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IMPACT ASSESSMENT OF INTEGRATED PEST MANAGEMENT STRATEGY FOR CONTROL OF MANGO FRUIT FLY ON WOMEN DECISION MAKING AMONG SMALLHOLDER MANGO PRODUCERS IN MACHAKOS COUNTY, KENYA

HANNAH MUMBI GICHUNGI

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A THESIS SUBMITTED TO THE DEPARTMENT OF AGRICULTURAL ECONOMICS IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF THE DEGREE OF MASTER OF SCIENCE IN AGRICULTURAL AND APPLIED ECONOMICS

DEPARTMENT OF AGRICULTURAL ECONOMICS

FACULTY OF AGRICULTURE, UNIVERSITY OF NAIROBI

NOVEMBER 2021

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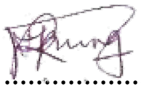
Signature:  ..... Date: 17 November, 2021

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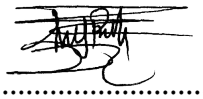
Signature:  ..... Date: ...25 November, 2021

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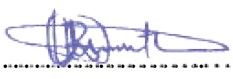
Signature.....  Date: ...25 November, 2021

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DEDICATION

This thesis is dedicated to my parents, Rev. Wilson Munene Gichungi and Mrs. Mercy Njeri Gichungi, for their moral and financial support.

ABSTRACT

Improved technology increases agricultural productivity which translates to increased income from the farm. This escalates women loss of control to agricultural production and marketing due to persistent gender disparities in access to productive resources. The International Centre of Insect Physiology and Ecology (*icipe*) developed an Integrated Pest Management (IPM) strategy for suppression of mango fruit flies among smallholder mango farmers in sub-Saharan Africa (SSA). Despite the impressive direct impacts of *icipe's* IPM strategies, it remains unclear how the adoption of IPM affects household gender relations. Using a sample of 470 households in Machakos County, a two-limit Tobit model of difference-in-difference was used assess the impact of IPM technology adoption on women decision-making in mango production and marketing activities among smallholder mango farmers. The results show that the adoption of IPM strategy led to a decrease in women decision-making index by 21.2 percent. Female spouse access to training, membership to a mango production or marketing group, access to credit, and the proportion of investment in mango production significantly influenced their decision-making index. Therefore, women's decision-making index in mango production and marketing can be enhanced through access to training by extension officers, membership to a mango production or marketing group, and access to credit.

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ABBREVIATIONS AND ACRONYMS

AFFP	African Fruit fly Programme
DiD	Difference-in-Difference
DMI	Decision making index
CIDP	County Integrated Development Plan
FAO	Food and Agriculture organization of United Nations
FAOSTAT	Food and Agricultural Organization Corporate Statistical Database
GDP	Gross Domestic Product
GPI	Gender Parity Index
GoK	Government of Kenya
icipe	International Center for Insects Physiology and Ecology
IPM	Integrated Pest Management
KALRO	Kenya Agricultural and Livestock Research Organization
KEPHIS	Kenya Plant Health Inspectorates Service
KSHS	Kenyan Shillings
MoALF	The Ministry of Agriculture, Livestock and Fisheries
OLS	Ordinary least square
SDGs	Sustainable Development Goals
SSA	Sub Saharan Africa
UN	United Nations
UNDP	United Nations Development Programme
UNECA	United Nations Economic Commission for Africa
US$	United states of America Dollar
USDA	United State Department of Agriculture
WEAI	Women Empowerment in Agriculture Index

CHAPTER ONE: INTRODUCTION

1.1 Background

Mango fruit (*Mangifera indica L.*) is a major contributor to the livelihood of majority of smallholder farmers in the tropical and subtropical lowlands (Chikez *et al*., 2021; Petros *et al*., 2021). Mango was ranked fifth in terms of quantity of production in the world among major fruit crops after bananas, citrus, grapes and apples (Ravani and Joshi, 2013). Global demand for mango has been increasing over the last few years; this is mainly due to the nutritional benefits attributed to mango consumption (Lebaka *et al*., 2021). In Kenya, the gross production value of mangoes, mangosteens and guavas in 2018 was 110,055(US$ thousand) which was an increase from 74816 (US$ thousand) in 2015 (Food Agricultural Organization of United Nations [FAOSTAT], 2021).

Despite the substantial contribution of mango to smallholder farmers' livelihoods, its production faces numerous challenges. These include post-harvest losses, poor infrastructure, pests, and diseases. The most important pest affecting mango production in Kenya is the mango fruit fly (Githiomi *et al*., 2019; Mwungu *et al*., 2020) causing about 40 percent loss of mangoes produced and an estimated loss in the African horticulture sector of US$ 2 billion annually (Ekesi *et al*., 2016) . Moreover, mango fruit fly hinders farmers' ability to access better markets abroad, mainly due to imposed restrictions due to quality standards for export markets (Midingoyi *et al*., 2019). Only 2 percent of mangoes produced in Kenya are exported to other countries while 98 percent are consumed locally (Korir *et al*., 2015).

In Kenya, most mango farmers use pesticides to control the mango fruit fly (Korir *et al*., 2015; Diiro, *et al*., 2016). However, this approach is unsustainable as pesticides are expensive for smallholder farmers and consume a lot of time during spraying (De Bon *et al*., 2014). Besides, the mango fruit fly is gaining resistance to the chemicals as farmers use a high concentration beyond the recommended level (Billah and Wilson, 2016; Midingoyi *et al.*, 2019), which is costly and dangerous to their health. In some cases, mango farmers increase the frequency of spraying to control the pest (Mwungu *et al.*, 2020). In addition, some of the farmers prefer to change from one brand of pesticide to another to make the chemicals more effective (Banson and Egyir-Yawson, 2014). Environmental and sustainability issues also arise, as the chemicals are termed to have adverse effects on the natural environment, producers, and consumers (De Bon *et al*., 2014; Mwungu *et al.*, 2020).

The International Center of Insect Physiology and Ecology (*icipe*) spearheaded the development of Integrated Pest Management (IPM) strategy as an alternative approach for suppressing mango

fruit fly in Africa. *Icipe*'s mango fruit fly IPM strategy is an amalgamation of five different techniques which are sustainable, environmentally friendly and minimizes use of synthetic insecticides namely; male annihilation technique, bio-pesticides, parasitoids, orchard sanitation and spot spraying food bait (Ekesi *et al*., 2016; Muriithi *et al*., 2016). *Icipe* developed the IPM strategy with the goal of reducing environmental damage and health risk as well as enabling farmers increase their profitability through lowering pest control costs (Kibira *et al*., 2015; Midingoyi *et al*., 2019; Muriithi *et al*., 2016). In a recent study Kibira *et al.* (2015) found that the uptake of IPM reduced insecticide expenditure by 46 percent among smallholder mango producers in Embu County, Kenya. In addition, the number of mangoes rejected in the market due to fruit fly infestation reduced by 54.5 percent while net farm income increased by 22.4 percent. According to Muriithi *et al.* (2016), applying the mango fruit fly IPM strategy led to a significant increase in household income owing to a reduction in mango yield losses by an average of 19 percent. Besides, IPM strategies help to control pests without having adverse effects on the environment (Mwungu *et al*., 2020).

The mango fruit fly IPM strategy was introduced in Mwala Sub-county of Machakos County in 2015 by *icipe* through the African fruit fly programme (AFFP). Machakos is the second highest mango producing County in Kenya after Makueni (Muthini *et al*., 2017). In Machakos, Mango is one the most important crops where 40-60 percent of its' population participate in the mango value chain(The Ministry of Agriculture, Livestock and Fisheries [MoALF], 2018). Mwala is the leading mango producing Sub- County in Machakos followed by Kangundo (MoALF, 2018). The proximity of Machakos to the Nairobi market, compared to other Mango producing counties in Kenya, made it a target of the AFFP programme.

The mango fruit fly IPM strategy is expected to increase the income of smallholder farmers in the County by reducing expenditure on pesticides and production losses due to fruit fly infestation. Various studies have been done to assess how fruit fly IPM strategy affects the environment, farmers' income and general welfare (Kibira *et al*., 2015;Githiomi *et al*., 2019; Mwungu *et al*., 2020). Since its introduction, Nyang'au *et al*. (2020) have noted positive welfare impact of the IPM strategy among the smallholder farmers who adopted the technology in Machakos. However, how adoption of the strategy affects gender roles in mango production and marketing household's decision making has not been addressed by previous literature.

1.1.1 Gender dimension on technology adoption

Gender equity and empowering women in agriculture are crucial contributors to the agricultural sector's development and national food security in developing nations (FAO, 2011). In sub-Saharan Africa (SSA), although men and women participate in agricultural production, their labour contribution varies. At the farm level, women dominate in most of the labour-intensive income-generating activities. Women are mostly involved in the production section, as men engage more in the marketing and income control sector (Doss, 2014). This trend is seen to worsen once the agricultural sector becomes more commercialized and market oriented.

New technologies or strategies in agriculture are invented and disseminated with the primary goal of improving the livelihoods of smallholder rural poor through enhancement of agricultural productivity. The innovations aim to improve productivity by reducing production costs while increasing yields. In most cases, this is achieved through a factor substitution approach, where the same level of inputs is used to produce more output (Uphoff, 2013). The direct and indirect benefits accruing from agricultural interventions/technologies are expected to raise household income and net social welfare for the household members. However, in developing nations, these dynamics might be different for the case of men and women farmers (Quisumbing and Pandolfelli, 2010). An increase in productivity due to the introduction of agricultural technologies, has shown to benefit men on women's expense.

Therefore, while technology adoption is expected to benefit women through increased income, it only serves to disenfranchise them due to the intra-household power imbalance. Investing in "women crops" might not necessarily benefit women farmers, as it might cause some negative gender dynamics within the household (Behrman *et al*., 2012). Instead, when new technology increases productivity, the activity is frequently taken over by male producers. (Fischer and Qaim, 2012; Daum e*t al*., 2021) argues that the adoption of new technologies often affects intra-household gender relations in labour and resource allocation. There is a common trend in past studies, where men increase their involvement in the production and marketing activities of high-income generating crops (Njuki *et al*., 2011; Shiundu and Oniang'o, 2007).

The increasing gender gaps in agriculture can be traced to unequal access to productive resources, where women lag in most developing countries (Quisumbing *et al*., 2014; Gottlieb *et al*., 2018). For instance, the lack of secure land tenure reduces women's access to land, denying them both a key input into the production process and vital collateral for farm credit. The gender inequalities

are common in commercial oriented agricultural enterprises as compared to subsistence farming (Njuki *et al.*, 2011; Fischer and Qaim, 2012).

The contribution of new agricultural technologies to the household welfare is often evaluated assuming a unitary household model, where a household is considered as a producer and consumer at the same time (Himmelweit *et al.,* 2013). This model assumes that household members have the same tastes and preferences. Hence household resources and incomes are pooled, and an altruistic household head makes decisions regarding production and consumption. However, according to literature (Mabsout and Van Staveren, 2010; Himmelweit *et al.* 2013), individuals within a household have different preferences and bargaining power to enforce their decisions.

The current study seeks to empirically examine the adoption of mango fruit IPM strategy affects intra-household gender dynamics concerning mango production and marketing in Mwala and Kangundo sub-counties. The findings of this study will provide empirical evidence that can be used in policy formulation by relevant stakeholders and donors who intend to promote the adoption of different IPM strategies among smallholder mango producers. Besides, the results will provide useful insights into the critical areas that need attention by different stakeholders.

1.2 Statement of research problem

The introduction of agricultural innovations provides an unrivaled pathway to transforming the livelihood of the rural poor. For example, agricultural technologies are expected to improve livelihoods through increasing yields, reducing production costs and yield losses, and linking farmers to better and more lucrative market outlets (Bedeke *et al*., 2019; Ngenoh *et al*., 2019; Opaluwah, 2021). In line with this, *icipe* introduced mango fruit fly IPM strategy among smallholder mango farmers to enhance sustainable mango production and marketing by addressing the fruit fly problem in Africa (Ekesi and Mohamed, 2016). IPM was expected to benefit smallholder mango farmers through reducing economic losses due to the mango fruit fly in terms of direct losses due to poor quality mango and indirect losses due to the use of chemicals to control the pest (Muriithi *et al*., 2020).

The ongoing dissemination and promotional activities of the mango IPM strategy in Machakos County demonstrate positive direct impacts as several growers are rapidly taking up the strategy (Korir *et al.,* 2015; Nyang'au *et al*., 2017). Since the introduction of the mango fruit fly IPM strategy among mango farmers, most studies have focused on evaluating the impact of the strategy on household income and food security considering the household as a unit of analysis (e.g., see Kibira *et al*. (2015); Nyang'au *et al.* (2017)) with little or no focus on the gender component within

it. Yet, there is growing empirical evidence that households cannot be treated as unitary, i.e., as if all members have the same preferences concerning income and resource allocation (Quisumbing and Maluccio, 2000). Previous studies have criticized the unitary decision-making model that assumes household members pool productive resources and share the same preference function in decision making (e.g., see Quisumbing (2003); Meinzen-Dick *et al*. (2011)) because normally, households have members with different tastes and preferences.

This study focuses on intra-household decision making using a collective bargaining model – a departure from the unitary household model most frequently used in past studies – to assess the impact of adoption of the mango fruit fly IPM strategy on mango production and marketing decisions. Studies show that the commercialization of the agricultural sector can result in unforeseen intra-household gender dynamics where men dominate what was initially women's sources of income (Jumba *et al*., 2020; Seebens, 2011). Therefore, women do not benefit equally from market-oriented production as men (Hamilton *et al.*, 2001). This is mainly due to inequality arising from ownership of productive resources that are primarily under men's control (Chigbu, 2019; Diiro *et al*., 2018). Although the IPM has been embraced by some of the mango farmers in Machakos County, the impact of this technology on intra-household gender dynamics remains unclear and hence this study.

1.3 Objectives of the study

The overall objective of this study was to assess the effect of adoption of mango fruit IPM strategy on women's role in decision making regarding mango production, marketing and control over its benefits among smallholder mango producers in Machakos County. The specific objectives are:

1. To characterize households based on female spouse empowerment status, in mango production and marketing decision-making in Machakos County.
2. To evaluate the impact of adoption of the mango fruit IPM strategy on women's decision making in mango production and marketing among smallholder mango farmers in Machakos County.

1.4 Hypotheses tested

1. There are no differences in the social-economic characteristics between households with female spouses who are empowered and those who are not empowered.
2. Relative to the baseline, IPM technology use has no effect on women's decision-making in mango production and marketing in Machakos County.

1.5 Justification of the study

Kenya's agricultural sector currently contributes to 26 percent of Kenya's GDP directly and 25 percent indirectly (Birch, 2018). Approximately 60 percent of the Kenya's employment is directly or indirectly associated with the agricultural sector (World Bank, 2018). One way of ensuring development in this sector is the adoption of productivity-enhancing agricultural technologies to raise farmer income (Muraya, 2017; Mgendi *et al*., 2019). Past studies show that introduction of new technologies in certain sub-sectors of agriculture such as rice and horticulture and linking smallholder farmers to markets reduce the role of women in agriculture (Shiundu and Oniang'o, 2007; Njuki *et al.,* 2011; Peterman *et al.,* 2014). Therefore, assessing the effect of agricultural interventions on the gender roles in decision making in agricultural production, marketing and decision-making is important in ensuring equitable sharing of technology benefits between men and women, and that it does not exacerbate existing disparities in income distribution and household power dynamics in rural communities.

