THE IMPACT OF CO-OPERATIVE MEMBERSHIP ON SMALLHOLDER RUBBER FARMERS' CHOICE OF SELLING OUTLETS AND INCOME IN LIBERIA

BY

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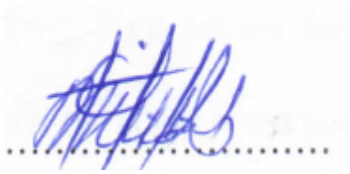
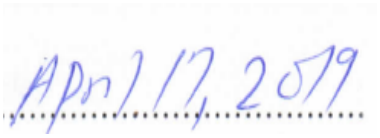
DECLARATION

I declared that this thesis is my original work and has not been submitted for a degree in any other University.

Signature:  Date: 

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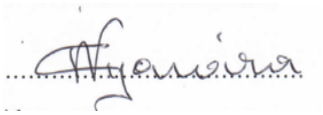
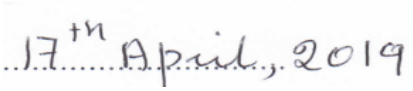
Signature:  Date: 

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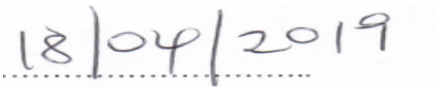
Signature:  Date: 

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DEDICATION

This thesis is dedicated to my late senior brother Samuel B. Mulbah and my beloved parents, Fred B. Mulbah and Lorpu K. Mulbah.

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LIST OF ABBREVIATION AND ACRONYMS

AfDB	African Development Bank
ATE	Average Treatment Effect
ATT	Average Treatment on the Treated
CAADP	Comprehensive Africa Agricultural Development Program
CBL	Central Bank of Liberia
CDA	Co-operative Development Agency
CIA	Conditional Independence Assumption
COPAC	Committee for the Promotion and Advancement of Co-operative
CSA	Common Support Assumption
FAO	Food and Agriculture Organization
GDP	Gross Domestic Product
GNI	Gross National Income
HDI	Human Development Index
ICA	International Co-operative Alliance
ICT	Information Communication Technology
IFPRI	International Food Policy and Research Institute
ILO	International Labor Organization
KBM	Kernel-Based Matching
MHH	Male-headed household
NNM	Nearest Neighbor Matching
NR	Natural Rubber
OLS	Ordinary Least square
PSM	Propensity Score Matching
RM	Radius Matching
SDG	Sustainable Development Goal
SSA	Sub-Saharan Africa
STCP	Sustainable Tree Crop Program
STCRSP	Smallholder Tree Crop Revitalization Support Program.

Std.Error	Standard Error
UNDP	United Nation Development Programme
UNMIL	United Nation Mission in Liberia
USA	United States of America
USAID	United States Agency for International Development
USD	United States Dollars
USDA	United States Department of Agriculture
VIF	Variance Inflation Factor

ABSTRACT

Rural households in Liberia depend on the production and sales of natural rubber for livelihood. It is the highest contributor to GDP and foreign exchange earner in the agricultural sector. Despite the importance of natural rubber to the Liberian economy, small and medium farmers that dominate the sector are faced with production and marketing constraints, particularly poor agronomic practices, lack of training in latex tapping and processing and limited selling outlets. Little attention has been given to natural rubber and the farmer co-operative handling it. This study determined the impact of co-operative membership on the choice of selling outlets and farm income in Liberia. Cross-sectional data was collected from 200 smallholder NR farmers stratified by co-operative and non-co-operative members in Gibi and Kakata districts using a structured questionnaire. Descriptive statistics were used to compare the socioeconomic, farm, and institutional characteristics of co-operative farmers with non-co-operative farmers. A logit model was used to determine the effect of co-operative on the choice of selling outlets used. The results showed that transaction costs variables specified as ownership of transport means, distance to the nearest local market, access to market information and time taken to find buyers) and socioeconomic characteristics (household size and access to extension service) significantly influenced household choice of selling outlets. Propensity score matching (PSM) was employed to determine the impact of the natural rubber co-operative on farm income. This required estimating the propensity scores for farmers' participating in the natural rubber co-operative using a logit model.

The results of the logit model indicate that socioeconomic characteristics (age, household size), institutional characteristics (training, access to production and market information, payment delays), and farm characteristics (farm size, disease type, and post-harvest losses)

significantly influenced household's participation decisions in the natural rubber co-operative. Using the Nearest Neighbor Matching, Radius Matching, and Kernel-Based Matching, the average treatment effect which is the difference between natural rubber co-operative farmers and non-co-operative farmers were found to be US$ 109, 138 and 138 respectively. This indicates that the natural rubber co-operative had a significant positive impact on members' income. The study recommends the establishment of market support services in the form of market information systems, accessible markets, and transportation means, will help provide up to date and reliable information on potential trading partners and prices. This will reduce the fixed transaction costs of accessing information and markets. Further, the study recommends the creation of awareness among non-co-operative farmers about the importance of collective action. This can be done through the Co-operative Development Agency of Liberia, government extension officers, and civil society organizations.

CHAPTER 1: INTRODUCTION

1.1 Background Information

Natural rubber is an important tree crop that is used in the manufacturing of a wide range of products. Natural rubber (Hevea brasilienesis), belonging to the family Euphorbiaceae is one of the vital cash crops that has sustained most of the economies in some developing countries, particularly Liberia, Ivory Coast and Laos in terms of job creation, better livelihoods, foreign exchange earnings and improved food and nutrition security. More than 20 million households globally, mostly smallholders depend on natural rubber (NR) cultivation as a primary source of income (Khin *et al*., 2008; Manivong and Cramb, 2008).

