z. (2010). *Smallholder agriculture in East Africa: Trends, constraints and opportunities*: African Development Bank Tunis.

Schonfeldt, H. C., Pretorius, B., & Hall, N. (2013). The impact of animal source food products on human nutrition and health. *South African Journal of Animal Science, 43*(3), 394-412.

Schultz, T. W. (1964). Transforming traditional agriculture. *Transforming traditional agriculture.*

Schultz, T. W. (1975). The value of the ability to deal with disequilibria. *Journal of economic literature, 13*(3), 827-846.

Singh, I., Squire, L., & Strauss, J. (1986). *Agricultural household models: Extensions, applications, and policy*: The World Bank.

Siphandouang, P., Wu, M., & Sanatem, K. (2002). Lao PDR. *M. Ali, The vegetable sector in Indochina countries: farm and household perspectives on poverty alleviation. Technical Bulletin*(27), 75-109.

Smith, K., Fry, P., Shannon, P., & Groebner, D. (2005). Business Statistics: A Decision-making Approach. *JOURNAL-OPERATIONAL RESEARCH SOCIETY, 56*(11), 1347-1347.

Smyth, A., & Dumanski, J. (1993). *FESLM: An international framework for evaluating sustainable land management*: FAO Rome.

Sonaiya, E. (1990). *The context and prospects for development of smallholder rural poultry production in Africa.* Paper presented at the CTA-Seminar proceedings on smallholder rural poultry production.

Sonaiya, E. (2007). Family poultry, food security and the impact of HPAI. *World's Poultry Science Journal, 63*(1), 132-138.

Swidiq, M., Mary, K. J., John, K., & Emmanuel, Z. (2011). A cost-benefit analysis for utilization of poultry manure in cabbage production among smallholder crop-livestock farmers.

TALIRI. (2015). The Role of Chicken in the Tanzanian Economy and Opportunities for Development: An Overview. *First ACGG Tanzania Innovation Platform Meeting,*.

TDHS-MIS. (2016). Tanzania Demographic and Health Survey and Malaria Indicator Survey (TDHS-MIS) 2015-16. From https://www.dhsprogram.com/pubs/pdf/SR233/SR233.pdf . Retrieved on 13th June, 2017,

Thorne, P. (1998). Crop–Livestock Interactions. A Review of Opportunities for Developing Integrated Models. *Consultant's Report, Systems Analysis and Impact Assessment Project. Nairobi, Kenya: International Livestock Research Institute*.

Thornton, P. K., & Herrero, M. (2015). Adapting to climate change in the mixed crop and livestock farming systems in sub-Saharan Africa. *Nature Climate Change, 5*(9), 830-836.

Tijjani, H., Tijani, B., Tijjani, A., & Sadiq, M. (2012). Economic analysis of poultry egg production in Maiduguri and environs of Borno State, Nigeria. *Scholarly Journal of Agricultural Science, 2*(12), 319-324.

TNNS. (2014). Tanzania National Nutrition Survey 2014. From https://www.unicef.org/esaro/Tanzania_National_Nutrition_Survey_2014_Final_Report_18012015.pdf Retrieved 13th June, 2017,

Van Marle-Köster, E., Hefer, C., Nel, L., & Groenen, M. (2008). Genetic diversity and population structure of locally adapted South African chicken lines: Implications for conservation. *South African Journal of Animal Science, 38*(4), 271-281.

Verbeek, M. (2008). *A guide to modern econometrics*: John Wiley & Sons.

Verbeek, M., & Leuven, K. (2000). Tilburg University. 2000. A Guide to Modern Econometrics: John Wiley & Sons Ltd., Chichester.

Voh, J., Ahmed, B., Olufajo, S., Dike, M., & Ishaku, F. (2001). Adoption of improved cowpea technologies in the savanna ecology of Nigeria. A report of survey conducted on PEDUNE/PRONAF project in Nigeria by Institute for Agricultural Research, Ahmadu Bello University Samaru. *Zaria, Nigeria*.

Von Grebmer, K., Bernstein, J., Nabarro, D., Prasai, N., Amin, S., Yohannes, Y., . . . Thompson, J. (2016). *2016 Global hunger index: Getting to zero hunger*: Intl Food Policy Res Inst.

WB. (2007). *World development report 2008: Agriculture for development*: World Bank.

