LINK BETWEEN FARM ENTERPRISE DIVERSITY AND DIETARY QUALITY AMONG SMALL-SCALE FARMERS HOUSEHOLDS IN MAKUENI AND NYANDO SUB-COUNTIES, KENYA

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A Thesis Submitted to the Graduate School in Partial Fulfillment of the Requirements for the Master of Science Degree in Agricultural Economics of Egerton University

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DECLARATION AND RECOMMENDATION

Declaration

I declare that this thesis is my original work and it has not been submitted in this or any other University for the award of a degree.

Signature ____  _____ Date _____11/05/2021_____

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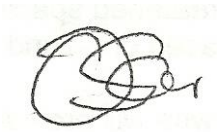
Recommendation

This thesis has been submitted with our recommendation as University Supervisors.

Signature _____  Date _____11/05/2021_____

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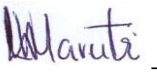
Signature: _  _____ Date: 11.05.2021_____

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DEDICATION

This thesis is dedicated to my parents Mr. and Mrs. Lucas Kiptoo, my husband Rodgers Kiptoo, my two daughters Delaney and Debra and my siblings.

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ABSTRACT

Majority of rural dwellers are small-scale farmers who depend directly on agriculture for their livelihoods, food and nutrition security. However, the diets consumed by small-scale farmers' households are of poor quality contributing to inadequate nutrient intakes. This contributes to increased incidences of malnutrition and morbidity especially among the vulnerable members of small-scale farmers' households. Farm enterprise diversity could help small-scale farmers to access diverse plant and animal source foods. This study sought to investigate the link between farm enterprise diversity and household dietary quality in Makueni and Nyando Sub-Counties. This study used secondary data generated from larger project survey conducted by the International Livestock Research Institute (ILRI) in partnership with Climate Change, Agriculture and Food Security Research Program (CCAFS). The survey was conducted in the months of October, November and December 2016 and targeted a total of 320 small-scale farmers' households. Data was collected using semi-structured questionnaires, was cleaned and analyzed using STATA 14. Descriptive statistics, Ordered Logit and Poisson models were employed during analysis. Simpson's Index and crop and livestock count were used to measure farm enterprise diversity. Household dietary quality was assessed based on 12 food groups recommended by Food and Agricultural Organization (FAO). The findings showed that the mean Simpson's Index was higher in Makueni (0.5±0.2) compared to Nyando (0.4±0.2) at 5% significance level. Farm enterprise diversity was positively influenced by age and education of the household head, land tenure, land size, slope of the land, access to irrigation, number of trainings attended and number of groups household members were engaged in. However, farm enterprise diversity was negatively influenced by access to aid. Overall, mean HDD was 7.0± 1.3 with no significant difference between households in Makueni (6.9±1.3) and Nyando (7.1 ± 1.3). Nearly all households (99.4%), consumed cereals followed by spices, condiments and beverages (95.9%), oils and fats (95.9%) and vegetables (95.3%). Except for milk and milk products which was consumed by 83.1% of households, consumption of other animal source foods including meats (12.5%), eggs (6.9%) and fish (11.0%) was notably low among the households. Farm enterprise diversity measure using crop and livestock count had a positive significant effect on household dietary quality at 5% significance level. Therefore, there is need for farmers to be sensitized to not only plant diverse crops and rear livestock species but to also consume them for good health and nutrition.

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LIST OF ABBREVIATIONS AND ACRONYMS

ASAL	Arid and Semi-Arid Land
CCAFS	Climate Change, Agriculture and Food Security Research Program
CLC	Crop and Livestock Count
DDS	Dietary Diversity Score
DFID	UK Department for International Development
FANTA	Food and Nutrition Technical Assistance
FAO	Food and Agricultural Organization of the United Nations
FEWS NET	Famine Early Warning Systems Network
GDP	Gross Domestic Product
GHG	Green House Gas
GOK	Government of Kenya
HDD	Household Dietary Diversity
HDDS	Household Dietary Diversity Score
ICF	International Classification for Functioning Disability
IDDS	Individual Dietary Diversity Score
IFAD	International Fund for Agricultural Development
ILRI	International Livestock Research Institute
KNBS	Kenya National Bureau of Statistics
NACOSTI	National Commission for Science, Technology and Innovation
NGOs	Non-Governmental Organizations
ODK	Open Data Kit
OLS	Ordinary Least Squares
RHoMIS	Rural Household Multi-Indicator Survey
SDGs	Sustainable Development Goals
SSA	Sub-Saharan Africa
STATA	Statistics and Data
UN	United Nations
UNICEF	United Nations Children's Emergency Fund
VIF	Variance Inflation Factor
WFP	World Food Program
WHO	World Health Organization

CHAPTER ONE
INTRODUCTION

1.1 Background information

Agriculture plays an important role in the economies of Sub-Saharan Africa Countries where majority of the population reside in rural areas (62.1%), with those employed in the agricultural sector accounting for an estimated 57.9% (Gero & Egbendewe, 2020). In Kenya, agriculture contributes to 34.1% of the total Gross Domestic Product (GDP) and 14.4% of the total private sector wage employment (KNBS, 2020). Small-scale farmers play a very vital role in the agricultural sector. Kamara *et al*. (2019) posited that the level of development in agriculture largely depends on agricultural productivity of small scale farmers. In addition, smallholder farmers in Kenya with average land sizes between 0.2 to 3 ha are the source of more than 70% of country's total agricultural produce (Kamau *et al*., 2018).

Generally, diets consumed by households from low income countries are less diverse since they are based mainly on starchy staples and lack nutrient dense foods like animal-source foods, fruits and vegetables (Jones *et al*., 2014). Furthermore, an estimated12% of Kenyan households consume unacceptable diets (WFP, 2016). This consumption of diets that lack diversity is one of the factors that contributes to the burden of malnutrition among the vulnerable members of the household. Malnutrition includes chronic under nutrition, micronutrient deficiencies and now the emerging problem of overweight and obesity. On the other hand, hunger is rising in almost all parts of Africa with the incidence of undernutrition almost at 20% which is considered the highest compared to other regions in the world (FAO, IFAD, UNICEF, WFP & WHO, 2019). The global burden of malnutrition remains to be great and an increasing number of people are being exposed to it at different points in life due to the rapid nature of nutrition transition (Nordhagen *et al*., 2019; Wells *et al*., 2020). Overweight and its related complications are rising at a higher rate even in middle and low income countries (Popkin, 2014). Globally, approximately 149 million children under the age of 5 are stunted, over 40 million wasted, nearly 17 million severely wasted and over 40 million overweight (UNICEF, WHO & World Bank group, 2019). Additionally, the global prevalence of anemia is at 32.8%, 9.7% among women aged between 20 and 49 years and 5.7% of girls between 15 and 19 years are underweight (Fanzo *et al*., 2018). Finding from the same report shows that, women have a higher prevalence of obesity at 15.1% compared to men (11.1%).

Malnutrition characterized by stunting, wasting, underweight and micronutrient deficiencies are still problems of public health concern in Kenya (Wagah *et al*., 2015). Malnutrition which is estimated at 50%, is also the single greatest underlying cause of child mortality in Kenya (GoK, 2017). According to the 2014 Kenya Demographic and Health Survey (KDHS), the prevalence of stunting, wasting, underweight and overweight among children under the age of 5 years was at 26%, 11% and 4% , respectively (KNBS & ICF Macro, 2015). Findings from the same report indicated that the prevalence of overweight/obesity and underweight among women between the ages of 15 to 49 in Kenya was at 33% and 9%, respectively. Rural areas are the most affected with the problem of malnutrition with 29.1% of children in the countryside being malnourished compared to 19.8% of those in the urban areas (WFP, 2016).

Micronutrient deficiencies are also a major problem in Kenya. Estimates from the Kenya National Micronutrient Survey conducted in 2011 showed that the highest incidence of anaemia (41.6%), iron deficiency (36.1%) and iron deficiency anaemia (26%) was in pregnant women (GoK, 2011a). Iodine deficiency prevalence was at 22.1% among school-age children and 25.6% among non-pregnant women and Vitamin A deficiency was at 4.1% for the combined sub-groups studied. Findings from the same report indicated that folate deficiency was at (32.1% vs. 30.9%) in pregnant and non-pregnant women respectively and vitamin B12 deficiency was at (7.7% vs. 34.7%) in pregnant and non-pregnant women respectively. Additionally, among all the population sub-groups, pre-school children had the highest incidence of zinc deficiency at 83.3%. The consequences of malnutrition are many and are well-documented (Fanzo, 2012; KNBS, 2015; Marshall *et al*., 2014; Muscaritoli *et al*., 2017; Vogliano *et al*., 2015).

Agriculture and nutrition are interconnected through provision of vital micronutrients to smallholder households (Bagnall-Oakeley *et al*., 2014; Yosef *et al*., 2015). Farm enterprise diversity is seen as one of the interventions in agriculture that can help small-scale farmers' households to access diverse foods. Moreover, agriculture has an impact on the quality of foods consumed by smallholder farmers through production and consumption of their own produce and through the sale of surplus produce to enable them purchase a variety of other foods not produced on the farms (World Bank, 2007). Nutrition-sensitive agriculture aims at improving agricultural systems to supply nutritious foods for the people who require them (Nordhagen *et al*., 2019).

There are four major pathways from agriculture to nutrition; subsistence production, income from agriculture, women empowerment and food prices. According to Pandey *et al*. (2016), studies that have majored on interventions in agriculture to promote production of foods rich in micronutrients for example using farm enterprise diversification reported a positive effect on dietary quality and intake of micronutrients. Rural households' decision about farm diversity and what to produce, eat, sell and buy from the market greatly influences their dietary diversity (Bellon *et al*., 2016). In addition, farm diversity has the capability to influence a household's dietary diversity hence nutritional status of individuals through income from sale of crops and food purchases and through subsistence farming (Jones *et al*., 2014). Sibhatu and Matin (2016) suggested that since farm households typically consume what they produce, production diversity could result in consumption of diverse diets thereby leading to improved dietary quality through the subsistence pathway. In Kenya, there has been some progress in promoting production of foods rich in nutrients and consumption of a variety of foods (Wagah *et al*., 2015).

Makueni and Nyando Sub-Counties were CCAFS project sites which aimed to improve farmers' access to climate information and use it in their production decisions with the hope that it will have an impact on their food and nutrition security. Most of the evaluation reports that have been done in the CCAFS project sites have ended up looking at the gender aspects of the project and how the use of the climate information on farm level decisions have impacted income and food security leaving out the nutrition aspect. This study focused on two low potential areas in Kenya, where farmers faced production risks which may have an impact on the quality of diets consumed by the small-scale farmers' households. Based on the foregoing, this study sought to address the gap on the role played by farm enterprise diversity in contributing to the quality of household diets in two low potential areas in Kenya. In addition, knowledge on farm enterprise diversity can help inform policy on how to improve quality of household diets among small–scale farmers in low potential areas.

1.2 Statement of the problem

Majority of rural dwellers are small-scale farmers who depend directly on agriculture for their livelihoods, food and nutrition security. However, the diets consumed in most of these households lack diversity as they are dominated by common starchy staples. As a result, there is inadequate intake of vital nutrients leading to the increased incidences of malnutrition and morbidity, especially among the vulnerable members in these small-scale farmers'

households. Agriculture interventions that promote farm enterprise diversity could go a long way in contributing to consumption of quality diets among small scale farmers' households. Farm enterprise diversity could help farmers to access a variety of crops and animal source foods that if well utilized could lead to consumption of quality diets. In addition, farm enterprise diversity could help in achieving food and nutrition security which is one of the big 4 agendas by the government of Kenya that seeks to increase large scale production of staple foods by the small-scale farmers. However, the link between farm enterprise diversity and household dietary quality is not clear in empirical literature. This study aimed at filling this gap among small-scale farmers in Makueni and Nyando Sub-Counties.

1.3 Objectives

1.3.1 General objective

The general objective of the study was to contribute to improved livelihood through enhanced farm enterprise diversity leading to household dietary quality among small-scale farmers in Makueni and Nyando Sub-Counties in Kenya.

1.3.2 Specific objectives

The specific objectives of the study were;

i) To determine farm and farmer characteristics by level of farm enterprise diversity among small-scale farmers in Makueni and Nyando Sub-Counties.
ii) To determine socio-economic and institutional factors influencing farm enterprise diversity among small- scale farmers in Makueni and Nyando Sub-Counties.
iii) To determine the link between farm enterprise diversity and household dietary quality among small-scale farmers in Makueni and Nyando Sub-Counties.

1.4 Research questions

i) What are the farm and farmer characteristics by level of farm enterprise diversity among small-scale farmers in Makueni and Nyando Sub-Counties?
ii) What socio-economic and institutional factors influence farm enterprise diversity among small-scale farmers in Makueni and Nyando Sub-Counties?
iii) What is the link between farm enterprise diversity and household dietary quality among small-scale farmers in Makueni and Nyando Sub-Counties?

1.5 Justification of the study

Good nutrition is important for the well-being of individuals as it promotes mental, social and physical well-being, leading to increased self-esteem and positive body image (WHO, 2006). According to Haddad *et al*. (2016), improved nutrition plays a key role in the sustainable development of countries since it leads to development in education, health, women empowerment, employment and reduction in inequality and poverty. In addition, sufficient nutrition is important for a child's growth and development since the period between birth and 2 years is where optimal cognitive, mental and physical growth and development takes place (KNBS & ICF Macro, 2015).

Sustainable agriculture is one of the important components of Sustainable Development Goals (SDGs) adopted by United Nations (UN) whose aim is to end hunger, reduce poverty and achieve food security and better nutrition (United Nations, 2016). However, reduced dietary quality has a great implication on the lives of both urban and rural people since it contributes to under nutrition, over nutrition and nutritional deficiencies. Diversification interventions including farm enterprise diversity therefore support consumption of diverse diets which are rich in essential nutrients (Fiorella *et al*., 2016). In addition, adequate farm enterprise diversity is essential since for one to access diverse foods from the market required that someone must produce those foods.

1.6 Scope and limitations of the study

The study was based on secondary data collected by ILRI in collaboration with CCAFS among small-scale farmers in Makueni Sub-County in Makueni County and Nyando Sub-County in Kisumu County in the months of October, November and December 2016. Data on HDD was based on 24-hour dietary recall and questions on crops grown by the households in the last main season were also based on farmer's recall of information which might have not been exact. Thorough probing of questions improved precision of data collected.

1.7 Operational definition of terms

Dietary quality: Is implied by dietary diversity, which is the number of different food groups consumed by a household in the past 24 hours. Dietary diversity is commonly used as a proxy indicator of dietary quality

Farm enterprise diversity: Refers to the number of different livestock and crop species reared by a small-scale farmer.

Household: Refers to individuals living in a household for at least 3 months in a year.

Macronutrients: Foods like fats, carbohydrates and proteins that are rich in energy and calories.

Malnutrition: Happens when a person's intake of nutrients and/or energy is less, excess or there is an imbalance.

Margalef: An index used to measure species richness.

Micronutrients: The minerals, vitamins, phytochemicals, trace elements, and antioxidants that are important for a healthy body.

Over nutrition: A form of malnutrition in which the amount of nutrients exceeds the amount required for normal growth, development and metabolism.

Shannon index: It is an index used in ecology to measure species richness and species abundance.

Simpson's Index: It is an index used in ecology and sometimes in crop diversity to measure species richness and species abundance.

Small-scale farmer: A farmer who is a land user and grows crops or rears livestock or aquaculture for own consumption and sells part of it.

Species: Types of crops grown or livestock reared by a small-scale farmer.

Species evenness: It is a measure of diversity which looks at the species' absolute abundance in an area.

Species richness: A measure of species diversity which is the total number of diverse species found in an area.

Under nutrition: Is being underweight (light for one's age), wasted (too thin for one's height), stunted (low height for one's age) and having micronutrient malnutrition (lack of vitamins and minerals).

CHAPTER TWO
LITERATURE REVIEW

The chapter reviews past and recent literature. It reviews; literature on agriculture in Kenya and the concept of agri-nutrition; nutritional outcome of small-scale farmers and dietary quality at household level and the concept and factors influencing farm enterprise diversity. Moreover, it provides a theoretical framework which underpins the study. The chapter concludes by conceptualizing the relationship between key variables used in the study.

2.1 Agriculture in Kenya

Agriculture is a very important sector in majority of developing countries. Agriculture is the main source of food and employment for more than 70% of poor people in SSA and a main source of income for around 2.5 billion people in the developing world (Dobermann *et al*., 2013; Muyanga & Jayne, 2014; Mwangi & Kariuki, 2015; Sibhatu *et al*., 2015). In Kenya, agricultural sector is equally a very important sector since out of the 70 percent rural dwellers in Kenya, 80 percent depend on agriculture as a source of income and food (FEWS NET, 2013). Since majority of poor rural dwellers depend on agriculture for their livelihoods, growth in agriculture can have great impact on poverty alleviation (Mottaleb, 2018).

Despite agriculture being a very important sector, it faces a lot of challenges. Low productivity is experienced in developing countries owing to the use of traditional methods of production by majority of the smallholder farmers (Mwangi & Kariuki, 2015). In addition, the process of economic development could be the reason behind declining relative importance of agriculture and the expansion of non-farm activities in rural areas of developing countries (Davis *et al*., 2017). Furthermore, despite agriculture providing food, raw materials and livelihoods its existence is threatened by climate change with farmers in developing countries having low adaptive capacity towards climate change (Tripathi & Mishra, 2017).

Agriculture in Kenya is mainly rain-fed and farm sizes range between 0.2-3 ha in high potential areas (Alpha, 2013). This is due to farms and farmlands being inherited from one generation to the next in smallholder production systems (Chege *et al*., 2015). In addition, Kenya has a high rural population density and as such land is unavailable for cropland expansion (Muyanga & Jayne, 2014). Natural calamities coupled with unreliable weather conditions are the main threats to agricultural sector in Kenya (Kotikot *et al*., 2020). As a

result, climate change and variability have a direct impact on food security and agricultural production since most of Kenyan population lives in rural areas and depend on agriculture for their livelihoods (Ochieng *et al*., 2016).

This study was carried out in Makueni and Nyando Sub-Counties where agriculture is the main economic activity. Most farmers in Nyando Sub-County practice mixed crop-livestock farming for their livelihoods on their own small farms which are on average less than an acre (Bryan *et al*., 2018). The main crops and livestock species produced in Nyando Sub-County include maize, beans, sorghum, goats and chicken. According to Mango *et al*. (2011), the food security and nutritional status of roughly one-fifth of households in Nyando Sub-County is dismal, as they are unable to meet their food needs for 3-4 months in a year. Makueni Sub-County on the other hand, is an arid and semi-arid area, with farmers here also engaged in mixed crop-livestock farming. Most households in Makueni grow maize, beans, cowpeas, pigeon peas, green grams, and citrus and mango trees (McKune *et al*., 2018). Farmers in Makueni Sub-County also practice bee keeping, small-scale agricultural produce trading and livestock. About three quarters of the people in Makueni are poor and live below the poverty line which has led to high levels of malnutrition, dependency ratio and school dropout rates (GoK, 2013).

2.2 The concept of agri-nutrition

Agriculture and nutrition are interdependent through the production and consumption of micronutrients required by the people for good health. According to Dobermann *et al*. (2013), agricultural strategies which is among the most critical interventions, is a solution to malnutrition during the first 1000 days of life. Influencing agriculture for nutrition could help address other barriers to collaboration and coordination like the lack of linkages between different mandates of the Ministry of Agriculture and the Ministry of Health (Wagah *et al*., 2015). The main pathways between agriculture and nutrition are through food production primarily for household consumption, food production for sale and through income from cash-cropping used for non-food expenses such education (DFID, 2014). The most visible pathways through which food system can affect human health and nutrition is through rearranging the goals of agriculture to address human health by meeting dietary guidelines (Jones & Ejeta, 2015).

A productive, diverse, ecologically and socially sustainable agricultural sector is important for shaping healthy diets and improving human nutrition (Jones & Ejeta, 2015). Adoption of improved agricultural technologies can serve as a basis in curbing malnutrition (Manda *et al*., 2016). Solutions to nutritional problems among smallholder farmers can also exist through interventions in agriculture. Planting and maintaining fruit tree species could be a way of survival among low resource endowed households for supplying nutritious products that are too expensive to be purchased (Nyaga *et al*., 2015). Further, Fiorella *et al*. (2016) suggested that increasing the availability of micronutrient-rich and animal source foods may serve nutritional goals when households are able to access these products.

Diversification interventions as one of the measures, improve nutritional status by supporting consumption of nutritious foods (Fiorella *et al*., 2016). In addition, agricultural interventions aiming at promoting increased production of fruits and vegetables have the potential to effectively address micronutrient deficiencies (World Bank, 2007). In a review by Pandey *et al*. (2016) on impact of agricultural interventions on the nutritional status in South Asia, they found that agricultural interventions for increasing the productivity and crop diversification promote targeted food production and consumption thereby leading to dietary quality. On the other hand, Ng'endo *et al*. (2016) suggested that increased dietary diversity among smallholder farmers requires more than subsistence-based production.

According to Mulwa and Visser (2019), dietary diversity could come from diversified crop and livestock production and through foods bought through incomes from other sources like selling of livestock and crop output. However, income from agriculture can also be used to purchase processed and low nutrient density foods that lead to overweight and poor health (Yosef *et al*., 2015). After harvesting agricultural produce that is of higher nutritional quality, a farmer may sell them and in turn buy foodstuffs with poor quality or divert cash towards non-food consumption (Maestre *et al*., 2017). There is also no guarantee that nutritious home produce will be consumed by women and children or in sufficient quantities enough to cause improvement in health and nutrition. Moreover, a major cause of micronutrient malnutrition in low income populations is the inability to access a variety of foods since the foods they consume lack many micronutrients (Miller & Welch, 2013).

Agriculture has not been able to meet nutritional challenges. Miller and Welch (2013) argued that the main focus of agricultural research, policy and practice has been on increasing yields and little attention is given to improving the nutrient output of farming systems. In addition, it

has increased production and availability of staple foods rich in calories but the production of micronutrient-rich non-staples like vegetables and animal products has not increased in equal proportion (Bouis & Saltzman, 2017). In a review by Pandey *et al*. (2016), they found that linkages between agriculture and nutrition require multi-sectorial and multi-dimensional approaches to deal with malnutrition. Moreover, the work of designing interventions for preventing micronutrient malnutrition is complex due to multifactorial nature of the problem (Miller & Welch, 2013).

Dillon *et al*. (2014) argued that there has been evidence of urban agricultural production having positive effects on nutrition. Urban agriculture is capable of improving food and nutritional security through direct access and availability of food and increased income from the sale of food products (Warren *et al*., 2015). Furthermore, the cultivation of crops and livestock species in urban and peri-urban areas is increasingly being practiced and holds potential to improve food access and overall food security and nutrition conditions in these areas (GoK, 2011b). Warren *et al*. (2015) suggested that urban agriculture is associated with increased dietary diversity and generally with food consumption.

Demeke *et al*. (2017) in a study that sought to establish the link between farm diversification and household diet diversification found out that production diversification measured using agriculture enterprise score was positively and significantly associated with household diet diversification. However, the use of unweighted categories in the agriculture enterprise score runs the risk of "masking" the nutritional implications of production practices. In addition, the authors used three indicators for household diet diversification that is, HDDS, Simpson's and Shannon Index which were strongly correlated. Therefore, this study used Simpson Index and crop and livestock count to measure farm enterprise diversity and HDDS to measure household dietary quality.

In a study by Jones (2017) on on-farm crop species richness is associated with household diet diversity and quality in subsistence and market-oriented farming households in Malawi, he found out that agricultural biodiversity was an important determinant of household diet diversity. Moreover, Remans *et al*. (2014) suggested that a major overlooked challenge in agricultural food systems is its ability to provide adequate diversity of nutrients necessary for healthy life. Ruel *et al*. (2013) argued that even though investments to enhance agricultural productivity are important in the long term, they do not solve the immediate problem of scarcity of access to nutritious and diverse diets that the poor face.

Households with educated heads, both livestock and crop production diversity and households with wage employment, earning business income and non-labor income in the last year had a higher dietary diversity and quality (Snapp & Fisher, 2015). Similar results were reported by Sibhatu and Qaim (2016) who found out that total farm size and educational levels contributed to higher dietary quality. On the contrary, there was a significant negative relationship between diversity of national food supplies and the national prevalence of child stunting and being underweight (Remans *et al*., 2014).

Walking distance to the market had a negative effect on dietary diversity and nutrition consumption (Sibhatu & Qaim, 2016). Similar results were reported by Sibhatu *et al*. (2015) who found out that better market access through reduced distances contributed to higher dietary diversity. According to Fiorella *et al*. (2016), market access dictates whether households eat or sell crops that they produce and the effect on their nutrition. In addition, both production systems and market access influence dietary diversity (Smale *et al*., 2015).

In a study by Dillon *et al*. (2014) on agricultural production and dietary diversity, households with the lowest agricultural revenue consumed the most food crops on average. On the other hand, household dietary diversity increased with the number of different species produced on the farm (Sibhatu & Qaim, 2016). Pandey *et al*. (2016) argued that diversification of agriculture towards production of fruits and vegetables and integrated agriculture-aquaculture can promote diet diversity and consequently improve nutritional outcomes.

2.3 Nutritional outcome of small-scale farmers

Micronutrient deficiencies are a major public health problem and the double burden of malnutrition is increasing particularly among women (Alpha, 2013). According to World Bank (2007), Vitamin A, iron, zinc, and iodine are the most widespread nutritional deficiencies worldwide and mostly affect women and children extremely. Lack of adequate nutrition to both children below the age of two years and in pregnant women has irreversible consequences to both the individuals and society at large (Maestre *et al*., 2017). Sibhatu *et al*. (2015) argued that deficiencies due to nutrition are not always as a result of low quantities of food consumed but also due to poor dietary quality and diversity. Moreover in Asia and Africa, the losses in GDP annually as a result of poor child growth, low weight and deficiencies in micronutrients estimates to 11% (Haddad *et al*., 2016).

Many people affected by malnutrition are in rural areas and majority of them are small-scale farmers. Similarly, a large part of the population that is micronutrient deficient live in rural areas, where they have limited access to processed foods that are fortified with essential micronutrients (Mcdermott *et al*., 2013). Majority of rural dwellers continue to rely on forests and other habitats in addition to agricultural crops for their food and nutrition needs (Broegaard *et al*., 2016). Furthermore, micronutrients deficiencies exist in soil and crops causing malnutrition of the population especially subsistence farming communities where cereal-based diets have little nutrient diversity (Dickinson *et al*., 2014). Of all the undernourished people in the world, smallholder farmers make up a majority of them (Chege *et al*., 2015). In Africa and Asia, majority of undernourished people are smallholder farmers who are mostly rural dwellers and as such diversifying their production is important in improving dietary diversity and nutrition (Sibhatu *et al*., 2015). About 70% of world's very poor people dwell in rural areas and a big proportion of poor and hungry are children and young people (Dobermann *et al*., 2013).