Liberia has one of the lowest GNI per capita of US$ 667 and ranked 181 out of 189 countries in the United Nations Development Programme (UNDP) 2018 Human Development Index report. Liberia has a low human capital index score of 0.32 compared to neighboring countries Ivory Coast and Sierra Leone that has a score of 0.35, respectively (UNDP, 2018; World Bank, 2019). About 54 percent of the population lives below the poverty line of US$ 1.90 per day, and the high level of poverty is in the rural farming areas where it is at 77 percent (Outlook, 2017; World Bank, 2018). The country depends on aid for budget support. According to the World Bank (2017), Liberia received the highest official development assistance among developing countries in Sub-Saharan Africa in 2016

The main sectors of the Liberian economy are, service, agriculture, fisheries, forestry, mining, and the manufacturing sector, but like many other developing countries with high poverty rate, the agriculture sector has a high impact on the economy. The agriculture sector accounted for 36 percent of the GDP in 2016 (Tyson, 2017). The sector is the largest source of employment and food supply in the Liberian economy and is responsible for 60 percent of the country's total

export revenue. Agriculture is a primary source of livelihood for 67 percent of the population (Republic of Liberia, 2014). The sector is dominated by smallholder farmers engaged in subsistence farming as well as cash crops like NR, palm oil, and cocoa bean.

Like many other SSA countries (Ivory Coast, Nigeria, and Cameroon), Liberia is highly dependent on NR production and commercialization for economic growth. NR is the most important cash crop in Liberia, it ranks second in value of export (after Iron ore) and is a major source of foreign exchange earnings for the government and rural livelihoods in Liberia (Republic of Liberia, 2014a). The crop has been the highest contributor to GDP from the agricultural sector since the establishment of the Firestone natural rubber plantation in 1926. For instance, from 2003-2010, it accounted for about 85 percent of the total export earnings (Tyson, 2017). In addition, NR accounted for 21.6 percent and 20 percent of total export earnings in 2015 and 2016, respectively (Republic of Liberia, 2017).

According to Daly *et al*. (2017), Liberia was ranked as the eighth globally, among the countries that export NR. In 2005, NR from Liberia accounted for two percent of total world exports. In 2015, it maintained the same rank but accounted for only one percent of total world exports. Moreover, it was ranked 14th among the world highest producers in 2015 and second in Africa. It is estimated that more than 20,000 people in Liberia are employed by multinational NR farms, while more than 60,000 smallholders depend on NR for livelihood (Warren-Thomas, 2011). The sector is dominated by small and medium farms and covers more than 5 percent of the agricultural land (Republic of Liberia, 2010).

Despite the contributions of NR to export earnings and reduction of rural poverty, the sector is still underdeveloped, and poverty rates are still high among NR farmers. About 58 percent

of the rural NR farmers suffer extreme poverty because of lack of access to support services and high transaction costs in accessing input and output markets (World Bank, 2018). For example, from 2007-2008, there was a 36,000 metric tons (Mt) reduction in the quantity of NR produced due to poor agronomic practices, limited access to improved NR varieties (FAOSTAT, 2008). There limited training opportunities on processing NR and few marketing outlets, resulting in poor quality latex, which fetches low price reducing the income of farmers. The underdevelopment and low performance of the NR sector are probably attributed to the lack of support services for smallholder farmers who dominate the sector. These farmers face serious constraints in accessing services and inputs such as extension services, training, finance, technology for production and processing facilities. Moreover, the distant to access markets to sell enough bulk, regular production, and acceptable quality is far (Simelane, 2011; USAID, 2016).

In order to improve the NR sector and reduce some of the constraints faced by smallholder, the donor community and civil society organizations have attempted to introduce co-operatives, hoping that they will facilitate farmers to improve their livelihoods by encouraging collective entrepreneur development, which generates productive employment and enhances rural development (Ampaire *et al*., 2013; Idris and Abdullah, 2011). It is hoped that farmers organized in co-operatives are more likely to reduce production and marketing costs, influence government and policymakers to pass registrations that better their welfare and counter the possible negative influence of large-scale growers. Farmers' desire to reap such benefits has led to the establishment of co-operatives in some of the major NR producing regions in the country.

1.2 Statement of the research problem

About 10.3 percent of the farming households in Liberia grow NR. NR farming is the largest employer in the agricultural sector (Republic of Liberia, 2017b). The Government of Liberia has initiated development goals to be a middle-income country by 2030 by increasing the output of key agricultural commodities through empowering smallholder farmers. NR being the country most important cash crop has been given first priority. However, the production of NR continues to decrease, which is generally attributed to the constraints faced by smallholder NR farmers. For instance, the output reduced from 76, 167 Mt in 2015 to 73,710 Mt in 2016 (FAOSTAT, 2016), representing a decreased of about 3.23 percent. Several attempts, such as the sustainable tree crop program (STCP) and Smallholder Tree Crop Revitalization Support Project (STCRSP) have been carried out to improve NR production and marketing of smallholder farmers (Republic of Liberia, 2006; World Bank, 2013). However, these projects have not been very effective in increasing output and linking farmers to high value markets.

The NR produced has very poor quality (cup lump) and low market value because of the processing method and the lack of training in latex coagulation. Poor quality and unprocessed NR is usually paid at a lower price up to about 33% (Southavilay, 2016). Due to the inability of the farmers to process their latex into acceptable grades on the world market and the moratorium placed by the government on the exportation of unprocessed NR, they are left with no other alternatives but to sell to large-scale processors and itinerant traders.