Understanding the impact of adoption of IPM strategies on gender relations within the household is important to researchers (IPM project funders and implementers), policymakers at both county and national levels, non-governmental organizations and other interested parties by contributing to the knowledge required for mainstreaming gender in the scaling up and of agricultural innovations. The results of this study provide information that can assist extension officers and researchers involved in designing and implementation of mango IPM strategies in such a way that they not only increase the welfare of the entire household but ensure that gender inequalities are not escalated. Therefore, this research contributes to the fifth sustainable development goal of achieving gender equality and empowering all women and girls.

The objectives of this study are also aligned with the government's Big Four agenda particularly food and nutrition security through investing in programmes such as the Youth and Women Empowerment in modern agriculture programme (Government of Kenya [GoK], 2020). The study will inform government's programmes targeting women on the best approach to take so as not to further disenfranchise women in agricultural production and marketing. Numerous studies (Negin *et al*., 2009; Sharaunga *et al*., 2016; Clement *et al*., 2019; Asitik and Abu, 2020) associate women empowerment in agriculture to alleviating poverty, achieving food security and economic development, therefore this study will contribute to the stock of scientific knowledge that is aligned with the government's objective of poverty alleviation and agricultural development.

1.7 Organization of the thesis

This thesis is organized as follows: Chapter one provides the research gaps on the impact of technology adoption on intra-household decision making. The chapter presents the statement of the research problem, study objectives, hypotheses tested and justification of the study. Chapter two presents literature review on mango production in Kenya, origin, and functionality of IPM, and the methods used for impact assessment. Chapter three provides detailed information on the study methodology including the conceptual and theoretical frameworks, sampling procedure, study area and analytical methods. Chapter four presents and discusses the key findings while Chapter Five presents the conclusions and recommendations of the study including areas that need further research.

CHAPTER TWO: LITERATURE REVIEW

2.1 A Review on Mango Production in Kenya

The mango, scientifically known as *Mangifera indica L*., plays an important economic role in the development of the agricultural sector in most of the nations in sub-Saharan Africa (Lux *et al*., 2003). Mango production in Kenya is ranked third after bananas and pineapples in terms of acreage and quantity supplied in the market(Nyang'au *et al*., 2020). Mangoes, guavas and mangosteens earned the Kenyan government US$ 16 million in 2019 of forex exchange earnings, accounting for 14 percent of total fruits and 3 percent of total fruits and vegetable exported (Food and Agricultural Organization database [FAOSTAT], 2021).

In Kenya, mangoes are produced mainly in the coast and eastern regions of the country accounting of 70 percent of mango producers (Mwembe *et al*., 2021). In 2019, the total value of mango produced was 867951 tons in 84,376 ha, which was increase from 2013 with a production of 581290 tons in area of 46,980 ha (FAOSTAT, 2021). Both men and women are involved mango production and marketing with men dominating the mango enterprise whenever it becomes lucrative (Fleming, 2020).

Despite the critical role of mangoes play in economic development, their contribution is increasingly being threatened by *inter alia*, pests and diseases. According to Mwungu *et al*. (2020) powdery mildew and anthrocnose are the major diseases affecting mangoes in Kenya. While the other pests such as mango weevil and mealybug are of economic importance to mango production, the mango fruit fly (*Bactrocera dorsalis*) causes most damage (Midingoyi *et al*., 2019; Mwungu *et al*., 2020). Various studies estimates mango fruit fly to causing 30 to 100 percent loss of mango produce (Ekesi *et al*., 2016).

The female fruit flies are termed to be the most dangerous to mango production, as they lay eggs which later hatches into larvae that that destroys flesh of mango (Sarwar, 2018). The affected fruit fetches lower prices in the local and international market, and even sometimes faces a total rejection from the traders as some of them are inedible. In some cases, the mango fruit fly lowers the prices of the mango mainly due to quarantine restrictions, where some of the fruits are banned from international markets (Ekesi *et al*., 2016). A review of literature reveals that about 30-70 percent yield loss in mango is due to local species of mango fruit fly infestation (Ekesi *et al*., 2016; Midingoyi *et al*., 2019). The variation in losses depends on the mango variety, region, and production season (Ekesi *et al.,* 2009). The introduction of the *Bactrocera spp.* has increased the

losses to 80 percent (Ekesi *et al.,* 2010). Thus, a rapid spread of this Asian species is becoming a major threat to mango production in East Africa.

Conventionally, mango farmers use insecticides to control mango fruit flies(Lux *et al*., 2003; Ekesi *et al*., 2009; Muriithi, *et al*., 2016). However, the methods are unsuitable due to high cost and their serious health and environmental effects (Midingoyi *et al*., 2019; Mwungu *et al*., 2020). Besides, according to (Lux *et al*., 2003), the mango fruit fly developed resistance to some synthetic pesticides such as Malathion, β-cypermethrine and abemectine. In some cases, mango farmers practice early harvesting where they harvest before the mangoes ripen and get attacked by pests(Ekesi *et al*., 2009). However, this method is not effective against some fruit fly species such as *B. invadens* and *C. cosyra* which attack the mangoes at an early stage (i.e., immature green mangoes) (Ekesi and Billah, 2007).

2.2 Origin and Introduction of mango fruit fly IPM Strategy in Kenya

The mango fruit fly IPM strategy was developed and implemented by *icipe* in collaboration with local and international partners under the African Fruit Fly Program (AFFP). The key local partners were the Kenya Agricultural and Livestock Research Organization (KALRO) and the Kenya Plant Health Inspectorate Service (KEPHIS) while international partners were Max Planck Institute of Chemical Ecology, University of Bremen, and the United State Department of Agriculture(USDA). The mango fruit IPM strategies used in Kenya include protein bait spray, male annihilation technique (MAT), exotic parasitoids, fungus-based bio-pesticide, mango orchard sanitation, and the *augmentorium* methods (Verghese *et al.,* 2006).

The MAT method involves using fruit fly traps to trap male fruit flies to curtail breeding (Sarwar, 2018; Abbas *et al.,* 2021). This technique uses a trap containing a male attractant combined with an insecticide, to trap and kill male fruit flies (Ekesi *et al*., 2007). The traps are distributed at determined intervals in the mango orchard. The sanitation of mango orchards usually involves the collection and disposal of infested mango. In this method, farmers are encouraged to augmentorium for proper disposal of infected mango (Mwangi, 2021). Under this technique, farmers can destroy the mango fruit fly eggs and maggots, which helps reduce the pest population. Besides, the use of augmentorium protects parasitoid wasps (Ekesi and Billah, 2007). This method plays a crucial role in controlling the population of mango fruit fly since one fruit in the field can host many eggs, which develop into maggots and later become mango fruit flies. Parasitoids, on the other hand, are natural enemies of the mango fly which feed on fruit fly eggs thereby inhibiting the breeding cycle (Birke *et al*., 2013).

The protein-baiting technique uses proteinaceous food baits to attract and kill adult fruit flies, mainly females. Mango fruit flies are killed immediately they ingest the bait, which is a toxic dose of insecticide mixed with proteinaceous foodstuffs, hence protecting the fruits (Prokopy *et al.,* 2003; Ekesi *et al.,* 2010). To use these chemicals, farmers should spray their mango trees weekly until harvest (Hossain *et al*., 2020).

2.3 Women Contribution to Agricultural Sector

Women play an essential role in agriculture globally. In developing countries, they contribute 43 percent of the agricultural labour force (Team and Doss, 2011). According to Quisumbing and Maluccio (2000), women are the engine that drives the agricultural sector in SSA and hence the need to focus on the enhancement of the productivity of women farmers. They produce about half of food globally of which 60 to 80 percent is staple food (Team and Doss, 2011). Women are mostly involved in activities that are labour-intensive, monotonous and time-consuming compared to men (Srivastava *et al*., 2020). Despite this contribution, their role is often not recognized in official statistics. Due to the increased migration of men to urban areas, agriculture is increasingly becoming a predominantly female sector (Luqman *et al.,* 2012). Women are involved in production and post-harvest activities such as processing in most SSA countries.

In Kenya, women contribute 42 to 65 percent of the labour force in agricultural production despite other domestic responsibilities such as child care (Onyalo, 2019). In addition, Kenyan women tend to produce for more localized spot markets and in small volumes than men and therefore dominate the lower levels of the supply chain than men (Tallontire *et al.,* 2005). Studies have shown that women participation in agriculture does not always lead to increased income for them or an increase in power in decision-making when sharing or utilizing household income (FAO, 2001).

The role of women in agriculture in Kenya as in the rest of the developing world, is often impeded by poor access to inputs such as land, information and credit (Team and Doss, 2011). An understanding of women farmers' role in agricultural production and marketing decision-making is a prerequisite to devising policies to improve their productivity and socio-economic development. In an ethnographic study in rural Mali, Wooten (2003) describes how a growing urban demand for vegetables prompted male villagers to claim garden land that had previously been cultivated by women. In Wooten's case, market-oriented vegetable production further limited rural women's ability to fulfill household obligations, while at the same time urban trade of the produce firmly rested in women's hands.

2.4 Theories Anchoring Intra-Household Gender Dynamics in Decision Making

Different theories have been advanced to explain intra-household gender dynamics arising from the adoption of agricultural interventions, which aims at improving household welfare. According to Udry (1999), the empirical analysis of consumer demand, labor supply, and household production decisions assume that a household behaves as an individual entity where the decision is made jointly by the partners/couples within the household. Hence, most studies that acknowledge this premise adopt a unitary decision-making model to understand gender dynamics and relations that might arise from innovations or interventions that aim to better household needs.

This household unitary model was developed by Becker (1965) and assumes that a household behaves as an individual in consumption and production decisions and acts within the principles of rational choice theory (Udry, 1999). The model further assumes that all household resources and incomes are pooled; therefore, the household head is an altruistic representative of all household members' tastes and preferences (Vermeulen, 2002;Fitzhenry, 2019). Accordingly, he/she makes consumption and production decisions benevolently on behalf of other household members (Saelens, 2019). According to Quisumbing and Maluccio (2000), this model can be explained by assuming that a household has two people male (m) and female(f) that have the same preferences. The household members derive utility from the consumption of commodity bundle y,x, which is influenced by household characteristics, g . Therefore, the i^{th} household utility function is presented by $U_i(x; g)$ which is maximized subject to an income constraint as shown in equation 2.1.

$$Y_i = y_i + y_m + y_f \quad (2.1)$$

where Y_i is the total household income composed of individual incomes represented by y_i,y_m and y_f. Therefore, by considering a unitary model all the household members are assumed to have homogeneous preferences and they pool household income and resources (Quisumbing and Maluccio, 2000).

However, the unitary household model has received a lot of criticisms. For example, some authors argue that there might be disagreements within the household, which hinders a fully unitary decision-making process to take place due to varying preferences (Alderman *et al*., 1995;Doss, 2013). Therefore, modeling a household as a single unit is empirically misleading, and it underestimates the impact of an intervention (an agricultural technology or policy) on household

welfare (Alderman *et al.*, 1995; Quisumbing and Maluccio, 2000). The unitary model has also been criticized for not being able to illustrate the individual utility gains derived from a given decision or who within the household benefits (Fortin and Lacroix, 1997; Doss, 1999). Based on these arguments, therefore, the unitary model does not seem to be suited for analyzing the impact of a given intervention like the mango fruit fly IPM control technology.

A better alternative to the unitary model is the collective model of Chiappori (1988) classified into cooperative and non-cooperative models. Based on the Cournot-Nash game theory, the collective bargaining model assumes a household with dual adults (male and female) who behave as a unit or as non-unit depending on the level of agreement (Chen and Woolley, 2001).

When employed within a non-cooperative game theory framework, the collective bargaining model assumes that each household member acts selfishly in a way that maximizes his or her own utility (Quisumbing and Maluccio, 2000). Thus, personal interests motivate individuals within the household to seek to maximize their utility rather than work collaboratively to maximize the benefits for all household members (Doss, 2013). In the non-cooperative game theory individuals do not pool their resources together and make separate decisions, therefore the outcome of their decisions are not Pareto-efficient (Doss, 2013). Though the non-cooperative models are used widely in economics, intra-household choices are cooperative (Cacheux, 2005; Himmelweit *et al*., 2013).

In the cooperative game theoretic framework, resources are pooled and individuals bargain to allocate them (Doss, 2013). Within a cooperative game theoretic framework, the collective bargaining model assumes that household members have diverse preferences, and hence varying bargaining power to enforce their decisions (Quisumbing and Maluccio, 2000). The bargaining power of an individual is influenced by their human capital or education, access to information, legal rights, bargaining skills, and the individual claim to resources including land, labor, and income (Doss, 1999; Deere *et al*., 2001; Pangaribowo and Tsegai, 2019). The cooperative game theory framework not only explains allocation of household's goods; it also reveals the bargaining power of different players within a household (Cacheux, 2005).

Based on the above description of the collective bargaining model, this study found the cooperative game theory better suited as a framework for assessing the impact of women's decision making in production, marketing and allocation of income among mango farmers in Machakos County. This

is because decision makers in a household attempts to maximize their own utility yet they are interdependent because they care about each other and there are public goods within the family (Chen and Woolley, 2001). Individuals in a household might pool their resources and behave as a unit in terms of decision making or the household might behave differently where a man and a woman might have different ownership of trees and make decision independently without consultation from their partners.

2.5 Impact evaluation in Intra-Household Decision Making

Impact evaluation assesses the changes attributed to a particular project, program, or policy on some welfare measure of individuals, households or communities (Baker, 2000; Van de Walle, 2009). The two dominant impact evaluation designs in intrahousehold decision making studies are experimental and quasi-experimental (Khandker *et al.*, 2010). The former assesses the effect of an intervention by identifying a group of subjects sharing similar characteristics and assigning the treatment randomly to a subset of the group (Cook *et al*., 2020). A non-treated group of subjects is then used for comparison to mimic counterfactual outcomes (Khandker *et al.*, 2010). Therefore, the impact of intrahousehold decision is evaluated by comparing the differences of who makes the decisions in the treated and non-treated groups.

The quasi-experimental impact evaluation designs are used when it is not possible to carry out experimental designs either due to cost or ethical limitations. In this regard, a sample is selected from the treated population and because it is not possible to observe the treated group simultaneously with and without the intervention (the problem of missing data), a counterfactual group (control group) with similar characteristics is chosen for comparison using different econometric techniques (Khandker *et al.,* 2010). This is referred to as the 'with and without' approach. The 'before and after' approach to impact evaluation compares the changes in the key variables during and after the intervention (Wainaina *et al.,* 2012). Many studies in intrahouseholds decisions have used the 'with and without' approach (e.g see, De Brauw *et al*., (2014); Tagat, (2020); Wiig, (2013); Zheng and Lu, (2021)) to deal with the problem of missing data.

Another problem encountered in impact evaluation is selection bias caused by the unobservable tendency of individuals to self-select to one group or another (Maddala, 1983). Several methods have been proposed in the impact evaluation literature to deal with the twin problems of counterfactual and selectivity bias (Greene, 2008). These methods include propensity score matching (PSM), difference-in-differences (DiD), and regression discontinuity methods, among others(Baker, 2000; Khandker *et al*., 2009; Wainaina *et al.,* 2012; Muriithi *et al*., 2016).

Propensity score matching (PSM) involves pairing the treated and control groups with similar observable characteristics, to correct the estimation of treatment effects controlling for self-selection problem (Kirchweger and Kantelhardt, 2012). This approach uses the pairing of individuals of similar characteristics to reduce biasness. However, PSM cannot match unobservable characteristics; hence there can be omitted variable bias (Wainaina *et al*., 2012).

Regression-Discontinuity (RD) elicits the causal effects of interventions assigning a cut-off threshold above or below which an intervention is assigned (Linden and Adams, 2012). The comparison group is composed of individuals or households that are close to the cut-off point but fall on the wrong side of the cut-off; hence they do not participate in the intervention (White and Sabarwal, 2014). The RD assumes that after controlling for the criteria used, the remaining differences between individuals directly below or above the cut-off score are not statistically significant; hence the results will not be biased. However, for this to hold, the cut-off criteria must be strictly adhered to (Khandker *et al.,* 2010).