Malnutrition is the single largest cause of death among children under the age of 5 and obesity is on the rise in low- income and transition countries (Fanzo, 2012). In many countries in SSA, everyday more than 8,000 children die from under nutrition despite global increases in wealth and technology (Dobermann *et al*., 2013). In addition, SSA is home to some of nutritionally insecure people in the world as their diets consist mainly of cereal or root staple crops and very little animal source proteins, micronutrient rich vegetables and fruits (Fanzo, 2012). Getting adequate nutrition is therefore important for preventing most of the malnutrition that the world is facing (Popkin, 2014). In a study by Manda *et al*. (2016) on determinants of child nutritional status in the Eastern Province of Zambia, the probability of being stunted reduced with each year of schooling for the most educated female household member and presence of adult females in the house. In addition, production of non-food cash crops and better education of the household head improved household living standards and nutrition of smallholder households while market distance had a negative effect (Euler *et al*., 2017).

2.4 Dietary diversity at household level

Dietary diversity is the number of foods or food groups consumed over a given reference period like the previous 24 hours or 7 days prior to the survey (Ruel, 2003). However, analysis of dietary diversity using the 24-hour recall period is easier compared to longer recall

periods that result in less accurate information (FAO, 2011; Food and Nutrition Technical Assistance, 2006). Dietary diversity is calculated based on data collected from 24-hour diet recalls and is used to compute dietary diversity scores (DDS) at household and individual levels (Ruel, 2003). Household dietary diversity score (HDDS) reflects the economic ability of a household to access a variety of foods while individual dietary diversity score (IDDS) reflects nutrient adequacy (FAO, 2011). Dietary diversity and nutrient adequacy are one of the major nutrition concerns worldwide since it has been demonstrated that optimal nutrient adequacy is important for higher mental and physical health status for everybody (Tavakoli *et al*., 2016).

Dietary diversity is commonly used as a proxy indicator of diet quality (Jones *et al*., 2014). According to Ruel (2003), increasing the number of food groups has a greater influence on diet quality than increasing the number of individual foods in the diet. Findings by Thorne-Lyman *et al*. (2009) suggested that dietary diversity scores can serve as a useful tool for assessment of food security status of households in rural Bangladesh. Further, variety and dietary diversity scores can be considered as good proxies for overall diet quality and in reflecting social and economic contexts of populations concerned (Ruel, 2003; Savy *et al*., 2005).

Household dietary diversity is a categorical measure of the number of different food groups consumed by the household during a given reference period, usually during the last 24 hours or 7 days preceding survey interviews. Household dietary diversity is frequently used to measure dietary quality from survey data (Sibhatu & Matin, 2016). Target respondent when collecting data for the 24-hour diet recall is the person responsible for food preparation for the household the day prior to the survey. Foods prepared in the home and consumed by any member of the household at home or outside the home are considered when computing HDD. Foods purchased and consumed outside the home are not included in the computation of HDD (FAO, 2011).

When assessing HDD, the 24-hour dietary recalls are conducted at household level that is, recall of all foods and beverages cooked and consumed at home by all household's members during the previous 24 hours. Data from the 24-hour dietary recalls is then used to generate HDDS, which is computed based on the following 12 food groups recommended by FAO: cereals, white tubers and roots, vegetables, fruits, meat, eggs, fish and other sea food, legumes, nuts and seeds, milk and milk products, oils and fats, sweets, spices, condiments and

beverages (FAO, 2011). If any member of the household consumes any food from any of these food groups a score of 1 is given and 0 if none of the household members ate food from any of the food groups. The number of food groups consumed by each household are then aggregated resulting in a score ranging from 0 to 12 with a high score reflecting high household dietary diversity (FANTA, 2006).

Ayenew *et al*. (2018) used unbalanced Random Effects model, Mundlak random effect model, Fixed Effects model and quantile regression on unbalanced panel data to estimate the relationship between production diversification and dietary diversity in Nigeria. The study found out that production diversity positively and significantly influences the diversity of diets of rural households. They also found out that the effect of production diversity on dietary diversity varied across seasons, and that its effect disappeared when the household approached the post-planting period. They attributed this to the seasonal nature of agricultural productions and their perishability. Despite the contribution of the study towards understanding the link between farm enterprise diversity and household dietary diversity, 7-day food balance sheet for the calculation of dietary diversity. Longer recall period reduces the accuracy of the data collected and thus, this study used 24-hour dietary recall.

According to a study by Sibhatu and Matin (2016), total farm size and agricultural cash revenues had a positive influence on dietary quality. On the contrary, in a study by Dillon *et al*. (2014), households with the lowest agricultural revenue consumed the most food groups on average since wealthier households may engaged in agriculture as a side hustle and therefore will fall in the lower agricultural quartile but have sufficient means to acquire diverse diets. In another study by Sharma and Chandrasekhar (2016), dietary diversity of rural households was positively related to landholding size. Higher asset values, total area cultivated in both growing seasons, access to paved roads, cellphone and radio ownership, adult literacy, higher long-term rainfall and greater availability of nutrients in the soil were strongly associated with more diverse diets (Jones *et al*., 2014; Smale *et al*., 2015). In addition, access to storage facilities like ownership of a refrigerator and lower costs of accessing a variety of foods had a positive association with dietary diversity (Snapp & Fisher, 2015).

In a study by Rajendran *et al*. (2014), level of education, household size, monthly per capita expenditure on food, net cultivated area under irrigation for all crops, proportion of total vegetable consumed from own production had a strong influence on dietary diversity. On the

contrary, household size was negatively associated with dietary diversity among smallholder farmers in Malawi (Koppmair *et al*., 2016). Furthermore, households with more persons in the 0-14 age groups were more likely to have a diverse diet according to a study conducted among rural agricultural households in Nigeria (Dillon *et al*., 2014). On the other hand, HDDS decreased in households with more children between 0-14 years in Malawi (Snapp and Fisher, 2015). Education of the household head was positively associated with dietary diversity (Dillon *et al*., 2014; Koppmair *et al*., 2016; Sibhatu & Matin, 2016; Snapp & Fisher, 2015). In a study by Jones *et al*. (2014), age of the household head and proportion of food consumed in the past one week that came from household's own production and non-food expenditures per capita in the previous month were negatively associated with dietary diversity. These results concurred with those from a study by Dillon *et al*. (2014) who found out that households with older household heads had less diverse diets.

Off-farm income and adoption of new agricultural technologies were positively associated with dietary diversity (Koppmair *et al*., 2016). In a study by Sibhatu *et al*. (2015), off-farm employment and smallholder access to agricultural markets had positive effects on household dietary diversity. Income from off-farm activities could have been used to purchase a variety of other foods from the market. Food expenditures per capita in the previous week, household size, the number of different non-agricultural income sources variable and population weighted national quintiles of consumption per person were positively associated with dietary diversity (Jones *et al*., 2014).

In a study by Snapp and Fisher (2015), female headed households had a lower dietary diversity compared to male-headed households since it reflects that female-headed households are poorer compared to male-headed households and are therefore less likely to afford diverse diets. On the contrary, male-headed households were less likely to have a diverse diet compared to female headed households (Dillon *et al*., 2014). In a study by Jones *et al*. (2014), households in which the control of agricultural earnings was shared by the household head and spouse showed higher dietary diversity compared to households in which only the household head controlled agricultural earnings. Decision-making and control of income by the female heads of the household had a strong influence on dietary diversity in Tanzania (Rajendran *et al*., 2014). Income in the hands of women had a greater benefit on HDD than income controlled by men (Snapp & Fisher, 2015).

According to a study by Sibhatu and Matin (2016), they established that market distance and the share of land under food crops had a negative effect on dietary diversity. This is the case since greater market distance increases transaction cost which discourages farmers from relying on the market. Furthermore, cash crop farming is equally important since the income earned from cash crop sales can be used to purchase a variety of other foods from the market. Rural households with rural-urban commuters had a higher dietary diversity compared to households without rural-urban commuters (Sharma &Chandrasekhar, 2016). In addition, households in remoter regions had lower dietary diversity than those in urban areas (Sibhatu *et al*., 2015). This could be because households in urban areas are closer to the market where they can purchase a variety of foods.

2.5 The concept and factors influencing farm enterprise diversity

Farm enterprise diversification is a very crucial risk management strategy used by farmers to deal with uncertainties associated with price, input and output (Amine & Fatima, 2016). Furthermore, greater diversity of an agricultural system in terms of variety, balance and disparity increases adaptive capacity and reduces vulnerability of the system to adverse trends and events like weather variability (Martin & Magne, 2014). Crop diversity helps in boosting crop production in cases of very low rainfall (Donfouet *et al*., 2017). Moreover, farm diversification could help in solving the problem of food insecurity due to rainfall uncertainty, pest and disease infestation and high cost of agricultural inputs (Mburu *et al*., 2016). This is because risk is reduced by having diverse farm enterprises such that when one enterprise fails, a farmer can still rely on the others for food security. Farm enterprise diversity which is the number of different plant and livestock species in a farm is also of great importance to households since they are able to access a variety foods contributing to good health and nutrition. Diversified agricultural production would lead to diverse diets for subsistence farmers (Jones *et al*., 2014).

Unweighted count measure that is the number of crop and livestock species produced on a farm can be used to measure farm enterprise diversity (Sibhatu *et al*., 2015). Unweighted count measure can be followed by two alternative measures to examine whether it influences the results significantly, the first being Margalef species richness Index which accounts for the area cultivated with different crop species. Secondly, a simple unweighted count of only the food crop species produced on the farm is used. An alternative to using a simple species count is production diversity score which indicates the number of different food groups

produced on a farm since it considers the nutritional functions of different commodities produced on a farm (Sibhatu & Qaim, 2016).

An alternative to measuring farm enterprise diversity is through a simple crop count variable that sums the total number of different crop species cultivated by the household. It can be followed by a crop and livestock count variable that adds to the crop count variable the number of different animal species reared by the household. Lastly, Simpson's Index that measures species diversity and sometimes crop diversity can be used (Jones *et al*., 2014). Alternative to Simpson or Margalef Index is Shannon-Weaver Index or Berger-Parker- Index.

For both African and non-African countries, households may diversify as a strategy to overcome market failure and manage risk or could be an individual in a household specializing due to individual attributes or comparative advantage (Davis *et al*., 2017). In addition, production systems influence the diversity of crops produced and sold (Smale *et al*., 2015). Farmers also position themselves towards subsistence production as strategy to mitigate risk and various market failures (Sibhatu & Qaim, 2016). Imperfect markets have driven farmers to switch to other crops based on improved high-yielding varieties due to financial incentives created by increasing intensification of the agricultural production system (Pallante *et al*., 2016).

Higher temperatures during the agricultural season together with increased production uncertainty may increase farmer's crop diversification (Dillon *et al*., 2014). According to Michler and Josephson (2017), motivation for diversification may be mitigation of risk or adaptation to climate change. Farmers that appear to be better off financially are more likely to reduce the number of livestock to adapt to climate change (Bryan *et al*., 2013). In addition to climate change, farmers who are resource-poor diversify their sources of food and income so as to manage risks (Sibhatu *et al*., 2015). Moreover, access to irrigation, food or other aid, extension services, farmers with access to fertile soils, larger land holdings, and those engaged in both crop and livestock production influenced household decision to change crop variety (Bryan *et al*., 2013).

Bellon *et al*. (2016) investigated the effect of on-farm diversity and market participation on dietary diversity of rural mothers in Southern Benin. They found that on-farm and market diversities were positively associated with mothers' dietary diversity ($p < 0.05$) when market opportunities, seasonality and other socio- economic factors were controlled for. The study

however, used the number of cultivated, wild and semi-wild species grown and collected by a household to measure on-farm diversity leaving out livestock species which is important for household dietary quality. This study therefore used two measures of farm enterprise diversity that is, Simpson's Index which considers the crops grown by a household and crop and livestock count which also considers the livestock kept by a household.

In a study by Mburu *et al*. (2016) on agro biodiversity conservation enhances food security in subsistence-based farming systems of Eastern Kenya, species diversity increased depending on the number of years the farm had been cultivated and age of the household head. On the other hand, there was a significant and a weak negative correlation between the level of education of the household head and crop diversity. Access to markets and credit and food prices can have an influence on what type of crops households grow (Dillon *et al*., 2014). Consequently, increase in the relative price of vegetables, jute and phosphate fertilizer, investment on research and development per farm, high rainfall over time increased agricultural land use (Rahman, 2016).

According to Michler and Josephson (2017), a neighboring household with large landholdings may grow diverse types of crops and on the other hand a household with little land holdings may likely grow staple crops for subsistence use. In a study by Jones (2017) on on-farm species richness is associated with household diet diversity and quality in subsistence and market-oriented farming households in Malawi, households diversified their production from subsistence maize production to additional subsistence crops owing to greater access to land and to manage agronomic risks. Furthermore, in a study by Achonga *et al*. (2015) on implication of crop and livestock enterprise diversity on household food security and farm incomes in the Sub-Saharan region, farmers who stayed far away from the market center were likely to diversify their crop enterprises and therefore were more likely to be food secure. Likewise, large households diversified their crop and livestock enterprises to be food secure.

2.6 Theoretical and conceptual framework

2.6.1 Theoretical framework

The study was anchored on the farm household model by Dusen and Taylor (2005) where a household is the consumer of goods both produced and purchased using income from production or wage labor. It is also a producer by choosing the allocation of labor and other inputs to crop-production (Taylor & Adelman, 2002). As a consumer, the household aims at

maximizing utility from the consumption of a set of commodity goods and leisure, by allocating resources of time, income and factors of production to the purchase or production of these goods (Tan, 2013). Household's objective is that of maximizing a discounted future stream of expected utility from a list of consumption goods including home-produced goods, purchased goods and leisure subject to a set of constraints (Taylor &Adelman, 2002).

Households derive their utility by consuming goods (X) from own production and from all market goods (Z) given a vector of exogenous socioeconomic and other characteristics ϕ_{HH}. Households maximize their utility subject to full income constraint and in this case income refers to farm income, exogenous income (Y) and endowment of family time T valued at the local market wage w.

Households choose which of j crops to produce, $j = 1,\ldots,J$ denoted by Qj and which of n livestock species to keep, $n = 1,\ldots,N$ denoted by Qn. Production is carried out subject to technological constraints embedded in cost function, $C(Q;\Phi_{prod})$ where, Φ_{prod} is a vector of exogenous farm characteristics. Market constraints $H(.)$ are functions of exogenous characteristics Φ_{market} and farmers' face shadow prices which reflect their household and market characteristics.

Adopting Smale *et al*. (2015) framework on farm household, a diversity constraint $D(.)$ defines the optimal bundle of food attributes or combination of foods consumed at the household level. Prices (p) are endogenous to the household and are, in turn, functions of household and market characteristics, as well as observed prices. These prices determine farmer choices but their values are unobserved.

Following agricultural model as presented by Dusen and Taylor (2005), the model was expressed as;

$$Max_{x,z}U(X,Z;\phi_{hh}) \quad \ldots\ldots (1)$$

$$Z = P*(Q-X) - C(Q;\Phi_{prod}) + \mathrm{Y} + wT \quad \ldots\ldots (2)$$

$$H(Q,X;\Phi_{market}) = 0 \quad \ldots\ldots (3)$$

$$D = D(Q,X,Z;\Phi_{market}) \quad \ldots\ldots (4)$$

The household chooses a vector of consumption levels (X, Z), therefore the solution to the maximization of household utility under binding constraints is a set of constrained optimal consumption levels $\mathrm{X}c, Z$:

$$\mathrm{X} = \mathrm{X}c\left(p, \mathrm{Y}c, \Phi_{HH}, \Phi_{market}, \Phi_{farm}\right) \quad (5)$$

$$Z = Zc\left(p, \mathrm{Y}c, \Phi_{HH}, \Phi_{market}, \Phi_{farm}\right) \quad (6)$$

$\mathrm{Y}c$ Represents the full income for the constrained optimal production levels Qc.

The household's constrained dietary quality outcome can be expressed in reduced form as indirect functions of price, income, and household farm and market parameters.

$$Dc = Dc\left(\mathrm{X}c, Zc\left(p, \mathrm{Y}c, \Phi_{HH}, \Phi_{farm}, \Phi_{market}\right)\right) \quad (7)$$

Improved household dietary quality depends on prices of goods, income in the household and farm and market parameters and not as a function of utility and income only.

2.6.2 Conceptual framework

Figure 1 presents the conceptualized interrelationship between the dependent and independent variables of the study. In this study, farm enterprise diversity measured using Simpson's Index and crop and livestock count was assumed to be affected by both socioeconomic and institutional factors. Better access to training and market together with household members engaged in more social groups were posited to make a household diversify their farm enterprises more than a household that did not have access to these services. Socioeconomic factors like age and education of the household head, gender, household size, income, land size, land tenure, slope of the land, access to irrigation, access to aid and location were posited to influence farm enterprise diversity. Climate was an intervening factor in farm enterprise diversification. In this study, farm enterprise diversity was used as the independent variable and household dietary quality assessed to measure HDD as the dependent variable. The study suggested that households can consume diverse diets when they produce different crops and livestock species. The link between household dietary quality and farm enterprise diversity was also postulated to be affected by both institutional and socio-economic factors. When households have better access to the market and household members get engaged in many social groups, they can have quality diets. Socioeconomic factors such as age, gender, education level, off-farm income, land size and location were thought to affect the quality of diets of small-scale farmers' households.

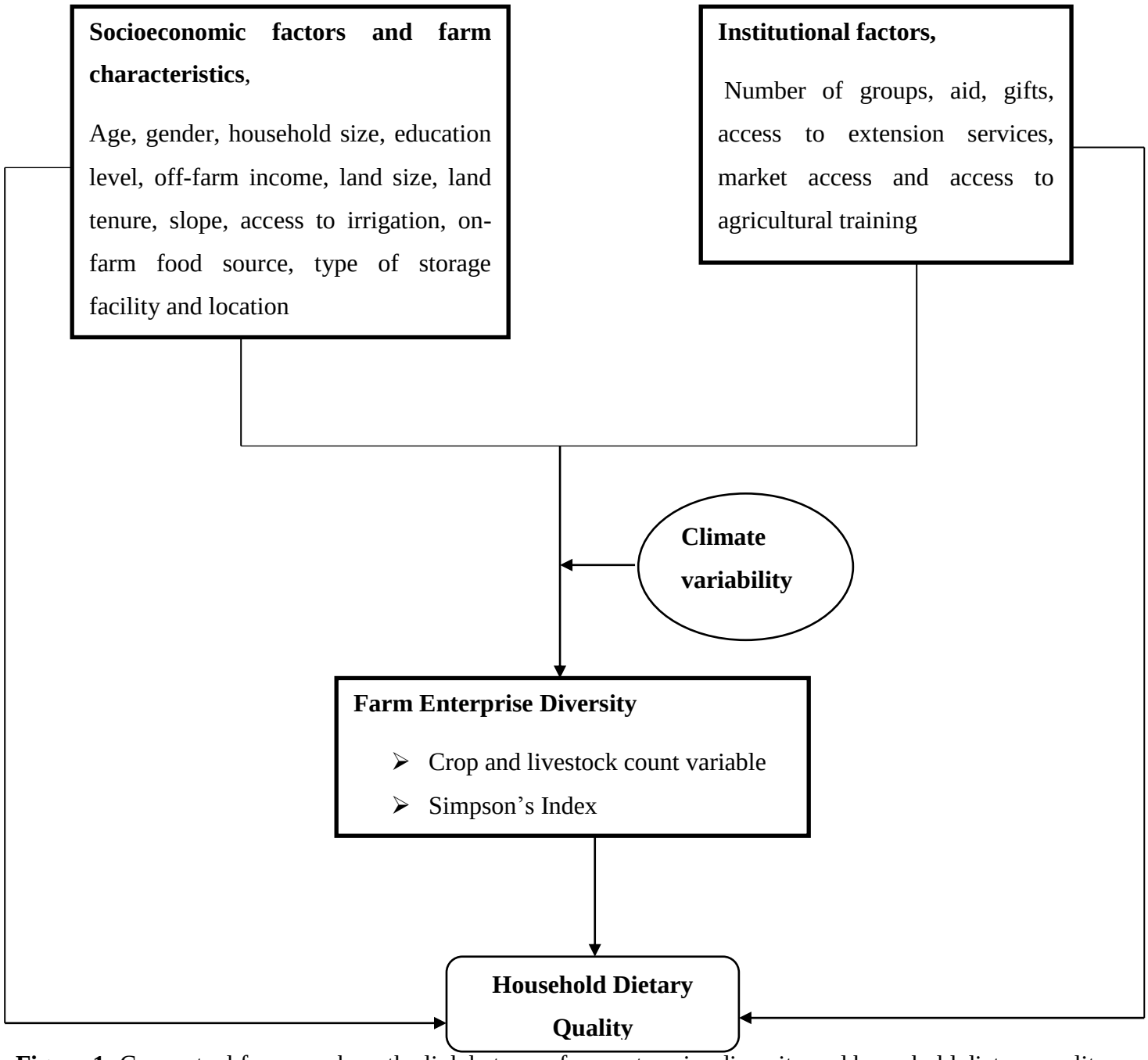

Figure 1: Conceptual framework on the link between farm enterprise diversity and household dietary quality

CHAPTER THREE
METHODOLOGY

This chapter starts by describing the two study areas, which are Makueni and Nyando Sub-Counties including a map showing the study areas location is also provided and this is then followed by sampling and sampling procedure and data collection. A brief description of data analysis is also provided. The chapter concludes by describing the analytical framework used for the three objectives.

3.1 Study area

The study was done in Makueni and Nyando Sub-Counties in Makueni and Kisumu Counties, respectively. The study sites were purposively selected using susceptibility to climate change, levels of poverty, agro-ecological conditions and agricultural production systems (Silvestri *et al*., 2015). According to Makueni County integrated development plan, Makueni Sub-County's total area is 1546.1 km^2 and lies between latitude 1º 35´ and 3º 00 South and Longitude 37º 10´ and 38º 30´ East (GoK, 2018a). It neighbors Mbooni, Kilome and Kibwezi Sub-Counties as shown in figure 2 below. Makueni Sub-County has bimodal rainfall pattern and experiences the long rains around March and April while the short rains which are 'their main season' between November and December. While some parts of Makueni Sub-County receive very little rainfall ranging from 250mm to 400mm other parts receive annual rainfall ranging from 800mm to 900mm (GoK, 2018a). The temperature in Makueni Sub-County can rise as high as 35.8º C. The largest part of Makueni Sub-County is mostly arid and semi-arid and prone to frequent droughts. The terrain in Makueni Sub-County is low-lying and rises up to 600m above the sea level.

According to the 2009 census, Makueni Sub-County's population was 193,798 persons with a concentration of 125 persons per square kilometre (GoK, 2018a). Generally, Makueni Sub-County is sparsely populated with a high concentration of people in Wote town. Administratively, the Sub-County has three divisions; Kaiti, Wote and Kee. The main economic activity in the Sub-County is Agriculture with the major crops grown including; maize, green grams, pigeon peas, sorghum, mangoes, pawpaw and oranges. Livestock production is another common economic activity with the animals reared including indigenous dairy and beef cattle, sheep, goats, donkeys, poultry and bee keeping (GoK, 2018a).

Nyando Sub-County on the other hand covers an area of 413.20 $km^2$and lies between longitudes 33º 20˙E and 35º 20˙E and latitudes 0º 20˙South and 0º 50˙South. It neighbours Kisumu East Sub-County, Kericho County, Muhoroni Sub-County, and Nyakach Sub-County in the West, East, North and South respectively (GoK, 2018b). Nyando Sub-County also has bimodal rainfall pattern and experiences long rains between March and May while the short rains are experienced between September and November. The Sub-County receives low annual rainfall between 1000mm and 1800mm towards the low lands. The annual maximum temperature averages between 25 º C and 35 º C while the annual minimum temperature averages between 16 º C and 18 º C. The elevation in the Sub-County is between 1,144m above the sea level towards the plains and 1,525m above the sea level towards Lower Nyakach Sub-County (GoK, 2018b).

The projected population for Nyando Sub-County according to 2009 census was 178,246 persons. The Sub-County is divided into five County Assembly Wards namely: East Kano Wawidhi, Kabonyo Kanyagwal, Ahero, Awasi Onjiko and Kobura (GoK, 2018b). The main economic activity in Nyando Sub-County is agriculture and majorly subsistence farming. The crops grown are; cereals (maize, finger millet and sorghum), legumes (beans and green grams), ground nuts, sweet potatoes and kales. Sugarcane farming is the major cash crop grown while tea and cotton are the other cash crops grown. Farmers in Nyando Sub-County store their crops on-farm and/or off-farm and majority of them use gunny bags for their grains which are kept inside their houses (GoK, 2018b). Dairy cattle, beef cattle, shoats, pigs, rabbits and poultry are the main livestock kept in the Sub-County in addition to bee keeping. The livestock sector faces a lot of challenges which include; livestock diseases, climate change, poor methods of farming and farmers keeping animals that are of poor quality together with other factors all of which result in low yields (GoK, 2018b).