Despite this and a century of NR cultivation in Liberia, smallholder NR farmers are still faced with constraints such as lack of access to fair markets and training in post-harvest handling, and agronomic practices. This has negatively affected farmers productivity and reduced their

incentives, resulting in farmers leaving the sector. Though there is a history of failure of co-operatives in Africa caused by poor management and lack of members' commitment, some studies have revealed the potential impact of co-operatives in linking farmers to both input and output markets. Studies by Manivong (2007) and Vorlaufer *et al.* (2012) found that agricultural co-operatives offered solutions to the constraints faced by smallholder farmers. The authors noted that NR and coffee co-operatives enabled smallholder farmers in Malaysia and Kenya, respectively to overcome production and marketing constraints by providing access to extension services, credit, access to quality input, and reduction of transaction costs in accessing improved markets. In Liberia, the Co-operative Development Agency (CDA) has encouraged farmers, especially those in the rural areas to form farmer organizations. This has been done with the anticipation that the NR co-operatives will produce similar results like Malaysia and Kenya that have been successful in the development of the smallholder sector resulting in increased productivity and access to high-value markets.

There are limited empirical studies on the success of co-operatives in improving incomes of NR farmers. Previous studies have mainly focused on forced labor on the plantation, effect of climate change on NR production and the determinant of farmer participation in agricultural production co-operatives (Kolleh, 2016; Topor, 2010; Warren-Thomas, 2011). Therefore, this study attempts to determine the impact of co-operatives on farmers income in Liberia and their choice of selling outlets given that this gap in knowledge has kept policymakers from looking at NR co-operatives as a means of rural poverty reduction.

1.3 Study objectives and hypotheses

The overall objective of this study is to determine the impact of co-operative membership on the choice of selling outlets and farm income in Liberia, Margibi County.

The Specific Objectives were to:

1. To compare the socioeconomic, farm, and institutional characteristics of co-operative and non-co-operative farmers.
2. To determine the effect of co-operative membership, institutional and socioeconomic factors on the choice of selling outlets used by smallholder NR farmers.
3. To evaluate the impact of participation in the NR co-operative on farm income.

In achieving the objectives above, the following hypotheses were tested

1. There is no difference between the socioeconomic (age, experience, household size), farm and institutional characteristics (distance, access to extension, and NR disease experienced) of co-operative and non-co-operative farmers.
2. Co-operative membership does not influence the choice of selling outlets used by smallholder natural rubber farmers.
3. There is no difference between the income of co-operative and non-co-operative farmers.

1.4 Justification of the study

The effect of co-operative membership and other socioeconomic factors on the choice of selling outlets used provides insight that will inform the central and county Government or non-governmental organizations to know the kind of support needed to promote the selling of NR in the county and Liberia as a whole. Access to market information and information about distance to the nearest market will help to address pillar two of Liberia Agenda for Transformation which seeks to increase smallholder access to markets through the provision of information on potential buyers and prices. Furthermore, the results will inform countries in

Africa to know the kind of support services in the form of access to extension services, road infrastructure and setting up selling outlets to reduce the distance and high transportation cost from farm to market to improve the selling of farmers in SSA. This conforms to pillar two of CAADP, which is to improve rural infrastructures, especially roads and markets facilities for both input and output markets to stimulate agricultural production and trade.

The study will inform the Government of Liberia and policymakers about important factors that influence farmers' decision to participate in NR co-operatives and the impact of participation on farmers income. These factors will help Government design policies or programs based on empirical findings to increase farmers' participation in the NR co-operatives. Moreover, this study provides the Government of Liberia with insights on the kind of support services in the form of access to extension, training, and agronomic practices needed for the smooth operation of co-operatives. This will help increase the income of farmers.

The results will help the Government of Liberia in achieving Liberia Agenda for Transformation, whose objective is to make Liberia a middle-income country by 2030, by increasing agricultural production and access to markets through farmer groups that will lead to improved income. Moreover, it will help the Liberian Government in achieving Sustainable Development Goal 8 (SDG 8) focusing on "sustainable economic growth and full productive employment."

CHAPTER 2: LITERATURE REVIEW

2.1 History of natural rubber production in Liberia

Natural rubber is an indigenous tree crop from the Amazon basin, South America and is used to manufacture a wide range of NR based products (Khin and Thambiah, 2014; Verheye, 2010) It is grown in fertilize soils with loamy and sandy clay texture, in areas with temperatures of 25 to 28°C and an annual rainfall of 2000 mm or more (Sethuraj and Mathew, 1992). Southeast Asia, Africa, and Latin America produce 92, 6 and, 2 percent of the global rubber, respectively (Venkatachalam *et al.,* 2013). The crop provides raw material to over 35,000 different products such as medical gloves, automobile, and aircraft tires (George and Chandrashekar, 2014; Goswami and Challa, 2007).

Natural rubber was introduced in Liberia by the South Americans in the 1900s as a smallholder crop (UNMIL, 2006). The first NR plantation in Liberia was established in 1907 by a British company called the Rubber Syndicate. However, increased manufacturing of vehicles resulted in high demand for tires from the United States of America population (Ghoshal, 1982). To meet the increased demand, the United States (U.S) Government encouraged investment in NR production and allocated funds and identified suitable land for its production. A team of NR experts in 1923 was dispatched to Latin America and other parts of the world to find a site to grow NR under the United States of America control. In their search, Liberia was selected because of the soil, climate, and closeness to New York. (Ghoshal, 1982; Mitchell, 1953). In 1926, the United States of America Government through the Firestone Natural Rubber Company signed a 99 years lease agreement with the Government of Liberia for 1,000,000 acres (Ghoshal, 1982) at a rent of 6 cents per acre. Firestone provided extension services to farmers and distributed bud-graft rubber, and this contributed to the adoption of the crop and

growth of the sector (Sawyer *et al*., 1964). The agreement was amended in 2008 and another 36 years were added (Kaul and Heuty, 2008).