The difference-in-difference (DiD) is used to compare the change in the outcome variable before and after the intervention in the treatment group and as compared to that of the control group over a period of time (Khandker *et al.,* 2010; Muriithi *et al*., 2016). Thus, the DiD simultaneously addresses the biases caused by unobserved factors that affect the outcome of interest and changes over time due to the intervention. The DiD is achieved through the two key assumptions, namely, the conditional assumption that some of the variables in the regression vary across time and may affect the outcome of interest, and the unconditional assumption that some of the explanatory variables do not change with time and might therefore not affect the variable of interest (Lechner, 2011). In addition, by using data from both treatment and control groups before and after the intervention, the DiD approach seeks to remove any bias from the two groups (Tuan, 2019). Consequently, the DiD approach accounts for selection bias due to time-invariant and additive unobservable differences among subjects in the treatment and control groups (Luther *et al*., 2018), and was therefore used in this study.

2.6 Review of past studies on intra-household decision making in agriculture

Anderson *et al*. (2017) employed an OLS model in exploring rural household's decision making in Tanzania. The objective of the study was to assess the factors influencing the wife's authority in 13 household and farm decisions. The respondent assigned a score between 0 and 10 for each question depending on their perception of the wife's authority in making the decision to compute a decision making index which was used as the dependent variable. The index comprised

household decisions on what crops to grow, where to sell the crops and livestock and how to use income generated from livestock and crops. The findings showed that age, education, wife's health, and the number of hours of wife's farm labour farm influenced her authority in intrahousehold decision-making. In addition, the husband's community standing, size of land cultivated, and the average age of children also influenced the wife's decision-making authority.

Mader and Schneebaum (2013) utilized a multinomial probit model to assess the gendered nature of intra-household decision making about the purchase of household items in Europe. The study predicted two outcomes; the individual in the household makes decisions alone or the couple makes decisions together. The independent variables predicting the two outcomes were nature of their relationship (legally recognized or not), household financial situation, length of relationship in years, working status, age (older or younger than partner), presence of children in relationship, individual's income relative to partner's, education (if more educated than partner) and the gender of individual. The results showed that decisions on children's purchases were likely to be made by women while most financial decisions were made by men. The larger the differences in income and education level, the less likely individuals in a household made decisions together. Partners in legal relationships were more likely to make decisions together. This study however, generalized the decisions questions; therefore, it is not possible to know which decisions the respondents had in mind when they answered the research questions.

Hwang *et al*. (2011) did a comparative study on factors influencing intra-household decision-making among rice farming households in Korean and Philippine. The farming decisions were choice of crop, variety of rice to be planted, when to sell rice and other crop and marketing of harvested crop. Using OLS regression analysis, the study found that age negatively affected women's authority in decision making. Primary occupation of the female spouse and size of land also had a significant influence on the wife's authority in decision making. However, in measuring the decision-making authority of the wife, the study used count of number of decisions made by the wife without taking to account that some decisions may carry more weight than others in measuring authority. Moreover, the farming decisions considered only covered a small range of decisions in agriculture production and marketing.

Meijer *et al*. (2015) used multinomial regression model to assess the association between gender and kinship type in 11 tree production decisions among farmers in Malawi. The decision makers were either the male household head, a female spouse or joint decision makers. The results showed that tree planting and management was male-dominated where most decisions were made by the

male household head solely or jointly but not female spouse solely. In patrilineal families, intrahousehold decisions were made more often by the husband alone compared to matrilineal ones where there was more joint decision-making. The study under review, however, did not control for other factors that may influence who makes the decision in the household. Therefore, the results of the level of association between gender of decision maker and kinship type may be biased.

2.7 Summary

From the literature reviewed in the foregoing sections, it is clear that a knowledge gap of the impact of IPM strategy adoption on decision making in mango production and marketing exist. A large number of past studies while assessing impact of various interventions on farmers' welfare, assume that a household is one unit and all members benefit equally. However, evidence has shown that interventions impact households members differently. Women in particular are negatively affected when a household adopts new agricultural technology. Therefore, this study assumes a Cournot-Nash equilibrium cooperative theory in assessing how adoption of IPM strategy impacts women's control over production, marketing and distribution of income in a household among mango farmers in Machakos County. The study uses a difference in difference Tobit equation to operationalize the cooperative theory.

CHAPTER THREE: METHODOLOGY

3.1 Conceptual Framework

The decision making in the household depends on several intra and extra household parameters. The characteristics of female spouse which include age, education level, farming experience, access to extension services and access to credit among many more factors influences the bargaining power of a woman within the household. Hence in this study, the characteristic of a woman is anticipated to either positively or negatively affect the decision-making level of a woman in production and marketing of mango. The characteristics of the husband are also anticipated to either positively or negatively influence the inclusion of female spouse in decision making within the household.

Household characteristics, which include farm size, household size, and number of male decision-makers in the household, are also anticipated to influence the participation of women in decision making in mango production and marketing. Besides, institutional factors expected to influence the household level decision-making. The link/association of the different factors is as presented in Figure 3.1. These characteristics influence the decision to adopt or not to adopt new agricultural technologies and, in this case, adoption of IPM strategies for controlling mango fruit flies. In addition to agricultural inputs, labor, capital, and skills, the skills of IPM strategies for controlling mango fruit flies influence the mango production system that contributes to household food security and income. An increase in agricultural productivity has been shown to have an impact on women empowerment. Empowerment in this study was measured by the involvement of women in decision making in mango production and marketing.

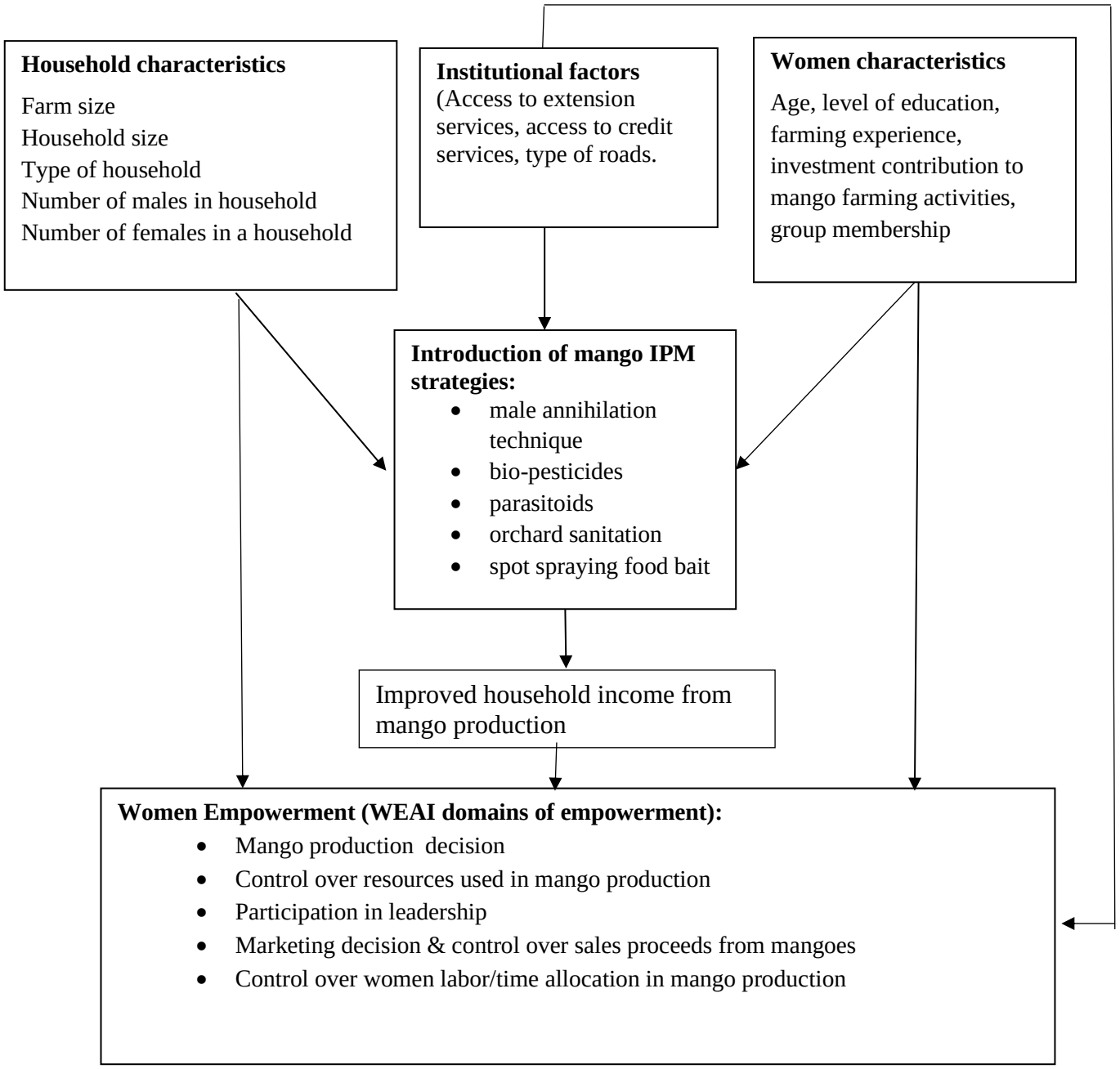

Figure 3.1: Conceptual framework for Impact of IPM strategy adoption on women's decision-making role in mango production and marketing

Source: Authors' conceptualization

3.2 Theoretical Framework

This study is anchored on the cooperative Cournot-Nash model of family decision making, to illustrate the impact of IPM adoption on inclusion of women in decision making among mango farmers in Machakos County, Kenya. The model assumes a simple household unit made up of an adult male (m) and adult female (f) living together as the key decision-making parties (Chen and

Woolley, 2001). Each decision maker (*i*) attempts to maximize their own utility yet they are interdependent because they care about each other and there are public goods within the family (x^h), thus each person's choice affects the other's wellbeing. The utility maximization problem in allocating household resources among the two family members (*i*), is solved by assuming, resource allocation between spouses are determined through bargaining or making the decision voluntary (cooperatively) (Sedghamiz *et al*., 2018; Van Heesch *et al*., 2020).

The two household members make decisions on whether to buy a personal good or household public good depending on the income at their disposal, *Y*, as shown in equation 3.1 below.

$$Y_I = x_i^h + px_i \qquad \text{for } i = m, f \tag{3.1}$$

where x^h denotes public good within household, and px_i is the personal good for either *m* or *f* in the household. Assuming that that the male decision maker has a disposable income y_m and the female decision maker disposable income is y_f, their joint income y_i is denoted in equation 3.2 as;

$$y_i = y_m + y_f + y_b \tag{3.2}$$

Each decision maker's wellbeing is dependent on his/her own consumption, and because they care for each other, it is also dependent on the other household member's wellbeing. Therefore, their utility function (u_i) is modeled in equation 3.3 below.

$$u_i = u(x_i, x_i^h) = u(x_i) + v(x_i^h) \tag{3.3}.$$

where x is the personal good (*p*) either for *m* or *f* in the household, while x^h is public good within the household, same as equation 3.1. The objective is to maximize their welfare function (w_i) shown in equation 3.4. Subject to the budget constraint y_i (Equation 3.2).

$$w_i = u_i + su_j = [u(x_i) + v(x^h)] + s\left[u(x_j) + v(x^h)\right] \qquad \text{for} \qquad i, j = m, f \tag{3.4}$$

Therefore, the optimization problem of one spouse, is denoted in equation 3.5 as follows;

$$\max W_i = \left[u\left(\frac{y_i - x^h{}_i}{p}\right) + v(x_i^h + x_j^h)\right] + \left[v\left(\frac{y_j - x_j^h}{p}\right) + v(x_i^h + x_j^h)\right] \tag{3.5}$$

The Kuhn-tucker condition (first derivative) is derived as shown in equation (3.6) below;

$$\partial W \frac{\partial W}{\partial x_i^h} = (1+s)v'(x_i^h + x_j^h) - \frac{1}{p} u \frac{\left(y_i - x_i^h\right)}{p} \leq 0 \qquad (3.6)$$

$$x_i^h \geq 0$$

Solving the Kuhn-tucker conditions for *m* and *f* simultaneously, yields the Nash-equilibrium (Equation 3.7), as one spouse who is well off spends on household good, the other's spouses spending decreases.

$$x_i^h \left(\frac{\partial w_i}{\partial x_i^h} \right) = 0 \qquad (3.7)$$

Therefore, a spouse's spending will depend on their bargaining power to enforce their decisions. The difference-in-difference (DiD) model (Equation 3.9), was used to assess whether the decision making patterns changed after adoption of the mango fruit fly's IPM strategy.

3.3 Empirical framework

3.3.1 Objective one: to characterize households based on female spouse empowerment status in mango production and marketing decision-making in Machakos County

Descriptive statistics were used to analyze objective one based on "before" versus "after" and "treated" versus "control" groups. A further categorization based on the women empowerment status in decision making regarding mango production, marketing, and control over its benefits was done. The difference in means or proportions between baseline versus follow-up, and treatment versus control groups, empowered versus disempowered groups were carried out using t-tests for continuous variables and chi-square test for categorical variables.

3.3.2 Objective Two: Evaluating the impact of adoption of the mango fruit IPM strategy on women's decision making in mango production and marketing

3.3.2.1 Computation of Women Decision-Making Index (DMI)

The study identified various mango production and marketing activities that involved the decisions of spouses in a household. These activities were referred to as gender roles. Fourteen indicators (see Table 3.1) in five key domains of intra-household decision-making were adapted from the Women's Empowerment in Agriculture Index (WEAI) guide developed by the International Food Policy Research Institute (IFPRI), Oxford Poverty and Human Development Initiative (OPHDI), and the United State Agency for International Development (USAID) (Alkire, Meinzen-dick, *et al*., 2013; Malapit *et al*., 2015).

Table 3.1: Catalogue of domains, indicators and weights used in constructing the decision-making index among smallholder mango farmers in Machakos County

Domain	Indicator	Weight
Production decisions	The place to acquire production inputs from	1/15
	How much input to acquire	1/15
	The distribution of the production inputs in each mango plot	1/15
Resources	The place to acquire credit	1/15
	When to acquire credit	1/15
	How much credit to acquire	
Income	The marketing channels to use	1/15
	Who receives the money from mango sales	1/15
	How the money was allocated to various household expenditure	1/15
Leadership	Who registers with mango growers' group	1/15
	Who attends mango growers' group meetings	1/15
	Who attends mango production, training and other related gatherings	1/15
Time/Labour	How much labor to be hired	1/10
	Distribution of labor among different plots	1/10

Source: Alkire *et al.* (2013)

The decision making index (DMI) was constructed from the responses of male and female spouses within the same household using the 14 indicators. A score of 1 was assigned if the female spouse was the sole maker or made decisions jointly with the household head and 0 otherwise. Following Alkire *et al*. (2013) and Malapit *et al*. (2015), each of the five domains was assigned a weight of 20 percent, divided among the three or two indicators in each domain to give a weight of 1/15 or 1/10 (Table 3.1).

The 14 indicators were used to compute the DMI as shown in Equation 3.8.

$$DMI_i = k_{j=1}(Score_{ji} \times Weight_j) \quad (3.8)$$

where DMI is the decision-making index for the ith household, j is the indicator ($j = 1, \ldots, 14$), k is the total number of indicators ($k = 1, \ldots, 14$), $Score_{ij}$ represents the status of the female spouse involvement in decision making for indicator j in household i (score =1 if female spouse was involved in the decision solely or jointly, and 0 otherwise), while $weight_j$ represents the weight

assigned to indicator j . The female spouse was considered empowered if she achieved an aggregate score of 80 percent in the five domains or achieved a full score in at least 4 of the 5 domains under consideration (Malapit *et al*., 2015). They DiD in DMI was calculated by subtracting the DMI for the IPM non-adopters (control group) from that for the adopters (treatment group) during the two production periods, i.e., the baseline (2013-2014 mango season) and follow-up (2014-2015 season). This gave a dataset with DMIs with values between 0 and 1. As such, Equation 3.8 was estimated using a Tobit model that was censored between zero and one (see Maddala, 1983).