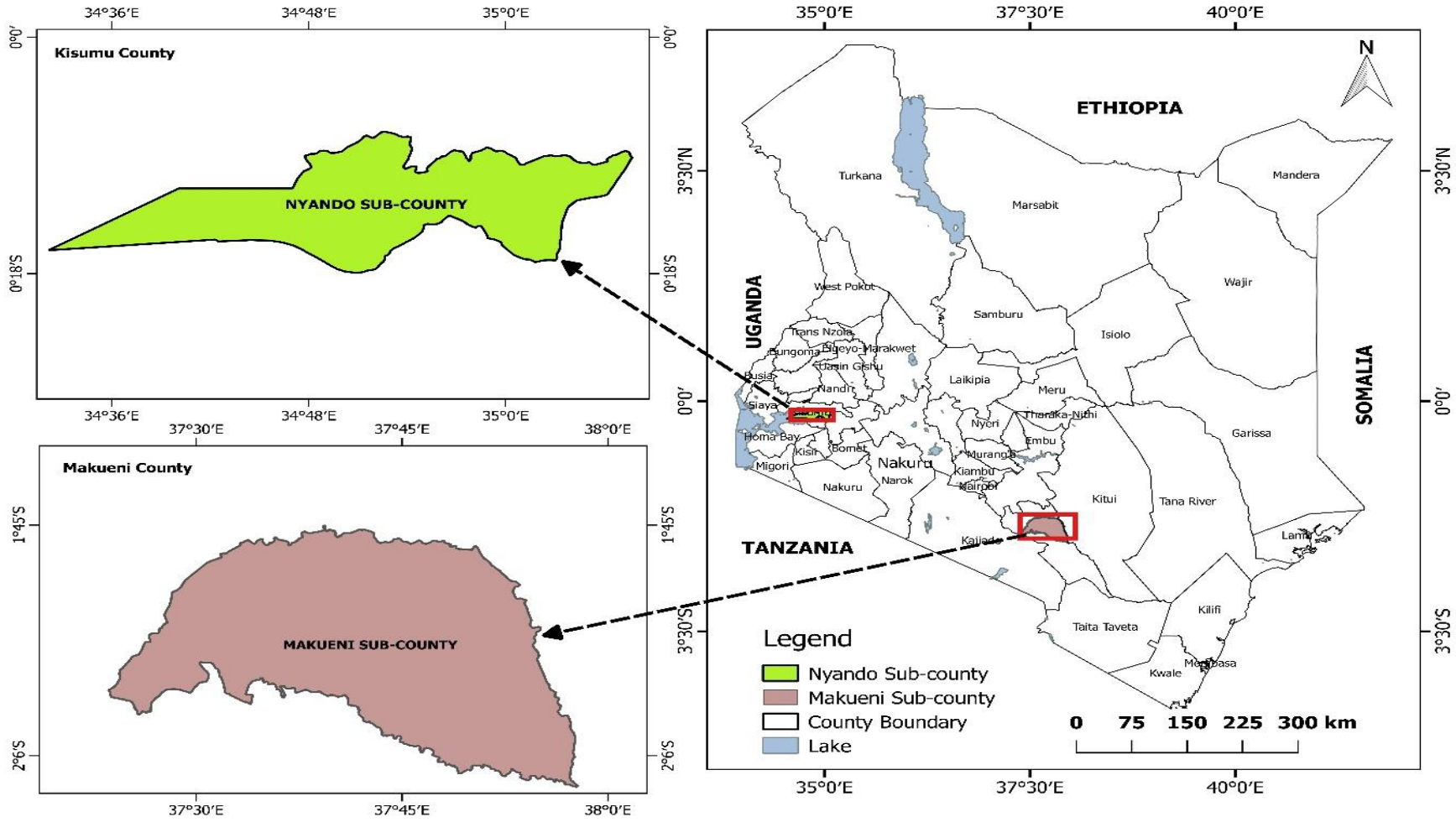

Figure 2: Map of Study Areas

Source: Geography Department, Egerton University, 2017

3.2 Sampling procedure

The sampling procedure used in the study was that applied by CCAFS as guided by ILRI. The target population for this study was small-scale farmers from Makueni and Nyando Sub-Counties. The two regions are semi-arid with a bimodal rainfall pattern, however the amount of rainfall received differ. Makueni and Nyando Sub-Counties have mixed production systems of crops and livestock. Nyando Sub-County has 3 kinds of production systems while Makueni has 2. The number of production systems per research grid was not fixed, but preferably not exceeding 4, to allow for sufficient number of small-scale farmers (50) per production system allowing for a maximum of 200 small-scale farmers per grid. The study was done through resampling households that were previously surveyed by CCAFS in 2012. A total of 200 households were surveyed per Sub-County resulting into an overall sample of 400 households surveyed in the year 2012. During the follow-up survey conducted in 2016, a total of 320 households were surveyed that is, 160 households per Sub-County. This was done through reducing the number of villages per production system rather than the number of households per village. During the follow-up survey conducted in 2016, 8 out of 10 villages per production system in Makueni Sub-County and 6 out 8 villages, 5 out 6 villages and 5 out of 6 villages from the 3 production systems respectively in Nyando Sub-County, were sampled making a total of 16 villages.

The procedure for selecting small-scale farmers included gathering secondary data for each research grid using satellite images, maps, available grey literature and consultations with local partners so as to identify the production systems. An equal number of villages within each production system was then randomly selected from the lists of villages constructed for each of the research grids resulting to a total of 16 villages per Sub-County, out of the 20 villages sampled in the year 2012. This was followed by creation of lists of small-scale farmers from the village lists whereby small-scale farmers considered for the survey were strictly land users, that is cultivating land or keeping livestock or doing fish farming (or both). Subsequently, there was random sampling of a total of 320 households that is 10 households from each of the 16 villages per Sub-County. Lastly, there was random selection of small-scale farmers for replacement purposes in cases where the sampled small-scale farmers were completely uncooperative, unavailable or where the selected small-scale farmers turned out to be unsuitable (Rufino *et al*., 2012).

3.3 Data and data collection

Prior to data collection, the research permit was sought from the National Commission for Science, Technology and Innovation (NACOSTI) (Appendix A). Informed consent was also sought from the study participants prior to data collection (Appendix B). Data was collected using Rural Household Multi-Indicator Survey (RHoMIS) tool (Appendix C) in the months of October, November and December, 2016. Rural Household Multi-Indicator Survey is a tool used for household survey and is designed to depict standardized indicators related to food security, agricultural production and market integration, nutrition, poverty and greenhouse gas emissions (Hammond *et al*., 2017). The main variables related to farm enterprise diversity and dietary quality contained in the RHoMIS tool included: socioeconomic and institutional factors like age, gender, household size and composition, group membership, land sizes, access to facilities like the market, crop productivity, key livestock species kept, off-farm income and HDD. Household dietary quality was assessed based on data collected from the 24-hour dietary recalls conducted 24 hours preceding the household surveys. The respondent was the person who was responsible for food preparation the day prior to the survey or anyone who was present at home and consumed the foods that were cooked at home throughout the day. The respondent was asked to recall all the foods and beverages cooked and consumed by any member of the household and probed to provide a detailed description of all ingredients used to prepare the meals. Foods that were considered for the 24-hour dietary recall were those cooked and consumed by any member of the household at home and foods cooked at home and taken to be eaten somewhere else (Gibson, 2005).

Questions in the RHoMIS tool were semi-structured and data was collected using Open Data Kit (ODK) installed on android tablets. The data collection exercise involved a team of well-trained enumerators, with a background in agriculture and field experience, a team leader and a supervisor. The data was collected through face to face interviews with the household head or their spouses at their homes. At the beginning of the data collection exercise, the team leader conducted spot checks to identify common problems or poor skills among the enumerators and advise was given accordingly. This helped evaluate and improve interviewer performance as a way of ensuring collection of high quality data. The team leader also conducted back checks by asking the small-scale farmers few questions to cross-check the authenticity of information collected by the enumerators. This also helped to ensure that the data collected was of high quality. Pretesting of the questionnaires was conducted at the Makueni Agricultural Training Centre (ATC) and these was a set of people that were not

included in the main survey. The objective of the pretest was to ensure that the questions being asked accurately reflected the information desired and that the respondent would be able to answer the questions. Thereafter, corrections or adjustments were made to the tool.

3.4 Data analysis

Before analysis, data was cleaned and basic descriptive statistics of the demographic, socio-economic and institutional characteristics of the study population were done. Household dietary diversity was used as a proxy for dietary quality. Data from the 24-hour diet recall was used to generate HDDS, which is calculated based on the 12 food groups recommended by FAO as shown in Appendix 4. If any member of the household consumed any food from these food groups a score of 1 was given and 0 if none of the household members ate food from any of the food group. The total number of different food groups that were eaten in every household were then aggregated resulting in a HDDS ranging from 0 to 12 (FANTA, 2006). The small-scale farmers' households were then further categorized into three groups to define the different levels of diversity as follows: those who had low dietary diversity (LDD), as those having consumed foods from 3 or less food groups, medium dietary diversity (MDD), having consumed foods from 4 to 5 food groups, and those having high dietary diversity (HDD), having consumed foods from 6 or more food groups, out of the recommended 12 food groups (Ochieng *et al*., 2017).

Crop and livestock count and Simpson's Index were used to measure farm enterprise diversity (Jones *et al*., 2014). To come up with a crop and livestock count variable, the different crop species a household planted during the last main season were summed up and added to the number of different livestock species the household kept. Secondly, Simpson's diversity Index which is used in ecology and sometimes in crop diversity to measure species richness and species abundance was calculated (Baumgärtner, 2006; Jones *et al*., 2014). The organized data was then analyzed using STATA 14 computer software program.

3.5 Analytical Framework

3.5.1 Objective 1: To determine farm and farmer characteristics by level of farm enterprise diversity among small-scale farmers in Makueni and Nyando Sub-Counties.

According to Jones *et al.* (2014), Simpson's Index is unique among other measures of crop diversity since it considers the number of different crop species planted as well the area planted on each crop. Margalef index on the other hand only considers the area planted on the

different species of crops. According to Nagendra (2002), Shannon diversity Index is most suitable in a land scape where the cover type is rare while Simpson's Index is suitable where the landscape is dominated by one cover type. In addition, Shannon Index does not have ecologically meaningful interpretation and is more difficult to calculate than Simpson's Index.

When taking into consideration the link between diversity in production and consumption, it is important to note that different species of crops have their own function in nutrition which is different from the other (Sibhatu & Matin, 2016). However, Simpson's Index does not take account of this. According to Lande *et al*. (2000), information becomes greatly biased when Shannon Index is used in small sample sizes while Simpson's Index is reliable since there is unbiasedness in its estimator because it is expected to position communities with their actual Simpson diversity and size of the sample.

Simpson's Index was developed by Simpson (1949) and has values between 0 and 1 where, 0 implies that the household is growing a single crop and 1 implies that land apportioned to all the crops grown is equal (Jones *et al*., 2014). The household is alluded to be more diversified when value of the Simpson's Index approaches 1 (Agyeman *et al*., 2014). Meaning that they are growing more crop species. The more the Simpson's Index is closer to zero the more specialized the household is implying that they are specializing in one crop. The calculated Simpson's Index is then used as a dependent variable in order to examine relationship between some key factors and crop diversification. Following Jones *et al*. (2014) methodology, the Simpson's Index can be written as;

$$\text{Simpson's Index}_i = 1 - \sum s_j^2 \quad \text{……………………………………………………………………. (8)}$$

Where, s_j is the part where household i used to plant crop j out of the total land size that was used to plant all crops.

A household that allocates 95% of land to growing beans and 5% to peas would have a lower Simpson's Index score. On the other hand, a household which allocates equal sizes of land to planting beans and peas would have a higher Simpson's Index Score. As the Simpson's Index approaches 0, specialization in a crop increases and as it approaches 1 crop diversification increases (Mbulukwa, 2014). Descriptive statistics such as standard deviation, mean, chi-square which is used to test relationship between variables, tabulation, T-test and F-test which are used to test the difference in means of the variables were used to analyze data to address

the objective on determining farm and farmer characteristics by level of farm enterprise diversity among small-scale farmers in Makueni and Nyando Sub-Counties.

3.5.2 Objective 2: To determine socioeconomic and institutional factors influencing farm enterprise diversity among small-scale farmers in Makueni and Nyando Sub-Counties

Ordered Logit and Poisson models were used to analyze the objective on key factors influencing farm enterprise diversity. Farm enterprise diversity as stated in objective one was measured through crop and livestock count and using the Simpson's Index. Simpson's index was used as the dependent variable and determinants of farm enterprise diversity as independent variables in Ordered Logit model. Probit and Logit models could be used but they assume that the dependent variable is either 0 or 1. Under such assumption, important information about farmers who have partially diversified their farm enterprises could be lost. Ordinary Least Squares model could have also been used but using it produces inconsistent and biased estimates because OLS reduces the slope thus underestimating the true effects of parameters (Gujarati, 2003). Tobit which is a censored model could have been used to analyze the objective since the dependent variable has lower and upper limit (Mesfin *et al*., 2011). However, since the dependent variable was ordered into three that is; 1= low, 2= medium and 3= high, Ordered Logit was a suitable model to use. Ordered Logit or Probit model is suitable for use when an outcome is ordered however, Ordered Logit results are easier to interpret (Min, 2013) . Following methodology by Zamasiya *et al*. (2017), Ordered Logit equation can be written as;

$$Y^{*} = BX_{i} + Ei \quad \text{..... (9)}$$

Where, Y is farm enterprise diversity which is categorized into three and B is a vector of coefficients to be estimated, X_i is vector of conformable parameters to be estimated and E_i is the error term.

$$Y = 0 \text{ if } y* \leq 0 \quad \text{..... (10)}$$

$$= 1 \text{ if } 0 \geq y^{*} \leq \delta 1 \quad \text{..... (11)}$$

$$= 2 \text{ if } \delta 1 \geq y^{*} \leq \delta 2 \quad \text{..... (12)}$$

$$= 3 \text{ if } \delta 2 \geq y^{*} \leq \delta 1 \quad \text{..... (13)}$$

$$= j \text{ if } \delta j - 1 \geq y* \quad \text{..... (14)}$$

The coefficients and cut points are estimated using maximum likelihood.

Poisson model was also used since crop and animal species count is a count data. Crop and livestock count y_i is a count data and is obtained from a Poisson distribution with factor λ_i related to independent variables x_i (Greene, 2007). The equation can be expressed as;

$$\text{Prob}\left(Y_i = y_{i|} \mid x_i\right) = \frac{e^{-\lambda}\lambda_i^{y_i}}{y_i!} \quad \text{.....(15)}$$

Log-linear form of λ_i which is mostly used is presented as;

$$\ln \lambda = x_i^{'}\beta \quad \text{.....(16)}$$

Expected mean value of farm enterprise diversity is expressed as;

$$\mathrm{E}[y_i \mid x_i] = Var[y_i \mid x_i] = \lambda_i = e^{x_i^{'}\beta}$$

$$\frac{\partial E[y_i \mid x_i]}{\partial x_i} = \lambda_i \beta \quad \text{.....(17)}$$

Where, $\mathrm{E}[y_i]$ is mean value of farm enterprise diversity for the *ith* farmer and β is a vector of unknown parameters.

The variables that were used in Ordered Logit and Poisson models as presented in Table 1, were generated from reviewing the works of; (Asante *et al*., 2017; Boncinelli *et al*., 2018; Ciaian *et al*., 2018; Dube & Guveya, 2016; Kasem & Thapa, 2011; Mburu *et al*., 2016; Mekuria & Mekonnen, 2018; Mesfin *et al*., 2011; Mishra *et al*., 2004; Rahman & Chima, 2016; Rehima *et al*., 2013; Turner *et al*., 2006).

Table 1: Variables used in Ordered Logit and Poisson models

Variable	Variable explanation	Expected sign
Dependent variables		
Clc	Crop and livestock species count	
Simpindex	Simpson's index	
Independent variables		
Age	Age of the head of the household in years	+
Gender	Gender of the head of the household Dummy 1 if male, 0 if female	+
Educ	Education level of the head of the household (HHH) 1= no formal education 0= otherwise (primary, secondary, post-secondary)	+
Tenure	Land tenure (1=own land, 2= own land and rent in 3= own land and rent out)	+
Nogrpsithhhmmbrs	Number of groups household members were engaged in (group membership)	+
Dstancetomkt	Access to market in (km)	−
Notrainatt	Access to agricultural training (Number of trainings)	+
Landsize	Land size (acres)	+
Slope	Slope of the land (1= flat 0= otherwise)	+
Offfarminc	Whether small-scale farmer had other source(s) of income apart from farming activities Dummy=1 if yes, 0 if no	+
Aid	Access to aid (1=yes 0=no)	−
Irrigation	Access to irrigation (1= yes 0= no)	+
Site	Geographical location (1= Makueni 0=Nyando)	

3.5.3 Objective 3: To determine the link between farm enterprise diversity and household dietary quality in Makueni and Nyando Sub-Counties

The objective on the link between farm enterprise diversity and dietary quality among small-scale farmers was analyzed using Poisson model which is a non-linear regression model. Multiple linear regression model could be an alternative but since there existed small values and the dependent variable was unique, it required the use of a model that takes into account those features (Greene, 2007). Household Dietary quality was assessed using HDD which represents count data that is not normally distributed and can take the values between 0 and 12. Poisson which is a probability distribution is appropriate for analysis of count data (Gujarati, 2003). Poisson model was used to avoid the approximation of count data by a continuous distribution, and to ensure non-negative predictions.

HDD y_i is a count data and is obtained from a Poisson distribution with factor λ_i related to independent variables x_i according to (Greene, 2007). Independent variables in the equation are; the Simpson's Index, crop and livestock count variable and other variables posited to affect the link between farm enterprise diversity and household dietary quality. Following Gido *et al*. (2015), the Poisson equation will thus be;

Prob

$$\left(\mathrm{Y}_i = y_{i|} \mid x_i\right) = \frac{e^{-\lambda}\lambda_i^{y_i}}{y_i!} \quad \text{.....(18)}$$

Log-linear form of λ_i which is mostly used is presented as;

$$\ln \lambda = x_i^{'}\beta \quad \text{..... (19)}$$

Expected HDD is written as;

$$\mathrm{E}\left[y_i \mid x_i\right] = Var\left[y_i \mid x_i\right] = \lambda_i = e^{x_i^{'}\beta}$$

$$\frac{\partial E\left[y_i \mid x_i\right]}{\partial x_i} = \lambda_i \beta \quad \text{..... (20)}$$

Poisson which is a non-linear model is easier to approximate using maximum likelihood (Greene, 2007). The equations are;

$$\frac{\partial \ln L}{\partial \beta} = \sum_{i=1}^{n} (y_i - \lambda_i) x_i = 0 \quad \text{..... (21)}$$

$$\ln L = \sum_{i=1}^{n} \left[-\lambda_i + y_i x_i' \beta - \ln y_i ! \right] \quad \text{..... (22)}$$

Coefficient estimates in Poisson distribution show by what percentage dietary quality changes when independent variables change by a unit (Sibhatu *et al*., 2015). In Poisson, it is assumed that mean and variance of dietary diversity are equal (Koppmair *et al*., 2016).

Table 2 presents variables that were used in Poisson model and were generated from reviewing the works of; (Dillon *et al*., 2015; Jones *et al*., 2014; Kang *et al*., 2018; Koppmair *et al*., 2016; Romeo *et al*., 2016; Sibhatu & Matin, 2016; Smale *et al*., 2015; Snapp & Fisher, 2015; Zanello *et al*., 2019).

Table 2: Variables used in Poisson model

Variable	Variable description	Expected sign
HDD	Household dietary diversity (number of food groups consumed by a household)	
	Explanatory variables	
Clc	Crop and livestock species count	+
Simpindex	Simpson's index	+
Age	Age of the head of the household in years	−
Educ	Education level of the head of the household (HHH) 1= no formal education 0= otherwise (primary, secondary, post-secondary)	+
Gender	Gender of the head of the household Dummy 1 if male, 0 if female	−
Landsize	Land size (acres)	+
Hhsize	Household size (individuals who dwell in the household for 3 or more months in a year)	−
Offfarminc	Whether small-scale farmer has other source(s) of income apart from farming activities Dummy=1 if yes, 0 if no	+
Dstancetomkt	Access to market in (km)	−
Nogrpsithhhmmbrs	Number of groups household members are engaged in (group membership)	+
Site	Geographical location (1=Makueni 0= Nyando)	

CHAPTER FOUR

RESULTS AND DISCUSSION

This chapter discusses the empirical findings of the study and is divided into three major sections. The first section starts by describing the basic characteristics of the study population and farm and farmer characteristics by levels of farm enterprise diversity. The second section presents result from the Ordered Logit and Poisson models on factors influencing farm enterprise diversity. In the third section, descriptive statistics of HDD and results of Poisson model on the link between farm enterprise diversity and household dietary quality are discussed.

4.1 Farm and farmer characteristics

4.1.1 Basic characteristics of the study population

The ages of household heads among the study participants ranged from 22 to 103 with an average age of 55 years. In addition, the household size ranged from 1 to 23 with an average household size of 6 members, Table 3.

Table 3: Basic characteristics of the study population for continuous variables

Variable	**Total**		**Makueni**		**Nyando**		
	Mean	Sd	Mean	Sd	Mean	Sd	**t-test value**
Age of household head(years)	55.3	15.4	56.1	16.1	54.6	14.7	-0.87
Household size	5.8	2.8	5.7	3.2	5.9	2.5	0.77
Land size	3.2	2.7	4.1	3.3	2.3	1.5	-6.20***
Distance to market (km)	3.2	2.9	2.7	2.5	3.7	3.3	2.89***
Number of trainings attended	0.7	1.3	0.9	1.3	0.5	1.4	-2.65***
Number of groups	2.2	2.0	2.7	2.0	1.6	1.8	-5.12***

Note: *** indicates significance at 1% level

Average land size was 3.2 acres with mean land size in Makueni (4.1±3.3) being significantly ($p< 0.01$) higher than in Nyando (2.3±1.5). Walking distance to the nearest market was shorter among small-scale farmers in Makueni (2.7±2.5 km) compared to those in Nyando (3.7±3.3 km). This finding indicated that there was a significant difference between walking distance to the nearest market at 1% significance level. The mean number of trainings attended by small-scale farmers in the past year on crop commercialization and risk mitigation was significantly ($p<0.01$) higher in Makueni (0.9±1.3) compared to Nyando (0.5±1.4). On

average, the number of social groups the household members were engaged was two (2.7±2.0) in Makueni and (1.6±1.8) in Nyando and significantly different between the two study sites at 1% significance level.

The findings in Table 4 show that majority of the households were male-headed (74.9%) with 76.3% in Makueni and 73.6% in Nyando.

Table 4: Basic characteristics of the study population for categorical variables

Variable	**Total** %	**Makueni** %	**Nyando** %	chi^2 **value**
Gender				
Male	74.9	76.3	73.6	0.3015
Female	25.1	23.8	26.4	
Education				
No formal education	18.2	16.9	19.5	4.8173
Primary	57.7	53.8	61.6	
Secondary	17.6	21.3	13.8	
Post-secondary	6.6	8.1	5.0	
Off-farm income				
No	7.8	8.1	7.6	0.0369
Yes	92.2	91.9	92.5	

Overall, a higher percentage (81.8%) of the household heads had formal education while 18.2% had no formal education. More than half (57.7%) of the household heads had attained primary-level education with slightly a higher percentage in Nyando (61.6%) than in Makueni (53.8%). The finding show that a majority (92.2%) of small-scale farmers received income from off-farm activities while 7.8% did not receive off-farm income.

Findings in Table 5 show that the average number of crops grown and livestock species kept by small-scale farmers was 9. On the other hand, the mean Simpson's Index was significantly ($p< 0.01$) higher in Makueni (0.5±0.2) than in Nyando (0.4±0.2).

Table 5: Farm enterprise diversity by location

Variable	**Total**		**Makueni**		**Nyando**		
	Mean	Sd	Mean	Sd	Mean	Sd	**t-test value**
Crop and livestock count	8.9	2.5	8.9	2.1	9.0	2.8	0.54
Simpson's Index	0.5	0.2	0.5	0.2	0.4	0.2	-3.17***

Note: *** indicates significance at 1% level

4.1.2 Socioeconomic characteristics of farmers by levels of farm enterprise diversity

In this section, farm enterprise diversity was measured using Simpson's Index which has values between 0 and 1. To present the findings with regards to farm enterprise diversity, the sample was further categorized into three groups using Simpson's Index as those having low farm enterprise diversity (0 to 0 .33), medium (0.34 to 0.66) and high (0.67 to 1) following (Riwthong *et al*., 2015). This study used a sample size of 319 instead of 320 since one small-scale farmer from Nyando was not growing any crop, therefore it was not possible to calculate Simpson's Index for the farmer.

There was a significant relationship between location and farm enterprise diversity at 10% significance level, Table 6. A slightly higher percentage (22.5%) of small-scale farmers from Makueni had high farm enterprise diversity compared to 16.4% from Nyando. On the other hand, a higher proportion of small-scale farmers (28.3%) from Nyando had low farm enterprise diversity compared to 18.1% from Makueni. This may be attributed to factors like small-scale farmers in Makueni having bigger land sizes, shorter distances to the market, a higher number of social groups household members were engaged in and attending more trainings on crop commercialization and risk mitigation compared to small-scale farmers in Nyando. In addition, the difference in production diversity maybe as a result of regional structural differences for example agronomic conditions, soil quality, quality of infrastructure or historical difference in land redistribution (Ciaian *et al*., 2018).

Table 6: Relationship between farm enterprise diversity and location based on using Simpson's Index

	Farm Enterprise Diversity			
Sub-County	**Low**	**Medium**	**High**	chi^2 **value**
Nyando	28.3	55.4	16.4	5.3370 *****
Makueni	18.1	59.4	22.5	
Overall	23.2	57.4	19.4	

Note: ***** indicates significance at 10% level

Table 7 presents findings with regards to the relationship between farm enterprise diversity and gender of the household head, education of the household head and off-farm income.

Table 7: Relationship between farm enterprise diversity and gender of the household head, education of the household head and off-farm income

		Farm Enterprise Diversity			
Variables	**Overall**	**Low**	**Medium**	**High**	
	%	**%**	**%**	**%**	chi^2 **value**
Gender of the household head					
Female	25.1	18.9	28.4	22.6	2.7846
Male	74.9	81.1	71.6	77.4	
Education of the household head					
No formal education	18.2	8.1	21.3	21.0	7.3837
Primary	57.7	66.2	55.2	54.8	
Secondary	17.6	20.3	16.9	16.1	
Post-secondary	6.6	5.4	6.6	8.1	
Off-farm Income					
No	7.8	8.1	7.7	8.1	0.0208
Yes	92.2	91.9	92.4	91.9	

A higher proportion (81.1%) of male-headed households had low farm enterprise diversity compared to 18.9% female-headed households. In addition, a higher percentage (77.4%) of households that had high farm enterprise diversity were male-headed whereas 22.6% were

female-headed. However, there was no significant relationship between gender of the household head and farm enterprise diversity. Having a male as the head of the household increases the chances of a household diversifying their farm enterprises due to male members of the household being more likely to have access to land, information and other resources unlike female members. Furthermore, Kankwamba *et al*. (2012) suggested that female headed households were more resource constrained in comparison to male headed households. According to Mulwa and Visser (2019), it is more likely that both spouses are present in male-headed households, thus they are likely to own a diverse livestock species since men tend to keep big ruminants like cattle while women tend to keep small ruminants and poultry.

More than half (66.22%) of farmers who had low farm enterprise diversity had attained primary school education compared to those who had medium (55.2%) and high (54.8%) farm enterprise diversity. On the other hand, a small percentage (8.1%) of small-scale farmers who had high farm enterprise diversity had post-secondary education compared to those who had medium (6.6%) and low (5.4%) farm enterprise diversity. Education could help improve one's knowledge regarding farming practices, where they can seek agricultural information and how to apply technology to improve one's farm enterprise. In addition, Weiss and Briglauer (2000) noted that schooling improves managerial skills which facilitates a farm operator to have a farm which is more diversified. Moreover, people who are educated are better informed about alternative crops and/or livestock adaptable to existing production conditions (Asante *et al*., 2017).

Overall, the finding indicated that a higher percentage of farmers who had low (91.9%), medium (92.4%) and high (91.9%) farm enterprise diversity received off-farm income compared to a small percentage of farmers who had low (8.1%), medium (7.7%) and high (8.1%) farm enterprise diversity who did not receive off-farm income. Off-farm income is key to increased farm enterprise diversity since the extra income small-scale farmers earn could help in buying more farm inputs and maintaining more livestock species in the farm. In addition, households having off-farm income generally have better access to information on alternative agricultural technologies and new market opportunities (Wollni *et al*., 2010). On the contrary, off-farm income was posited to reduce the degree of farm diversification possibly due to incompatibility with the labour demands of farm diversification (Mesfin *et al*., 2011). In addition, off-farm income is a disincentive to farm enterprise diversity since farmers may channel the income to other uses other than farming (Mekuria & Mekonnen, 2018).