2.1.1 Planting material

Natural rubber seeds were traditionally obtained from under the NR trees planted in the field directly by farmers, but currently, seedlings are raised in nurseries for transplanting into the field as a seedling or rootstock (Williams, 1975). There are three methods used in planting NR, seedling, budded stumps, and clonal seedling. Plants propagated through seedling method produce low latex compared to those from budded stumps and clonal seedlings. Clonal seedling is mainly used by large scale farmers like Firestone Natural Rubber Company (Manivong, 2007). In Liberia, smallholder farmers use seedling and budded stumps. Budded stump is a form of bud grafting that is done with NR in order for the tree to produce more latex. Seedlings are generally obtained from a farmer farm, and there is no direct cost except the time spent collecting them. Such seedlings have a poor quality, which translates into low yields. Seedling requires less input and capital investment compared to budded stumps and clonal seedling (Menz *et al*., 1999; Nayanakantha and Seneviratne, 2009).

2.1.2 Production trends in Liberia

Production is measured as the total volume of NR produce in Liberia in a year. Production has been experiencing a decline since 2009 (Figure 2). Figure two shows that the high production from 2006-2008 is mainly attributed to donors assistance toward smallholder farmers in the form of extension services for production, pesticides, and the favorable weather condition. The low production from 2009-2016 may be attributed to the lack of training such as training in latex tapping, disease management, post-harvest losses in the form of contamination of latex

by plant materials, lack of improved planting materials and the conversion of NR farms to other enterprises like oil palm (Abdulla and Arshad, 2017).

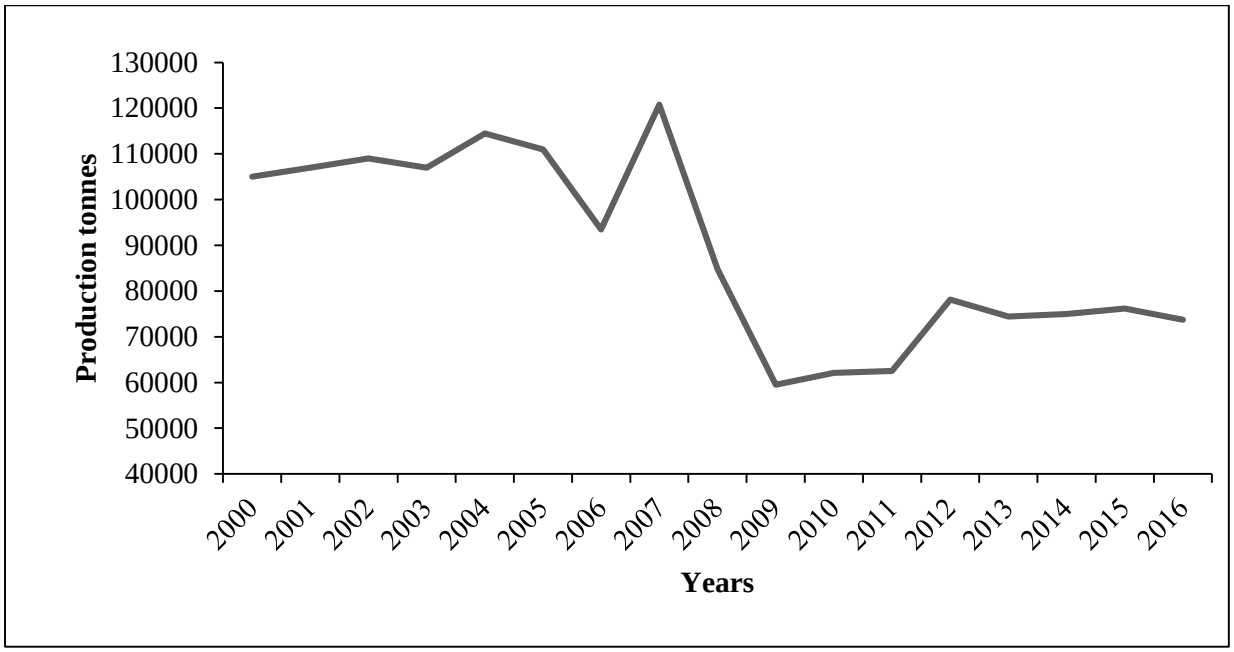


Figure 2. 1: Trends in Production of natural rubber in Liberia (2000 -2016)

Source: FAOSTAT (2016).

2.1.3 Constraints in rubber production by smallholder farmers

The constraints in rubber production are categorized as production and marketing constraints. The major constraints affecting smallholder farmers are lack of access to training in the production of NR, tapping and processing of NR latex, shortage of skilled tappers and high cost of labor, long gestation period, and lack of information about improved planting materials such as budded stump (Zaw and Myint 2016). The gestation period of natural is seven years; throughout this period, the farmer earns no income from the tree. NR is usually tapped after seven years of planting or when the circumference of the tree reaches 45 cm. Due to the long gestation period and the urgent need for cash, smallholder farmers mostly tapped before the mentioned circumference and years. Premature tapping reduces the total latex production during the lifespan of the tree (Manivong, 2007). Additionally, the farmers lack rain guards to use during the rainy season for latex tapping, and absence of credit.

NR diseases are a major hindrance in the production of latex. The disease affects the quantity of latex yield. NR disease varies from one country to another (Liyanage 1985;Narayanan and Mydin, 2012). The most common diseases found in Liberia are panel, stem, and root diseases. Panel disease prevents tapping and hinders back regeneration; stem disease leads to severe damage of the stem while the root disease damage the root of the tree and prevents it from growing (Lieberei, 2007; Nandris *et al*., 1987; Wastie, 1975).