WB. (2008). The growth report: Strategies for sustained growth and inclusive development. *Commission on Growth and Development Final Report, Washington, DC*.

WB. (2013). Livestock Data Innovation in Africa: The Tanzania National Sample Census of Agriculture 2007/2008 - A Livestock Perspective. From http://documents.worldbank.org/curated/en/427941468312037830/pdf/864090BRI0Issu00Box385180B00PUBLIC0.pdf, *Retrieved on 26th Nov. 2017*.

WB. (2014). Employment in agriculture (% of total employment): International Labour Organization, Key Indicators of the Labour Market database. From http://data.worldbank.org/indicator/SL.AGR.EMPL.ZS?locations=TZ. *Retrieved on 26th Nov. 2017*.

WB. (2015). Agriculture, value added (% of GDP): World Bank national accounts data, and OECD National Accounts data files.

Weinberger, K. (2004). *Indigenous vegetables in Tanzania: Significance and prospects* (Vol. 600): AVRDC-WorldVegetableCenter.

Weinberger, K., & Lumpkin, T. A. (2007). Diversification into horticulture and poverty reduction: a research agenda. *World development, 35*(8), 1464-1480.

Weinberger, K. M., & Lumpkin, T. A. (2005). Horticulture for poverty alleviation-the unfunded revolution.

Zootechnica. (2016). The poultry sector in Tanzania. From http://zootecnicainternational.com/news/poultry-sector-tanzania/ *Retrieved on 26th Nov. 2017*

APPENDIX

Table 11. Profitability of V-P integration (N=250)

Variables (in Tsh)	**Non-integrators (1) N=110**	**Integrators (2) N=140**	**t-test (1-2)**
V-P GM per household	327,466	443,717.1	-1.139
V-P GM per household/16 birds	327,466	479,901.1	-1.482
V-P GM per household/17 birds	327,466	489,405.8	-1.5701
V-P GM per household/18 birds	327,466	498,910.4	-1.658 *
V-P GM per household/19 birds	327,466	508,415.1	-1.7452 *
V-P GM per household/20 birds	327,466	517,919.7	-1.832 *
V-P GM/hectare/70 birds	958,407	2,630,002	-1.6476
V-P GM/hectare/71 birds	958,407	2,639,507	-1.6568 *

Note: * denote the level of significance of difference in means at 10%

Source: own calculation based on the data collected

Table 12. Maximum likelihood estimates of logit model for V-P integration

Variables	Coefficients	Std.error
Gender of household head (=1 if head of household is male)	-1.509 **	0.653
Marital status of household head (=1 if married and 0 otherwise)	1.257 **	0.577
Household size (number)	0.143 *	0.081
Education level of household head (years)	0.101	0.062
Age of household head (years)	-0.005	0.014
Land owned (ha)	0.488 ***	0.178
Off-farm income (=1 if the household gets off-farm income)	-0.864 **	0.333
Total income (Tsh)	1.41E-06 **	6.11E-07
Credit (=1 if access to credit)	-0.075	0.375
Attending V-P training (=1 if attended V-P training)	0.406	0.334
Extension (=1 if access to extension services)	0.123	0.347
Awareness of V-P benefits (=1 if aware of V-P integration benefits)	1.256 **	0.595
Vegetable farm size (ha)	-1.956	1.894
Bermi (=1 if the farmer is from Bermi)	0.279	0.504
Galapo (=1 if the farmer is from Galapo)	-0.895 *	0.485
Matufa (=1 if the farmer is from Matufa)	-0.308	0.482
Shaurimoyo (=1 if the farmer is from Shaurimoyo)	0.437	0.507

Constant	-2.435	1.123
Number of observation	250	
χ2	0.0000	
Pseaudo- R^2	0.1899	
Log likelihood	-138.91573	

Note: *****, **,*** denote the level of significance of difference in means at 1%, 5% and 10% respectively
Source: own calculation based on the data collected

PERSONAL DECLARATION

I hereby affirm that I have prepared the present paper self-dependently, and without the use of any other tools, than the ones indicated. All parts of the text, having been taken over verbatim or analogously from published or not published scripts, are indicated as such. The thesis hasn't yet been submitted in the same or similar form, or in extracts within the context of another examination.

Bonn, 13th February 2018

____

Student's signature