Findings with regards to differences in the mean values of age of the household head in years, land size in acres and household size by levels of farm enterprise diversity are presented in Table 8.

Table 8: Differences in the mean values of age of the household head, land size and household size by levels of farm enterprise diversity

Variable	Farm enterprise diversity						
	Low		Medium		High		
	Mean	Sd	Mean	Sd	Mean	Sd	F-test
Age of the household head (years)	51.8	14.6	55.4	15.6	59.4	15.0	4.22**
Household size	5.8	2.5	5.6	2.7	6.4	3.4	1.85
Land size (acres)	3.4	8.9	2.9	8.5	3.7	8.9	1.88

Note: ** indicate significance level at 5%; Sd means standard deviation

Findings from the study show that there was significant difference in the mean ages of the household head at 5% significance level. It shows that mean age of small-scale farmers who had high farm enterprise diversity was higher than for those who had low farm enterprise diversity. Older farmers are more likely to have experiential knowledge regarding farming practices and more resources that they can use to cultivate more crop and livestock species compared to young farmers. Moreover, Amine and Fatima (2016) suggested that there is a possibility of young farmers starting small and specialized in their farming and as a result become more diversified as they expand their operations. However, Mesfin *et al.* (2011) suggested that older farm operators are less risk-averse and less diversified compared to young and beginning farm operators who are more risk-averse.

Households that had low, medium and high farm enterprise diversity had an average of 6 household members. However, there was no significant difference in the mean of household sizes by farm enterprise diversity. More household members provide labour needed in the farm to produce adequate food for all the household members. Furthermore, Mesfin *et al.* (2011) and Kankwamba *et al*. (2012) suggested that larger household size allows the household to pool together resources needed for cultivation of a high number of crops. In addition, farmers who have access to labour can diversify their farm enterprises by growing crops that are of high value (Kumar *et al*., 2012).

Small-scale farmers who had high farm enterprise diversity had an average land size of 3.7 acres whereas those who had low had an average land size of 3.4 acres. Having a bigger farm size could make a farmer grow more crops and keep diverse livestock species. In addition, a farmer can rent out a part of the land so as to get money to grow and maintain more crops and livestock species. Mandal and Bezbaruah (2013) and Sichoongwe *et al*. (2014) postulated that an increase in the size of land enables farmers to diversify their cropping pattern to a bigger extent. In addition, Amine and Fatima (2016) suggested that an agricultural producer with a larger land size maybe more determined in engaging in diversified farming since they face more risks in production.

Findings with regards to the relationship between farm enterprise diversity and access to irrigation and land tenure, are summarized in Table 9. The relationship between access to irrigation and farm enterprise diversity was statistically significant at 10% significance level. Less than half (30.7%) of farmers who had high farm enterprise diversity had access to irrigation compared to 20.4% who had low farm enterprise diversity. Access to irrigation gives a farmer a chance to grow more crops even in the dry season. Furthermore, Mesfin *et al*. (2011) mentioned that access to irrigation by farmers gives them opportunities to grow more crops. In addition, provision of irrigation enables farmers to do irrigation also during the dry season (Manda *et al*., 2016).

The relationship between land tenure and farm enterprise diversity was statistically significant at 10% significance level. Overall, a high percentage of small-scale farmers who had low (73.0%), medium (88.0%) and high (82.3%) farm enterprise diversity used their own land for farming compared to small-scale farmers who had low (2.7%), medium (0.6%) and high (1.6%) farm enterprise diversity who used their own land and rented-in more land for farming. Land ownership gives a farmer the exclusive rights and security to use land to cultivate more crop and livestock species. Kpadonou *et al*. (2017) suggested that land-insecure farmers may get discouraged to adopt technology since they may not be able to control the land long enough to reap the full benefits of their investments.

Table 9: Relationship between farm enterprise diversity and access to irrigation and land tenure

Variables	Farm Enterprise Diversity				
	Overall %	Low %	Medium %	High %	chi^2 value
Irrigation					
No	79.6	78.4	83.6	69.4	5.8897*
Yes	20.4	21.6	16.4	30.7	
Land tenure					
Own land	83.4	73.0	88.0	82.3	9.1604 *
Own land rent in land	15.4	24.3	11.5	16.1	
Own land rent out	1.3	2.7	0.6	1.6	

Note: * indicate significance level at 10%.

4.1.3 Institutional characteristics of farmers

A summary of the difference in the mean values of the distance to the nearest market in kilometers, number of trainings attended and number of groups household members were engaged in by levels of farm enterprise diversity are presented in Table 10.

Table 10: Difference in the mean values of the distance to the market, number of groups household members were engaged in and number of trainings attended by levels of farm enterprise diversity

Variable	Farm Enterprise Diversity						
	Low		Medium		High		
	Mean	Sd	Mean	Sd	Mean	Sd	F-test
Distance to the market	3.6	3.4	3.2	2.7	2.7	3.1	1.59
Number of trainings attended	0.3	0.7	0.7	1.4	1.1	1.7	5.40 ***
Number of groups	2.0	1.6	2.2	2.2	2.3	1.9	0.63

Note: *** indicate significance level at 1%.

Small-scale farmers who had low farm enterprise diversity travelled an average of 3.6 km to the nearest market whereas those who had high farm enterprise diversity travelled an average of 2.7 km. Distance to the market is used as a proxy for access to information and is also used to determine how easily a farmer can get their farm produce to the market and procure inputs

thus saving on cost. Farmers who are closer to the market tend to diversify their farm enterprises in order to meet the changing market demand for different products at different times of the year (Asante *et al*., 2017; Dube & Guveya 2016).

The average number of trainings attended by small-scale farmers who had medium and high farm enterprise diversity was 1 whereas for small-scale who had low was 0. The finding showed that there was a significant difference in the mean number of trainings attended by farmers on crop commercialization and risk mitigation by farm enterprise diversity at 1% significance level. Farmer training is a means by which farmers are taught on ways of mitigating risk, commercializing their produce as well as the use of different farming technologies to improve on production of the different crops and livestock species. Mesfin *et al*. (2011) suggested that there is a possibility of a farmer engaging in production of more enterprises if they have more contacts with an extension agent.

The average number of social groups small-scale farmers who had low, medium and high farm enterprise diversity were engaged in was 2. Social groups offer avenues in which members can gain knowledge through being trained together as a group as well as sharing information among each other. It is also through groups that members can acquire loans for example through table banking that can be used to diversify their farm enterprises. Membership to farmers' groups makes it easy for extension agents to reach members, helps members to frequently interact with service providers and saves on cost since reaching members in a group is cheaper (Gido *et al*., 2015).

From the finding in Table 11, a higher percentage (79.0%) of the small-scale farmers did not receive any aid in terms of food, agricultural inputs, animals, cash or any other item in the past year whereas 21.0% received an aid. Less than half (18.92%) of small-scale farmers who received an aid had low farm enterprise diversity compared to 16.1% who had high farm enterprise diversity. Dependency on aid by farmers can make them not to have an incentive to diversify their farm enterprises since they have a ready source of food. On the other hand, aid can be good since some farmers can be able to get agricultural inputs which can be used to diversify their farm enterprises.

Table 11: Relationship between farm enterprise diversity and access to aid

Variables	Farm Enterprise Diversity				
	Overall	Low	Medium	High	
	%	%	%	%	chi^2 value
Aid					
No	79.0	81.1	76.5	83.9	1.7676
Yes	21.0	18.9	23.5	16.1	

Note: ** indicates significance level at 5%

4.2 Socio-Economic and institutional factors influencing farm enterprise diversity among small- scale farmers in Makueni and Nyando Sub-Counties.

This objective was analyzed using both Ordered Logit and Poisson models.

4.2.1 Preliminary diagnostics of the variables used in the regression model

Preliminary diagnostics were done to test for the presence of multicollinearity and heteroskedasticity among the independent variables used in the study. The presence of heteroskedasticity was examined using White test and the results are presented in Table 12. The results showed that there was heteroskedasticity problem since a chi-square value of 240.45 was significantly ($p< 0.05$) high. Therefore, robust standard errors were used in all the models to deal with the problem.

Table 12: White test for the presence of heteroskedasticity

Source	chi^2	df	p-value
Heteroskedasticity	240.45	202	0.0332
Skewness	18.43	19	0.4939
Kurtosis	2.26	1	0.1325
Total	261.14	222	0.0368

According to Wooldridge (2015), multicollinearity exists when there is high but not perfect correlation between two or more independent variables. VIF was used to measure multicollinearity among continuous independent variables. Each variable should have a VIF value of less than 5 otherwise a VIF greater than the limit implies that there is presence of multicollinearity (Hair *et al.*, 2011; Kock & Lynn, 2012). The highest VIF value was 1.08 as

presented in Table 13 implying no presence of multicollinearity among the continuous independent variables.

Table 13: Variance inflation factor for continuous variables

Variables	**VIF**	**1/VIF**
Land size	1.08	0.9262
Household size	1.07	0.9360
Number of groups household members are engaged in	1.05	0.9529
Age of the household head	1.05	0.9539
Number of trainings attended	1.04	0.9587
Distance to the nearest market	1.02	0.9838
Mean VIF	1.05	

Pairwise correlation was used to measure multicollinearity among categorical independent variables. Contingency coefficients having a value below the cut-off point of 0.75 implies that there is no problem of multicollinearity (Mesfin *et al*., 2011). All the values were below 0.75 which showed that there was no linear relationship among the categorical variables as presented in Table 14.

Table 14: Pairwise correlation

	Gender	Education	Tenure	Slope	Off-farm income	Irrigation	Site	Aid
Gender	1.0000							
Education	0.5182	1.0000						
Tenure	0.0051	-0.0335	1.0000					
Slope	0.0174	0.0626	-0.1383	1.0000				
Off-farm income	0.1004	0.0439	0.0694	0.017	1.0000			
Irrigation	0.0054	0.0342	0.1011	-0.0134	-0.0842	1.0000		
Site	0.0307	0.0921	-0.2207	0.2364	-0.0108	-0.1806	1.0000	
Aid	-0.1278	-0.1257	0.0748	-0.1031	0.0358	-0.0125	0.1754	1.0000

4.2.2 Effect of socio-economic and institutional factors on farm enterprise diversity

In Ordered Logit model, the log likelihood for the overall fitted model was -289.7121 and chi-square of 45.64 strongly significant at 1% level. Test for over dispersion revealed that Poisson model was the best model to use to determine factors influencing farm enterprise diversity compared to Negative Binomial model since the value of chi-square in the goodness of fit was 166.49 and an insignificant test statistic as shown in Appendix E. In addition, likelihood ratio test at the bottom of negative binomial analysis is a test of the over dispersion parameter alpha. In this case, alpha was insignificant revealing that Poisson was the best model to use. Thus, explanatory variables of socioeconomic and institutional factors are able to satisfactorily explain changes in farm enterprise diversity.

Ordered Logit and Poisson models were used to determine factors influencing farm enterprise diversity and the results are presented in Table 15. Both Ordered Logit and Poisson models results revealed that age of the household head had a positive influence on farm enterprise diversity at 1% and 10% significance levels, respectively. The results implied that older household heads were more likely to have diversified farm enterprises. This could be attributed to factors related to old age like being more risk averse, farming experience gained over the years and access to more resources leading to age having a positive effect on farm enterprise diversity. Similar findings were reported by Asante *et al*. (2017) and Mburu *et al*. (2016) who found out that farm diversity increased with age and the number of years the farm had been cultivated since older farmers are more risk averse due to their farming experiences. Contrary, Mesfin *et al*. (2011) and Mishra *et al*. (2004) alluded that the negative association between age and farm diversity could be due to older farmers being less risk-averse and therefore having less diversified farms compared to younger farmers since they have more wealth.

Table 15: Ordered Logistic and Poisson table on factors influencing farm enterprise diversity

	Simpson's Index		Crop and livestock count	
Variables	**Coeff.**	**Robust Standard Errors**	**Coeff.**	**Robust Standard Errors**
Socioeconomic factors				
Gender	0.1309	0.2972	-0.0166	0.0389
Age of the household head	0.0233***	0.0086	0.0018*	0.0010
Education of the household head	-0.0680	0.1435	0.0371**	0.0160
Off-farm income	0.4167	0.4264	0.04320	0.0507
Land tenure				
Own land rent in land	-0.4923	0.3921	0.0861**	0.0363
Own land rent out land	-0.7497	1.5369	0.2678***	0.0450
Land size	-0.0342	0.0517	0.0141***	0.0045
Slope	-0.1484	0.1108	0.0261*	0.0144
Irrigation	0.5567*	0.3227	0.2052***	0.0304
Aid	-0.4917*	0.2916	0.04134	0.0329
Institutional characteristics				
Distance to the market	-0.0404	0.0493	-0.0080	0.0050
Number of trainings attended	0.2789***	0.0900	0.0353***	0.0076
Number of groups	0 .0193	0.0472	0.0150**	0.0075
Location dummy	0.5243*	0.2746	-0.0568*	0.0335
-Constant			1.7716***	0.1077
Wald chi2 (14)	34.66		190.05	
Prob> chi2	0.0016		0.0000	
Pseudo R2	0.5640		0.3721	
Log likelihood	-293.8035		-723.75029	
Number of observations	319		319	

Note: *, **, ***, indicates significance level at 10%, 5% and 1% respectively

Education of the household head had a positive significant effect on farm enterprise diversity at 5% significance level. Higher education level of the household head was associated with more farm enterprise diversity. With education, a farmer is able to look for new information

and technologies to help in diversifying their farm enterprises. In addition, an educated household head could probably be working and may use income they earn to purchase and maintain more crop and livestock species. The results are similar to those of Boncinelli *et al*. (2018) and Rahman and Chima (2016) who found out that education of the household head had a significant positive effect on the decision to adopt a diversified cropping system since the ability to process information increases with education. In addition, education which contributes to household head's human capital, boosts the ability to hold new production technologies quickly, seek new information on technology and to meet more complex requirements for crop diversification (Rehima *et al*., 2013).

Land tenure in form of owning land and renting in some more had a significant positive effect on farm enterprise diversity at 5% significance level. Land tenure gives a farmer a sense of security and control over the land and this could encourage them to grow more crops and keep more livestock species. In addition, small-scale farmers who rent in more land maybe those who have scarcity of land. Therefore, this enables them to increase their operations thus having more diversified farm enterprises. On the other hand, land tenure in form of owning land and renting out part of it had a positive significant effect on farm enterprise diversity at 1% level of significance. By renting out part of their land, the small-scale farmers could have received an income which they may have used to develop their farm enterprises. The results contrast the findings by Mekuria and Mekonnen (2018) who found out that land rent out had a negative significant effect on crop-livestock diversity since a household that rented-out its land was unlikely to diversify its farming activities since the same piece of land could have been used to produce more crops and forages and keep animals on it.

Land size in acres was found to have a significant positive effect on farm enterprise diversity at 1% level of significance. Farmers who have bigger land sizes are more likely to diversify their farm enterprises since they face high production risk. This result is similar to those of Amine and Fatima (2016), Mekuria and Mekonnen (2018) and Rehima *et al*. (2013) who found out that farm size had a significant positive effect on crop-livestock diversification since more landholding enabled farmers to allocate their farming activities in multiple productions compared to small farms thereby minimizing income, production and price risks.

Slope of the land had a positive significant effect on farm enterprise diversity at 10% significance level. The result implied that farms lying on flat land encouraged the small-scale farmers to diversify their crops and livestock species. Flat lands are suitable for growing more

crop species and keeping more livestock compared to steep land since they are prone to erosion and landslides. The results are in line with the findings of Boncinelli *et al*. (2017) and Dube and Guveya (2016) who found out that slope of the land influences diversity of cropping enterprises since farmers having farms in flat terrains have more chances of diversifying their cropping patterns as compared to farmers with farms in slopy terrains.

Access to irrigation had positive significant effect on farm enterprise diversity in both Ordered Logit and Poisson models at 10% and 1% significance levels, respectively. Both Makueni and Nyando Sub-Counties are semi-arid lands. Therefore, having access to irrigation by the small-scale farmers helped them solve the problem of uncertainty in production associated with water scarcity. Thus, this encouraged the farmers to grow more crop species under irrigation even during the dry season. The results are in line with those of Ciaian *et al*. (2018); Dube and Guveya (2016) and Mekuria and Mekonnen (2018) who found irrigation having a positive effect on crop-livestock diversification since irrigation increases crop-livestock diversity by supplementing water during times when it is scanty and also households that can irrigate their fields can grow a wide spectrum of crops.

Access to aid had a negative but significant effect on farm enterprise diversity at 10% level. Farmers who received an aid reduced their probability of diversifying their farm enterprises by 4.9%. Reliance on aid can make farmers not have incentive of diversifying their farm enterprises since they get contented by depending on what they are given. In addition, aid through cash can make farmers channel the money to other uses they had already planned for. The findings are in line with those of Turner *et al*. (2006) who found that majority of farmers who had diversified their farm enterprises were farmers who did not receive grant aid. The reason could be due to pressures on farm incomes and copying from farmers who were less risk averse and had diversified their farm enterprises.

The number of trainings attended by a farmer had a significant positive effect on farm enterprise diversity in both models at 1% significance level. Farmers who have access to more trainings on crop commercialization and risk mitigation diversify their farm enterprises to mitigate risk in times of crop failure and to market their produce to earn an income. The results corroborate the findings of Kasem and Thapa (2011) who found out that farmers who had diversified farms had attended more training sessions conducted by both public and private agencies which enabled them gain more knowledge on technical know-how, economic benefits and marketing opportunities related to new crops.

Number of groups household members were engaged in had a positive significant effect on farm enterprise diversity at 5% significance level. Groups act as information channels where members are able to exchange ideas, are taught collectively by extension agents and members offer support to each other for example through providing labour in the farms. Group members also act as guarantors for other members enabling them to access loans to buy farm inputs which promote farm enterprise diversity. The findings are consistent with those from Kasem and Thapa (2011) who found out that crop diversification was adopted by farmers who had better interactions with farmer's groups responsible for the dissemination of information on crop diversification and organizing training programs for their members. These results are in contrast to those of Rehima *et al*. (2013) who found that social organizations had a negative significant effect on crop diversification since cooperatives may have their own objective and specialize in particular crops thereby narrowing the probability of farmers diversifying their farm enterprises.

Location dummy had a significant positive effect on farm enterprise diversity at 10% significance level in Ordered Logit model and a negative significant effect on farm enterprise diversity at 10% level of significance in Poisson model. These results implied that small-scale farmers in Makueni had more diverse crop species compared to farmers in Nyando and on the other hand less diverse livestock species compared to farmers in Nyando as shown in Tables 5 and 6. The reason for the higher number of crop species in Makueni could be attributed to the fact that small-scale farmers in the Sub-County have bigger sizes of land, being closer to the market and extension services, having attended more trainings on crop commercialization and risk mitigation in the past year and household members' engagement in more social groups than small-scale farmers in Nyando. On the other hand, the higher number of livestock species in Nyando Sub-County compared to Makueni could be a strategy by the small-scale farmers to overcome risk associated with crop failure. In addition, the results could be attributed to the difference in agroecological conditions of the two Sub-Counties and the types of production systems. Dube and Guveya (2016) found out that farmers with farms in drier agroecological zones had higher probability of adopting crop diversification compared to farms in better agroecological zones since there is high risk of crop failure due to erratic rainfall patterns.

4.3 Effect of farm enterprise diversity on household dietary quality in Makueni and Nyando Sub-Counties

4.3.1 Basic descriptive statistics of household dietary quality

The results with regards to households' consumption of foods from different food groups are presented in Figure 3.

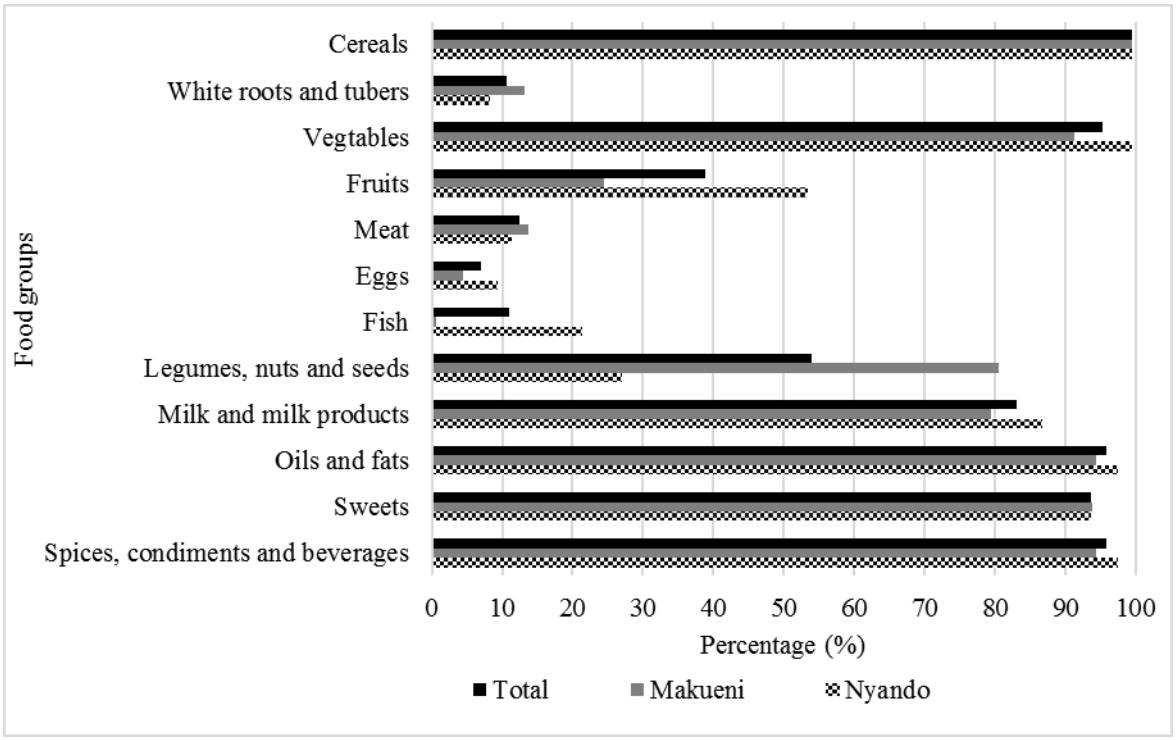

Figure 3: Percentage of households who consumed foods from different food groups in the past 24 hours

Overall, a high proportion of households consumed cereals (99.4%), spices, condiments and beverages (95.9%), oils and fats (95.9%) and vegetables (95.3%). The same scenario with regards to nearly all the households consuming cereals, spices, condiments and beverages and oils and fats was reported in both Makueni and Nyando. More than half of the households (53.9%) consumed legumes, nuts and seeds, with a higher percentage in Makueni (80.6%) compared to Nyando (27.0%). While less than half of the households surveyed (38.8%) consumed fruits, more households in Nyando (53.3%) consumed fruits compared to their counterparts in Makueni (24.4%). Except for milk and milk products which was consumed by 83.1% of households, consumption of other animal source foods including meats (12.5%), eggs (6.9%) and fish (11.0%) was notably low among the households. However, a higher percentage of households in Nyando consumed fish (21.4%) and eggs (9.4%), compared to

(0.6%) and (4.4%) in Makueni. On the other hand, a slightly higher percentage of households in Makueni consumed meat (13.8%) compared to those from Nyando (11.3%).

A higher consumption of fish in Nyando could be attributed to the location nearness to Lake Victoria which is a source of fish. On the other hand, the higher consumption of legumes, nuts and seeds in Makueni could be because *githeri* and *muthokoi* are staple foods among the households in the region, therefore eaten by most households. However, since data on food consumption was based on 24-hour recall, what the households ate in the past 24-hours may not be what they consume on a typical day. In addition, some crops like fruits and some vegetables are seasonal and have a short shelf-life. The low consumption of nutrient dense foods among households in both Makueni and Nyando Sub-Counties could be attributed to lack of nutrition knowledge on their importance for good health. From the Kenya National Food and Nutrition Security Implementation Framework 2017-2022, the main hindrance to achieving good nutrition status in Kenya include inadequate awareness and knowledge on nutritionally adequate diets, limited resource allocation and capacity to support the implementation of comprehensive nutrition programs in the country (GoK, 2017). In most developing countries like African countries, dietary patterns are comprised of starchy foods low in energy, few animal source-foods, fruits and vegetables (Leyna *et al*., 2010). In a study by Ochieng *et al*. (2017), they found out that the consumption of eggs among the households was low since many households are not able to purchase animal products which are rarely eaten at home but are frequently sold to the market. In another study by Keding *et al*. (2012), the consumption of fruits was found to be low a situation that could be linked to seasonality of the fruits and lack of nutrition knowledge on their importance in the diet.

Overall, the mean HDD was 7.0± 1.3 with no significant difference between small-scale farmers' households in Makueni 6.9±1.3 and Nyando 7.1 ± 1.3. This implies that on average, the households from both Makueni and Nyando Sub-Counties consumed foods from 7 food groups. Overall, 89.0% of the small-scale farmers' households had high dietary diversity that is they had consumed foods from 6 or more food groups in the past 24 hours compared to 0.9% who had low household dietary diversity (had consumed foods from ≤3 food groups), Table 16. Results comparing the two study locations showed that there was no significant relationship in the proportions of households who had high (89.9% vs. 88.1%), medium (8.8% vs. 11.3%) and low (1.3% vs. 0.6%) dietary diversity between Nyando and Makueni, respectively. The foods consumed by members of these small-scale farmers' households

might have been from their own production and with a variety of other foods being purchased from the market. According to Gitagia *et al*. (2019), instead of households producing foods from all the food groups at home, they can purchase foods from the market which contributes to improvement of dietary diversity.

Table 16: Distribution of HDDS categories by location

Location	**Low (≤3 food groups) %**	**Medium (4-5 food groups) %**	**High (≥ 6 food groups) %**	chi^2 **value**
Overall	0.9	10.0	89.0	0.8443
Makueni	0.6	11.3	88.1	
Nyando	1.3	8.8	89.9	

Results with respect to HDDS by level of farm enterprise diversity are summarized in Table 17. A higher percentage of small-scale farmers who had low farm enterprise diversity (87.8%) had high dietary diversity compared to 90.2% and 87.1% who had medium and high farm enterprise diversity, respectively. The results indicated that there was no significant relationship between farm enterprise diversity measured through the Simpson's Index and household dietary quality. Farm enterprise diversity as measured using the Simpson index, only considered the different crops grown, and not the animals reared, hence the effect of the livestock on household dietary quality was masked. Keding *et al*. (2012) suggested that improvement in dietary diversity can be achieved through promotion of homestead food production and purchase and selling of vegetables.