3.3.2.2 Factors influencing Women Decision Making

Given the panel nature the dataset, the "before and after", and "with and without" survey design, the study employed difference-indifference (DiD) model to estimate the impact of IPM fruit fry strategy on DMI. Two-year panel data set collected for 2013-2014 and 2014-2015 production seasons were used in the analysis. The DiD model has the advantage of comparing the participants (treated group) and the non-participants (control group) using two periods of study, the baseline, and the follow-up surveys (Imbens and Wooldridge, 2008). Besides, DiD helps to handle the bias caused by unobserved factors that affects outcomes of interest and changes along with the project (Khandker *et al.,* 2010).

The DiD analysis considered two key assumptions: first, the conditional assumption where some of the variables used in the Tobit regression vary across the years and may affect the outcome of interest. Second, was the unconditional assumption where some of the explanatory variables are time invariant and hence might not affect the variable of interest (Glewwe and Jacoby, 2000). In addition, by using data from both treatment and control farmers before and after the intervention, the DiD approach removed any biases from permanent differences between the two groups.

The DiD is calculated by subtracting pre-existing differences (baseline differences) between the treated and control group, $(T_0 - C_0)$ from the differences after the IPM intervention has been implemented $(T_1 - C_1)$. Therefore, the DiD is shown on the right side of the last row in Table 3.2 below.

Table 3.2: DiD estimation of average effect of IPM adoption on women's DMI

Time period	Treatment (*T*)	Control (*C*)	Differences (Treatment and control)
Follow-up	T_1	C_1	$(T_1 - C_1)$
Baseline	T_0	C_0	$(T_0 - C_0)$
Differences (baseline and follow up)	$T_1 - T_0$	$C_1 - C_0$	DiD= $(T_1 - C_1) - (T_0 - C_0)$

The expression of DiD model used in this study is as illustrated in the equation 3.9:

$$y_i = T_i + t_i + T_i^* t_i + \beta x_{it} + \varepsilon_i \quad (3.9)$$

where y_i is the DiD for the decision-making index (DMI) in household i, capturing the level of women empowerment in decision making, T_i is the dummy variable of either being in the treated category or not, t_i is the dummy indicating time of survey x_i is the set of factors that might influence the level of women involvement in decision making in mango production and marketing. The coefficient of interaction represented by $T_i^* t_i$ estimates the effect of *icipe*-IPM strategy on women decision making in production and marketing. This represents the average differences between the treated and control groups. The time trend for both treated and control group is represented by t while β indicates a vector of coefficient of the explanatory variables(x_i). The random error term for household i in the model is represented by ε_i.

Use of the DiD model makes it easier to compare the treated against a set of similar but untreated households that are identified based on observable characteristics, with comparisons being made both before and after the intervention. This approach offers a better means of evaluating the impact of IPM program because it solves the counterfactual problem and controls for self-selection bias. The estimated equation for DID with properly identified fixed (slightly varying) and varying variables is as shown in equation 3.10.

$$DMI_{dif} = IPM_i + FAGE_i + FTRN_{it} + FEXP_{it} + FIVT_i + FEXT_{it} + FGRP_{it} + FEDU_i + FCRT_i + FRM\_SIZE_i + NMAL_i + NFEM_i + HHS\_SIZE_{it} + TYP\_FAM_i + LOWN_{it} + HINC_{it} + MRT\_STATUS_{it} + a_i + i + i_t \quad (3.10)$$

Table 3.3 below presents the description and hypothesized signs of factors influencing decision making index (DMI).

Table 3.3: Description and hypothesized signs of factors influencing decision making index

Variable	Meaning	Measurement	Expected sign
Female spouse characteristics			
FAGE	Age of female	Years	+
FTIME	Time spent by female spouse on farming activities	Working hours	+
FTRN	Female access to training on IPM technology	1=Yes, 0=otherwise	+
FINC	Female off-farm income	1=Yes, 0=otherwise	+
FEXP	Female spouse number of years growing mangoes	Years	+
FIVT	Female % investment in mango production	Percentage	+
FEXT	Female number of contacts with extension service providers	Number	+
FGRP	Female membership in a mango production or marketing group	1=Yes, 0=otherwise	+
FEDU	Female number of years completed in school	Years	+
FCRT	Female spouse access to credit	1=Yes, 0=otherwise	+
Male spouse characteristics			
HINC	Husband's off-farm income	1=Yes, 0=otherwise	+
HEDU	Husband's education	Years	+
Household characteristics			
FRM_SIZE	Land size under mango production	Acres	+
NMAL	Number of male decision-makers in household	Number	-
HHS_SIZE	Number of household members	Number	-
TYP_FAM	Type of family	1=Extended, 0=Nuclear	-

3.3.2.3 Description of Regressors and their Expected Signs

Education (FEDU) (years) the level of the female spouse was expected to have a positive influence on DMI. Formal education equips female spouses with knowledge, which enables them to make informed decisions with minimal dependence on their male spouses. Enete and Amusa (2010) in their study on determinants of women contribution to farming decisions in cocoa-based agroforestry in Nigeria found that women's level of education contributed positively to their involvement in farm decision-making.

Age of the female spouse (FAGE) (years) Age of the female spouse measured in years was expected to have a positive relationship with DMI. This relation could be attributed to the knowledge female spouse had gained through years of exposure to mango production and marketing. The older the individual is the more experience they are likely to have in farming; hence, they tend to be more involved in decision-making. Kiriti *et al*. (2001) evaluated factors that determine female participation in decision making in agricultural households in Nyeri, Kenya. The findings showed that age had a significant influence on women's bargaining power.

Group membership (FGRP) (dummy; 1=active member of at least one social group). Social group membership measured in a dummy form was expected to have a positive effect on DMI. Women groups empower female spouses and increase their bargaining power in intra-household decision making. For example, Fischer and Qaim (2012) found that group membership had a positive effect on female control over household income. The study also demonstrated that women involvement in groups reduced the negative impact resulting from collective action that encouraged the commercialization and adoption of new technologies.

Amount of investment in mango production (FINV) (continuous; proportion invested by female spouse). It was expected that the larger the share of amount a woman contribute to the investment in mango production, the higher will be her bargaining power. Damisa and Yohanna (2007) assessed women participation in agricultural production in Kaduna state, Nigeria and found that the level of investment contribution to agriculture had significant impact on the inclusion of female spouse in decision making regarding agricultural production.

Women access to credit (FCRT) (dummy; 1=access to credit). It was expected access to financial service such as loans/credit would positively correlate with women DMI in mango production and marketing. Women often lack collateral to secure loans to support farm operations. Hence, they often are unable to financially contribute to production (Enete and Amusa, 2010). This leads to low bargaining power in decision making.

Access to information (FINFO) (dummy; 1=access to extension service in the last two mango production seasons). It was expected to be positively correlated with DMI. Information on better mango production practices, input prices, the best marketing channels and market prices was likely to have a positive impact on women involvement in decision making. Training increases the skills of women in production and marketing; hence it is expected to have a positive effect on women participation in decision making.

Household size (HHS_SIZE) (continuous: number of people within the household). It was expected to have a negative correlation with DMI. This could be because as household size increases, the less likely women have control in production and marketing decisions. In assessing how migration of household members affected women's bargaining power in decision making in Bangladesh Jabbar (2021), found that the smaller the household size, the higher the women's involvement in agriculture decision making.

Farm size (FRM_SIZE) (continuous: acres) It was expected to be positively correlated with DMI. Resource requirements, including management decisions, are expected to increase with farm size; hence women are likely to contribute more in decision making with larger farm size than smaller farms. Enete and Amusa (2010) found that the larger the farm size, the more women contributed to farming decisions in Cocoa Based Agroforestry in Nigeria.

Male household members (H_MALES) (continuous variable: number of adult males within the household): The number of male decision-makers within the household was expected to have a negative correlation with DMI because in patriarchal societies, such as those in the study area, men dominate decision making in production and marketing (Muneer, 2003; Acosta *et al*., 2020). Therefore, a large number of adult males in a household would diminish the chances of a female spouse being involved in decisions concerning the production and marketing of mangoes. Khan *et al* (2012) found that the number of adult males in a household had a negative effect on women participation in agriculture Peshawar District, Pakistan because when there are more male adults in household, women do households chores than farming activities.

Type of marriage (MRT_STATUS) (dummy; 1=polygamous marriage, 0=otherwise): It was expected that type of marriage would affect women's DMI in mango production and marketing. Women in a polygamous were expected to be less involved in mango production and marketing decision. This was mainly because women in polygamous marriages face competition regarding household resource allocation from their co-wives unlike the case in a monogamous marriage(Vaghasiya, 2018).

Female spouse off-farm income (FINC) (continuous variable). It was expected that female spouse participation in off-farm income positively influenced her DMI in mango production. This is because if the female spouse has access to off-farm income, she is likely to be more empowered and therefore engage in decision making related to agricultural production. Having own source of

income creates self-confidence and boosts one's self-esteem that directly increases the ability and willingness to make decisions regarding the allocation of agricultural resources (Kiriti *et al.*, 2001).

3.6 Model Diagnostics

3.6.1 Multicollinearity test

Multicollinearity problem occurs in regression analysis when there is a strong association among explanatory variables. According to Gujarati *et al* (2012), multicollinearity problem results in inflation of error terms, hence giving biased results. This could cause commission of type II error by accepting false null hypothesis. In this study, the variance inflation factor (VIF) was used to check for multicollinearity (see equation 3.11 below).

$$VIF_{(X_I)} = \frac{1}{(1-R_i^2)} \tag{3.11}$$

where R_i^2 represents the squared multiple correlation coefficient between/among the independent variables. According to Gujarati (2012), the bigger the value of VIF, the more severe the multicollinearity problem with a VIF value greater than 10 indicating a high presence of multicollinearity among the independent variables. The mean VIF in this study was 1.5, implying there was no multicollinearity between independent variables.

3.6.2 Test for Heteroskedasticity

Heteroskedasticity occurs when the variance of the error term in a regression is non-constant although still unbiased (Wooldridge, 2002). The presence of heteroskedasticity leads to regression results in poor estimates (Gujarati, 2012). In this study, heteorskedasticity among the explanatory variables was tested using the Breusch-Pagan test. A significant Breusch-Pagan test rejects the null hypothesis of the homoscedasticity (Coenders and Saez, 2000). The Breusch-Pagan test was significant; thus the null hypothesis of homoscedasticity was rejected.

3.7 Study Area

This study was conducted in Machakos County (Figure 3.2) which was the second highest county in mango production(Muthini *et al*., 2017) and one of the target sites of *Icipe's* African Fruit Fly programme (AFFP). Besides, mango play a significant role in the livelihoods of majority of the rural population in the region, and yet the fruit fly is the main threat to their wellbeing (MoALF), 2018). Machakos County stretches from latitudes 00 45' south to 10 31' south and longitudes 360 45' east to 370 45' east (Mutua *et al*., 2018). The county falls between an altitude of 700m to 1700m above sea level, and it is generally hot and dry. It covers 6,281.4 km^2 most of which is

semi-arid. The county is divided into eight sub-counties: Masinga Yatta, Machakos Town, Matungulu, Kangundo, Kathiani, Mwala, and Mavoko.

The region experiences two rain seasons; long rains start at the end of March and ends in May while the short rains begin in October and continue till December (MoALF, 2018). The annual rainfall averages between 500mm to 1300mm and is often unreliable (GOK, 2009). The monthly temperature varies between 18^0 C and 25^0 C (MoALF, 2018). Machakos has a population of 1,421,932 with a one to one ratio of women and men, and 71 percent of population living in rural area of the county (KNBS, 2019). The main economic activities are dairy farming, beekeeping, trade, horticulture, and self-employed off-farm activities (MoALF, 2018). The major crops grown are maize, beans, cowpeas, pigeon peas, sorghum, millet, cassava, grafted mangoes, and oranges (Machakos County, 2015).

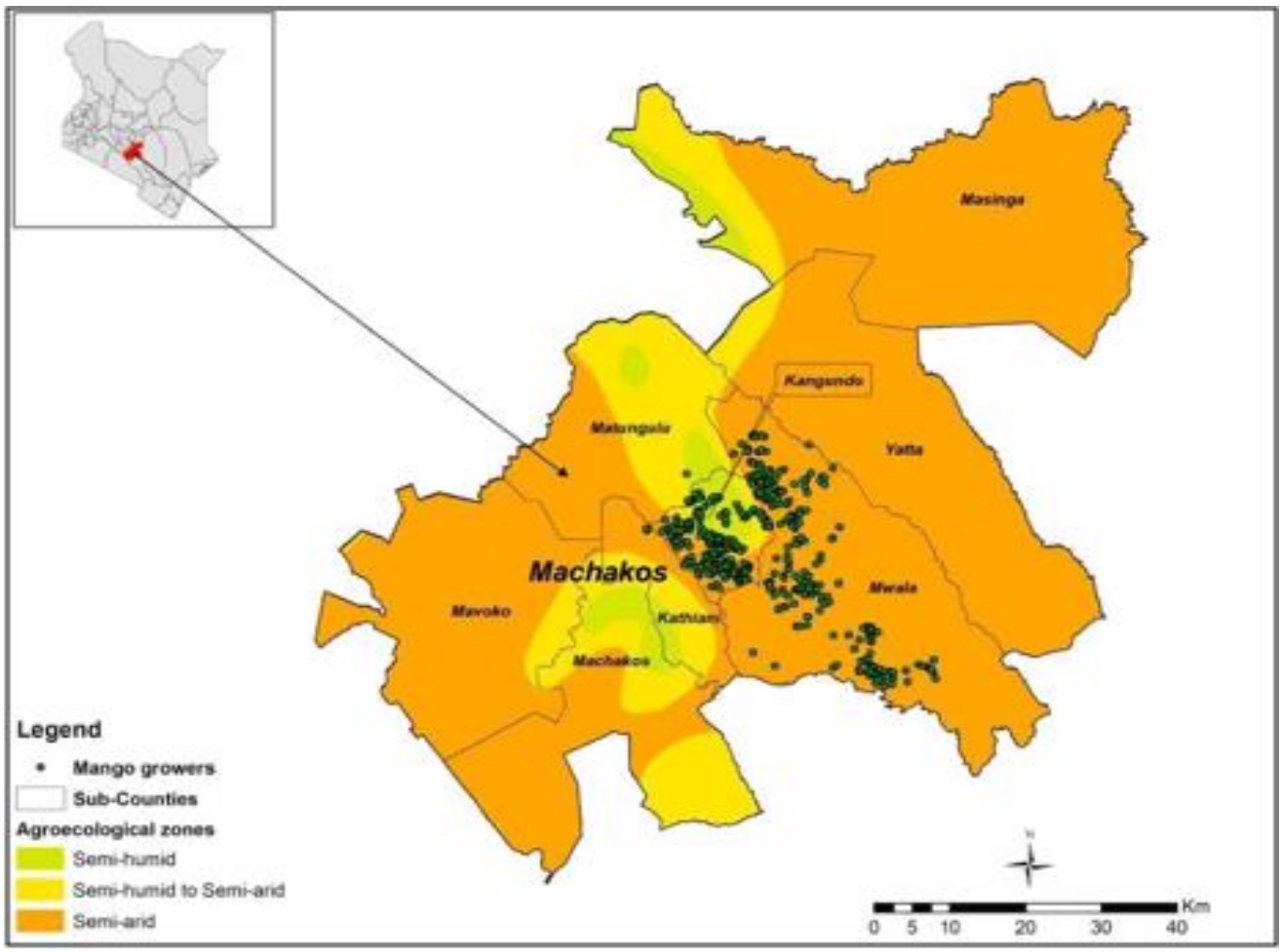

Figure 3.2: Map of Machakos County
Source: *icipe* (GIS)

3.8 Research design and sampling procedure

This study was based on the quasi-experimental impact evaluation design where the treated and control households were interviewed before and after the mango fruit fly IPM intervention. A pre-tested semi-structured questionnaire (see Appendix 1) was used to collect primary data from the households. The data collection focused on the smallholder mango farmers' socio-economic characteristics, mango farm characteristics, decision making regarding mango production, marketing decisions, and control over benefits (women empowerment indicators), and institutional characteristics in the region. The questionnaire was administered by carefully-trained enumerators supervised by *icipe*'s Socio-Economics and impact assessment team including the author.