2.1.4 Marketing constraint by smallholder rubber farmers

Natural rubber latex obtains from the farm or plantation is called fresh latex or field latex. Latex harvested is white and similar in appearance to dairy milk. It is bulky because 55-60 percent of the weight is water. It takes eight hours to coagulate when sulfuric acid is not added, during this period, contamination by impurities and microorganism decrease the quality of the latex (Jayanthy and Sankaranarayanan, 2005; Nga, 2008).

The bulky nature of NR and long distances to the markets lead to high transportation cost in accessing markets. This limits access to output markets and reduces the transmission of key market information. Lack and out-of-date market information about buyers, prices, and selling outlets have an impact on where smallholder farmers sell their NR. These attributes of NR and the lack of training for buddings to increase output, latex tapping, and processing to acceptable grades on the world market restrict the markets for NR at farm-gate (Nga , 2008; Makhura, 2001).

The international market determines the price of NR. Farmers are offered low prices because of the lack of information on prices, where to sell their NR, low bargaining power, and the quality of NR latex. Farmers with low quantities of NR do not have the financial means of

accessing distant markets for better prices sell at the farm gate. While those who own transport means and selling in group access distant market outlets like processors for better prices (Nhoybouakong, *et al*., 2009; Southavilay, 2016). Natural rubber is different from other commercial crops in that frequency of harvesting and transaction is high. In Asia, some farmers tap their NR three times a week to reduce the labor cost associated with tapping. However, in Liberia, farmers tap daily because of the urgent need of cash for subsistence. This means the farmers need a ready market for the sales of their latex (Zaw and Myint, 2016)

2.2 Definition of Agricultural Co-operative

According to the ILO-ICA, (2015), agricultural co-operative is an autonomous association of people united voluntarily to meet their economic and social needs through an agricultural enterprise such as NR that is owned and democratically controlled by the members. The donor and non-governmental organizations have mostly made the formation of co-operatives a prerequisite for receiving inputs and training. Agricultural co-operative attracts funds since donors or non-government organizations prefer to work in areas where farmer are organized (Chambo, 2009; James and Madaki, 2014). For example, in Kenya, the Mmadinare dairy co-operative society benefited immensely from the continued funding of the African Development Fund (Seleke and Lekorwe, 2010).

2.3 Contribution of agricultural co-operatives

Agricultural co-operative is view as one of the means through which the Sustainable Development Goals (SDGs) can be achieved, which aimed to end hunger by 2030 and double agricultural productivity and income of smallholder farmers (Schwettmann, 2014). For example, increase agriculture productivity, which is one of the key targets of goal two can be achieved through co-operatives. Co-operatives enable farmers to adopt new technology, which

increases productivity through efficient allocation of resources and also minimize costs by collective production and marketing.

2.3.1 Increasing agricultural productivity

Productivity is measured as the quantity of NR produce for a given set of inputs used (Mozumdar, 2012). Co-operative increase productivity through the provision of inputs and services provided to smallholder farmers. Accessing inputs in rural areas is difficult even if a farmer has the cash to purchase and transportation cost is high. Co-operatives carry on bulk purchase of inputs. This reduces transportation costs and brings about economies of scale. Timely availability and application of inputs increase productivity. For example, Simelane (2011) noted that dairy co-operatives in Swaziland collectively purchased and timely provided inputs to members that brought about economies of scale and increased in milk production.

Co-operatives provide extension services and training in post-harvest losses and good agronomic practices such as curtailing of farm diseases. The training brings about capacity building and human capital development, making farmers more competitive. The extension services provided by the co-operative help farmers to adopt new technology such as improved variety, which increase farmers' productivity. For instance, Abebaw and Haile (2013) found that co-operative membership had a positive impact on fertilizer adoption in Ethiopia.

2.3.2 Connecting farmers to markets

Agricultural co-operative played a vital role in social networking and opening up new market opportunities for smallholder farmers by satisfying stringent production and marketing requirements such as selling in bulk, and value-addition to increase smallholder farmers entry

into improved markets to receive a better price and become more competitive in the global supply chain (Markelova *et al.*, 2009). It enables members to carry on activities that, if undertaken individually, will require high transaction costs such as time spent looking for commercial vehicles to access markets and find buyers. The study by Verhofstadt and Maertens (2014) found that in Rwanda co-operative minimized the numerous constraints faced by farmers in accessing markets by providing reliable market information and selling outlets.

Furthermore, it minimizes the high transportation costs that hinder smallholder farmers' market access by setting up collection centers for crops and carry on collective marketing. This increase farmers income by participating in markets that they formerly had no access to (Ortman and King 2007). For instance, in Kenya, co-operatives have 72, 95 and 76 percent of the market shares in coffee, cotton, and dairy, respectively (Wanyama, 2016)

2.3.3 Improvement of market information and bargaining power

Co-operatives improve bargaining power and reduce transaction cost costs of accessing production and marketing information. Through agricultural co-operatives, the transaction costs of acquiring information on innovative production and marketing practices, sharing price information is lower compared to individual farmers (Narrod *et a*l., 2009; Vanni, 2014). With co-operative, farmers can receive information about price through calls or text messages that improve their bargaining power while trading (Courtois and Subervie, 2014). Co-operatives use their bargaining power to make farmers voice hear and influence decisions such as prices and policies that may negatively affect members. For instance, Kodama (2007) noted that in Ethiopia, the existence of co-operatives in the coffee market resulted in the improvement of coffee price.

2.3.4 Increase farm income

Several empirical studies show positive impacts of agricultural co-operatives membership on farm income and profit. Fischer and Qaim (2012), find that co-operative membership had a positive impact on smallholder banana farmers income in Kenya. Ito *et a*l. (2012) show that co-operative membership had a positive impact on watermelon farmer's income China. Further, Verhofstadt and Maertens (2014), indicate that participation in co-operative increased farmers' income in Rwanda. These studies reported that access to improve markets and adoption of technology resulted in improved farm income.