Table 17: Household dietary diversity score categories (%) by level of farm enterprise diversity measured using the Simpson Index

	Farm enterprise diversity			
HDDS Classification	**Low**	**Medium**	**High**	
	%	**%**	**%**	chi^2 **value**
LDD (≤ 3 food groups)	0.0	1.6	0.0	3.7525
MDD (4-5 food groups)	12.2	8.2	12.9	
HDD (≥ 6 food groups)	87.8	90.2	87.1	

Note: LDD stands for Low Dietary Diversity, MDD stands for Medium Dietary Diversity and HDD stands for High Dietary Diversity

The results with regards to the percentage of households who consumed foods from different food groups by farm enterprise diversity measured using Simpson's index are presented in Figure 4. Generally, the consumption of milk was high among all the households with a higher percentage (90.5%) among households who had low farm enterprise diversity compared to 82.0% and 77.3% who had medium and high farm enterprise diversity respectively. Even though the consumption of animal source foods with the exception of milk and milk products was generally low, more households with low farm enterprise consumed meat (14.9%) and eggs (8.1%) compared to (9.7%) and (4.8%) who had high farm enterprise diversity. On the other hand, more households with medium farm enterprise diversity consumed fish (12.0%) compared to 11.3% and 8.1% with high and low farm enterprise diversity respectively. A slightly higher percentage of households with low farm enterprise diversity (43.2%) consumed fruits in comparison with 37.1% who had high farm enterprise diversity. Furthermore, more households with low farm enterprise diversity consumed roots and tubers (16.2%) compared to those with high farm enterprise diversity (8.1%). These results could be explained by the fact that farm enterprise diversity as measured using the Simpson index, only considered the different crops grown, and not the animals reared, hence the effect of the livestock on the consumption of foods from different food groups was disguised.

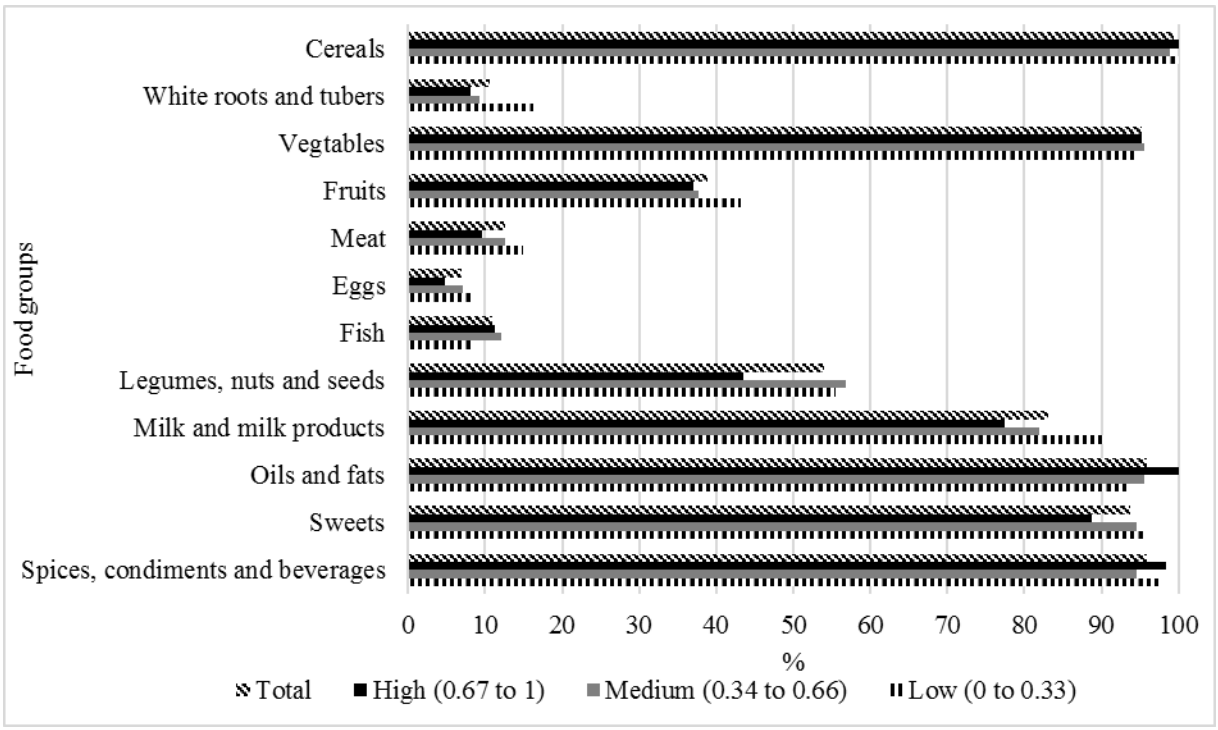

Figure 4: Percentage of households who consumed foods from different food groups in the past 24 hours by farm enterprise diversity measured using the Simpson Index

4.3.2 Link between farm enterprise diversity and household dietary quality

This section started with testing for the existence of multicollinearity between Simpson's Index and crop and livestock count using VIF and for the presence of endogeneity. Results in Table 18 showed that there existed no linear relationship between the two variables since a VIF value of 1.02 was considerably low. Thus, the two variables were used in analysis.

Table 18: VIF test between Simpson index and crop and livestock count

Variable	**VIF**	**1/VIF**
Crop and livestock count	1.02	0.9841
Simpson's Index	1.02	0.9841
Mean VIF	1.02	

To test for endogeneity, land size and slope of the land were used as instruments following (Bellon *et al*., 2016; Hirvonen & Hoddinott, 2017). The results revealed that endogeneity was

not a problem since the added residual was not statistically significant as shown in Appendix E.

Poisson model was used to model the results with HDD as the dependent variable and all other variables including Simpson's Index and crop and livestock count as independent variables. Test for over dispersion revealed that Poisson model was the best model to use to test for the effect of farm enterprise diversity on household dietary quality compared to Negative Binomial model since the value of chi-square was small in the goodness of fit that is 67.09 and an insignificant test statistic, Appendix E. In addition, likelihood ratio test at the bottom of negative binomial analysis is a test of over dispersion parameter alpha and in this case, alpha is insignificant revealing that Poisson was the best model to use.

From the results in Table 19, crop and livestock count had a positive significant effect on household dietary quality at 5% significance level. The result suggested that households produced different crops and livestock to meet their dietary needs and sold some of their produce and used the income to purchase a variety of other foods increasing their HDD. The finding corroborate with those from studies conducted by Snapp and Fisher (2015) and Zanello *et al*. (2019) who also found out that the crop and livestock diversity had a positive effect on dietary quality since households are able to consume some of the produce from their farms. Dillon *et al.* (2015) also found that production diversity had a positive significant effect on household dietary diversity. In addition, Koppmair *et al*. (2016) also found out that cash income from the sales of maize and other crops can be used to purchase diverse foods from the market thus having positive effect on dietary diversity.

Age of the household head had a negative but significant effect on household dietary quality at 1% significance level. Households with older household heads were associated with low dietary quality. Older household heads may not be earning an income to enable them purchase a variety of other foods for their households from the market to substitute foods from the farm compared to young and working household heads. This finding is in line with those of Dillon *et al.* (2015); Jones *et al*. (2014) and Romeo *et al*. (2016) who found out that households with older household heads had less diverse diets.

Table 19: Link between farm enterprise diversity and household dietary quality

HDD	Coefficients	Standard Errors	dy/dx
Socioeconomic factors			
Simpson's Index	-0.0202	0.0151	-0.1404
Crop and livestock count	0.0090 **	0.0037	0.0629
Gender	-0.0118	0.0262	-0.0820
Age of the household head (years)	-0.0018***	0.0007	-0.0123
Education of the household head	0.0215*	0.0119	0.1499
Household size	-0.0084**	0.0040	-0.0584
Off-farm income	0.0402	0.0535	0.2799
Land size (acres)	0.0090**	0.0037	0.0626
Institutional characteristics			
Distance to the nearest market (km)	0.0027	0.0033	0.0186
Number of groups	0.0167***	0.0039	0.1162
Location dummy	-0.0541***	0.0220	-0.3761
-Constant	1.9060***	0.0961	
Wald chi2(11)	63.53		
Prob> chi2	0.0000		
Pseudo R2	0.5806		
Log pseudolikelihood	-640.11518		
Number of observations	319		

Note: *, **, ***, indicate significance level at 10%, 5% and 1% respectively

The level of education attained by the household head was also found to have a significant positive effect on household dietary quality at 10% significance level. The result alluded that having educated household heads implies that they could probably be working hence earn an income which could be used to purchase a variety of other foods to substitute those from the farm. This result corroborates the finding by Dillon *et al.* (2015); Sibhatu and Matin (2016) and Snapp and Fisher (2015) who found out that households with educated heads had better quality diets. This is because since they could be working, they can purchase a variety of other foods for their households using the income they earn.

Household size was found to have a significant negative effect on household dietary quality at 5% level of significance. Households with more members were associated with low dietary quality since there are more mouths to feed. Therefore, the households may choose to purchase more of one type of food group at the expense of buying foods from different food groups so as to be able to feed the big number of household members. The result is in line with those of Gitagia *et al*. (2019) and Koppmair *et al*. (2016) who found out that as the number of household members increases, the intra-household food distribution is affected and food may become more limited thus limiting the access to different food groups. Some household members like the elderly and very young children are unable to provide the much needed labour for food production, yet they must feed, thus constraining the available food (Whitney *et al*., 2018). The result contrasted the finding of Jones *et al*. (2014) and Sekabira and Nalunga (2020) who found a positive association between household size and HDDS since more household members provide the labour that is needed to provide different types of food.

Land size had a significant positive effect on household dietary quality at 5% significance level. As farmers' land sizes increased, the probability of their households consuming high quality diets also increased. The result could imply that farmers are in a position to grow and keep more crop and livestock species if they have more land consequently leading to their households having better diets through subsistence pathway. In addition, by growing and keeping diverse crop and livestock species, farmers are able to sell the surplus and use the income to buy a variety of other foods that are of high quality for their households. Similar results were reported by Smale *et al.* (2015) who the total area cultivated in both growing seasons having a significant positive effect on dietary diversity by a bigger magnitude.

Number of social groups household members were engaged in was found to have a significant positive effect on household dietary quality at 1% significance level. Through group memberships, household members are in a better position to access money through merry-go-round, table banking and savings and credit which they could use to buy a variety of foods for their households. These social groups may also be sources of food during times of deficit by one relying on people who are in their network that is the kinship and nonkinship ties thereby helping one access better diets. Kang *et al*. (2018) reported that mothers engaged in two or more groups had higher DDS compared to mothers without group membership. This could be

as a result of individuals being able to gain knowledge through interacting with people who are in one's social networks.

Location dummy had a negative significant effect on household dietary quality at 1% significance level. The result implied that households in Nyando had better diets compared to households in Makueni. The difference in household dietary quality in the two regions could be attributed to the difference in agroecological conditions since certain crops and livestock species do well in one region and not the other. There is also cultural and lifestyle difference since some foods are eaten more in one region and less in the other for example, legumes were consumed more in Makueni and fish was consumed more in Nyando. This result corroborate with the findings from a report by Nasongo and Okeyo-Owuor (2017) in selected parts in Kisumu County which showed that 76% of the respondents consumed *omena,* a type of small fishes which is less costly. They also argued that ethnic and cultural background influence food choices and that since a majority of the respondents were from the Luo community, hence their preference for fish. On the other hand, *githeri* which is a mixture of maize and beans is a staple food among households in Makueni, a fact that could explain the higher consumption of legumes, nuts and seeds among households in this study location compared to those in Nyando (ACF-USA, 2012). In addition, some crops are seasonal and market days differ and since data on household dietary quality was based on 24-hour diet recall, it may not have adequately portrayed dietary patterns of the households.

CHAPTER FIVE
CONCLUSIONS AND RECOMMENDATIONS

This chapter presents the summary of the study, conclusions, recommendations for policy and practice, and then suggestions of areas for further research.

5.1 Summary of the study

This study aimed establishing the link between farm enterprise diversity and dietary quality among small-scale farmers' households in Makueni and Nyando Sub-Counties. The specific objectives of the study were to determine farm and farmer characteristics by level of farm enterprise diversity, determine the socio-economic and institutional factors influencing farm enterprise diversity among small- scale farmers and to determine the link between farm enterprise diversity and household dietary quality among small-scale farmers in Makueni and Nyando Sub-Counties. To analyze these objectives, farmers were categorized into three groups using the Simpson Index as those having low farm enterprise diversity (0 to 0 .33), medium (0.34 to 0.66) and high (0.67 to 1). The mean Simpson's Index was significantly ($p<$ 0.01) higher in Makueni (0.5±0.2) compared to Nyando (0.4±0.2). Ordered Logit and Poisson models revealed that age, education of the household head, land tenure, land size, slope, access to irrigation, number of trainings attended and number of groups household members were engaged in had a positive significant effect on farm enterprise diversity. However, access to aid and location dummy had a significant negative affect on farm enterprise diversity.

Overall, a high percentage of the small-scale farmers' households had high dietary diversity that is, they had consumed foods from 6 or more out of 12 food groups in the past 24 hours. Further, nearly all households consumed cereals, spices, condiments and beverages, oils and fats and vegetables. On the other hand, except for milk and milk products, consumption of other animal source foods including meats, eggs and fish was notably low among the households. In addition, less than half of the households consumed fruits. While HDD did not vary with location, a higher proportion of households in Nyando consumed fish, eggs and fruits compared to their counterparts in Makueni. On the other hand, a higher percentage of households in Makueni consumed meat and legumes, nuts and seeds compared to households in Nyando. The results imply that, since small-scale farmers in Nyando had lower farm enterprise diversity compared to those in Makueni, they could have depended on the market to purchase most of their foods

Poisson model on the link between farm enterprise diversity and household dietary quality showed that crop and livestock count, education of the household head, land size and number of groups household members are engaged in had a positive significant effect on household dietary quality. On the other hand, age of the household head, household size and location had a negative significant effect on farm enterprise diversity. Therefore, farm enterprise diversity positively influenced the quality of household diets since they could have produced the different crops and livestock species to meet their dietary needs and sold some of their produce and used the income to purchase a variety of other foods further increasing their HDD.

5.2 Conclusions

i) Farm enterprise diversity varies with location. This may be attributed to factors like small-scale farmers in Makueni having bigger land sizes, shorter distances to the market, a higher number of social groups household members are engaged in and attending more trainings on crop commercialization and risk mitigation compared to small-scale farmers in Nyando. This implies that location matters when it comes to farm enterprise diversity.

ii) The likelihood of small-scale farmers diversifying their farm enterprises is influenced by both socioeconomic and institutional factors. Generally, households with older and educated household heads and more land had high farm enterprise diversity due to factors like being more risk averse due to their past experiences, endowment with more resources, being able to look for new information and technologies and to minimize production risks. Number of trainings attended in the past year and number of groups household members were engaged in are the institutional factors affecting farm enterprise diversity.

iii) Farm enterprise diversity positively influences household dietary quality. This is because by producing the different crops and livestock species, households are able to consume a range of foods as well as sell some of their produce and use the income earned to purchase a variety of other foods from the market further diversifying their diets. However, except for milk and milk products, consumption of other animal source foods including meats, eggs and fish was notably low among the households. In addition, less than half of the households consumed

fruits. Lack of nutrition knowledge could be the reason why the consumption nutrient dense foods was low in both Makueni and Nyando Sub-Counties.

5.3 Recommendations

There is need for policies and programs by the government and development partners that promote access to education, productive resources and good infrastructure to the small-scale farmers. For instance, policies that favour access to land and capital to young and starting farmers can go a long way in helping them diversify their farm enterprises resulting in their households consuming high quality diets. Enhanced knowledge on education will improve the use of technology and information by the farmers. In addition, good infrastructure makes transportation easier and as such farmers are able to get their produce to the market within a short time and at low cost and access information with ease.

The County governments should invest in introducing programs where farmers are trained on adequate planning and risk mitigation measures as well as crop commercialization. This will help them be prepared in times when there is crop failure due to harsh climatic conditions like drought and erratic rainfall as well as commercializing their produce so that they are able to earn an extra income to purchase more diverse diets. In addition, the county governments through nutrition departments should also invest in training small-scale farmers on the importance of consuming a variety of foods for good health and nutrition. Farmers should be sensitized to not only plant but also to consume diets made from diverse crops and livestock species. This will in turn contribute to their households consuming high quality diets.

Lastly, programs and policies by government geared towards making market prices for farmers' produce better is key in achieving household dietary quality since farmers consume not only what they produce on their farms but also what they buy. Therefore, there is need for a conducive environment for the farmers to do business.

5.4 Areas of future research

The main aim of the study was to assess the link between farm enterprise diversity and household dietary quality among small-scale farmers so as to advocate for policies that contribute to improved dietary quality in Kenya. However, the study recommends further research;

i) In examining the role of the markets in addition to farm enterprise diversity in improved household dietary quality.

ii) In examining the role of nutrition knowledge in improving dietary quality of small-scale farmers' households.
iii) Using panel data to assess the role of farm enterprise diversity on household dietary quality so as to capture the seasonality aspect of production and variation in dietary patterns.
iv) In assessing the role of farm enterprise diversity on dietary quality at individual level.

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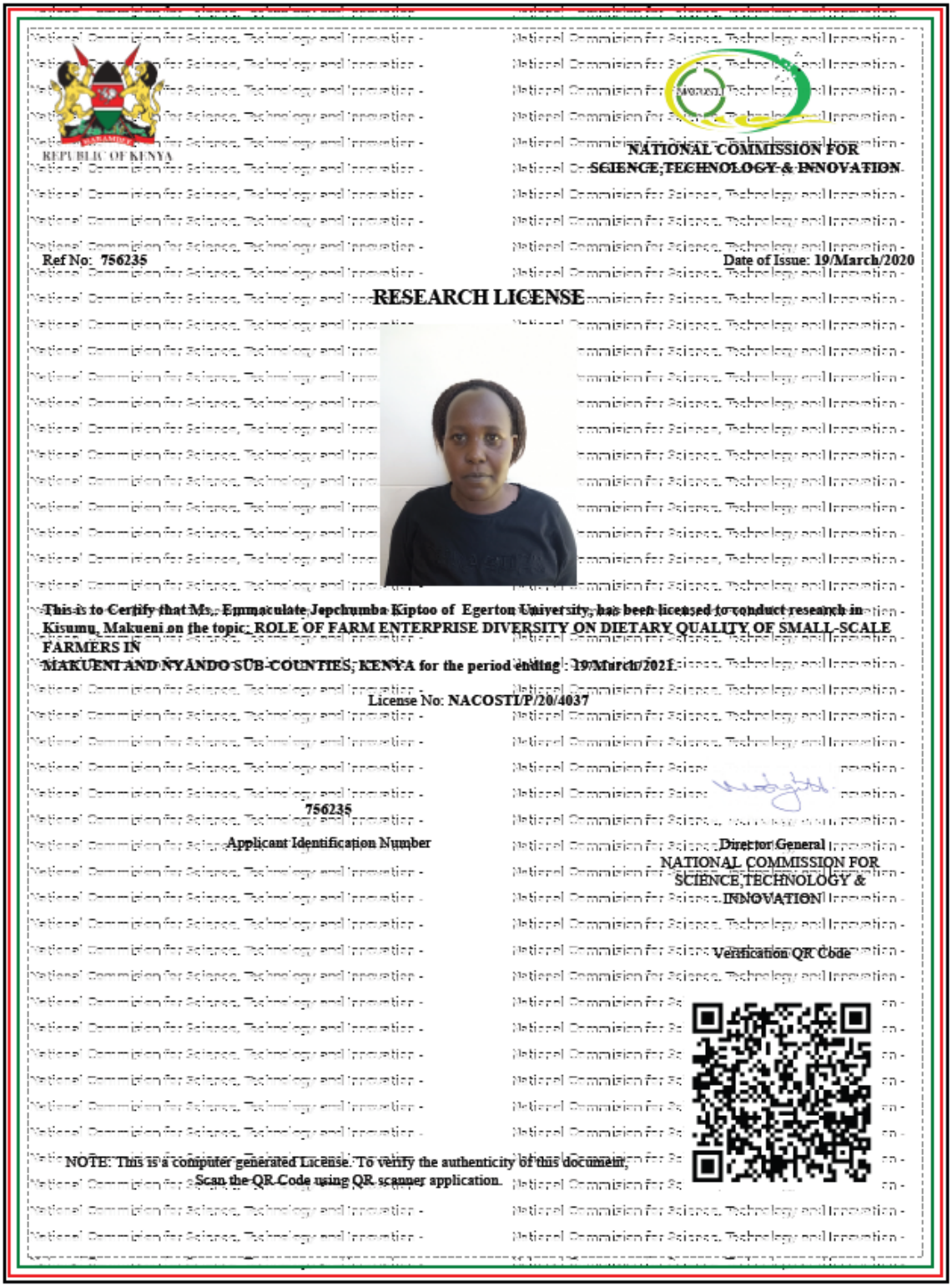
APPENDICES

Appendix A: Research Permit



REPUBLIC OF KENYA

NATIONAL COMMISSION FOR SCIENCE, TECHNOLOGY & INNOVATION

Ref No: 756235

Date of Issue: 19/March/2020

RESEARCH LICENSE

This is to Certify that Ms., Emmaculate Jepchumba Kiptoo of Egerton University, has been licensed to conduct research in Kisumu, Makueni on the topic: ROLE OF FARM ENTERPRISE DIVERSITY ON DIETARY QUALITY OF SMALL-SCALE FARMERS IN MAKUENI AND NYANDO SUB-COUNTIES, KENYA for the period ending : 19/March/2021.

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Appendix B: Consent Form

Hello, my name is _____ and I am a researcher working with International Livestock Research Institute (ILRI) which is in collaboration with Climate Change, Agriculture and Food Security (CCAFS). The study is a revisit survey targeting small-scale farmers surveyed in 2012 with the CCAFS Impact Lite tool. Data collected in this study will help the study team to assess changes in poverty, food security, nutrition and livelihood strategies in the last four years since the implementation of the initial study. I will take time to explain more about the research, please stop me whenever you need clarifications or to clarify meanings of words that you don't understand. I therefore request you to kindly respond to the questions in this survey to help us understand your livelihood strategies, food security and agricultural productivity. The information that I will collect from this study will be managed carefully. Any information about you will have a number instead of your name if it is accessed by persons other than the researchers collecting the data. Only these researchers will know what your number is and we will protect that information securely. It will not be shared or given to anyone except the researchers in this project. Some of the collected information, which cannot be linked to you, will be made publically available for further research after a certain time period, as demanded by the project donor.

Appendix C: Questionnaire

Rural Household Multiple Indicator survey (RHoMIS)

1.0 Household identification

	General information	
Country		
Site name		
Village		
Name of Interviewer		
Household ID		
	Latitude decimal degrees	Longitude degrees
Household GPS code		
Name of the respondent		
Gender		
Age		
Position in household		
Household type		

Position in household	**Household type**
1= Married to Head	1= Has partner (married or non-married)
2= Child of head	2= Single woman
3= Parent of head	3= Single man
4= Other family member	4=Woman at home, man works away
5= Not a family member	5= Man at home, woman works away
	6= Both work away

2.0 Household Roster

2.1 How old is the head man of the household? _____

2.2 How old is the head woman of the household? _____

2.3 What is the highest level of education the head man or woman has completed? _____

1= illiterate 2= literate 3= primary 4= secondary 5= post-secondary

3.0 Members of the household

Include only members who live there at least 3 months per year.