The data were collected in two phases: baseline and follow-up surveys. During the baseline, a multi-stage sampling procedure was used to select the respondents. The first stage involved the purposive selection of Machakos County for being one of the leading counties in mango production in Kenya. In the second stage, two sub-counties were purposively selected in Machakos County, based on their proximity to the Nairobi market and being one of the sites target by *icipe's* African Fruit Fly Program (AFFP). This criterion led to the selection of Mwala (treatment area) and Kangundo (control area) sub-counties.

The third stage involved simple random selection of the respondents from the sampling frame. The process started by carrying out a census of smallholder mango growers in the study areas with the help of the Sub-county agricultural extension officers. However, it was not possible to determine the exact population of mango growers in the two sub-counties. Therefore, the Cochran technique (Ahmad and Halim, 2017) of determining sample size when the population is unknown was employed as shown in equation 3.12 below.

$$n_0 = \frac{z^2 p(1-p)}{e^2} \tag{3.12}$$

where n_0 denotes the sample size that will be estimated, p denotes the percentage of population estimated to be available during the survey period, e denotes the acceptable margin of error for the percentage of population being estimated, while z denotes the desired confidence interval's critical value. that would be available during the survey period is 50 percent in each sub-county with a 5 percent margin of error and 95 percent confidence interval whose z score is 1.96, therefore the sample size in each sub-county was calculated as follows (equation 3.13);

$$n_0 = 1\frac{1.96^2 \times 0.5(1-0.5)}{0.05^2} = 384 \tag{3.13}$$

However, due to limited time and resources, only 300 households were interviewed in each Sub-county.

3.9 Data collection procedure

All the 600 respondents were successively interviewed during the baseline survey carried out between February and March 2015. The data collected during the baseline focused on 2013/2014 mango production season. In each household, the interview was conducted with both spouses present to ensure that the information collected was as accurate as possible. Upon completion of the baseline survey, farmers in the treatment group received IPM package and trained on how to implement it for fruit fly suppression. For proper administration of the IPM strategies, a close monitoring of the implementation was done until the end of the harvesting season. This intervention triggered the need for a follow-up study to determine its impact on gender relations within the household.

A follow-up survey targeting the same households was undertaken in December 2015 capturing information on the 2014/2015 mango production season. During the follow-up survey, 4 percent of the respondents had dropped out. Therefore, a total of 289 respondents were interviewed in the treatment site (Mwala Sub-county) and 277 in the control site (Kangundo Sub-county). Some of the questionnaires were dropped since they were incomplete; this reduced the sample size to 470 respondents. The distribution of the sample by the study sites is shown in Appendix 2.

Besides the questionnaire interview in the second survey, 12 gender-disaggregated focus group discussions (FGDs) were carried out to understand household gender relations, social norms and intra-household gender dynamics surrounding IPM adoption. In this regard, 6 FGDs were conducted with male smallholder mango farmers (3 male FGDs with IPM adopters and 3 male FGDs with IPM non-adopters), and 6 with female smallholder mango farmers (3 female FGDs IPM adopters and 3 female FGDs with IPM non-adopters).

3.10 Data Management and Analysis

The household questionnaire was programmed to Open Data Kit (ODK) software to enhance data integrity and quality. The programme collected meta data which showed the start and end time of interview, the date of data collection, and the location where the interview was conducted. Advanced skip logics and constraints were developed to ensure that quality data was collected. With the software, it was possible to give hints to enumerators and constraints messages that minimized errors. Data collection using ODK collect also eliminated errors that may occur during

data entry. The data was then downloaded from the ODK aggregate platform in CSV format and converted to STATA version 13 for cleaning and analysis.

CHAPTER FOUR: RESULTS AND DISCUSSION

4.1 Respondents' DMI profiles

Table 4.1 presents the respondents' DMI profiles. On average, the women's DMI was 57.9 percent in the treated group (Mwala Sub-county) during the baseline survey. This level of DMI implies that, on average, the female spouses achieved adequate scores in 57.9 percent of the weighted indicators. Each of the indicators took a value of 1 if the female spouse within the household solely or jointly participated in making the decision and 0 if otherwise. During the follow-up survey however, the average DMI significantly dropped to 37.2 percent (Table 4.1) in the treatment area. The large difference between baseline and follow-up is in the treatment area could be explained by men taking over mango production and marketing after IPM adoption. Due to the anticipated increase in income from mangoes due adoption of IPM, men could have taken over decisions on borrowing for mango production thus the significant decrease in women involvement in the resource domain.

The decrease of in the leadership domain could be explained by *icipe*'s target of mango production or marketing group members as project beneficiaries, therefore more men joining groups thus displacing women as only one member per household is chosen as project a beneficiary. The distribution of the decrease in weighted indicators was as follows: the production domain decreased from 8.5 percent to 6.3 percent, the resource domain decreased from 10.1 to 5.4 percent, the income domain decreased from 16.4 to 12.4 percent and the leadership domain decreased from 9.3 to 5.8 percent. According to Chete (2019), new technologies to African women increased men's interest in agriculture, which led women to lose control of the lucrative enterprise or agricultural activities.

Table 4.1: Descriptive statistics about the decision-making index

Domains	IPM adopters		IPM non-adopters		
	Mean	**Std. dev**	**Mean**	**Std. dev**	**t-value**
Baseline survey					
Production domain	0.085	0.069	0.050	0.061	5.753 ***
Resource domain	0.101	0.060	0.071	0.053	5.573***
Income domain	0.164	0.077	0.138	0.093	3.300***
Time domain	0.136	0.076	0.047	0.084	12.095***
Leadership domain	0.093	0.097	0.072	0.091	2.505**
DMI	0.579	0.291	0.378	0.290	7.489***
Follow-up survey					
Production domain	0.063	0.070	0.073	0.072	-0.035
Resource domain	0.054	0.061	0.051	0.054	2.306**
Income domain	0.124	0.097	0.130	0.098	-0.504
Time domain	0.073	0.094	0.080	0.095	-0.33
Leadership domain	0.058	0.083	0.049	0.076	2.608**
DMI	0.372	0.320	0.383	0.302	-1.36

Note: * $p < 0.10$, ** $p < 0.05$, *** $p<0.01$.

The mean difference in the DMI between IPM adopters and non-adopters was statistically significant for the production, resources, income, leadership, and time domains in the baseline survey (Table 4.1). In Kangundo Sub-county (the control area), the average DMIs were 5, 7.1, 13.8, 4.7 and 7.2 percent in the production, resource, income, and time domains, respectively. This was significantly lower than those in Mwala Sub-county. However, there was no significant difference in the DMI between the treatment and control groups in the follow-up survey apart from the resource and leadership domains where the decision-making index was slightly higher in the treatment group.

4.2 Household Characteristics, Information Access, and Social Norms

Tables 4.2, 4.3, 4.4, and 4.5 present selected household characteristics, information access and social norms variables generated from the literature and study context, which were likely to influence the women's decision-making index. Tables 4.2 and 4.3 compare the time-varying variables between the fruit fly IPM adopters and non-adopters that were obtained during the baseline and follow-up surveys, respectively, while Tables 4.4 and 4.5 compare the fixed variables

for the two IPM groups collected from the baseline and follow-up surveys, respectively. The female spouses in households with DMIs greater than or equal to 0.8 were regarded as having control in mango production and marketing decisions and were hence considered empowered. Female spouses whose DMIs were less than 0.8 were classified as not empowered (Alkire *et al.*, 2013). The socio-economic characteristics of fruit fly IPM adopters and non-adopters were also compared using these two categories (Tables 4.2-4.5).

As shown in Tables 4.2 and 4.5, the number of households with an empowered female spouse in mango production and marketing activities decreased from 82 to 34 in Mwala Sub-county (IPM Adopters) after the IPM intervention. As highlighted earlier, the introduction of an agricultural innovation that increased income for farm enterprises may reduce women's control even if they were initially the primary managers of the enterprise (Njuki *et al.,* 2011; Doss, 2001; Dolan, 2001). The decrease in the number of empowered female spouses could be attributed to the adoption of the fruit fly IPM, as it reduces mango losses and hence rapidly increases mango income.

During the baseline survey there were no significant differences on the time-varying household characteristics between those with empowered and those without empowered female spouses in both the treatment and control groups. However, households with empowered primary female household members, had a significantly higher percentage of husbands with off-farm income (Table 4.2). Households with empowered women, had 63 percent of husbands with off-farm income compared to 50 percent in the disempowered category. Off-farm income often translates to off-farm employment for men in a household which means less involvement in the household's agricultural production activities. Therefore, women are left to make most production and marketing decisions. Zhllima *et al*. (2021) in assessing women's role in farms in Albania, found that men's migration from farms for off-farm income left the farm management decisions to women.

During the follow-up survey, more time-varying household characteristics significantly differed between households with and without empowered female spouses. For instance, 44 percent of female spouses in the control and treatment groups, invested in mango production compared to only 24 and 25 percent in the treatment and control groups, respectively. Women's investment in agricultural production gives them more bargaining power in decision making therefore they are involved in making more decisions in production, marketing, and distribution of income from their

farm's proceeds. In accessing the relationship between women's contribution to household income and decision making in Bangladesh, Roy *et al*. (2017) found that the more the women's contribution to income the more they were involved in decision making.

Table 4.2: Descriptive statistics of the time-varying variables for the baseline survey for the adopters and non-adopters of the IPM strategy according to the decision-making index

Variable	Adopters of IPM strategy				Non-adopters of IPM strategy			
	DMI≥ 0.8 (n=82)	DMI< 0.8 (n=156)	Std. Err.	t/z-stat	DMI≥ 0.8 (n=34)	DMI< 0.8 (n=198)	Std. Err	t/z-stat
Household resources								
Husband's off-farm income (dummy)	0.63	0.50	0.07	-1.98**	0.65	0.70	0.09	0.64
Female off-farm income (dummy)	0.29	0.26	-0.06	-0.49	0.59	0.61	0.09	0.20
Female investment to mango production (%)	28.41	29.43	3.60	0.28	26.91	28.15	4.88	0.25
Log household income (KES)	11.99	11.64	0.12	-2.95	12.14	12.06	0.16	-0.47
Access to market and institutional information								
Female number contacts with extension service providers	0.61	0.47	0.16	-0.87	0.12	0.20	0.12	0.65

* p < 0.10, ** p < 0.05, *** p<0.01.

Table 4.3:Descriptive statistics of the time-varying variables for the follow-up survey for adopters and non-adopters of the IPM strategy according to the decision-making index

Variable	Adopters of IPM strategies				Non-adopters of IPM strategies			
	DMI ≥ 0.8 (n=34)	DMI< 0.8 (n=204)	Std. Err.	t/z-stat	DMI≥ 0.8 (n=36)	DMI< 0.8 (n=196)	Std. Err	t/z-stat
Household resources								
Husband's off-farm income (dummy)	0.71	0.59	0.08	-1.30	0.67	0.73	0.09	-0.63
Female off-farm income (dummy)	0.71	0.66	0.08	-0.51	0.69	0.65	0.10	-0.47
Female investment mango production (%)	44.41	24.02	4.77	-4.27***	43.85	25.96	5.34	-3.35***
Log household income (KES)	11.94	11.76	-0.19	-0.95	12.24	12.10	0.19	-0.72
Access to market and institutional information								
Number of female spouse access to extension service	2.18	1.40	0.21	-3.75***	0.38	0.21	0.17	-1.06

Note: * p < 0.10, ** p < 0.05, *** p<0.01.

As alluded to earlier, the fixed variables are those variables that did not change within the period between the baseline and follow-up surveys. Though the variables were not time-varying they were computed differently in the baseline and follow-up surveys since the number of households with empowered female spouse changed in the follow-up. In the control group, the empowered category slightly increased from 34 to 36 in the follow-up survey. As stated earlier, the number decreased significantly from 82 to 34 in the treatment group.

The results in Table 4.4 show that the larger the area under mango production, the more women lose control over decision making in both the treatment and control groups. Among IPM adopters, average area under mango production was 0.83 acres for the empowered compared to 1.27 acres for the disempowered. This means that households producing mangoes in larger scale men may take control over production and marketing because of the fact that income is positively associated with scale of production(Sebatta *et al*., 2014). Similar results were observed among IPM non-adopters where households with disempowered women had significantly larger mango orchards (1.74) compared to those with empowered women (0.84). In the control group, female spouses were about five years older in the empowered category than in the disempowered category. The results were as expected, as age is correlated with experience which is likely to translate to more bargaining power in production and marketing decision making.

During follow-up survey, the level of education between the disempowered and empowered categories significantly differed for the control group. The empowered were more educated than the disempowered categories, that is, 10 and 8.78 years, respectively as shown in Table 4.5. The results were according to expectation as educated women are more likely to get involved in decision making due to having production and marketing skills, and off-farm income that translates into more investment and the likelihood to know their legal rights. In analyzing the respective contribution of husband and wife in farming households effect on decisions regarding the use of income in Kenya, Osanya *et al*. (2020) found that women's higher education levels empowered women in decision making. In addition, Maligalig *et al*. (2019) found that off-farm employment among rice farmers in the Phillipines increased women empowerment in investment decision making.

Table 4.4: Descriptive statistics of fixed variables for adopters and non-adopters of the IPM strategy according to the decision-making index (baseline survey)

Variable	Adopters of IPM strategies				Non-adopters of IPM strategies			
	DMI≥0.8 (n= 82)	DMI< 0.8 (n=156)	Std. Err.	t/z-stat	DMI≥ 0.8 (n=34)	DMI< 0.8 (n=198)	Std. Err	t/z-stat
Household characteristics								
Age of female spouse	48.99	48.82	1.64	-0.10	54.85	50.17	2.20	-1.71*
Husband's level of education	9.24	8.63	0.24	-1.22	9.67	10.69	0.71	1.44
Female spouse's level of education	8.41	7.89	0.23	-1.09	8.29	9.02	0.66	1.09
Number of female decision-makers	1.40	1.48	0.10	0.78	1.41	1.45	0.12	-0.31
Number of male decision-makers	1.70	1.69	0.13	-0.07	1.74	1.67	0.17	-0.38
Household size	4.88	5.26	0.28	1.35	4.91	4.70	0.33	-0.64
Household type	0.37	0.39	0.07	0.38	0.29	0.43	0.09	1.53
Household resources								
Farm area under mango production (acres)	0.83	1.27	0.50	1.67*	0.84	1.74	0.37	1.77*
Number of years that the female spouse has grown mangoes	11.27	11.29	1.37	0.01	10.89	10.58	2.05	0.15

Note: * p < 0.10, ** p < 0.05, *** p<0.01.