However, there are lots of empirical studies about co-operatives increasing smallholder productivity, increasing market participation, and farm income. There are cases where co-operatives did not improve the production and marketing of farmers due to poor management, economic need to venture, biased in enforcing rules for fear of losing friends, and Lack of members commitment and trust among members (Hellin *et al.*,2009). For example, in Ethiopia, Shumeta and D'Haese, (2016) found no impact on the overall income of farmers participating in coffee co-operatives.

2.4 Role of co-operatives in natural rubber production

Natural rubber co-operatives in developing countries provide the following benefits for farmers.

2.4.1 Improvement in latex production

Natural rubber co-operatives enable farmers to forgo the traditional methods of farming to a more productive method that increases production. It encourages the formation of group nurseries and supplies improved planting material like budded stumps. The yield of NR

depends on the way the trees are transferred from the nursery and planted in the field (Sethuraj and Mathew, 2012). Most of the smallholder farmers are ignorant about the required distance need between the trees. Moreover, farmers do not observe tapping time, and they still used the traditional method of tapping their parents taught them. Late and wrongful tapping of the trees reduce the quantity of the latex and the lifespan of the trees. As indicated by Thomas (2004), NR co-operatives provided training in innovative planting and tapping methods that increased latex production in Kerala.

2.4.2 Processing and marketing of latex

NR latex can be processed and marketed in several forms. The most common forms are technical specified rubber, ribbed smoked sheet, condense latex, latex concentrate, unsmoked sheet, and crumb rubber. Smallholder farmers in Southeast Asia, for example, India and Lao process their NR into ribbed smoked sheets. This method is graded from one to six in terms of quality, with one as the highest quality. However, smallholder farmers in Liberia processed their latex into cup lump, which is the least grade of NR and is not accepted on the international market (Manivong, 2007).

Natural rubber co-operatives contribute to the development of rural infrastructures such as the construction of smokehouse for the processing of latex into ribbed smoked sheets and provision of equipment such as platform balance to weight the latex and chemical balance to weight sample coagulum. Smallholders normally process their latex into cup lump or ribbed smoke sheet. They apply sulfuric or formic acid for coagulation. The quantity of acid added and time spend during coagulation also affect the quality. Most farmers are not knowledgeable about this, therefore, co-operatives offered training in processing of latex to cup lump and ribbed smoked sheets. In India, Anuja *et al*. (2012) found that the rubber producer society processed

smallholder farmers NR into ribbed smoke sheets and other acceptable grades of NR and provided inputs for production.

2.4.3 Access to inputs and credit

Natural rubber co-operatives assure farmers' supplies of inputs and access to credit with reasonable rates and payment terms. The access to credit brings about the acquisition of land and input such as latex collection cups, tapping knives for tapping of the tree, headlights for tapping early in the morning to get more latex from the trees, spray oil and tapping panel protection for the protection of the trees from fungal diseases after tapping (Anuja, 2012). The provision of these inputs helps to improve productivity and the quality of NR harvested. Lack of inputs leads to farmers using alternative materials that bring about post-harvest losses and reduction in latex quality. For example, smallholder NR farmers in Sri Lanka once used half coconut for cup for latex collection while in Liberia smallholder NR sometime used milk cup (Manivong, 2007)

2.5 Factors influencing co-operative membership and choice of selling outlets: Justification and expected signs

There is scanty empirical evidence in the literature of factors influencing household participation in NR co-operatives specifically. Therefore, factors influencing households decision to participate in other agricultural co-operatives are likely to shape households decision to participate in NR co-operatives. Different empirical studies, Bernard and Spielman, (2009), Debeb and Hail, (2016) Fischer and Qaim, (2012), Simelane, (2011), Sigei et al. (2015), and Kuma *et al*. (2013) identified socioeconomic factors (gender, age, experience, household size, dependency ratio), institutional factors (extension access, access to production

and market information, time taken to find buyers and training in NR production and marketing and co-operative membership), and farm characteristics (planting material, farm size, distance to the nearest market, disease types, and post-harvest losses) to influence farmers' participation in co-operatives and choice of selling outlets. For this study, the choice of selling outlets are grouped into two categories, farm gate, and alternative markets. Alternative markets are co-operative, traders, local markets, large scale holder or processors, and international markets.

2.5.1 Socioeconomic factors

The socioeconomic factors in this study include gender, age of the household head, experienced in NR production and marketing, household size, and dependency ratio. Male-headed households (MMHs) are expected to participate in agricultural co-operatives and access distance marketing outlets because of the social norms that lower the socioeconomic status of women access to opportunities and participation in formal groups (Woldu *et al.,* 2013). Awotide *et al.* (2015) noted that MHHs were more likely to participate in rice co-operative in Nigeria. The authors reported that women face obstacles in participating in male-dominated co-operatives. Further, Sigei *et a*l. (2015) and Morrison *et al.* (2007) found that in Kenya MMHs were more likely to sell to alternative markets because they are capable of traveling long distances and females farmers are faced with constraints such as household chores that limit their time from accessing distant markets. Therefore, the current study hypothesized MMHs to have a positive influence on households' decision to participate in the NR co-operative and negative influence to sell at farm-gate.