3.1 How many people in your household? _____

ID	Age	Number of male	Number of female
1	Aged 3 or under		
2	4-10		
3	Aged 11-24		
4	Aged 25-50		
5	Over 50		

4.0 Farm land sizes

4.1 Does your household own land, rent land or use common land? _____

1= Own land 2= Rent land 3= Use common land

Land size	How much land does your household own?	Who owns your household's land?	About how much land does your household rent for use?	About how much land does your household rent out for other people to use?	In total, how much land do you use for growing crops?
Area					
Unit					

Unit: 1= Acre 2= Hectare 3= Other

Ownership: 1= Husband or other male 2= Wife or other female 3= Male youth or child 4= Female youth or child

4.2 Is your land flat, sloping or steep slopes?

1= Flat 2= Gentle Sloping 3= Sloping 4= Steep slope

4.3 Do you have a home garden? Yes/ No _____

4.4 Do you use any grazing land for your animals? Yes/ No

4.5 Do you own any of the grazing land? _____

1= Own it 2= Do not own it 3= Own some of it

4.6 Who works on your land- household members or other people too? _____

1= Household members 2= Reciprocal arrangements with family, friends or neighbours 3= Hired labour

5.0 Crop productivity

5.1 Do you grow any crops? Yes/ No _____

List the 8 most important crops grown by the household in past year in the table below

ID	CROP	About how much of your land did you use for this crop during the last year?	About how much did you harvest in the last year	Weight unit	Was the harvest good or bad in the last year?	Did you grow this crop alone, or did you grow it mixed with other crops? 1= Alone 2= Mixed with other crops	What do you do with the main harvest of this crop?	About how much of the crop was consumed by the household in the last year?
1								
2								
3								
4								
5								
6								
7								
8								

Proportions

1= All or nearly all (90-100%) 2= More than half of it (60-90%) 3= About half of it (40-60%) 4= Less than half of it (10-40%) 5= A small amount (1-10%) 6= None (0%)

Weight Unit: 1= kg 2= Gorogoro 3= Debe 4= Tons

Harvest: 1= Good harvest 2= Normal harvest 3= Bad harvest

Crop use: 1= Eat it/ use at home 2= Sell it 3= Feed to livestock 4=Give away/exchange

ID	Crop	About how much of the crop was sold by the household in the last year?	About how much of the crop was fed to livestock in the last year?	How much did you make from selling the crop during the last year?	Sale price unit	What do you do with the crop residues?	Who usually sells or trades the harvest?	Who usually decides when to eat the crop?
1								
2								
3								
4								
5								
6								
7								
8								

Sale price unit: 1= Price per kg 2= Price per Gorogoro 3= Price per Debe 4= Other

Who: 1= Husband or other male 2= Wife or other female 3= Male youth or child 4= Female youth or child

Crop residues: 1= Leave it in the soil 2= Burn it in the fields 3= Use it as fuel 4= Feed it to animals 5= Make compost 6= Use as construction materials 7= Sell it

5.2 What other crops were grown or harvested by your household during the past year?

_____

5.3 Who decided which crops to plant? _____

1=Husband or other male 2= Wife or other female 3= Male youth or child 4= Female youth or child

5.4 Did you harvest any of your crops early in the last year? Yes/ No _____

5.5 Which crops did you harvest early?

_____

5.6 Why did you harvest the crops early? _____

1= Fear of theft 2= Hunger 3= Needed Income 4= Erratic rainfall or poor weather 5= Other

5.7 Do you make any of your crops into products you can store or sell? Yes/ No _____

If yes,

	Product	Do you eat this product at home?	Do you sell product ?	How much money did you make from selling the products in the last year?	Who usually sells the products?	Who decides when to eat the products?
1	Flour or Meal					
2	Foods for sale (breads, snacks, meals)					
3	Food ingredients (e.g. spices, coffee, tea)					
4	Dried fruits, nuts or similar					
5	Sweet preserves (jams, syrups etc)					
6	Pickled foods (preserved in vinegar)					
7	Drinks (alcoholic or non-alcoholic)					
8	Medicines					
9	Baskets, carvings, etc					
10	Fuel wood, charcoal, etc					

Who: 1= Husband or other male 2= Wife or other female 3= Male youth or child 4= Female youth or child

6.0 Agricultural inputs

6.1 Do you use any inputs on your farm? Yes/ No _____

6.2 What do you use? _____

1= Urea 2= NPK 3= CAN 4= DAP 5= SSP 6= TSP 7= Other

6.3 On which crops did you use fertilizers during the last year?

6.4 How much fertilizer in total was used on your farm in the last year? _____

Fertilizer amount units: 1=kg 0= other

6.5 What types of fertilizer do you normally use?

_____

6.6 On which crops did you use manures or compost during the last year?

_____

6.7 On which crops did you use pesticides during the last year?

_____

6.8 For which crops did you use improved seed varieties during the last year?

_____

7.0 Storage

7.1 How do you store your crops after harvest? _____

1= Traditional granary 2= Sacks 3= Metal silos 4= Hermetic bags 5= Other

7.2 Do you add anything to help preserve the crops in the storage? Yes/ No _____

7.3 What do you add to help preserve the crops? _____

1= Pesticide or insecticide 2= Traditional ash 3= Other

8.0 Irrigation

8.1 Do you grow any crops under irrigation? Yes/ No _____

8.2 Which crops did you irrigate during the last year?

_____

8.3 Which months of the year do you irrigate?

_____

8.4 Where do you get the water for irrigation from? _____

1= Communal pond 2= Household pond 3= Household pond with fish 4= River 5= Well 6= Rainwater harvesting 7= Other

8.5 What type of irrigation method do you use? _____

1= Basin dug around plant 2= Gravity- fed (river diversion) 3= Sprinkler 4= Drip 5= Other

8.6 Do you use an electric or diesel powered water pump? Yes/ No _____

9.0 Innovative technologies

Current use of innovative technologies

		Current use
Cropping	Mechanised land preparation (tractor ploughing) [% of cult. Land]	
	Use of purchased seed (any crop, produced as seed) [% of cult. Land]	
	Use of pesticide [% of cult. Land]	
	Use of manure as fertilizer [% of cult. Land]	
	Use of chemical fertilizer [% of cult. Land]	
	Mechanised harvest [% of cult. land]	
livestock	Improved breed [% of total herd]	
	Artificial insemination (AI) [% of total herd, females]	
	Vaccination [% of total herd]	
	Deworming [% of total herd]	

10.0 Integrated farming

10.1 Do you make use of any trees on your land? Yes/No _____

10.2 What do you use the trees for? _____

1= Food or fruits 2= Fuel wood 3= Timber 4= Animal food 5= Good for land (soil, water, shelter etc) 6= Only cut trees to clear land 7= Other

10.3 Do you till or plough your land? Yes/ No _____

10.4 If yes, how do the tillage? _____

1= By hand 2= Use animal power 3= Use a machine

10.5 Do you grow legumes (peas, beans) in combination with other crops? Yes/ No _____

10.6 Do you grow legumes (peas, beans) in rotation with other crops? Yes/ No _____

10.7 Do you grow trees and crops mixed together? Yes/ No _____

11.0 Key livestock species

11.1 Does your household own any livestock or animals? Yes/No_____

	How many owned	Breed	How many used for draught power	No. bought the last year	No. sold in the last year	Total amount earned from selling	Who owns the animals?	Who sold the animals?	Amount of time spent in stable or pen?
Cattle									
Goats									
Sheep									
Pigs									
Chicken									
Other birds									
Horses, donkeys, or similar									
Rabbits									
Fish									
Bee hives									
Other 1									
Other 2									
Other 3									

Who: 1= Husband or other male 2= Wife or other female 3= Male youth or child 4= Female youth or child

Amount of time in pen: 1= All or nearly all (90- 100%) 2= More than half of it (60- 90%) 3= About half of it (40-60%) 4= Less than half of it (10- 40%) 5= A small amount (1-10%) 6= None (0%)

Breed: 1= Local 2= Improved or hybrid 3= Both

12.0 Animal products:

12.1 Animal products: Meat

	No. slaughtered in the last year	About how much do you eat	About how much do you sell	How much money did you make from selling the meat in the last year?	Who usually sells the meat?	Who usually decides when to eat the meat?
Cattle						
Goats						
Sheep						
Pigs						
Chicken						
Other birds						
Fish						

Who: 1= Husband or other male 2= Wife or other female 3= Male youth or child 4= Female youth or child

Proportions: 1= All or nearly all (90-100%) 2= More than half of it (60-90%) 3= About half of it (40-60%) 4= Less than half of it (10-40%) 5= A small amount (1-10%) 6= None (0%)

12.2 Animal products: Milk

	How much milk produced in the good season	Unit of milk production	Bad season milk produced?	About how much milk do you consume?	About how much milk do you use for making dairy products?	About how much milk do you sell?	How much money do you make from selling the milk?	Sales Unit	Who usually sells the milk?	Who usually decides when to eat the milk?
Cows										
Goats										

Sheep										

Who: 1= Husband or other male 2= Wife or other female 3= Male youth or child 4= Female youth or child

Proportions: 1= All or nearly all (90-100%) 2= More than half of it (60-90%) 3= About half of it (40-60%) 4= Less than half of it (10-40%) 5= A small amount (1-10%) 6= None (0%)

Sales unit: 1= Total 2= Per liter product

Milk unit: 1= Liters per animal per day 2= Total liters per day

12.3 Animal products: Eggs

	How many eggs produced during the good season?	How many eggs produced during the bad season?	Egg unit	About how many eggs do you keep for eating?	About how many eggs do you sell?	How much money do you make from selling the eggs	Unit sales	Who usually sells the eggs?	Who usually decides when to eat the eggs?
Chicken									
Other birds									

Who: 1= Husband or other male 2= Wife or other female 3= Male youth or child 4= Female youth or child

Proportions: 1= All or nearly all (90-100%) 2= More than half of it (60-90%) 3= About half of it (40-60%) 4= Less than half of it (10-40%) 5= A small amount (1-10%) 6= None (0%)

Egg unit: 1= Eggs per animal per day 2= Eggs per day 3= Eggs per week 4= Eggs per month 5= Other

12.4 Animal products: Honey

	How much honey do you collect in the year?	Honey Unit	About how much honey do you eat?	About how much honey do you sell?	How much money do you make from selling the honey?	Unit sales	Who usually sells the honey?	Who usually decides when to eat the honey?
Honey								

Who: 1= Husband or other male 2= Wife or other female 3= Male youth or child 4= Female youth or child

Proportions: 1= All or nearly all (90-100%) 2= More than half of it (60-90%) 3= About half of it (40-60%) 4= Less than half of it (10-40%) 5= A small amount (1-10%) 6= None (0%)

Honey Unit: 1= Kg 2= Gorogoro 3= Debe 4= Liters 5= Other

Unit Sales: 1= Total 2= Per unit product

12.5 Processed animal products and other products

	How much do you usually produce ?	Units of production	About how much do you eat/ use at home?	About how much do you sell?	How much money do you make from selling?	Unit sales	Who usually sells the produce	Who usually decides when to eat the produce
Cheese								
Butter								
Wool								
Other 1								
Other 2								

Who: 1= Husband or other male 2= Wife or other female 3= Male youth or child 4= Female youth or child

Proportions: 1= All or nearly all (90-100%) 2= More than half of it (60-90%) 3= About half of it

(40-60%) 4= Less than half of it (10-40%) 5= A small amount (1-10%) 6=None (0%)

Units of production: 1= Kg 2= Gorogoro 3= Debe 4= Liters 5= Other

Unit Sales: 1= Total 2= Per unit product

13.0 Livestock input use

13.1 Do you buy or use any medicines for your livestock? Yes/ No If yes:

	Use: Yes/ No?	Which animals do you give the medicines to?
Vaccinations		
De-worming		
Antibiotics		
Traditional medicines		
Other		

Which animals: 1= Cattle 2= Goats 3= Sheep 4= Pigs 5= Chicken 6= Other birds 7= Horses 8= Fish 9= Bees 10= Other

14.0 Animals: Manure

14.1 What do you do with the manure from the animal pens? _____

1= Put on crops 2= Put in a pile for more than a month before use 3= Store inside a closed space for more than a month before use 4= Put in a digester 5= Use as fuel 6= Sell it 7= Dispose it

	Proportion put on crops	Proportion put in a pile for more than a month before use	Proportion stored inside an enclosed space for more than a month before use	Proportion put in a digester	Proportion used as fuel	Proportion sold	Proportion disposed
All animals							

Proportions: 1= All or nearly all (90-100%) 2= More than half of it (60-90%) 3= About half of it (40-60%) 4= Less than half of it (10-40%) 5= A small amount (1-10%) 6= None (0%)

15.0 Wild foods

15.1 Do you or your family gather any wild foods? Yes/ No _____

15.2 If yes, which months of the year do you collect wild foods?

_____

15.3 What types of foods did you gather in the last year? _____

1= Meat 2= Fish 3= Insects 4= Plants 5= Fruits 6= Nuts 7= Honey 8= Mushrooms

15.4 How important is it for you to collect wild foods? _____

1= Very important food source 2= Very important for selling 3= Common part of the diet 4= Not important

15.5 Approximately, which proportion of your household's food comes from wild foods? _____

Proportions: 1= All or nearly all (90-100%) 2= More than half of it (60-90%) 3= About half of it (40-60%) 4= Less than half of it (10-40%) 5= A small amount (1-10%) 6= None (0%)

16.0 Food security

Food security	
Is there a time of the year when there is less food available compared to other times?	1=Yes 0= No
If so, which months?	
Which is the worst month of the year for food?	
Which is the best month of the year for food?	
During the worst month	
How often did somebody have to go a whole day and night without eating anything?	
How often did somebody have to go to sleep hungry at night?	
How often was there no food to eat of any kind in your household?	
If the answer to **all three** above questions was "never", proceed and ask the following 6 questions. Otherwise, move on to the next section.	
How often did somebody have to eat fewer meals than they wanted?	
How often did somebody have to eat smaller meals than they wanted	

How often did somebody have to eat some foods that you really did not want to eat?	
How often did someone have to eat a less variety of foods?	
How often was someone in the house not able to eat the kinds of foods they wanted to?	
How often do you ever worry that there will not be enough food for your household?	

Options: 1= A lot (daily or more than three times per week 2= Sometimes (Once or twice a week) 3= A little (Once or twice a month) 4= Rarely or never (less than once a month)

17.0 Nutrition Knowledge

Main source of nutrition knowledge (tick all that apply**)**

Farmer-to-farmer	Government extension	Non-gov extension	Print and visual media	Others (specify)

18.0 Dietary diversity

Dietary Diversity	How often?	Where does this food come from?
Think of: grains, rice, flour, or starchy white vegetables. How often were these eaten in your house? (e.g. rice, maize, ugali, muthokoi, nshima, porridge, bread, plantain, yam, cassava, potato, kohlrabi, white or pale sweet potato)		
Worst month?		
Good month?		
Think of: beans, peas, lentils. How often were these eaten in your house? (e.g. gram, cow pea, beans, peas, lentils)		
Worst month?		
Good month?		

Think of: nuts or seeds. How often were these eaten in your house? (e.g. peanut, groundnut, cashew, pumpkin seeds, sunflower seeds, nuts, seeds)		
Worst month?		
Good month?		
Think of: leafy green vegetables. How often were these eaten in your house? (e.g. amaranth, mustard leaves, pea shoots, Chinese cabbage, spinach, kale, sweet potato leaves, broccoli)		
Worst month?		
Good month?		
Think of: orange coloured vegetables or fruits. How often were these eaten in your house? (e.g. pumpkin, squash, carrot, orange sweet potato, red pepper, red palm oil, palm nuts, mango, ripe papaya, peach, mandarin, orange, avocado, persimmon, cantaloupe, apricots)		
Worst month?		
Good month?		
Think of: other vegetables. How often were these eaten in your house? (e.g. tomato, cabbage, onions, gourd, cauliflower, lettuce, chayoute fruit, cucumber, eggplant)		
Worst month?		
Good month?		
Think of: other fruits. How often were these eaten in your house? (e.g. durian, green papaya, guava, lemon, white sappote, banana, watermelon, longan, pomelo, apple, pineapple, Hanoi plum, strawberry, mulberry)		
Worst month?		
Good month?		
Think of: meat, poultry or fish. How often were these eaten in your house? (E.g. chicken, beef, pork, goat, duck, buffalo, meat, liver, heart, frog, river fish, sea fish, crab etc.)		
Worst month?		

Good month?		
Think of: eggs. How often were these eaten in your house? (e.g. chicken eggs, duck eggs, any other eggs)		
Worst month?		
Good month?		
Think of: milk or dairy foods. How often were these eaten in your house? (e.g. cow milk, goat milk, cheese, butter, yoghurt)		
Worst month?		
Good month?		

How often:1= A lot (daily, or more than 3 times per week) 2= Sometimes (1 or 2 times per week) 3= A little (1 or 2 times per month) 4= Rarely or never (less than once a month)

Where does the food come from: 1= Self-produced 2= Purchased 3= Both 4= Gathered, gifted or traded

19.0 Household Dietary Diversity

19.1 Please describe the foods (meals and snacks) that you or any member of your household ate or drank yesterday during the day and night. Include only foods consumed at home, not those purchased and consumed outside of the home. Start with the first food eaten in the morning.

Write down in the spaces below all foods and drinks mentioned. When composite dishes are mentioned ask for the list of ingredients. Probe for any meals/snacks not mentioned. When the recall is complete, fill in the food groups based on the foods mentioned during the recall. For any food groups not mentioned, ask the respondent if a food item from this group was consumed.

Breakfast	Snack	Lunch	Snack	Dinner	Snack

Question No.	**Food group**	**Example**s	**Yes=1 No=0**
1	CEREALS	Bread, noodles, biscuits, cookies or any other foods made from millet, sorghum, maize, rice, wheat, ugali, muthokoi, nshima, porridge or pastes or other locally available cereal foods	
2	VITAMIN A RICH VEGETABLES AND TUBERS	Pumpkin, carrots, squash, or sweet potatoes that are **orange** inside and other locally available vitamin-A rich vegetables (e.g. sweet pepper)	

3	WHITE TUBERS AND ROOTS	White potatoes, white yams, cassava, or foods made from roots	
4	DARK GREEN LEAFY VEGETABLES	Dark green/ leafy vegetables, including wild ones + *locally available vitamin A-rich leaves such as cassava leaves etc.*	
5	OTHER VEGETABLES	Other vegetables (e.g. tomato, onion), including wild vegetables	
6	VITAMIN A RICH FRUITS	Ripe mangoes, cantaloupe, dried apricots, dried peaches + other locally available vitamin A-rich fruits	
7	OTHER FRUITS	Other fruits, including wild fruits	
8	ORGAN MEAT (IRON-RICH)	Liver, kidney, heart or other organ meats or blood-based foods	
9	FLESH MEATS	Beef, pork, lamb, goat, rabbit, wild game, chicken, duck, or other birds	
10	EGGS	Any eggs	
11	FISH	Fresh or dried fish or shellfish	
12	LEGUMES, NUTS AND SEEDS	Beans, peas, lentils, nuts, seeds or foods made from these	
13	MILK AND MILK PRODUCTS	Milk, cheese, yoghurt or other milk products	
14	OILS AND FATS	Oils, fats or butter added to food or used for cooking	
15	SWEETS	Sugar, honey, sweetened soda or sugary foods such as chocolates, sweets or candies	
16	SPICES, CONDIMENTS, BEVERAGES	Spices (black pepper, salt), condiments (soy sauce, hot sauce), coffee, tea, alcoholic beverages OR local examples	
17	INSECTS	Termites, grass-hoppers	

Other characteristics of yesterday's food

	Yes= 1 **No= 0**
Did you or anyone in your household eat anything (meal or snack) OUTSIDE of home yesterday?	
Was yesterday a celebration or feast day where you or anyone in your household ate special foods or was it a day where you or any member of your household ate more or less than usual?	

Comments _____

20.0 Access to facilities

Please indicate the distance to the following facilities

a) What is the distance from your homestead to the nearest **extension advice?**	**dextn**	_____ km
b) What is the distance to the nearest **A.I** service provider	**aikm**	_____ km
c) What is the distance from your homestead to the nearest **market place** for f**arm produce**	**mktkm**	_____ km

Extension service providers and training

20.1 Did the household receive agricultural extension contacts in the last year?

1= Yes, 0=No **Exten** _____ If yes, specify the number of times: **Extennum** _____

20.2 Has anyone in the household attended a farmer training last year?

1= Yes, 0= No **Train** _____ If yes, how many times: **Trainnum** _____

21.0 Social capital

21.1 Is anybody in the household a member of a group? 1= Yes 0= No

21.2 How many household members belong to groups **Hhgroupmem**_____?

21.3 How many groups do household members belong to **Groupnum_____?**

21.4 Fill details of the group, which is most important to the household for agricultural production;

Group type	No. of female members	No. of male members	Group activities	Rank your participation in decision making in group [scale	Rank level of trust to group members [scale of 1-10, 10=

				of 1-10; 10= most]	most]

Group types: 1= Self-help group 2= Welfare group 3= Cooperative society 4= Other (specify)

Group activities: 1= Crop production 2= Livestock production 3= Marketing 4= Other (specify)

22.0 AID

22.1 Have you received aid from the government, NGOs or other organizations in the last year? Yes/ No _____

22.2 If yes, which type?

1= Food 2= Agricultural inputs (fertilizers, seeds, crops etc.) 3= Animals 4= Cash 5= Other

22.3 During the last year, about how much of the food eaten by your household was from aid sources? _____

1= All or nearly all (90-100%) 2= More than half of it (60-90%) 3= About half of it (40-60%) 4= Less than half of it (10-40%) 5= A small amount (1-10%)

22.4 Have you received any significant gifts from family, friends, and neighbours in the past year? Yes/No _____

22.5 If yes, which type _____

1= Food 2= Agricultural inputs (fertilizers, seeds, crops etc.) 3= Animals 4= Cash 5= Other

22.6 During the last year, about how much of the food eaten by your household was from gift sources? _____

1= All or nearly all (90-100%) 2= More than half of it (60-90%) 3= About half of it (40-60%) 4= Less than half of it (10-40%) 5= A small amount (1-10%)

23.0 Debt

23.1 Do you have any debts or loan, or did you have any in the last year? Yes/ No _____

23.2 In the last year, did you ever find it difficult to pay the debts? Yes/ No _____

24.0 Off farm income

24.1 Do you have any sources of income apart from selling what you produce on the farm? Yes/ No _____

24.2 If yes,

Type of income	Does your household earn money from this source? 1= yes 0= no	Which months does your household earn money from this source?	Who decides how to spend the money from this source?

Labour on other farms			
Labour, not on a farm			
Work in local business			
Have own business			
Remittances			
Work for government or public institution			
Rent out land to others			
Rent out equipment or animals to others			
Other			

Who: 1= Husband or other male 2= Wife or other female 3= Male youth or child 4= Female youth or child

24.3 Think of all the money earned in your household during the last year from selling crops and livestock, and from off farm work. Did more come from off farm work or more from sales of crops and livestock? _____

1= All or almost all from off-farm- almost none from farm 2= Most from off-farm- some from farm 3= Half from off-farm- most from farm 4= Some from off-farm- most from farm

24.4 What sort of things do you spend the money on that is earned from off-farm sources?

1= Buying food 2= Buying possessions e.g. clothes, household items 3= Improve the farm e.g. machinery, fertilizers 4= Spend on people e.g. education, health care, travel to city

24.5 What sort of things do you spend the money that is earned from your farm, by selling crops and livestock?

1= Food 2= Possessions 3= Invest on the farm 4= Invest on people (education etc)

25.0 Influence of ideas on one's life

Idea	**What influence has it had on your life?**
Living in a peaceful community and a peaceful country	
Being curious and learning about new things	
Having authority, leading and commanding other people?	
Self-discipline, self-restraint, and resistance to temptation	
Taking care of the natural environment, such as trees, soil, water, animals	
Obtaining wealth, possessions, money	
Honouring parents and elders, and showing respect	
Leading an exciting life	
Fairness, justice, and care for the weak	
Being influential, having an impact on people and events	
Family security and safety for loved ones	
Having new experiences and testing out new ways of doing things	

Influence: 1= Big influence 2= Small influence 3= No influence

26.0 Farm changes

26.1 Compared to four years ago, do you own more, or less or about the same?

Item	More	Less	About the same
Land			
Harvest			
Changes in crops grown			
Inputs for crop production			
Livestock			

Changes in livestock type kept			
Inputs for livestock production			
Produce sold			
Earnings from off-farm activities			

Item	(a)If more or less, did you want to or forced to by circumstances	(b) If wanted to, where did you get the idea from?	(c)If forced to, why?
Land			
Harvest			
Changes in crops grown			
Inputs for crop production			
Livestock			
Changes in livestock type kept			
Inputs for livestock production			
Produce sold			
Earnings from off-farm activities			

a) 1=Wanted to 2= Forced to

b) 1= Was my own idea 2= Extension workers or other organizations 3= Neighbours, friends or family 4= Others (specify)

c) 1=Climate or weather-related 2= Market related 3= Labour/ time shortage 4= Could not afford to continue 5= Other

26.2 What are your main plans for your farm in the next 5 years?

_____

26.3 When a new thing comes along for example a new crop or a new fertilizer, are you the first

to try it out, or do you wait and see how it works out for other people?

1=First 2= Wait to see if it works for others 3= One of the last 4= I don't try new things

26.4 If you had a good harvest and earned more cash than usual, what would you spend the money on?

1= Buying food 2= Buying possessions 3= Improving the farm 4= Spend on people 5= Save the money

26.5 Would you like your children to be farmers?

1= Yes 2=No 3= Some of them 4= Don't have any

26.6 Do your children want to be farmers? _____

1= Yes 2=No 3= Some of them 4= Too young to decide 5=Don't have any

26.7 Overall, how satisfied are you with your situation in life? *Includes health, family, happiness, community, food, income, opportunities.* _____

1= Very satisfied 2= Satisfied 3= Unsatisfied 4= Very unsatisfied

27.0 Progress out of poverty indicator

	Response
How many members does your household have?	1= Nine or more 2= Seven or eight 3= Six 4= Five 5=Four 6= Three 7= One or two
What is the highest school grade that the female head or spouse has completed?	1= None or pre-school, 2= Primary standards 1 to 6, 3= Primary standard 7, 4= Primary standard 8 or secondary forms 1 to 3, 5= No female head/spouse, 6= Secondary form 4 or higher
What kind of work is the main occupation of the male head/ spouse?	1= Does not work 2= No male head/spouse 3= Agriculture, hunting, forestry, fishing, mining, or quarrying 4=Any other
How many habitable rooms does this household occupy?	1= One 2= Two 3= Three 4= Four or more
What material is the floor of the house made of?	1= Wood, earth or other 2= Cement or tiles
What is the main fuel used for lighting?	1= Collected firewood, purchased firewood, grass, or dry cell (torch) 2= paraffin, candles, biogas, or other 3= Electricity, solar, or gas
Does your household own any electric or	Yes/No

charcoal irons?	
How many mosquito nets does your household own?	1= None 2=One 3= Two or more
How many frying pans does your household own?	1= None 2=One 3= Two or more

28.0 Closing the survey

Before we finish, do you have any question or comments?

_____

Thank you for your time and for sharing the information!

Time interview **ended** :	HH:		MM:		

To be answered privately by the enumerator immediately following the interview

How many people contributed to answering the survey? _____

In your opinion, how easily did you establish rapport with the respondent? _____

1 = easy

2 = medium

3 = difficult

4 = very difficult

How reliable do you think these answers are? Consider the accuracy and willingness to answer. _____

5 = very reliable

4 = reliable

3 = ok

2 = occasional doubts

1 = regular or serious doubts

Do you have any notes or comments from the interview?

_____

I certify that I have checked the questionnaire two times to be sure that all the questions have been answered, and that the answers are legible.

Signed: _____ Date ____/____/____

Appendix D: Food groups used in the calculation of HDDS

	Food Groups	**Score**
1	Cereals	1
2	Roots and tubers	1
3	Vegetables	1
4	Fruits	1
5	Meat, poultry, offal	1
6	Eggs	1
7	Fish	1
8	Pulses/legumes/nuts	1
9	Milk and Milk products	1
10	Oils/fats	1
11	Sugar/honey	1
12	Spices, condiments and beverages (miscellaneous)	1
Household Dietary Diversity Score (HDDS) was obtained by summing the number of food groups consumed in the household in the past 24 hours. The minimum score of food groups per day is 0 and 12 being the maximum.		