Table 4.5: Descriptive statistics of the fixed variables for adopters and non-adopters of the IPM strategy according to the decision-making index (follow-up survey)

Variable	Adopters of IPM strategies				Non-adopters of IPM strategies			
	DMI≥0.8 (n=34)	DMI< 0.8 (n=204)	Std. Err.	t/z-stat	DMI≥ 0.8 (n=36)	DMI< 0.8 (n=196)	Std. Err	t/z-stat
Household characteristics								
Age of female spouse	51.53	49.60	2.22	-0.87	55.23	50.08	2.45	-2.10**
Husband's level of education	9.21	8.78	0.68	-0.62	10.58	10.49	0.80	-0.10
Female spouse level of education	8.32	8.03	0.66	-0.45	10	8.78	0.74	-1.65*
Number of female decision-makers	1.23	1.47	0.15	1.60	1.07	1.04	0.02	-0.57
Number of male decision-makers	1.62	1.54	0.18	-0.41	1.12	1.07	0.08	-0.62
Household size	4.79	5.27	0.38	1.24	5.08	4.72	0.38	-0.94
Household type	0.32	0.39	0.09	0.76	0.38	0.41	0.10	0.23
Household resources								
Farm area under mango production (acres)	1.06	1.59	0.29	1.04	0.74	0.95	0.91	-0.05
Number of years that the female spouse has grown mangoes	10.09	12.65	1.86	1.38	9.62	12.24	2.30	1.14

Note: * p < 0.10, ** p < 0.05, *** p<0.01.

4.3 Impact of mango fruit fly's IPM strategy on women's decision making in mango production and marketing among smallholder mango farmers in Machakos County

4.3.1 DiD of women decision-making index in mango production and marketing in Machakos County

Table 4.6 shows DID of women's decision making index in mango production and marketing in Machakos County among IPM adopters (Mwala Sub-county) and IPM non-adopters (Kangundo Sub-county). The results indicate that the average difference of DMI between baseline and follow-up among IPM adopters was negative (-0.207) and statistically significant, implying that adoption of IPM strategy decreased women's control over mango production and marketing. The overall difference of DMI among IPM adopters and non-adopters during baseline and follow-up surveys was negative (-0.212), further emphasizing that adoption of IPM strategy led to decrease of women decision making in mango production and marketing.

Table 4.6: Difference-in-difference of women's decision-making in mango production and marketing in Machakos County

Survey period	IPM Adopters (Treated (T))	IPM non-Adopters (control(c))	Difference between T-C
Follow-up survey (2014-2015 production period)	0.372	0.383	-0.011
Baseline survey (2013-2014 production period)	0.579	0.379	0.201***
Difference-in-Difference	-0.207***	0.004	-0.212***

Note: *** Represent significance at 1% level

4.3.2 Factors influencing women decision making index in mango production and marketing in Machakos County

Table 4.7 presents the parameters estimates of the Tobit model. The model fit the data well, as shown by the pseudo-R^2 of 0.174 and the statistically significant chi-square value of 104.16. The coefficient of the fruit fly IPM technology was negative but statistically significant, implying that adoption of the technology led to a decrease in the women's DMI by 20.4 percent. This decrease could be attributed to women's general lack of bargaining power in production, marketing, and control over benefits when the IPM package was introduced. This observation tallies with that of Theis *et al*. (2018) who noted that men took over selling of rice in warehouses when irrigation technology was adopted by small-scale farmers in Tanzania .

Table 4.7: Tobit parameter estimates of the impact of IPM package adoption on women's decision-making in mango production and marketing in Machakos County

Variables	Marginal effects	Std. Err.	t-value
IPM (1=Treatment area)	0.204***	0.033	6.15
Time (1=follow-up period)	-0.058*	0.034	-1.69
IPM*Time (1=used IPM strategy)	-0.215***	0.047	-4.56
Age of female spouse	0.002*	0.001	1.73
Husband major economic activity (1=off-farm)	0.047	0.030	1.57
Husband's level of education	-0.005	0.004	-1.49
Female major economic activity (1=off-farm)	0.007	0.032	0.24
Female spouse's level of education	0.003*	0.004	1.84
Number of years that the female spouse has grown mangoes	-0.001	0.001	-0.09
Proportion of female spouse's investment in mango production	0.003***	0.000	5.71
Female number of contacts with extension service providers	0.033***	0.011	3.08
Farm area under mango production (acres)	-0.003*	0.002	-1.69
Number of male decision-makers in the household	-0.026*	0.014	-1.78
Number of female decision-makers in the household	-0.019	0.018	-1.05
Household size	-0.012*	0.007	-1.81
Household type	-0.001	0.025	-0.03
Log annual household income	-0.001*	0.014	1.88
Constant	0.344**	0.169	2.03
Pseudo R-squared	0.1742		
F (18, 922)	10.26***		
Number of observations	940		

Dependent variable decision-making index (DMI); 135 left-censored observations DMI≤0, 2 right-censored observations DMI≥1 and 803 uncensored observations; * $p < 0.10$, ** $p < 0.05$, *** $p<0.01$.

As expected *a priori*, a woman's age positively influenced her DMI such that an additional year in her age would raise the DMI by 0.2 percent. Studies (e.g., Kiriti *et al*., 2001; Alkire *et al*., 2013) show that older female spouses possess more knowledge gained through experience in production practices and the local environment, thus increasing their level of bargaining power in decision-making both in mango production and marketing. Ogunlela *et al*. (2009) in assessing women participation in farm management decision making process in Nigeria, found that women participation increased with their age.

The number of years' education that a woman had attained had a statistically positive effect on her DMI as hypothesized. Thus, an extra year of formal education would increase her DMI in mango production and marketing by 0.3 percent. This finding tallies with those of Damisa and Yohanna (2007) and Bushra and Wajiha (2015). Women with better formal education possess knowledge and understanding of their rights within the household and hence have a higher chance of contributing to the decision-making process compared to their less-educated counterparts. In assessing husband and wife perspective on farm household decision making authority in Tanzania, Anderson *et al*. (2021) found that education had a significant positive relationship with the wife's authority in decision making.

The number of adult men within the household was negatively associated with the women's DMI as expected from theory. Accordingly, an extra adult male in a household would lower the women's ability to contribute to decision-making on mango production and marketing by 2.6 percent. This could be attributed to men's patriarchal role of men as heads of household in most African societies (e.g., see Luqman *et al.* (2012)). Kantor (2003) in assessing women's control over enterprise income and decision making with the household in India had similar findings that the number of adult men in a household negatively affected women's control over income and participation in decision making.

The size of the household also had a negative association with the women's DMI as expected *a priori*. Therefore, women in larger households were less involved in making decisions on mango production and marketing, perhaps because they were more involved in household chores. An extra household member reduced a woman's DMI by 1.2 percent. According to Jabbar (2021), the lower the number of household members the higher the women's bargaining power in the household. Soharwardi and Ahmad (2020) in assessing the determinants of women empowerment in developing countries found that household size negatively influenced women's decision making.

The proportion that a woman had invested in mango production had a positive and significant effect in explaining the woman's DMI as expected *a priori*. As such, a 1 percent increase in the proportion that a woman had invested in mango production would increase her DMI by 0.3 percent. This suggests that women's financial contributions to production increase their intra-household bargaining power. Lecoutere and Jassogne (2016) reported that participatory decision-making is positively related to investment in common household farms in Uganda. Enete and Amusa (2010) in assessing the determinants of women's

contribution to farming decisions in Nigeria, found that women's financial contribution to farming activities increased their input in decision making in the activities.

As expected from theory, the size of cultivated land allocated to mango production was negatively but significantly related to the DMI. Thus, a unit increase in land size under mango production would reduce a woman's DMI by 0.3 percent. This is plausible, as men are more likely to take control of mango production and marketing as the area under mango production increases – i.e., as the farming activity becomes more commercialized (Njuki *et al.,* 2011).

The total annual household income had a negative but significant influence on the woman's DMI this was contrary to what was expected. Specifically, a one percent increase in annual household income would reduce a woman's DMI by 0.1 percent, suggesting that higher collective (household) income does not necessarily translate into greater women empowerment in the household. This finding corroborates that of Njuki *et al*. (2011) who observed that when beans were identified as a crop of economic importance in Malawi, bean production and household income increased; however, women's control of income from crops decreased significantly. However, the findings are contrary to those of Al-Shami *et al*. (2017) in assessing household welfare and women empowerment through microcredit financing in Malaysia, found that increase in household income increased women empowerment.

The access of a female's spouse to extension services had a positive and significant effect on a woman's DMI as was expected from theory. Thus, a shift from lack to access to extension services would increase the woman's DMI by 3.3 percent. Agricultural extension services empower women with knowledge and enable them to contribute ideas about agronomic practices at the farm and marketing activities (Diaz and Najjar, 2019). Women who have accessed extension service are likely to involve themselves in decision making because training may provide information on better mango production practices, input prices, the best marketing channels and market prices, hence encouraging women to participate in decision-making in the management of the crop enterprise. Besides, training increases the skills of women in agricultural production and marketing hence expected to have a positive impact on women participation in decision making (Quisumbing and Pandolfelli, 2010).

However, caution should be taken in using the results of this study because the period between the baseline and follow-up was one year, therefore the mango farmers had only one season of implementing the IPM strategy before the impact assessment was done. The baseline data was collected several months after the

season of interest, therefore it relied heavily on the respondent's memory on some variables. Due to limited resources and time, questions on who makes decisions on mango production and marketing were not always answered by both male and female primary decisions makers in a household, but by the one who was present at the time of interview, thus highly subjective. Also due to time difference between the baseline and follow-up survey, the baseline and follow-up questionnaire could have been administered to different respondents (either the spouse or household head) in some households.

CHAPTER FIVE: SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 Summary

Both government and non-governmental organizations fund the generation and dissemination of new agricultural innovations with the aim of increasing agricultural productivity among smallholder farmers. However, past research has shown that despite the increase in household income and food security as a result of technology adoption, gender roles in intrahousehold decision making are often affected. Women tend to lose control of decision on production, marketing, and utilization of proceeds thereto. Mainstreaming gender in agriculture is important for a country to achieve its development goals as well as national food security. Thus, involvement of women in agricultural production and marketing is important. Women are often at the receiving end because of the gender differences in access to production resources such as land, capital, and skilled labour, among others. Therefore, when a crop becomes more profitable due to a new innovation, men become interested in the crop and they take over from women who are left with little to no bargaining power.

The overall objective of this study was to evaluate the impact of adopting IPM technology package on women's decision-making on mango production and marketing in Mwala and Kangundo sub-counties of Machakos County. Using a quasi-experimental programme theoretic study design with a two-limit Tobit Difference-in-Difference (DiD) model of women's decision-making index (DMI), the study found that IPM strategy negatively impacted female spouse involvement in mango production and marketing decision. The percentage of empowered women (with DMI above 80 percent), reduced from 34 during baseline to 14 percent during follow-up among IPM adopters while among non-adopters, only 15 percent were empowered both baseline and follow-up. The average DMI among adopters reduced from 58 percent during baseline to 37 percent after IPM adoption, while the average DMI among non-adopters was 38 percent in both baseline and follow-up survey. Further, the results show that the female spouse's age, contact with extension officers, formal education and investment in mango production significantly increased their DMI. However, number of adult male decision makers, household size, farm area under mango production and household income had a negative effect on women's DMI.

5.2. Conclusion

Evidence from this study show that women are greatly disenfranchised when IPM strategy for controlling mango fruit fly is adopted. Women lost control in decision making in all the agricultural domains namely; production, resources, income, leadership and time among IPM strategy adopters. The result also showed that increase in scale of production and household income led to women losing control over production and marketing decisions. Therefore, this study underscores the importance of mainstreaming gender in

agricultural interventions so as not to escalate the existing gender inequalities among smallholder farmers. While this study provides useful insights regarding women involvement in mango production and marketing decision making in rural Kenya, caution should be taken while generalizing the results to other contexts as gender roles largely depend on prevailing socio-economic conditions and culture, which may differ considerably from one region to another.

5.3 Policy recommendations

1. Organizations developing programmes aimed at increasing agricultural productivity should consider pairing their interventions with women empowerment. For instance, trainings on new agricultural technology should provide for both the male and female primary decision makers in a household to attend.
2. Development partners and government should provide extension services and credit in mango production targeting women specifically because, results from this study have shown that women participation in mango production and marketing decisions can be enhanced through contact with extension officers and access to credit.
3. Collective action among women farmers should be encouraged while adopting new agricultural technology, evidence from this study shows that group active membership has a positive effect on women's decision making.

5.4 Areas for further research

In evaluating the impact of mango fruit fly's IMP strategy adoption on women's DMI, this study had various limitations. Firstly, resources and time constraints that prevented interviewing at least two primary decision makers within a household, hence the results of this study are highly subjective. Further research should be done in this area administering the questionnaire on decision making to both the household head and female spouse to have more objective results. Secondly, the two time periods baseline and follow-up, which are only one year apart, do not support a rigorous examination of the impact of IPM strategy on women's control over mango production and marketing, therefore further research should be done using panel data of more than one period to closely examine how women's DMI is affected. Thirdly, this study is among mango farmers from one County in Kenya, therefore not a representative of how women are affected by adoption of new agricultural technology nationally. Thus, further studies should replicate this study in other areas to produce a more generalizable picture of the impact of the adoption of mango fruit fly technology on intra-household decision-making.

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APPENDIX

Appendix 1: Household questionnaire

IMPACT ASSESSMENT OF MANGO IPM FRUIT FLY CONTROL TECHNOLOGY PACKAGE

Section A: Personal Details and household information

1.0 Household information

01. Questionnaire ID	
02. Date of the interview (dd.mm.yy)	
03. Start time	
04. Enumerator name***:1=Euphemiah Miroyo 2=Henry Nyanaro 3=Paul Nyangau 4=Chris Miyinzi 5=Nancy Gathongo***	
05. Household head Name (*three names*):	
06. Gender of the household head (1=Male 0=female)	
07. Respondent Name (*three names*):	
08. Phone number (*of household head*)	
09. Sub- County	
012. Village	

1.1 Household's consent obtained [_____] 1=YES 0=NO

1.2 If No (1.1),why?_____ (**End Survey)**

1.3 Has a new member been added (or left) to this household since the last survey?

Name (first name only)	Age (yrs)	Relationship with HHH (code **(b)**	Sex **1 = M, 0 = F**	Primary (main) Activity Occupation (code **(a)**	Secondary activity (if applicable) (code**(a)**	Physiological status of women 14-60 years only **(code (c)**	Years of schooling
1							
2							
3							
4							
5							

Activity codes (code (a)		**Codes (c):** Physiological status of women	
0 = None **1** = Mango production **2**=Cereal production **3**= Livestock production **4**=Artisan	**5**=Casual labourer **6**=Salaried employee **7=Business** **8** = In school/college **9** = Pre-school age **10**= Other(specify)_____	1= Not pregnant or lactating 2= Pregnant 3=Breastfeeding child <6months 4=Breastfeeding child>6months	5= Pregnant & breastfeeding child<6months' 6=Pregnant & breastfeeding child>6months

Codes for relationship with household head (code (b)				
1=head **2**=spouse; **3**=son/daughter;	4=step child; 5=Father/mother; 6=brother/sister;	7=nephew/niece; 8=son/daughter-in-law; 9=grandchild;	10=unrelated; 11=brother/sister-in-law; 12=Father/Mother-in-law:	13=worker 14=other relative (specify)____