Co-operatives enable farmers to adopt new technology such as the processing of latex into an acceptable form on the international market like ribbed smoked sheets and technical specified rubber. Older farmers have more experienced than younger farmers and make better decisions

which increase their participation in formal groups (Simelane, 2011). Experienced farmers know the importance of collective action, therefore, are willing to venture into new farm practices to improve productivity and market participation. Abebaw and Haile (2013), found that the likelihood of participating in agricultural co-operatives in Ethiopia increased with age up to 37 years and subsequently declined. On the contrary, Fischer and Qaim (2012), found that age had a positive influenced on farmer participation in banana co-operatives in Kenya. Likewise, Mugabekazi (2014), who study factors influencing membership of coffee co-operative in Rwanda found experienced in years to positively influence farmers' decisions to participate. Based on this evidence, it is hypothesized that age in years can negatively or positively affect households' decision to participate in the NR co-operative and experience in years is hypothesized to positively affect households' decisions to participate in the NR co-operative.

Household size is measured as the number of people living in the same house who make common provision for food and other requirements for living, while dependency ratio is the number of persons in a household below the ages of 15 and above 64 years (World Bank, 2016 ;United Nations, 2017). Large household size might have much need for cash for the livelihood of the family. Hence, less amount of money will be available to invest in NR production due to high consumption (Mutoko, 2008). Large household size also indicates more family labor available to produce bulk quantities of NR for the market. The gestation period for NR is long, therefore, for farmers to receive credit is difficult, and banks preferred dealing with organizations than individuals. Farmers may need co-operatives to act as credit and other inputs service provider since they carry on bulk purchase of inputs at a minimum rate. On the other hand, the shortage of labor is one of the major constraints faced by farmers, as mentioned in the previous section. A study conducted by Warren-Thomas (2011), on child labor on rubber

plantations in Liberia shows that most farmers used child labor because of the lack of finance to hire skilled laborer which is against the labor law of Liberia.

A study carried on by Abate *et al.* (2014), Bernard and Spielman, (2009), in Ethiopia show that a unit increase in the household size increased the probability of participating in agricultural co-operatives because they have more labor available that can help in the production and marketing activities of the co-operatives. Furthermore, Jagwe and Machethe (2011) and Girma and Abebaw (2012), found household size to positively influenced the decision of banana and livestock farmers to sell in alternative markets in the great lake region of Africa and Ethiopia. These authors noted that large household size mostly helps in the marketing of food corps that has a shorter value chain. Hoken and Su (2015) and Francesconi and Heerink (2010), found that households with more children and older parents in China and Ethiopia were less likely to participate in agricultural co-operatives because children are mostly in school and do not have the time to participate in farming activities. Household size is hypothesized to positively influence household decision to join the NR co-operative and to have a negative influence on the decision to sell at farm gate. Similarly, the dependency ratio is anticipated to have a negative influence on farmers decisions to join the NR co-operative.

2.4.2 Institutional factors

Institutions are rules and policies put in place to govern how farmers access services to improve the production and selling of NR. The variables in this category are extension access, access to production and market information, training, time taken to find buyers, co-operative membership, and payment delay. Farmers may access information on NR production, output prices, and improved selling outlets due to interaction with extension workers. Extension workers are more likely to discuss the importance of collective action to farmers and encourage

them to join co-operatives. Abebaw and Haile (2013) and Negeri (2017) reported that access to extension services positively influenced farmers' decision to participate in agricultural c-operative and coffee farmers to access alternative markets. These authors mentioned that extension access enhanced farmers understanding about significant market and agricultural information, which enable them to make better decisions about production and marketing. Therefore, extension access is hypothesized to positively influence participation in the NR co-operative and negatively influence the decision to sell at farm gate.

Farmers having access to training are more likely to know the costs and benefit of collective action. Through training in NR production and marketing such as tapping and processing of latex, farmers can increase their social capital through interaction with other farmers, which make the cost of obtaining certain information on NR cheaper. Training in processing enables farmers to access improved markets that require standardization and certification. Moreover, training in agronomic practices such as tapping and the used of budded stumps improve production. This helps farmers to access markets that require a large quantity. Hence, the current study hypothesized training to have a positive influence on farmers decision to join the NR co-operative and negative influence on farmers decisions to sell at farm-gate.

Collective action improves farmers bargaining power and brings about a reduction in transaction costs in accessing markets. A farmer will only participate in a farmer co-operative if the expected utility of participation is more than the utility without participation. According to Sharma (2015), being a member of a farmer co-operative positively influenced dairy farmers decision to access alternative markets in India. Jari and Fraser (2014), reported that when farmers market their produce in groups, it positively influenced their decision to use alternative selling outlets. Moreover, Sigei *et al*. (2015) found that farmers in Kenya in pineapple co-

operatives used alternative markets instead of farm-gate. These authors indicated that collective marketing brings about less transaction costs such as costs of information on prices and transportation costs in accessing markets. Based on this evidence, co-operative membership is expected to have a negative influence on households decision to sell at farm-gate.

Access to information such as information on improved planting materials, post-harvest losses, processing of NR latex, prices, buyers and selling outlets through rural producer organizations, extension workers, information communication technology, and community members play a significant role in disseminating information about the benefits of co-operatives and choice of selling outlets for NR. The gathering of these relevant information motivates household to participate in agricultural co-operatives and sell at alternative markets. Randela *et al.* (2008), found that access to market information increased market participation of cotton farmers in South Africa. Similarly, Siziba *et al.* (2011), found that access to market information increased the likelihood of participating in cereal markets in SSA. These authors reported that the more information a household has, the lesser the fixed transaction costs of accessing the market. Therefore, access to information is hypothesized to have a positive influence on farmers decisions to participate in the NR co-operative and negative influence on farm-gate sales.

Household marketing decisions are mostly based on the availability of potential buyers and the price offered. Since NR latex coagulates within 8 hours, farmers who have information about potential buyers and where to sell their NR within 8 hours are mostly encourage to access distant selling outlets for better prices compared to those who take more than 8 hours and do not have information about where to sell their NR. Jari and Fraser (2014), reported that the availability of information on potential buyers increased the selling of vegetable farmers in

South Africa. This study hypothesized that time taken to search for buyers positively or negatively influence household decision to sell at farm-gate.