Appendix E: Stata Output

Testing for multicollinearity for continous variables

```
.reg simpindex3 agehhhd hhsize landsize dstancetomkt notrainatt nogrpsithhhmmbrs

      Source |       SS           df       MS      Number of obs   =       319
-------------+----------------------------------   F(6, 312)       =      4.00
       Model |  9.67496748         6  1.61249458   Prob > F        =    0.0007
    Residual |  125.873622       312  .403441096   R-squared       =    0.0714
-------------+----------------------------------   Adj R-squared   =    0.0535
       Total |  135.548589       318  .426253426   Root MSE        =    .63517

------------------------------------------------------------------------------
      simpindex3 |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-----------------+------------------------------------------------------------
         agehhhd |   .0074742   .0023659     3.16   0.002     .0028189    .0121294
          hhsize |   .0141448   .0130283     1.09   0.278    -.0114896    .0397791
        landsize |  -.0076061   .0135165    -0.56   0.574     -.034201    .0189889
    dstancetomkt |   -.015967   .0122319    -1.31   0.193    -.0400343    .0081004
      notrainatt |   .0835223   .0273299     3.06   0.002      .029748    .1372966
nogrpsithhhmmbrs |   .0117836   .0183786     0.64   0.522    -.0243781    .0479453
           _cons |   1.459749   .1705861     8.56   0.000     1.124105    1.795394
------------------------------------------------------------------------------

. vif

    Variable |       VIF       1/VIF
-------------+----------------------
    landsize |      1.08    0.926153
      hhsize |      1.07    0.936024
nogrpsithh~s |      1.05    0.952850
     agehhhd |      1.05    0.953884
  notrainatt |      1.04    0.958732
dstancetomkt |      1.02    0.983844
-------------+----------------------
    Mean VIF |      1.05
```

Testing for multicollinearity for categorical variables

```
. pwcorr gender educ tenure slope offfarminc irrigation site aid

             |   gender     educ   tenure    slope offfar~c irriga~n     site
-------------+------------------------------------------------------------------
      gender |   1.0000
        educ |   0.5182   1.0000
      tenure |   0.0051  -0.0335   1.0000
       slope |   0.0174   0.0626  -0.1383   1.0000
  offfarminc |   0.1004   0.0439   0.0694   0.0170   1.0000
  irrigation |   0.0054   0.0342   0.1011  -0.0134  -0.0842   1.0000
        site |   0.0307   0.0921  -0.2207   0.2364  -0.0108  -0.1806   1.0000
         aid |  -0.1278  -0.1257   0.0748  -0.1031   0.0358  -0.0125   0.1754

             |      aid
-------------+---------
         aid |   1.0000
```

Test for heteroskedasticity

```
. estat imtest
Cameron & Trivedi's decomposition of IM-test

---------------------------------------------------
              Source |       chi2     df      p
---------------------+-----------------------------
  Heteroskedasticity |     240.45    202    0.0332
            Skewness |      18.43     19    0.4939
            Kurtosis |       2.26      1    0.1325
---------------------+-----------------------------
               Total |     261.14    222    0.0368
---------------------------------------------------
```

Objective one results and descriptive statistics

```
.  ttest agehhhd, by ( site )
Two-sample t test with equal variances
------------------------------------------------------------------------------
   Group |     Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]
---------+--------------------------------------------------------------------
  Nyando |     159    54.55346    1.167374    14.72002    52.24779    56.85913
```

```
 Makueni |     160       56.05    1.271723    16.08617    53.53835    58.56165
---------+--------------------------------------------------------------------
combined |     319    55.30408     .863038    15.41435    53.60609    57.00206
---------+--------------------------------------------------------------------
    diff |           -1.496541     1.72676                -4.8939    1.900818
------------------------------------------------------------------------------
    diff = mean(Nyando) - mean(Makueni)                           t =  -0.8667
Ho: diff = 0                                     degrees of freedom =      317
    Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(T < t) = 0.1934         Pr(|T| > |t|) = 0.3868          Pr(T > t) = 0.8066
.  ttest hhsize , by ( site )
Two-sample t test with equal variances
------------------------------------------------------------------------------
   Group |     Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]
---------+--------------------------------------------------------------------
  Nyando |     159    5.930818    .1950995    2.460111    5.545478    6.316157
 Makueni |     160      5.6875    .2490844    3.150696    5.195559    6.179441
---------+--------------------------------------------------------------------
combined |     319    5.808777    .1582163    2.825833    5.497495     6.12006
---------+--------------------------------------------------------------------
    diff |            .2433176     .316638                -.37966    .8662952
------------------------------------------------------------------------------
    diff = mean(Nyando) - mean(Makueni)                           t =   0.7684
Ho: diff = 0                                     degrees of freedom =      317
    Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(T < t) = 0.7786         Pr(|T| > |t|) = 0.4428          Pr(T > t) = 0.2214
.  ttest landsize , by ( site )
Two-sample t test with equal variances
------------------------------------------------------------------------------
   Group |     Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]
---------+--------------------------------------------------------------------
  Nyando |     159    2.278931    .1190492    1.501153    2.043798    2.514064
 Makueni |     160    4.078125    .2637827    3.336616    3.557155    4.599095
---------+--------------------------------------------------------------------
combined |     319    3.181348     .153312     2.73824    2.879714    3.482982
---------+--------------------------------------------------------------------
    diff |           -1.799194    .2900072               -2.369776   -1.228612
------------------------------------------------------------------------------
```

```
    diff = mean(Nyando) - mean(Makueni)                           t =  -6.2040
Ho: diff = 0                                     degrees of freedom =      317
    Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(T < t) = 0.0000         Pr(|T| > |t|) = 0.0000          Pr(T > t) = 1.0000
.  ttest dstancetomkt , by ( site )
Two-sample t test with equal variances
------------------------------------------------------------------------------
   Group |     Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]
---------+--------------------------------------------------------------------
  Nyando |     159    3.671698    .2601802    3.280748    3.157818    4.185578
 Makueni |     160    2.731875    .1952369    2.469573    2.346283    3.117467
---------+--------------------------------------------------------------------
combined |     319    3.200313    .1643712    2.935764    2.876921    3.523706
---------+--------------------------------------------------------------------
    diff |            .9398231    .3250035                .3003867     1.57926
------------------------------------------------------------------------------
    diff = mean(Nyando) - mean(Makueni)                           t =   2.8917
Ho: diff = 0                                     degrees of freedom =      317
    Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(T < t) = 0.9980         Pr(|T| > |t|) = 0.0041          Pr(T > t) = 0.0020
.  ttest notrainatt , by ( site )
Two-sample t test with equal variances
------------------------------------------------------------------------------
   Group |     Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]
---------+--------------------------------------------------------------------
  Nyando |     159    .4842767    .1088604    1.372678    .2692673    .6992861
 Makueni |     160        .875     .099823    1.262672      .67785     1.07215
---------+--------------------------------------------------------------------
combined |     319    .6802508    .0745236    1.331034    .5336291    .8268724
---------+--------------------------------------------------------------------
    diff |           -.3907233    .1476611               -.6812428   -.1002037
------------------------------------------------------------------------------
    diff = mean(Nyando) - mean(Makueni)                           t =  -2.6461
Ho: diff = 0                                     degrees of freedom =      317
    Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(T < t) = 0.0043         Pr(|T| > |t|) = 0.0085          Pr(T > t) = 0.9957
.  ttest nogrpsithhhmmbrs , by ( site )
Two-sample t test with equal variances
```

```
------------------------------------------------------------------------------
   Group |     Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]
---------+--------------------------------------------------------------------
  Nyando |     159    1.622642    .1432279    1.806035    1.339753     1.90553
 Makueni |     160     2.71875    .1589005     2.00995    2.404922    3.032578
---------+--------------------------------------------------------------------
combined |     319    2.172414     .111162    1.985416    1.953708     2.39112
---------+--------------------------------------------------------------------
    diff |           -1.096108     .213996                -1.51714   -.6750766
------------------------------------------------------------------------------
    diff = mean(Nyando) - mean(Makueni)                           t =  -5.1221
Ho: diff = 0                                     degrees of freedom =      317
    Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(T < t) = 0.0000         Pr(|T| > |t|) = 0.0000          Pr(T > t) = 1.0000
. tabulate gender

  Gender of |
        the |
  Household |
       head |      Freq.     Percent        Cum.
------------+-----------------------------------
     Female |         80       25.08       25.08
       Male |        239       74.92      100.00
------------+-----------------------------------
      Total |        319      100.00

. tabulate gender site, chi2 column

+-------------------+
| Key               |
|-------------------|
|     frequency     |
| column percentage |
+-------------------+

 Gender of |
       the |
 Household |         site
```

```
      head |    Nyando    Makueni |     Total
-----------+----------------------+----------
    Female |        42         38 |        80
           |     26.42      23.75 |     25.08
-----------+----------------------+----------
      Male |       117        122 |       239
           |     73.58      76.25 |     74.92
-----------+----------------------+----------
     Total |       159        160 |       319
           |    100.00     100.00 |    100.00
          Pearson chi2(1) =   0.3015   Pr = 0.583
. tabulate education site, chi2 column
+-------------------+
| Key               |
|-------------------|
|     frequency     |
| column percentage |
+-------------------+
                     |         site
           education |    Nyando    Makueni |     Total
---------------------+----------------------+----------
No formal education |        31         27 |        58
                     |     19.50      16.88 |     18.18
---------------------+----------------------+----------
             Primary |        98         86 |       184
                     |     61.64      53.75 |     57.68
---------------------+----------------------+----------
           Secondary |        22         34 |        56
                     |     13.84      21.25 |     17.55
---------------------+----------------------+----------
     Post-secondary |         8         13 |        21
                     |      5.03       8.13 |      6.58
---------------------+----------------------+----------
               Total |       159        160 |       319
                     |    100.00     100.00 |    100.00
          Pearson chi2(3) =   4.8173   Pr = 0.186
. tabulate offfarminc site, chi2 column
+-------------------+
```

```
| Key               |
|-------------------|
|     frequency     |
| column percentage |
+-------------------+
  Off Farm |         site
    Income |    Nyando    Makueni |     Total
-----------+----------------------+----------
        No |        12         13 |        25
           |      7.55       8.13 |      7.84
-----------+----------------------+----------
       Yes |       147        147 |       294
           |     92.45      91.88 |     92.16
-----------+----------------------+----------
     Total |       159        160 |       319
           |    100.00     100.00 |    100.00
          Pearson chi2(1) =   0.0369   Pr = 0.848
.  ttest clc , by ( site )
Two-sample t test with equal variances
------------------------------------------------------------------------------
   Group |     Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]
---------+--------------------------------------------------------------------
  Nyando |     159    9.006289    .2224372    2.804826    8.566955    9.445623
 Makueni |     160     8.85625    .1672584     2.11567    8.525915    9.186585
---------+--------------------------------------------------------------------
combined |     319    8.931034    .1388766    2.480416    8.657801    9.204268
---------+--------------------------------------------------------------------
    diff |            .1500393    .2780647               -.3970462    .6971248
------------------------------------------------------------------------------
    diff = mean(Nyando) - mean(Makueni)                           t =   0.5396
Ho: diff = 0                                     degrees of freedom =      317
    Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(T < t) = 0.7051         Pr(|T| > |t|) = 0.5899          Pr(T > t) = 0.2949
.  ttest simpindex2 , by ( site )
Two-sample t test with equal variances
------------------------------------------------------------------------------
   Group |     Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]
---------+--------------------------------------------------------------------
```

```
  Nyando |     159    .4320126    .0155351    .1958906    .4013293    .4626959
 Makueni |     160    .5019375    .0156825    .1983691    .4709647    .5329103
---------+--------------------------------------------------------------------
combined |     319    .4670846    .0111933    .1999181    .4450624    .4891069
---------+--------------------------------------------------------------------
    diff |           -.0699249    .0220753               -.1133575   -.0264923
------------------------------------------------------------------------------
    diff = mean(Nyando) - mean(Makueni)                           t =  -3.1676
Ho: diff = 0                                     degrees of freedom =      317
    Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(T < t) = 0.0008         Pr(|T| > |t|) = 0.0017          Pr(T > t) = 0.9992
. tabulate simpindex3 site, chi2 column
+-------------------+
| Key               |
|-------------------|
|     frequency     |
| column percentage |
+-------------------+

                      |         site
           simpindex3 |    Nyando    Makueni |     Total
----------------------+----------------------+----------
  Low Diversification |        45         29 |        74
                      |     28.30      18.13 |     23.20
----------------------+----------------------+----------
Medium Diversificatio |        88         95 |       183
                      |     55.35      59.38 |     57.37
----------------------+----------------------+----------
 High Diversification |        26         36 |        62
                      |     16.35      22.50 |     19.44
----------------------+----------------------+----------
                Total |       159        160 |       319
                      |    100.00     100.00 |    100.00

          Pearson chi2(2) =   5.3370   Pr = 0.069
. oneway agehhhd simpindex3 , tabulate
           |  Summary of Age of Household Head
 simpindex3 |        Mean   Std. Dev.       Freq.
------------+------------------------------------
  Low Diver |   51.756757   14.564745          74
```

```
  Medium Di |   55.355191   15.607464         183
  High Dive |   59.387097   15.026048          62
------------+------------------------------------
      Total |   55.304075   15.414351         319
                      Analysis of Variance
    Source              SS         df      MS            F     Prob > F
------------------------------------------------------------------------
Between groups      1965.26083      2   982.630417      4.22     0.0155
 Within groups      73592.2439    316   232.886848
------------------------------------------------------------------------
    Total           75557.5047    318   237.602216

Bartlett's test for equal variances:  chi2(2) =   0.5211  Prob>chi2 = 0.771
. oneway hhsize simpindex3 , tabulate

            |      Summary of Household Size
 simpindex3 |        Mean   Std. Dev.       Freq.
------------+------------------------------------
  Low Diver |   5.8108108   2.4755001          74
  Medium Di |   5.6065574   2.7272255         183
  High Dive |   6.4032258    3.409051          62
------------+------------------------------------
      Total |   5.8087774   2.8258329         319

                      Analysis of Variance
    Source              SS         df      MS            F     Prob > F
------------------------------------------------------------------------
Between groups      29.3925859      2   14.6962929      1.85     0.1589
 Within groups      2509.94284    316   7.94285708
------------------------------------------------------------------------
    Total           2539.33542    318   7.98533152

Bartlett's test for equal variances:  chi2(2) =   7.6358  Prob>chi2 = 0.022
oneway landsize simpindex3 , tabulate

            |     Summary of Land Size
 simpindex3 |        Mean   Std. Dev.       Freq.
------------+------------------------------------
```

```
  Low Diver |   3.3912162   2.7981202          74
  Medium Di |    2.936612    2.320844         183
  High Dive |   3.6532258   3.6315204          62
------------+------------------------------------
      Total |    3.181348   2.7382404         319

                      Analysis of Variance
    Source              SS         df      MS            F     Prob > F
------------------------------------------------------------------------
Between groups      28.0256756      2   14.0128378      1.88     0.1544
 Within groups      2356.32584    316   7.45672736
------------------------------------------------------------------------
    Total           2384.35152    318   7.49796076

Bartlett's test for equal variances:  chi2(2) = 20.7421 Prob>chi2 = 0.000
. oneway dstancetomkt simpindex3 , tabulate
            | Summary of Distance to Farm Produce
            |            Market Place
 simpindex3 |        Mean   Std. Dev.       Freq.
------------+------------------------------------
  Low Diver |    3.572973    3.408181          74
  Medium Di |   3.2262295   2.6672352         183
  High Dive |   2.6790323   3.0589368          62
------------+------------------------------------
      Total |   3.2003135   2.9357641         319

                      Analysis of Variance
    Source              SS         df      MS            F     Prob > F
------------------------------------------------------------------------
Between groups      27.2471824      2   13.6235912      1.59     0.2063
 Within groups      2713.50279    316   8.58703413
------------------------------------------------------------------------
    Total           2740.74997    318   8.61871059
Bartlett's test for equal variances:  chi2(2) =   6.9169  Prob>chi2 = 0.031

. oneway notrainatt simpindex3 , tabulate
            |   Summary of Number of Trainings
            |              Attended
 simpindex3 |        Mean   Std. Dev.       Freq.
------------+------------------------------------
```

```
  Low Diver |   .33783784   .70763018          74
  Medium Di |   .68306011   1.3700435         183
  High Dive |   1.0806452   1.6526024          62
------------+------------------------------------
      Total |   .68025078   1.3310345         319
                      Analysis of Variance
    Source              SS         df      MS            F     Prob > F
------------------------------------------------------------------------
Between groups      18.6172654      2   9.30863268      5.40     0.0049
 Within groups      544.768315    316   1.72395036
------------------------------------------------------------------------
    Total            563.38558    318   1.77165277
Bartlett's test for equal variances:  chi2(2) =  46.4506  Prob>chi2 = 0.000
. oneway nogrpsithhhmmbrs simpindex3 , tabulate
           |     Summary of Nogrpsithhhmmbrs
 simpindex3 |        Mean   Std. Dev.       Freq.
------------+------------------------------------
  Low Diver |   1.9459459   1.5693284          74
  Medium Di |   2.2349727    2.174902         183
  High Dive |   2.2580645   1.8460013          62
------------+------------------------------------
      Total |   2.1724138   1.9854164         319
                      Analysis of Variance
    Source              SS         df      MS            F     Prob > F
------------------------------------------------------------------------
Between groups      4.96631499      2    2.4831575      0.63     0.5341
 Within groups      1248.55093    316   3.95111053
------------------------------------------------------------------------
    Total           1253.51724    318   3.94187812
Bartlett's test for equal variances:  chi2(2) =  10.7198  Prob>chi2 = 0.005

. tabulate gender simpindex3, chi2 column
+--------------------+
| Key                |
|--------------------|
|     frequency      |
| column percentage |
+--------------------+
```

Gender of the Household head	simpindex3			
	Low Diver	Medium Di	High Dive	Total
Female	14	52	14	80
	18.92	28.42	22.58	25.08
Male	60	131	48	239
	81.08	71.58	77.42	74.92
Total	74	183	62	319
	100.00	100.00	100.00	100.00

Pearson chi2(2) = 2.7846 Pr = 0.249

. tabulate tenure simpindex3, chi2 column

Key
frequency
column percentage

Tenure	simpindex3			
	Low Diver	Medium Di	High Dive	Total
Own land	54	161	51	266
	72.97	87.98	82.26	83.39
Own land rent in land	18	21	10	49
	24.32	11.48	16.13	15.36
Own land rent out lan	2	1	1	4
	2.70	0.55	1.61	1.25
Total	74	183	62	319
	100.00	100.00	100.00	100.00

Pearson chi2(4) = 9.1604 Pr = 0.057

. tabulate aid simpindex3, chi2 column

```
+-------------------+
| Key               |
|-------------------|
|     frequency     |
| column percentage |
+-------------------+

           |            simpindex3
       Aid | Low Diver  Medium Di  High Dive |     Total
-----------+---------------------------------+----------
        No |        60        140         52 |       252
           |     81.08      76.50      83.87 |     79.00
-----------+---------------------------------+----------
       Yes |        14         43         10 |        67
           |     18.92      23.50      16.13 |     21.00
-----------+---------------------------------+----------
     Total |        74        183         62 |       319
           |    100.00     100.00     100.00 |    100.00

          Pearson chi2(2) =   1.7676   Pr = 0.413

. tabulate offfarminc simpindex3, chi2 column
+-------------------+
| Key               |
|-------------------|
|     frequency     |
| column percentage |
+-------------------+

  Off Farm |            simpindex3
    Income | Low Diver  Medium Di  High Dive |     Total
-----------+---------------------------------+----------
        No |         6         14          5 |        25
           |      8.11       7.65       8.06 |      7.84
-----------+---------------------------------+----------
       Yes |        68        169         57 |       294
           |     91.89      92.35      91.94 |     92.16
-----------+---------------------------------+----------
     Total |        74        183         62 |       319
           |    100.00     100.00     100.00 |    100.00

          Pearson chi2(2) =   0.0208   Pr = 0.990
```

```
. tabulate irrigation simpindex3, chi2 column
+-------------------+
| Key               |
|-------------------|
|     frequency     |
| column percentage |
+-------------------+

      Land |            simpindex3
 Irrigated | Low Diver  Medium Di  High Dive |     Total
-----------+---------------------------------+----------
        No |        58        153         43 |       254
           |     78.38      83.61      69.35 |     79.62
-----------+---------------------------------+----------
       Yes |        16         30         19 |        65
           |     21.62      16.39      30.65 |     20.38
-----------+---------------------------------+----------
     Total |        74        183         62 |       319
           |    100.00     100.00     100.00 |    100.00

          Pearson chi2(2) =   5.8897   Pr = 0.053
tabulate education simpindex3, chi2 column

+-------------------+
| Key               |
|-------------------|
|     frequency     |
| column percentage |
+-------------------+

                    |            simpindex3
          education | Low Diver  Medium Di  High Dive |     Total
--------------------+---------------------------------+----------
No formal education |         6         39         13 |        58
                    |      8.11      21.31      20.97 |     18.18
--------------------+---------------------------------+----------
            Primary |        49        101         34 |       184
                    |     66.22      55.19      54.84 |     57.68
--------------------+---------------------------------+----------
          Secondary |        15         31         10 |        56
```

```
                    |     20.27      16.94      16.13 |     17.55
--------------------+---------------------------------+----------
     Post-secondary |         4         12          5 |        21
                    |      5.41       6.56       8.06 |      6.58
--------------------+---------------------------------+----------
              Total |        74        183         62 |       319
                    |    100.00     100.00     100.00 |    100.00

          Pearson chi2(6) =   7.3837   Pr = 0.287

tabulate site simpindex3, chi2 column

+--------------------+
| Key                |
|--------------------|
|     frequency      |
| column percentage  |
+--------------------+

           |            simpindex3
      site | Low Diver  Medium Di  High Dive |     Total
-----------+---------------------------------+----------
    Nyando |        45         88         26 |       159
           |     60.81      48.09      41.94 |     49.84
-----------+---------------------------------+----------
   Makueni |        29         95         36 |       160
           |     39.19      51.91      58.06 |     50.16
-----------+---------------------------------+----------
     Total |        74        183         62 |       319
           |    100.00     100.00     100.00 |    100.00

          Pearson chi2(2) =   5.3370   Pr = 0.069
```

Objective two results

```
. ologit simpindex3 gender agehhhd educ aid i.tenure offfarminc landsize
dstancetomkt notrainatt site irrigation nogrpsithhhmmbrs slope, vc

> e (robust)


Iteration 0:   log pseudolikelihood = -311.37685
Iteration 1:   log pseudolikelihood = -294.11227
Iteration 2:   log pseudolikelihood = -293.80412
Iteration 3:   log pseudolikelihood =  -293.8035
Iteration 4:   log pseudolikelihood =  -293.8035
```

```
Ordered logistic regression                     Number of obs     =        319
                                                Wald chi2(14)     =      34.66
                                                Prob > chi2       =     0.0016
Log pseudolikelihood =  -293.8035               Pseudo R2         =     0.5640

------------------------------------------------------------------------------
             |               Robust
 simpindex3 |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
------------+----------------------------------------------------------------
      gender |    .1309029   .2972426     0.44   0.660    -.4516818   .7134877
     agehhhd |    .0232885    .008648     2.69   0.007     .0063387   .0402384
        educ |   -.0680122    .143523    -0.47   0.636    -.3493121   .2132877
         aid |   -.4917164   .2915801    -1.69   0.092    -1.063203   .0797701
             |
      tenure |
 Own land rent in land |   -.4923339    .392109    -1.26   0.209    -1.260853   .2761855
Own land rent out land |   -.7497004   1.536903    -0.49   0.626    -3.761975   2.262574
             |
    offfarminc |    .4166735    .426403     0.98   0.328     -.419061   1.252408
      landsize |   -.0342386   .0516973    -0.66   0.508    -.1355634   .0670862
  dstancetomkt |   -.0404383    .049261    -0.82   0.412     -.136988   .0561115
    notrainatt |    .2789468   .0900106     3.10   0.002     .1025293   .4553643
          site |    .5243201   .2745745     1.91   0.056    -.0138361   1.062476
    irrigation |    .5566565   .3227475     1.72   0.085    -.0759169   1.18923
nogrpsithhhmmbrs |    .0193237   .0472012     0.41   0.682     -.073189   .1118364
         slope |     -.14838   .1107558    -1.34   0.180    -.3654574   .0686974
------------------------------------------------------------------------------
```

```
                 /cut1 |    .1203185    .8523484                      -1.550254
1.790891
                 /cut2 |    2.983101    .8650939                       1.287548
4.678654
------------------------------------------------------------------------------
------
```

Test for Over dispersion

```
. poisson clc gender agehhhd educ hhsize tenure landsize offfarminc dstancetomkt
notrainatt aid site irrigation nogrpsithhhmmbrs slope

Iteration 0:   log likelihood = -723.78766

Iteration 1:   log likelihood = -723.78764

Poisson regression                              Number of obs     =        319
                                                LR chi2(14)       =      55.91
                                                Prob > chi2       =     0.0000
Log likelihood = -723.78764                     Pseudo R2         =     0.3721

------------------------------------------------------------------------------
             clc |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-----------------+------------------------------------------------------------------
          gender |  -.0205628   .0512547    -0.40   0.688    -.1210202    .0798945
         agehhhd |   .0018921   .0014642     1.29   0.196    -.0009776    .0047618
            educ |   .0376722   .0235713     1.60   0.110    -.0085267    .0838711
          hhsize |   .0032748   .0069356     0.47   0.637    -.0103187    .0168684
          tenure |   .1000023   .0453446     2.21   0.027     .0111285     .188876
        landsize |   .0136289   .0071932     1.89   0.058    -.0004696    .0277274
      offfarminc |   .0450002   .0720596     0.62   0.532     -.096234    .1862343
    dstancetomkt |  -.0078316   .0069139    -1.13   0.257    -.0213826    .0057194
      notrainatt |   .0339205   .0135696     2.50   0.012     .0073246    .0605163
             aid |   .0432818   .0479087     0.90   0.366    -.0506176    .1371811
            site |  -.0531909   .0470166    -1.13   0.258    -.1453417    .0389598
      irrigation |    .204714   .0454517     4.50   0.000     .1156304    .2937976
nogrpsithhhmmbrs |   .0141869   .0097816     1.45   0.147    -.0049848    .0333585
           slope |   .0244983   .0190379     1.29   0.198    -.0128152    .0618118
           _cons |   1.651215   .1658368     9.96   0.000     1.326181    1.976249
------------------------------------------------------------------------------

. poisgof

         Deviance goodness-of-fit =   170.024
         Prob > chi2(304)         =    1.0000
         Pearson goodness-of-fit  =  166.4921
         Prob > chi2(304)         =    1.0000
```

```
. nbreg clc gender agehhhd educ hhsize tenure landsize offfarminc dstancetomkt
notrainatt aid site irrigation nogrpsithhhmmbrs slope

Fitting Poisson model:

Iteration 0:   log likelihood = -723.78766

Iteration 1:   log likelihood = -723.78764

Fitting constant-only model:

Iteration 0:   log likelihood = -1034.6883

Iteration 1:   log likelihood =  -751.7429

Iteration 2:   log likelihood =  -751.7429

Fitting full model:

Iteration 0:   log likelihood = -723.91573

Iteration 1:   log likelihood = -723.78765

Iteration 2:   log likelihood = -723.78764

Negative binomial regression                    Number of obs     =        319
                                                LR chi2(14)       =      55.91
Dispersion     = mean                           Prob > chi2       =     0.0000
Log likelihood = -723.78764                     Pseudo R2         =     0.3721

------------------------------------------------------------------------------
             clc |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-----------------+------------------------------------------------------------------
          gender |  -.0205628   .0512547    -0.40   0.688    -.1210202    .0798945
         agehhhd |   .0018921   .0014642     1.29   0.196    -.0009776    .0047618
            educ |   .0376722   .0235713     1.60   0.110    -.0085267    .0838711
          hhsize |   .0032748   .0069356     0.47   0.637    -.0103187    .0168684
          tenure |   .1000023   .0453446     2.21   0.027     .0111285     .188876
        landsize |   .0136289   .0071932     1.89   0.058    -.0004696    .0277274
      offfarminc |   .0450002   .0720596     0.62   0.532     -.096234    .1862343
    dstancetomkt |  -.0078316   .0069139    -1.13   0.257    -.0213826    .0057194
      notrainatt |   .0339205   .0135696     2.50   0.012     .0073246    .0605163
             aid |   .0432818   .0479087     0.90   0.366    -.0506176    .1371811
            site |  -.0531909   .0470166    -1.13   0.258    -.1453416    .0389598
      irrigation |    .204714   .0454517     4.50   0.000     .1156304    .2937976
nogrpsithhhmmbrs |   .0141869   .0097816     1.45   0.147    -.0049848    .0333585
           slope |   .0244983   .0190379     1.29   0.198    -.0128152    .0618118
           _cons |   1.651215   .1658368     9.96   0.000     1.326181    1.976249
-----------------+------------------------------------------------------------------
        /lnalpha |  -57.81918          .                           .           .
-----------------+------------------------------------------------------------------
```

```
          alpha |   7.75e-26          .                           .           .
------------------------------------------------------------------------------

Likelihood-ratio test of alpha=0:  chibar2(01) =    0.00 Prob>=chibar2 = 1.000

. poisson clc gender agehhhd educ aid i.tenure offfarminc landsize dstancetomkt
notrainatt site irrigation nogrpsithhhmmbrs slope, vce (rob

> ust)


Iteration 0:   log pseudolikelihood = -723.75032

Iteration 1:   log pseudolikelihood = -723.75029


Poisson regression                              Number of obs     =        319

                                                Wald chi2(14)     =     190.05

                                                Prob > chi2       =     0.0000

Log pseudolikelihood = -723.75029               Pseudo R2         =     0.03721


------------------------------------------------------------------------------
             |               Robust
         clc |      Coef.   Std. Err.       z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
      gender |  -.0166459   .0388941    -0.43   0.669    -.0928769    .059585
     agehhhd |   .0018047   .0009518     1.90   0.058    -.0000609    .0036703
        educ |   .0371031   .0160127     2.32   0.020     .0057187    .0684874
         aid |   .0413382   .0328634     1.26   0.208     -.023073    .1057494
             |
      tenure |
 Own land rent in land  |   .0860573   .0362932     2.37   0.018     .0149239    .1571907
Own land rent out land  |   .2678145   .0450083     5.95   0.000     .1795999    .3560291
             |
    offfarminc |   .0432037   .0507417     0.85   0.395    -.0562482    .1426556
      landsize |   .0141484   .0045376     3.12   0.002     .0052549    .0230419
   dstancetomkt |  -.0080118   .0050164    -1.60   0.110    -.0178437    .0018202
```

```
            notrainatt |    .0353057    .0075715       4.66    0.000       .0204659
.0501456
                  site |   -.0567872     .033537      -1.69    0.090      -.1225185
.008944
            irrigation |    .2051895    .0303944       6.75    0.000       .1456176
.2647615
      nogrpsithhhmmbrs |    .0150322    .0074806       2.01    0.044       .0003706
.0296938
                 slope |    .0260988    .0144327       1.81    0.071      -.0021887
.0543864
                 _cons |    1.771555    .1076966      16.45    0.000       1.560474
1.982637
------------------------------------------------------------------------------
-----
```