2.0 Household dwelling

2.1. Ownership of household 's house [_____] 1=YES 0=NO

2.2. Material of the house 's wall (code) _____

0=concrete	**2**=clay
1=timber	**3=**Other(specify)_____

2.3. Material of the house 's roof: [_____] 1=Slab 2=corrugated iron or tile 3=Other

(specify)_____

2.4. Electricity at home [_____] 1=YES 0=NO

2.5. Tap water [_____] 1=YES 0=NO

2.6. Type of toilet: [_____] 0=No toilet 1=Pit latrine 2=Flush toilet

3.0 Assets owned

3.1. Livestock

3.1.1 Do you own livestock? [_____] 1=YES 0=NO

3.1.2 If **YES,** tell us about the herd of livestock you owned for the last 12 months

Livestock type	**Total number**	**Who owns (codes a)**	**Estimated value (Kshs)**
a) Cattle adult			
b) Calve			
c) Goat			
d) Sheep			
e) Pig			
f) Donkey			
g) Camel			
h) Horse			
i) Poultry			
j) Rabbit			
k) Fish			
l) Bee hives			

Who owns codes: 1=Head 2=Spouse	3=Household(all) 4=Head's father	5=Head's mother 6= Spouse's mother	7= Spouse's father 8= son 9=Daughter	10= Other joint (specify codes) __ 11= Other (specify)_____

3.1.3 What percent of annual household income is generated from animals and animal products? _____%

3.2 **Land**

3.2.1 Please provide the following information about the land used by the household in the last 12 months (also include rented land, and fallow/ grazing land)

	Total agricultural cultivated land			Own land left fallow	Land given to other family members		Grazing land			Home stead land
	Own land	Gift land	Rented-in		Rented out	Gift	Own	Rented-in	Obtained as gift	
Acres										

If you rented out land, how much did you earn in the last 12 months? Kshs_____]

3.2.2 Give details about the plots of land cultivated (including the rented in land) for the last 12 months 2014in Rainy and dry season, permanent crops (for example coffee) to be recorded in the rainy season crop. For a plot that has **been intercropped/ mixed cropped,** for example with 2 crops, divide the size of plot by two. Also provide estimated total ***labour time*** in hours per day and ***number of days per months*** allocated to each crop

Season **1)Rainy 2)Dry 3)All**	Plot (no.)	Crop code **(a)**	Area (acres)	Grown for 1=Home use 2=For sale 3=Both give % of each)	Who owns the plot (codes) **(b)**	Who manages the plot (codes) **(b)**	Total labour time allocated		Land quality (codes) (c)	Was the land irrigated 1=Yes, 2=No	If YES, percentage of land irrigated	Did you use fertilizer **1=Yes 2=No**	Did you use manure (any type) **1=Yes 2=No**	Crop output 1			Market price (per unit)	Crop output 2			Market price (per unit)	Who receives the money **(b)** if sold
							Hrs per day	Number of days /month						Quantity	Units (codes d)	Cash income (Appx)		Quantity	Units (codes d)	Cash income (Appx)		
		Mango																				

Crop code (a)

Arrow roots =28	Butternuts=39	Godgets=43	Mango=56	Pyrethrum=30	Sweet potatoes=22
African indigenous vegetables=40	Cabbages =6	Green grams=55	Maize=1	Rice=31	Tangerines=57
Avocado=54	Capscum=47	Flowers=14	Melons=34	Snow peas=3	Tea=33
Baby corns =5	Carrots=52	Fodder=37	Miraa=38	Sorghum=21	Tobacco=27
Bananas=53	Cassava =25	French beans=2	Napier grass=36	Soya beans=62	Tomatoes=8
Barley=18	Chick pea=12	Irish potatoes=23	Ndania=50		Wheat=19
	Coffee =17	Lemons=60			Yam =20

Who own/manage (b)

1=Head
2=Spouse
3=Household (all)
4=Head's father
5=Head's mother
6=Spouse's mother
7=Spouse's father

Land quality (c) 1=Fertile, 2=Moderately fertile, 3=Infertile

Units (coded)

1=Kgs
2=50Kgs bag
3=90kgs bag
4= numbers/ pieces
6=gorogoro
7=debe
8=ox-cart
9=bale
10=pickup
16=20litres bucket

Beans=24 Beetroots=41 Black night shade(managu)=11 brinjals /biriganya=44 Bracoli=51	Cotton=26 Cow peas =13 Cucumbers=42 Garden peas=45	Lettuce=49 Linseed =15 Lintels =16 Macadamia nuts =29	Onions=9 Oranges=59 Pawpaw=58 Pigeon peas=46 Pumpkins=35	Spinach=10 Sugar snaps=4 Sugar cane=48 Sukuma wiki =7 Sun flower=32	(Other specify)_____= 63	8=Son 9=Daughter 10= Other joint (specify codes) 11= Other (specify)	5=Wheelbarrow 11=bunches 12=crate 13=120 kg bag 14=6 kgs carton 15=4 kgs carton	17=17kgs bucket 18=Lorry 19=Tones 20=grams 21=litre 22=milliliter 23=Other(specify

3.2.3 How long have you been cultivating this farm? _____years/ months (own farm)

3.2.4 Is the land under mango rented or owned? [_____]0 = Rented 1 = owned

3.2.5 If land is rented for mango production, what is the rental rate per year _____/Ksh/acre?

3.3 **Household assets**

3.3.1 At present, do you own the following assets?

Assets	No. owned now	Current Total Value	Who owns (codes	Asset	No. owned now	Current Total Value	Who owns (codes)
Farm assets				23= ploughs for tractor/animal			
1= spray pump				24= tractor			
2= water pump				25= harrow/tiller			
3= Sprinkler				26= combine harvesters			
4= water tanks				27= planter			
5= stores(chemical/grain store etc)				28= generator			
6= grinder				29= green house			
7= weighing machine				**Household assets**			
8= power saw				30= radio			
9= wheel barrow				31= TV			
10= animal traction plough				32= telephone/ mobile phones			
11= zero-grazing units				33= solar panels			
12= milking equipment/shed				34= sewing/knitting machine			
13= Motorized/ hand thresher				35= posho mill			
14= chaff cutter				36= battery (car)			
15= cattle dip				37= gas cooker			
16= water trough				38= bicycle			
17= pig-stys				40= motorcycle			
18= poultry houses				41= car			
19= borehole or well				42= truck			
20= dam				43= trailer			
21= pestle and mortar				44= Refrigerator			
22= cart				45= Computer			

Who owns codes:	3=Household(all)	5=Head's mother	7= Spouse's father	10= Other joint (specify codes)
1=Head	4=Head's father	6= Spouse's mother	8= son	__
2=Spouse			9=Daughter	11= Other (specify)_____

SECTION B: Mango Production

4.1. a) How many years has the household head been producing mangoes? (Years) [____]

4.1. b) How many years has the spouse been producing mangoes? (Years) [_____]

4.2. a) Did the household head attend mango production training over the last 12 months [___] 1=Yes 0=NO

4.3. a) If YES, how many training sessions did the household head attended? [_____]

1=Between 1 and 5	2= 5 and 10
3 = 10 and20	4= over 20

4.4. b) From whom did the household head receive training? (List codes) [_____]

1- Government officer	**2**= ICIPE staff	**3**= Techno serve
4= HCDA	**5**= GIZ	**6**=Other (specify)

4.2. b) Did the spouse attend mango production training over the last 12 months [___] 1=YES 0=NO

4.3. b) If YES, how many training sessions did the spouse attended? [_____]

1=Between 1 and 5	2= 5 and 10
3 = 10 and20	4= over 20

4.4. b) From whom did the spouse receive training? (List codes) [_____]

1- Government officer	**2**= ICIPE staff	**3**= Techno serve
4= HCDA	**5**= GIZ	**6**=Other (specify)

4.5. a) Did the household head have contact with an extension agent on mango production? [___] 1=Yes 0=NO

4.6. a) If YES, how many times did the household head meet the extension officer in the last mango season? _____

4.5. b) Did the spouse have contact with an extension agent on mango production? [_____]

1=Yes 0=NO

4.6. b) If YES, how many times did the spouse meet the extension officer in the last mango season? _____

4.7 a. Is the household head a member of any mango growers' group [_____] 1=YES 0=NO

4.8. a. If **yes, w**hat is the name of the mango growers' group household head a member of? Household head [_____]

4.9 a. If yes, what are the functions of the mango growers' group that the household head is a member of? (List 2 major)

a) _____

b) _____

4.7. b) Is the spouse a member of any mango growers' group [_____] 1=YES 0=NO

4.8. b) if **yes, w**hat is the name of the mango growers' group spouse a member of ()? Household head [_____]

4.9. b) If yes, what are the functions of the mango growers' group that the spouse is a member of? (List 2 major)

a) _____

b) _____

4.10 a) Does the household head have access to credit for mango production activities? [___] 1= YES. 0= NO

4.11 a) If YES, how much credit did the household head receive in the last mango season (year)? [_____]

4.10. b) Does the spouse have access to credit for mango production activities? [___] 1= YES. 0= NO

4.11. b) If YES, how much credit did the spouse receive in the last mango season (year)? [_____]

4.12 Which mango varieties/cultivars you have in the orchard?

Variety	What is the number of mature trees (producing) on this parcel?	What is the number of young trees not in production on this parcel	Cropping system 1=Intercrop 2=pure stand	If intercrop what is the other enterprise(s)
Improved				

1. Apple				
2. Tommy atkins				
3. Ngowe				
4. Kent				
5. Van dyke				
6. Keitt				
7. Sensation				
8. Haden				
9. Sabine				
10)Other specify1				
11) Other specify2				
12) Other specify3				
13) **Local varieties1**				
14) **Local varieties2**				
15) **Local varieties3**				

4.13 a) Has the house hold head heard about fruit fly IPM control packages? [___] 1= YES. 0= NO.

4.14 a) If yes, from who did the household head first hear about it? (*codes*) [_____] and when _____year

1- Government Extension officer	**2**= ICIPE staff	**3**= Buyer
4= Other farmers	5=Agro chemical company)	6= Other (specify

4.13. b) Has the spouse heard about fruit fly IPM control packages? [_____] 1= YES. 0= NO

4.14 b) If yes, from who did the spouse you first hear about it? (*codes*) [_____] and when ____year

1- Government Extension officer	**2**= ICIPE staff	**3**= Buyer
4= Other farmers	5=Agro chemical company)	6= Other (specify

4.15 Did you apply pesticides on mango trees during the last mango season? [_____] 1= YES. 0= NO.

4.17 If **yes**, please fill in the details in the table below: (name of pesticides- Chris)

Pesticides name	No. of times applied	Amount used each time	Unit	Total amount used	Product price per unit	Total cost (Kshs)
a)						
b)						
c)						
d)						
e)						

Units (code d)

1=Kgs	5=Wheelbarrow	10=pickup	15=4 kgs carton	20=grams
2=50Kgs bag	6=gorogoro	11=bunches	16=20litres bucket	21=litre
3=90kgs bag	7=debe	12=crate	17=17kgs bucket	22=milliliter
4= numbers/pieces	8=ox-cart	13=120 kg bag	18=Lorry	23=Other(specify
	9=bale	14=6 kgs carton	19=Tones	

4.16 Provide the following information on other inputs that were applied on mango in the last season

Input	No. of times applied	Amount used each time	Unit	Total amount used	Product price per unit	Total cost (Kshs)
a)Own Organic matter/manure/ farmyard manure						
b)Purchased Organic matter/manure/ farmyard manure						
c)Fertilizers (list) below:						
c1)						
c2)						
c3)						
c4)						
d)Herbicides						
d1)						
d2)						
d3)						
d4)						
e)Electricity/fuel for irrigation						
f)Other inputs(specify)						

Units (code d)				
1=Kgs 2=50Kgs bag 3=90kgs bag 4= numbers/pieces	5=Wheelbarrow 6=gorogoro 7=debe 8=ox-cart 9=bale	10=pickup 11=bunches 12=crate 13=120 kg bag 14=6 kgs carton	15=4 kgs carton 16=20litres bucket 17=17kgs bucket 18=Lorry 19=Tones	20=grams 21=litre 22=milliliter 23=Other(specify

4.17 Provide the following information on labor costs for mango production in the last mango season (Please fill in the table below) (first five columns record both family and hired labour, the rest only hired labour)

Activity	Number of times?	No. of persons involved		No. of days each time	No. of hours per day	How many of those were hired laborers		Total cost paid (Kshs)
		Male	Female			Male	Female	
a)Digging up								
b)Weeding								
c)Irrigating								
d)Fertilizer application								
e)Manure application								
f)Pesticide application								
gHerbicide application								
h)Pruning of dead twigs								
i)Orchard sanitation								
j)Top working								
k)Harvesting								
l)Grading								
m)Transport to market								
n) other specify								

4.18 What is the cost of hiring casual laborer (Kshs/day)_____

4.19 Was a tractor, an ox-plough or hand plough hired **from the beginning of the season** for land preparation (ploughing and harrowing)**?** [_____] 0=No, 1=Yes

4.20 Please fill the following information for the total produce harvested during the last season for that particular mango variety

Varieties	**Total quantity sold**			**Total consumed at home**		**Total quantity damaged by fruit fly**		**Total quantity damaged by diseases**		**Total quantity produced(not in tab)**	
	Qty	**Unit**	**Price per unit**	**Qty**	**Unit**	**Qty**	**Unit**	**Qty**	**Unit**	**Qty**	**Unit**
Improved											
1. Apple											
2. Tommy atkins											
3. Ngowe											
4. Kent											
5. Van dyke											
6. Keitt											
7. Sensation											
8. Haden											
9. Sabine											
10) Other (specify1)											
11) Other (specify2)											
12) Other (specify3)											
Local varieties:											
13) **Local varieties1**											
14) **Local varieties2**											
15) **Local varieties3**											

Units (code d)

1=Kgs	5=Wheelbarrow	9=bale	13=120 kg bag	17=17kgs bucket	21=litre
2=50Kgs bag	6=gorogoro	10=pickup	14=6 kgs carton	18=Lorry	22=milliliter
3=90kgs bag	7=debe	11=bunches	15=4 kgs carton	19=Tones	23=Other(specify
4= numbers/pieces	8=ox-cart	12=crate	16=20litres bucket	20=grams	

4.21 Who make decisions on the following activities regarding mango production and harvesting (use table)

Activity	Decision	Who make the decision **(code (a**)
4.22a) Labour	1)How much labour to be hired	
	2)Distribution of labour among different plots	
4.22b)Inputs	1)Where to acquire inputs and	
	2) how much to purchase	
	3)How much to use in a particular mango plot	
4.22c) Training	1) Who to attend mango training and other related gatherings?	
4.22d) Credit	1) Where and when to take credit?	
	2) what to do with the credit	
4.22e) Group participation	1)who will be registered with mango growers group	
	2)who should attend growers group meetings	
4.22f) Market	1)marketing channel to sell produce	
	2)who to receive money from mango sales	

	3) how to use money received from mango sales	
4.22g)Planting mangoes	1)Whether to plant mangoes	
4.22 h) Land	1) To buy , sell or hire land for mango production	

Codes (a) 1=Head	2=Spouse 3=Household(all)	4=Head's father 5=Head's mother	6= Spouse's mother 7= Spouse's father	8=son 9=Daughter 10= Other joint (specify codes) 11= Other (specify)

4.22 What are the main constraints or challenges you experience in mango production?

1)……
2)……
3)……
4)……

4.23 In your opinion how is the mango production this **<u>last season</u>** compared to the **<u>previous season</u>**? (Code) [_____]

1=Much worse now	3=No change	5=Much better now
2=Little worse now	4=Little better now	

4.24 Is there a market for your mango produce? [_____] 1= YES 0= NO

4.25 If yes, where do you sell your mangoes (code) [_____]

1=Neighbours	3=Urban markets*(farmer takes Mangoes to markets further than Machakos town)*	5=Brokers
2=Export markets	4=Local markets*(farmer takes Mangoes to Machakos town)*	

4.28 How would you rate the market you have for your mango produce? [_____]

1=Very poor	2=fair	3=poor	4=Good	5=Very good

4.26 What are the main constraints or challenges you experience in mango marketing?

1)……
2)……
3)……
4)……

SECTION C: Gender Empowerment

5.1 Provide the following information regarding ownership of mango trees and distribution of income from Mango sales: ***(Use column B for ownership of trees. If different household members own particular type of mango tree variety, use Columns C and D. Ensure the type of mango variety given (or number of trees) are the same as those given in question 4.10)***

a. Mango Variety	b. Who owns the **plot** (**code a**)	c. Number of trees owned by a male household member	d. Number of trees owned by a Female household member	e. Who receive the money from mango sales (**code a**)	Management of income from mango sales		
Improved					f. % by Man	g.% by woman	h.%both
1. Apple							
2. Tommy atkins							
3. Ngowe							
4. Kent							
5. Van dyke							
6. Keitt							
7. Sensation							
8. Haden							

a. Mango Variety	b. Who owns the **plot** (**code a**)	c. Number of trees owned by a male household member	d. Number of trees owned by a Female household member	e. Who receive the money from mango sales (**code a**)	Management of income from mango sales		
Improved					f. % by Man	g.% by woman	h.%both
9. Sabine							
10)Other specify1							
11) Other specify2							
12) Other specify3							
Local varieties							
13) **Local varieties1**							
14) **Local varieties2**							
15) **Local varieties3**							

Code a					
1=Head **2**=Spouse	**3**=Household(all) **4**=Head's father	**5**=Head's mother **6**= Spouse's mother	**7**= Spouse's father **8**=Son	**9**= Daughter **10**= Other joint (specify codes)	**11**=Other (specify) _____

5.2 How is income from mango commonly spent in the households (use table below)?

	Item spent	**% of the mango income spent on this item**		**Item spent**	**% of the mango income spent on this item**
1	Food		5.	Entertainment	
2	Clothing		6.	Investment (specify)	
3	School fees		7.	Insurance (specify)	
4.	Health care		8.	Other expenses(specify)	

5.3.1 What is your opinion on the ease of access to information about mango production and marketing for the household head and the spouse?

	Household head				Spouse			
	No access	Difficult to access	Fair access	Easy access	No access	Difficult to access	Fair access	Easy access
Input Prices								
Output Prices								
Market availability								

5.3.2 How many female and male decision makers are in the household? Female [____] Male [___]

5.3.3 What percentage of total investment in mango production did the female spouse invest in Mango Production?

SECTION D: Household distribution of income, consumption and wealth

6.1 Household expenditure on school fees

6.1.1 Are there any household members that were attending school in the last 12 months? [__] 1=Yes 0=No

6.1.2 If **YES**, what was the TOTAL SCHOOL FEES paid in the last 12 months (or approximate per year)?Ksh____

6.2 Household expenditure on food

6.2.1 Approximate how much money did you use on food in the last 12 months (year estimate)? Ksh_____ (*NB: if respondent cannot recall annual expenditure, ask for monthly expenditure, then multiply by 12*)

6.3 Household Expenditure on training

6.3.1 Are there any household members who attended **TRAINING** during the last 12 months? [__] 1=Yes 0=No

6.3.2 If **YES**, what kind of training? _____

6.3.3 If **YES**, where was the training undertaken? _____

6.3.4 What was the total amount paid in those 12 months? Ksh _____

6.4 Household savings

6.4.1 Was any member of the household **SAVING** during the last 12 months? [__] 1=Yes 0=No

6.4.2 If **YES,** how many household members were saving during that period? _____

6.4.3 If **YES**, where did the member/s save? (code)_____ 1

1)=Commercial Bank	3)SMEs	5) mobile banking
2) ROSCA groups	4) SACCOs	6)Other specify_____

6.4.4 What was the **average monthly** household **savings** (in a **normal month)**? Kshs_____

6.5 Expenditure on entertainment

6.5.1 Does any household member spend on **entertainment and relaxation**? [__] 1=Yes 0=No

6.5.2 If YES, what is the total **average monthly** expenditure on **entertainment and relaxation**? (E.g. beer, holidays etc.) Ksh._____

6.6 What is the **average annual** expenditure on **clothing**? Kshs_____

6.7 Expenditure on health

6.7.1 Did any of the household member fall sick in the last 12 months? [__] 1=Yes 0=No

6.7.2 If **YES,** how many household members fell sick during this period? _____

6.7.3 What were the annual medicare expenses during this period? Kshs. _____

6.7.4 Do you think the last 12 months was a normal year? [__] 1=Yes 0=No

6.7.5 If **No**, what are the **average annual Medicare expenses** in a normal year? **_____**

6.8 Expenditure on energy and fuel

6.8.1 What is the **monthly** expenditure on **energy for lighting?** Ksh**_____**

6.8.2 What is the average monthly expenditure on fuel/ energy for cooking? Ksh**_____**

6.8.3 What is the monthly expenditure on **fuel/ energy for other uses**?(SPECIFY) Ksh**_____**

6.9 Household's investments

6.9.1 Did any household member **INVEST** in the last 12 months? [__] 1=Yes 0=No

6.9.2 If **YES**, what was the annual investment for the following:

1. Land **(Ksh.)**_____	2. Shares **(Ksh)**_____
3. Business (capital) **Ksh**._____	4. Other investments (**specify**)…… ……. **(Ksh)**_____

6.9.3 Do you think the last 12 months was a normal year? [__] 1=Yes 0=No

6.9.4 If **No**, what is the **annual household expenditure on investment** in a normal year? Ksh_____

6.10 Expenditure on donations

6.10.1 Does any member of the household contribute donations? [__] 1=Yes 0=No

6.10.2 If **YES**, what was the total household expenditure on donations in the last 12 months? Ksh_____

6.11 Did you purchase any major assets such as n farm working implements electronic, the last 12 months? [__] 1=Yes 0=No

6.12 If Yes, state the asset you bought and the amount spent: Item_____ Ksh _____

6.13 Expenditure on furniture

6.13.1 Was there any **FURNITURE** bought in the household during the last 12 months? [__] 1=Yes 0=No

6.13.2 If **YES,** what was bought? _____, _____,_____

6.13.3 What was the total expenditure on furniture for the 12 months' period? **Ksh. _____**

6.13.4 Do you think the last 12 months was a normal period? [__] 1=Yes 0=No

6.13.5 If **No,** what is the **annual household expenditure on furniture** in a normal year? **Ksh._____**

6.14 Expenditure on transport

6.14.1 Does any member of the household spend money on **transport** to work or to perform other household activities? [__] 1=Yes 0=No

6.14.2 If **YES,** what is the **average monthly** expenditure on transport? **_____**

6.15 Expenditure on insurance

6.15.1 Does any member of the household spend money on **insurance?** [__] 1=Yes 0=No

6.15.2 If **YES,** what kind of insurance? (code)_____

1=Private health insurance	3=Crop insurance (specify crop)____	5=Other (specify)_____
2=Public health insurance (NHIF)	4=Livestock insurance	

6.15.3 What was the **annual expenditure on insurance** in the last 12 months? Ksh_____

6.16 Other household expenses

6.16.1 Are there any other expenses in the household**?** [__] 1=Yes 0=No

6.16.2 If **YES,** specify? _____

6.16.3 What is the **Monthly** household expenditure on **other specify?** Ksh_____

6.17 What is the share of food consumed at home is obtained from own farm? (%)[_____]

6.18 Rank the different sources of income to the household and provide **ANNUAL** estimate by source. **For ranking: 1=Main source of income, 2=2nd source 3=3rd source etc**

Source of income	**Rank**	Annual estimate (Kshs)	Income managed by both adult male & female (%)	Income managed by adult male (%)	Income managed by adult females (%)
Income from mango					
Income from other horticultural crops (fruits & vegetables)					
Income from other farm crops					
Income from livestock sales and livestock products (e.g. milk)					
Income from other farm activities (e.g. brew making, charcoal burning etc), other specify……					
Income from wages/ salaries/ non-farm, pension and (specify profession)_____					
Income from business activities					
Income from remittances/ gifts from absent family members and other external income					
Income from rental houses					
Income from other sources, specify:					
Note: if the respondent cannot estimate annual income, ask for monthly income then multiply by 12 months					

SECTION E: FOOD SECURITY

7.1 **Dietary diversity indicators (30 days' recall):** Please provide the following information about all the different foods that you have eaten in the last **30 days**. Tell us whether you ate the following foods **(The respondent of this question should be the person who is responsible for food preparation or another adult who was present and ate in the household during the 30 days of recall)**

Food item	**Frequency (codes)**	**Food item**	**Frequency (code)**
Cereals		**Fruits**	
1=Maize		21=Bananas	
2=Rice		22=Oranges	
3=Millet		23=Pawpaws	
4=Sorghum		24=Mangoes	
5=Bread /Chapati		25=Pineapple	
6=Other cereals (specify)		26=Lemons	
Roots and Tubers		27=Avocado	
7=Irish potatoes		43**=** Other fruits	
8=Sweet potatoes		Meat	
9= Cassava		28=Beef	
10=Ground nuts		29=Goat /sheep	
11=Other tubers		30=Chicken	
Vegetables		31=Fish (any)	
12= Sukuma wiki		32=Other sea food	
13= French beans		33= Other meat(specify)	
14=Spinach		**Milk products**	
15=Tomatoes		34=Cow milk	
16=Onions		35=Goat milk	
17=Carrots		36=Butter	
18=Okra		37=Other milk products	
19=Other vegetables		**Other items**	
20=African indigenous vegetables		38=Beans	
		39=Eggs	
		40=Edible oils/saturated fats	
		41=Sugar	
		42=Honey	
		43=other food types	
Food intake frequency codes			
1= 0 days in the last one month **2**=1 to 3 days in the last month;	**3**=4 to 15 days in the last one month (once or twice in a week; **4**=16 to 30 days in the last days (at least every day)		

7.2 Calorie intake (7 days recall)

Code	**Group**	**Food Item**	**Consumption in the household over the last 1 week**		**Consumption in the household over last 24 hours**
			Quantity	**Unit**	**0=no; 1=yes**
1	Cereals	Maize			
		Millet			
		Sorghum			
		Rice			
		Wheat (and wheat flour)			
		Other:			
2		Orange fleshed sweet potatoes			

	Tubers and starchy food, high in vitamin A, yellow or orange in colour	Other:			
3	Tubers II, low in vitamin A, usually white in colour	Sweet potatoes			
		Irish potatoes			
		Cassava			
		Arrow roots			
		Yams			
4	Vegetables high in vitamin A, dark green or orange	Carrots			
		Kale			
		Other green leafy vegetables including AIVs			
		Pumpkin leaves/ pumpkin fruits			
5	Vegetable II, low in Vitamin A	Onion			
		Cabbage			
		Okra			
		Tomato			
6	Fruits I (high in vitamin A)	Orange/Citrus			
		Mango			
		Papaya			
7	Fruits II(low in vit A)	Avocado			
		Bananas			
		Passion fruit			
		Pineapples			
8	Meat				
9	Eggs				
10	Fish				
11	Beans	Common Beans			
		Cowpeas			
		Soya			
		Groundnuts			
		Peas(field, pigeon)			
		Green grams			
		Faba beans,			
		Dolicholis(lablab/njahi)			
12	Dairy products (milk, yoghurt….)	Milk			
		Cheese			
13	Fat and Oils	Oil			
		Butter			
		Homemade butter/ ghee			
14	Sugar and Honey				
15	Other (condiments, coffee, tea)	0=no; 1=yes			

Units (code d)

1=Kgs	5=Wheelbar	10=pickup	15=4 kgs carton	20=grams
2=50Kgs bag	row	11=bunches	16=20litres bucket	21=litre
3=90kgs bag	6=gorogoro	12=crate	17=17kgs bucket	22=milliliter
4= numbers/pieces	7=debe	13=120 kg bag	18=Lorry	23=Other(specify
	8=ox-cart	14=6 kgs carton	19=Tones	

	9=bale			

7.3 Household food shortage coping strategies: Please tell us if you applied the following food shortage copping strategies within the household in the last **seven days** (*codes; 1=Never; 2=Rarely (may be once); 3=From time to time (2-4 times); 4=Often (>5 times))*

Strategy	Code
a. Consumed less of the preferred food?	
b. Reduced the quantity of food serve to men in the household?	
c. Reduced the quantity of food serve to women in the household?	
d. Reduced own food consumption?	
e. Reduced the quantity of food served to children in the household?	
f. Some or all members skipped some meals during the seven days?	
g. Some or all members skipped meals for a whole day?	

7.4 Household hunger scale: Please tell us about the following food-related concerns about your household for the past **30 days**

Question	***Code***
1. Did you lack any food to eat of any kind in your house because of lack of resources to get food? *(0=No (skip 2); 1=Yes)*	
2. How often did this happen? (***code a)***	
3. Did you or any household member go to sleep at night hungry because there was not enough food? *(0=No(skip 4); 1=Yes)*	
4. How often did this happen? (**code (a)**	
5. Did you or any household member go a whole day and night without eating anything at all because there was not enough food? *(0=No(skip 6); 1=Yes)*	
6. How often did this happen? (**code (a)**	
***Codes (a); 1**=Never; **2**=Rarely (may be once); **3**=From time to time (2-4 times); **4**=Often (>5 times)*	

7.5 Maize Stocks

7.5.1 How many 90 kg bags of **maize** did you have **in stock** from **your own production** just **before** you began **harvesting** your 2014/ 2015 main season maize crop (Jan-March 2015) _____ (bags)

7.5.2 How many 90 kg bags of **maize** do you have **in stock** right **now from the last harvest**? _____ (bags) **(record "=0" if the household did not plant maize.)**

7.5.3 IF *question 7.5.2=0* (no maize stocks), in which **month** and **year** did you run out of maize stocks from your own production? _____ (month) _____(Year) (2013,2014,2015, other years(specify)____

1=January 2=February	3=March 4=April	5=May 6=June	7=July 8=Aug	9=September 10=October	11=November 12=December
13 =2013	14=2014	15=2015			

7.6.4 Did you receive relief food in the last 12 months?

7.6.5 If Yes, how many months _____

END

(Please remember to thank the farmer genuinely)

0.11 Household location GPS coordinates

longitude_____

Latitude_____

Altitude_____

The enumerator to answer section 8 below privately immediately after the interview

8.1 In your opinion, how did you establish rapport with this respondent /_____/

1=with ease	**2**=with some persuasion	**3**=with difficulty	**4**=it was impossible

8.2 Overall, how did the respondent give answers to the questions /_____/

1=willingly	**2**=reluctantly	**3**=with persuasion	**4**=it was hard to get answers

8.3 How often do you think the respondent was telling the truth/_____/?

1=rarely	**2**=sometimes	**3**=most of the times	**4**=all the time

I (the enumerator) 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/_____/End time:

Appendix 2: Test for multicollinearity

Variable	VIF	1/VIF
IPM	2.16	0.46221
TIME (1=Follow-up survey)	1.95	0.5123
Female major economic activity (1=off-farm)	1.94	0.515193
Husband major economic activity (1=off-farm)	1.92	0.520201
Female spouse level of education	1.85	0.53921
Age of female spouse	1.62	0.618157
Husband's level of education	1.62	0.618792
Log annual household income	1.5	0.667378
Female number contacts with extension service providers	1.44	0.693507
Household size	1.44	0.694956
Household type	1.24	0.804482
Farm under mango production (acres)	1.24	0.805627
Number of male decision makers in the household	1.22	0.818164
Proportion of female spouse investment to mango production	1.19	0.837394
Number of female decision makers in the household	1.19	0.840142
Female spouse number of years growing mangoes	1.18	0.844442
Female membership to a mango production or marketing group	1.18	0.847006
Female spouse access to credit	1.06	0.939672
Mean VIF	1.5	