Objective three results

```
. tabulate ddscateg simpindex3, chi2 column
+--------------------+
| Key                |
|--------------------|
|     frequency      |
| column percentage  |
+--------------------+
    Dietary Diversity |            simpindex3
     Score Categories | Low Diver  Medium Di  High Dive |     Total
----------------------+---------------------------------+----------
Low Dietary Diversity |         0          3          0 |         3
                      |      0.00       1.64       0.00 |      0.94
----------------------+---------------------------------+----------
Medium Dietary Divers |         9         15          8 |        32
                      |     12.16       8.20      12.90 |     10.03
----------------------+---------------------------------+----------
High Dietary Diversit |        65        165         54 |       284
                      |     87.84      90.16      87.10 |     89.03
----------------------+---------------------------------+----------
                Total |        74        183         62 |       319
                      |    100.00     100.00     100.00 |    100.00
          Pearson chi2(4) =   3.7525   Pr = 0.441
.  tabulate ddscateg site, chi2 column
+--------------------+
| Key                |
|--------------------|
```

```
|     frequency     |
| column percentage |
+-------------------+

    Dietary Diversity |         site
     Score Categories |    Nyando    Makueni |     Total
----------------------+----------------------+----------
Low Dietary Diversity |         2          1 |         3
                      |      1.26       0.63 |      0.94
----------------------+----------------------+----------
Medium Dietary Divers |        14         18 |        32
                      |      8.81      11.25 |     10.03
----------------------+----------------------+----------
High Dietary Diversit |       143        141 |       284
                      |     89.94      88.13 |     89.03
----------------------+----------------------+----------
                Total |       159        160 |       319
                      |    100.00     100.00 |    100.00

          Pearson chi2(2) =   0.8443   Pr = 0.656
```

Test for multicollinearity of Simpson's Index and crop and livestock count

```
reg dds simpindex2 clc
      Source |       SS           df       MS      Number of obs   =       319
-------------+----------------------------------   F(2, 316)       =      7.89
       Model |  25.5154162         2  12.7577081   Prob > F        =    0.0005
    Residual |  511.230665       316  1.61781856   R-squared       =    0.4755
-------------+----------------------------------   Adj R-squared   =    0.0415
       Total |  536.746082       318  1.68788076   Root MSE        =    1.2719
------------------------------------------------------------------------------
         dds |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
  simpindex2 |  -1.044579   .3596501    -2.90   0.004     -1.75219   -.3369673
         clc |   .0885015   .0289873     3.05   0.002      .031469     .145534
       _cons |   6.669284    .298906    22.31   0.000     6.081186    7.257381
------------------------------------------------------------------------------
. vif

    Variable |       VIF       1/VIF
```

```
-------------+----------------------
         clc |      1.02    0.984097
  simpindex2 |      1.02    0.984097
-------------+----------------------
    Mean VIF |      1.02
```

Test for endogeneity

```
. reg dds simpindex3 clc gender agehhhd educ hhsize aid offfarminc dstancetomkt
nogrpsithhhmmbrs site

      Source |       SS           df       MS      Number of obs   =       319
-------------+----------------------------------   F(11, 307)      =      4.16
       Model |  69.5806555        11  6.32551414   Prob > F        =    0.0000
    Residual |  467.165426       307  1.52171149   R-squared       =    0.1296
-------------+----------------------------------   Adj R-squared   =    0.0984
       Total |  536.746082       318  1.68788076   Root MSE        =    1.2336

------------------------------------------------------------------------------
             dds |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-----------------+------------------------------------------------------------------
      simpindex3 |  -.1525915   .1096551    -1.39   0.165    -.3683621    .0631791
             clc |   .0714907   .0290362     2.46   0.014     .0143555    .1286259
          gender |  -.0781261   .1884741    -0.41   0.679    -.4489906    .2927383
         agehhhd |  -.0101182   .0052912    -1.91   0.057    -.0205298    .0002933
            educ |   .1696773   .0869776     1.95   0.052    -.0014704     .340825
          hhsize |  -.0467161   .0254156    -1.84   0.067    -.0967269    .0032947
             aid |   .1352883   .1774504     0.76   0.446    -.2138846    .4844612
      offfarminc |   .1914889   .2614982     0.73   0.465    -.3230667    .7060444
    dstancetomkt |   .0244826   .0242321     1.01   0.313    -.0231994    .0721645
nogrpsithhhmmbrs |   .1209891   .0373719     3.24   0.001     .0474516    .1945266
            site |  -.2759241   .1506326    -1.83   0.068    -.5723271     .020479
           _cons |   6.612411   .5929098    11.15   0.000      5.44573    7.779093
------------------------------------------------------------------------------

. reg dds landsize slope gender agehhhd educ hhsize aid offfarminc dstancetomkt
nogrpsithhhmmbrs site

      Source |       SS           df       MS      Number of obs   =       319
-------------+----------------------------------   F(11, 307)      =      4.19
```

```
       Model |   70.110062        11    6.373642   Prob > F        =    0.0000
    Residual |  466.636019       307  1.51998703   R-squared       =    0.1306
-------------+----------------------------------   Adj R-squared   =    0.0995
       Total |  536.746082       318  1.68788076   Root MSE        =    1.2329

------------------------------------------------------------------------------
             dds |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-----------------+------------------------------------------------------------
        landsize |   .0768085   .0280837     2.73   0.007     .0215476    .1320694
           slope |   .0409317   .0695883     0.59   0.557    -.0959987     .177862
          gender |  -.0846745   .1883162    -0.45   0.653    -.4552283    .2858794
         agehhhd |  -.0125381   .0053333    -2.35   0.019    -.0230326   -.0020436
            educ |   .1740873   .0867168     2.01   0.046     .0034528    .3447218
          hhsize |  -.0549415    .025589    -2.15   0.033    -.1052937   -.0045894
             aid |   .2194867   .1775992     1.24   0.217    -.1299789    .5689524
       offfarminc |   .2726291   .2637718     1.03   0.302    -.2464002    .7916584
    dstancetomkt |   .0122679   .0245328     0.50   0.617    -.0360058    .0605415
nogrpsithhhmmbrs |   .1281379   .0372082     3.44   0.001     .0549225    .2013533
            site |  -.5001786   .1635262    -3.06   0.002    -.8219527   -.1784045
           _cons |   6.834833   .5615384    12.17   0.000     5.729882    7.939784
------------------------------------------------------------------------------
```

```
. predict resid23, res
```

```
. reg dds simpindex3 clc gender agehhhd educ hhsize aid offfarminc dstancetomkt
nogrpsithhhmmbrs site resid23
```

```
      Source |       SS           df       MS      Number of obs   =       319
-------------+----------------------------------   F(12, 306)      =   1186.91
       Model |  525.456985        12  43.7880821   Prob > F        =    0.0000
    Residual |  11.2890963       306  .036892472   R-squared       =    0.9790
-------------+----------------------------------   Adj R-squared   =    0.9781
       Total |  536.746082       318  1.68788076   Root MSE        =    .19207

------------------------------------------------------------------------------
             dds |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-----------------+------------------------------------------------------------
      simpindex3 |  -.0260598   .0171117    -1.52   0.129    -.0597314    .0076118
```

```
             clc |   .0169392   .0045476     3.72   0.000     .0079906    .0258878
          gender |  -.0962132   .0293468    -3.28   0.001    -.1539603   -.0384661
         agehhhd |  -.0101548   .0008239   -12.33   0.000     -.011776   -.0085337
            educ |    .192627   .0135444    14.22   0.000      .165975     .219279
          hhsize |  -.0431556   .0039575   -10.90   0.000    -.0509429   -.0353683
             aid |   .1826236   .0276332     6.61   0.000     .1282484    .2369987
      offfarminc |   .1778076   .0407168     4.37   0.000     .0976873    .2579279
    dstancetomkt |   .0220839   .0037731     5.85   0.000     .0146593    .0295084
nogrpsithhhmmbrs |   .1276915   .0058193    21.94   0.000     .1162406    .1391424
            site |  -.3242716   .0234583   -13.82   0.000    -.3704315   -.2781116
         resid23 |   .9958098   .0089582   111.16   0.162     .9781823    1.013437
           _cons |   6.798321   .0923342    73.63   0.000     6.616631    6.980011
------------------------------------------------------------------------------

.. tab cereals

    Cereals |      Freq.     Percent        Cum.
------------+-----------------------------------
         No |          1        0.63        0.63
        Yes |        159       99.38      100.00
------------+-----------------------------------
      Total |        160      100.00

. tab whtertsntbers

White Roots |
 and Tubers |      Freq.     Percent        Cum.
------------+-----------------------------------
         No |        139       86.88       86.88
        Yes |         21       13.13      100.00
------------+-----------------------------------
      Total |        160      100.00

. tab eggs

       Eggs |      Freq.     Percent        Cum.
------------+-----------------------------------
         No |        153       95.63       95.63
```

```
        Yes |          7        4.38      100.00
------------+-----------------------------------
      Total |        160      100.00

. tab fish

       Fish |      Freq.     Percent        Cum.
------------+-----------------------------------
         No |        159       99.38       99.38
        Yes |          1        0.63      100.00
------------+-----------------------------------
      Total |        160      100.00

. tab legnutseds

    Legumes |
   Nuts and |
      Seeds |      Freq.     Percent        Cum.
------------+-----------------------------------
         No |         31       19.38       19.38
        Yes |        129       80.63      100.00
------------+-----------------------------------
      Total |        160      100.00

. tab mlknprdcts
   Milk and |
       Milk |
   Products |      Freq.     Percent        Cum.
------------+-----------------------------------
         No |         33       20.63       20.63
        Yes |        127       79.38      100.00
------------+-----------------------------------
      Total |        160      100.00

. tab oilsnfats
   Oils and |
       Fats |      Freq.     Percent        Cum.
------------+-----------------------------------
         No |          9        5.63        5.63
```

```
        Yes |        151       94.38      100.00
------------+-----------------------------------
      Total |        160      100.00

. tab sweets

     Sweets |      Freq.     Percent        Cum.
------------+-----------------------------------
         No |         10        6.25        6.25
        Yes |        150       93.75      100.00
------------+-----------------------------------
      Total |        160      100.00

. tab spcscondbvrgs

     Spices |
 Condiments |
        and |
  Beverages |      Freq.     Percent        Cum.
------------+-----------------------------------
         No |          9        5.63        5.63
        Yes |        151       94.38      100.00
------------+-----------------------------------
      Total |        160      100.00

. tab veg

 Vegetables |      Freq.     Percent        Cum.
------------+-----------------------------------
         No |         14        8.75        8.75
        Yes |        146       91.25      100.00
------------+-----------------------------------
      Total |        160      100.00

. tab fruits

     Fruits |      Freq.     Percent        Cum.
------------+-----------------------------------
         No |        121       75.63       75.63
        Yes |         39       24.38      100.00
------------+-----------------------------------
      Total |        160      100.00

. tab Meat

       Meat |      Freq.     Percent        Cum.
------------+-----------------------------------
         No |        138       86.25       86.25
```

```
        Yes |         22       13.75      100.00
------------+-----------------------------------
      Total |        160      100.00

. tab cereals

    Cereals |      Freq.     Percent        Cum.
------------+-----------------------------------
         No |          1        0.63        0.63
        Yes |        158       99.37      100.00
------------+-----------------------------------
      Total |        159      100.00

. tab whtertsntbers

White Roots |
 and Tubers |      Freq.     Percent        Cum.
------------+-----------------------------------
         No |        146       91.82       91.82
        Yes |         13        8.18      100.00
------------+-----------------------------------
      Total |        159      100.00

. tab eggs

       Eggs |      Freq.     Percent        Cum.
------------+-----------------------------------
         No |        144       90.57       90.57
        Yes |         15        9.43      100.00
------------+-----------------------------------
      Total |        159      100.00

. tab fish

       Fish |      Freq.     Percent        Cum.
------------+-----------------------------------
         No |        125       78.62       78.62
        Yes |         34       21.38      100.00
------------+-----------------------------------
      Total |        159      100.00

. tab legnutseds

    Legumes |
   Nuts and |
      Seeds |      Freq.     Percent        Cum.
------------+-----------------------------------
```

```
         No |        116       72.96       72.96
        Yes |         43       27.04      100.00
------------+-----------------------------------
      Total |        159      100.00

. tab mlknprdcts
   Milk and |
       Milk |
   Products |      Freq.     Percent        Cum.
------------+-----------------------------------
         No |         21       13.21       13.21
        Yes |        138       86.79      100.00
------------+-----------------------------------
      Total |        159      100.00
. tab oilsnfats

   Oils and |
       Fats |      Freq.     Percent        Cum.
------------+-----------------------------------
         No |          4        2.52        2.52
        Yes |        155       97.48      100.00
------------+-----------------------------------
      Total |        159      100.00
. tab sweets

     Sweets |      Freq.     Percent        Cum.
------------+-----------------------------------
         No |         10        6.29        6.29
        Yes |        149       93.71      100.00
------------+-----------------------------------
      Total |        159      100.00
. tab spcscondbvrgs
     Spices |
 Condiments |
        and |
  Beverages |      Freq.     Percent        Cum.
------------+-----------------------------------
         No |          4        2.52        2.52
```

```
        Yes |        155       97.48      100.00
------------+-----------------------------------
      Total |        159      100.00

. tab veg

 Vegetables |      Freq.     Percent        Cum.
------------+-----------------------------------
         No |          1        0.63        0.63
        Yes |        158       99.37      100.00
------------+-----------------------------------
      Total |        159      100.00


. tab fruits

     Fruits |      Freq.     Percent        Cum.
------------+-----------------------------------
         No |         74       46.54       46.54
        Yes |         85       53.46      100.00
------------+-----------------------------------
      Total |        159      100.00

. tab Meat

       Meat |      Freq.     Percent        Cum.
------------+-----------------------------------
         No |        141       88.68       88.68
        Yes |         18       11.32      100.00
------------+-----------------------------------
      Total |        159      100.00
```

Test for Over dispersion

```
. poisson dds simpindex3 clc gender agehhhd educ hhsize landsize offfarminc
dstancetomkt nogrpsithhhmmbrs site


Iteration 0:   log likelihood = -640.11518
Iteration 1:   log likelihood = -640.11518

Poisson regression                              Number of obs     =        319
                                                LR chi2(11)       =      10.94
                                                Prob > chi2       =     0.4484
Log likelihood = -640.11518                     Pseudo R2         =     0.0085

------------------------------------------------------------------------------
```

```
             dds |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-----------------+------------------------------------------------------------------
      simpindex3 |  -.0201859   .0335583    -0.60   0.547     -.085959    .0455872
             clc |   .0090429   .0089834     1.01   0.314    -.0085642      .02665
          gender |  -.0117976   .0579769    -0.20   0.839    -.1254303    .1018351
         agehhhd |  -.0017614   .0016506    -1.07   0.286    -.0049965    .0014737
            educ |   .0215497   .0266971     0.81   0.420    -.0307756    .0738749
          hhsize |  -.0083964   .0081107    -1.04   0.301    -.0242931    .0075003
        landsize |   .0090066   .0086283     1.04   0.297    -.0079045    .0259178
      offfarminc |   .0402466   .0823238     0.49   0.625    -.1211051    .2015984
    dstancetomkt |   .0026747   .0074201     0.36   0.718    -.0118684    .0172178
nogrpsithhhmmbrs |   .0167131   .0109748     1.52   0.128    -.0047971    .0382233
            site |  -.0540738   .0483652    -1.12   0.264    -.1488679    .0407204
           _cons |   1.906019   .1839867    10.36   0.000     1.545412    2.266626
------------------------------------------------------------------------------

. poisgof

         Deviance goodness-of-fit =  74.82753
         Prob > chi2(307)         =    1.0000

         Pearson goodness-of-fit  =   67.0921
         Prob > chi2(307)         =    1.0000

. nbreg dds simpindex3 clc gender agehhhd educ hhsize landsize offfarminc
dstancetomkt nogrpsithhhmmbrs site

Fitting Poisson model:

Iteration 0:   log likelihood = -640.11518
Iteration 1:   log likelihood = -640.11518

Fitting constant-only model:

Iteration 0:   log likelihood =  -960.3134
Iteration 1:   log likelihood = -645.58483
Iteration 2:   log likelihood = -645.58483  (backed up)
```

```
Fitting full model:

Iteration 0:   log likelihood = -640.12194
Iteration 1:   log likelihood = -640.11518
Iteration 2:   log likelihood = -640.11518

Negative binomial regression                    Number of obs     =        319
                                                LR chi2(11)       =      10.94
Dispersion     = mean                           Prob > chi2       =     0.4484
Log likelihood = -640.11518                     Pseudo R2         =     0.0085

------------------------------------------------------------------------------
             dds |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-----------------+------------------------------------------------------------
      simpindex3 |  -.0201859   .0335583    -0.60   0.547     -.085959    .0455872
             clc |   .0090429   .0089834     1.01   0.314    -.0085642      .02665
          gender |  -.0117976   .0579769    -0.20   0.839    -.1254303    .1018351
         agehhhd |  -.0017614   .0016506    -1.07   0.286    -.0049965    .0014737
            educ |   .0215497   .0266971     0.81   0.420    -.0307756    .0738749
          hhsize |  -.0083964   .0081107    -1.04   0.301    -.0242931    .0075003
        landsize |   .0090066   .0086283     1.04   0.297    -.0079045    .0259178
      offfarminc |   .0402466   .0823238     0.49   0.625    -.1211051    .2015984
    dstancetomkt |   .0026747   .0074201     0.36   0.718    -.0118684    .0172178
nogrpsithhhmmbrs |   .0167131   .0109748     1.52   0.128    -.0047971    .0382233
            site |  -.0540738   .0483652    -1.12   0.264    -.1488679    .0407204
           _cons |   1.906019   .1839867    10.36   0.000     1.545412    2.266626
-----------------+------------------------------------------------------------
        /lnalpha |  -32.48503          .                           .           .
-----------------+------------------------------------------------------------
           alpha |   7.80e-15          .                           .           .
------------------------------------------------------------------------------
Likelihood-ratio test of alpha=0:  chibar2(01) =    0.00 Prob>=chibar2 = 1.000.

. poisson dds simpindex3 clc gender agehhhd educ hhsize landsize offfarminc
dstancetomkt nogrpsithhhmmbrs site,vce (robust)

Iteration 0:   log pseudolikelihood = -640.11518
Iteration 1:   log pseudolikelihood = -640.11518
```

```
Poisson regression                              Number of obs     =        319
                                                Wald chi2(11)     =      63.53
                                                Prob > chi2       =     0.0000
Log pseudolikelihood = -640.11518               Pseudo R2         =     0.5806

------------------------------------------------------------------------------
             |               Robust
         dds |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
  simpindex3 |  -.0201859   .0151089    -1.34   0.182    -.0497989    .0094271
         clc |   .0090429   .0037362     2.42   0.016       .00172    .0163658
      gender |  -.0117976   .0262297    -0.45   0.653    -.0632069    .0396117
     agehhhd |  -.0017614   .0007084    -2.49   0.013    -.0031498    -.000373
        educ |   .0215497   .0118608     1.82   0.069     -.001697    .0447963
      hhsize |  -.0083964   .0040387    -2.08   0.038    -.0163121   -.0004807
    landsize |   .0090066   .0037458     2.40   0.016     .0016651    .0163482
  offfarminc |   .0402466   .0534505     0.75   0.451    -.0645144    .1450077
dstancetomkt |   .0026747   .0032894     0.81   0.416    -.0037724    .0091218
nogrpsithhhmmbrs |   .0167131   .0039275     4.26   0.000     .0090152    .0244109
        site |  -.0540738   .0220305    -2.45   0.014    -.0972528   -.0108947
       _cons |   1.906019   .0961023    19.83   0.000     1.717662    2.094376
------------------------------------------------------------------------------

margins,dydx(*) atmeans

Conditional marginal effects                    Number of obs     =        319
Model VCE    : Robust

Expression   : Predicted number of events, predict()
dy/dx w.r.t. : simpindex3 clc gender agehhhd educ hhsize lndcultivated offfarminc
dstancetomkt nogrpsithhhmmbrs site
at           : simpindex3      =    1.962382 (mean)
               clc             =    8.931034 (mean)
               gender          =    .7492163 (mean)
               agehhhd         =    55.30408 (mean)
               educ            =    2.959248 (mean)
               hhsize          =    5.808777 (mean)
               landsize        =    3.181348 (mean)
               offfarminc      =    .9216301 (mean)
```

```
                dstancetomkt     =     3.200313 (mean)
                nogrpsithh~s     =     2.172414 (mean)
                site             =     .5015674 (mean)

------------------------------------------------------------------------------
                  |            Delta-method
                  |      dy/dx   Std. Err.      z    P>|z|     [95% Conf. Interval]
------------------+-----------------------------------------------------------------
      simpindex3 |  -.1403853   .1052334    -1.33   0.182     -.346639    .0658683
             clc |   .0628897   .0259675     2.42   0.015     .0119944    .1137851
          gender |  -.0820478   .1825185    -0.45   0.653    -.4397775    .2756819
         agehhhd |    -.01225   .0049012    -2.50   0.012    -.0218562   -.0026437
            educ |   .1498697   .0823747     1.82   0.069    -.0115818    .3113212
          hhsize |  -.0583937   .0280788    -2.08   0.038    -.1134271   -.0033603
        landsize |   .0626376    .026006     2.41   0.016     .0116667    .1136085
      offfarminc |      .2799   .3710758     0.75   0.451    -.4473953    1.007195
    dstancetomkt |   .0186016   .0228617     0.81   0.416    -.0262066    .0634097
nogrpsithhhmmbrs |    .116233   .0273413     4.25   0.000     .0626451     .169821
            site |  -.3760625   .1533365    -2.45   0.014    -.6765965   -.0755286
------------------------------------------------------------------------------
```

Appendix F: Abstract of the Journal Paper

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cogent food & agriculture

FOOD SCIENCE & TECHNOLOGY | RESEARCH ARTICLE

Linking farm production to household diets: Evidence from two low potential areas in Kenya

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Additional information is available at the end of the article

Abstract: Despite the role played by small-scale farmers in agricultural production, majority of these farmers' households in developing countries consume diets that are of low quality. This consumption of poor quality diets is a major factor contributing to the high burden of malnutrition. Farm enterprise diversification as one of nutrition-sensitive agriculture interventions, improve nutritional status by supporting consumption of nutritious foods. This study aimed at examining the role of farm enterprise diversity on household diet quality among small-scale farmers in two low potential areas in Kenya. The cross-sectional study targeted 320 randomly selected small-scale farmers' households in Makueni and Nyando Sub-Counties and semi-structured questionnaires were used to collect data. From the results, livestock count had a positive significant effect on household diet quality at 5% significance level. This finding indicates that household dietary diversity (HDD) can also be achieved through the income pathway since people can purchase a variety of other foods from the market using the income they earn. Thus, there is a need to sensitize small-scale farmers on the importance of producing a variety of crops and animal species for household consumption and sale for improved HDD.

Subjects: Agriculture; Agricultural Economics; Agriculture and Food; Nutrition

Emmaculate Kiptoo

ABOUT THE AUTHOR

Emmaculate Kiptoo The study contributes to the existing body of knowledge on the role of farm enterprise diversity on household diet quality based on data from Integrated Modelling Platform for Mixed Animal Crop Systems (IMPACT) lite project. The study was part of the larger project by International Livestock Research Institute (ILRI). The aim of the project was to modify Impact to be able to collect household level data detailed enough to capture within site variability on key performance and livelihood indicators that could be used for a range of analysis. The first author is a graduate student in Agricultural Economics in Egerton University and was a Research Assistant in the project. The second author is a lecturer of Nutrition at Egerton University, Department of Human Nutrition. The third author is a lecturer of Agricultural Economics at Egerton University, Department of Agricultural Economics and Agribusiness Management.

PUBLIC INTEREST STATEMENT

Small-scale farmers play a very crucial role in the agricultural sector. Therefore, it is important to understand how these small-scale farmers' households can benefit from agricultural production through the diets they consume. This study investigated the role of farm enterprise diversity on household diet quality among small-scale farmers in two low potential areas in Kenya. The results indicated that a simple count of livestock species, education of the household head, land size and number of social groups had a positive effect on household diet quality. On the other hand, age of the household head and difference in the study site location had a negative effect on household diet quality. There is a need for stakeholders to emphasize on interventions that focus on improving the quality of household diets among small-scale farmers in low potential areas.