Though traders paid lower prices, they pay cash upon delivery of the commodity. Co-operatives take days or weeks to pay farmers. Delays in payment have been a major problem experienced by co-operative farmers in sub-Saharan Africa (Malan *et al*., 2015). For instance, Shiferaw *et al*. (2009) found that grain marketing co-operative in Kenya took more than four weeks to pay farmers. Similarly, Calkins and Ngo (2010), reported that cacao co-operatives in Cote d'Ivoire took three weeks to pay farmers. In this study, payment delay, which is a binary variable, was hypothesized to influence farmers participation in the NR co-operative negatively.

2.5.3 Farm characteristics

Variables in this category are farm size, distance to the nearest market, ownership of transport means, planting material, natural rubber diseases, and post-harvest losses.

The size of the natural rubber farm is the total area of land in acres under NR production. A bigger farm may need more quality inputs to increase production coupled with reliable and timely market information for the sales of NR. Co-operatives provide these services at a minimum cost. Moreover, holding all factors constant, as the size of the farm increases, production may also increase, leading to more produce available for sales. This encourages farmers to sell their produce at alternative markets because of the lower transaction costs (Sigei *et al*., 2015).

In Ethiopia, a unit increase in the size of the land cultivated positively influenced household decision to participate in agricultural co-operatives (Francesconi and Heerink, 2010; Abebaw and Haile, 2013; Wossen *et al*., 2017). Jagwe *et al.* (2010), reported that the land size of

banana farmers in the great lake region of Africa influenced farmer decision to use alternative markets because of the output and economies of scale. In this study, farm size is hypothesized to positively influence farmers decision to participate in the NR co-operative and a positive or negative influence on farm-gate sales.

The availability of alternative markets for NR is very scarce. Long distances and bad road network increase the transportation cost of accessing the limited selling outlets available. However, ownership of transport means can minimize the high transportation costs and the long distance market constraints faced by farmers. Ownership of transport means offers more understanding of the choice of selling outlets to use. Kuma *et al*. (2013) and Nyaga *et al*. (2016) confirm that distance to the nearest market negatively influenced dairy farmers from accessing Alternative markets because of the high transportation cost. According to Rao *et al*. (2011), ownership of transport means positively influenced farmers decisions to use alternative markets for better prices compared to farm-gate. Also, Azam *et al*. (2012) and Negeri (2017) found that ownership of transport means positively affect alternative marketing outlets for coffee farmers in Ethiopia. The current study hypothesized distance to the nearest market to positively influence farmers decision to sell at farm-gate, while ownership of transport means is anticipated to have a negative influence on farmers decision to sell at farm-gate.

Farmers use seedlings because of the low cost. The cost of obtaining budded stump is high, and it requires special skills which farmers lack. NR being the major cash crop in the country, co-operative farmers usually receive training organized under the auspice of the co-operative about NR varieties and bud grafting of rubber. This encouraged farmers to join co-operative to benefit from such training. Hence, we hypothesized that planting material positively influences household decision to participate in the NR co-operative.

Natural rubber diseases impose a high cost both through foregone revenue from losses in latex yield and through expenditure used to mitigate the disease (Fuller *et al.,* 2017). NR diseases cause multi-year losses in the production of latex, leading to a decrease in farm income. Smallholder farmers lack the inputs such as spray oil and skills needed to curtail fungal disease (Anuja *et al*., 2012). Therefore they participate in agricultural co-operatives to get input such as panel protectant and training in agronomic practices to curb the disease. The current study hypothesized that experiencing NR diseases positively influence farmers decision to participate in the NR co-operative.

NR latex harvested latex or coagulum should be kept from impurities such as plastic, soil, plant materials in the form of leaves, tree bark and should be stored in a shaded area to avoid losses. Moreover, the latex should be tapped in a plastic cup, not milk cup as done by smallholder farmers in Liberia. A large quantity of NR is loss during tapping due to traditional post-harvest management strategies and lack of improved storage facilities. This has resulted in a reduction in revenue received by farmers (Chapoto *et al*., 2016). Co-operatives can reduce these losses by training members on post-harvest losses and provide storage facilities for farmers to minimize losses. To mitigate these losses, NR farmers choose to join co-operatives. Therefore, the current study hypothesized post-harvest losses to positively influence household decision to participate in the NR co-operative.

CHAPTER 3: METHODOLOGY

3.1 Conceptual Framework

The conceptual framework in Figure 3.1 shows factors influencing farmers' decisions to participate in NR co-operative and the choice of selling outlets used. Participation in the NR co-operative is based on the expected utility of the farmers from evaluation of the NR co-operative as a means of increasing their production, linking them to alternative markets and increasing farm income. The expected utility is influenced by households' socio-economic characteristics (age, gender, household size, and experience), institutional characteristics (access to extension and access to market information). Co-operative membership along, with the socio-economic and institutional factors, determines whether a farmer sells at farm-gate or alternative markets. The factors influencing participation in the NR co-operative and the choice of selling outlets cause a variation in farmer's production and market participation. This leads to the determinant of the impact of the NR co-operative, which was farm income.

3.2 Theoretical Framework

3.2.1 Random utility theory

The random utility theory postulates that NR rubber farmers are rational decision-makers. Their decisions to participate in the NR co-operative depends on the expected utility they will derive from participation. According to McFadden (1978), an individual i has a set of alternatives j (participation in the NR co-operative or not) to choose from the choice set (B) to maximize their utility. In other words, a farmer can decide to participate in the NR co-operative or not, to maximize their expected utility.

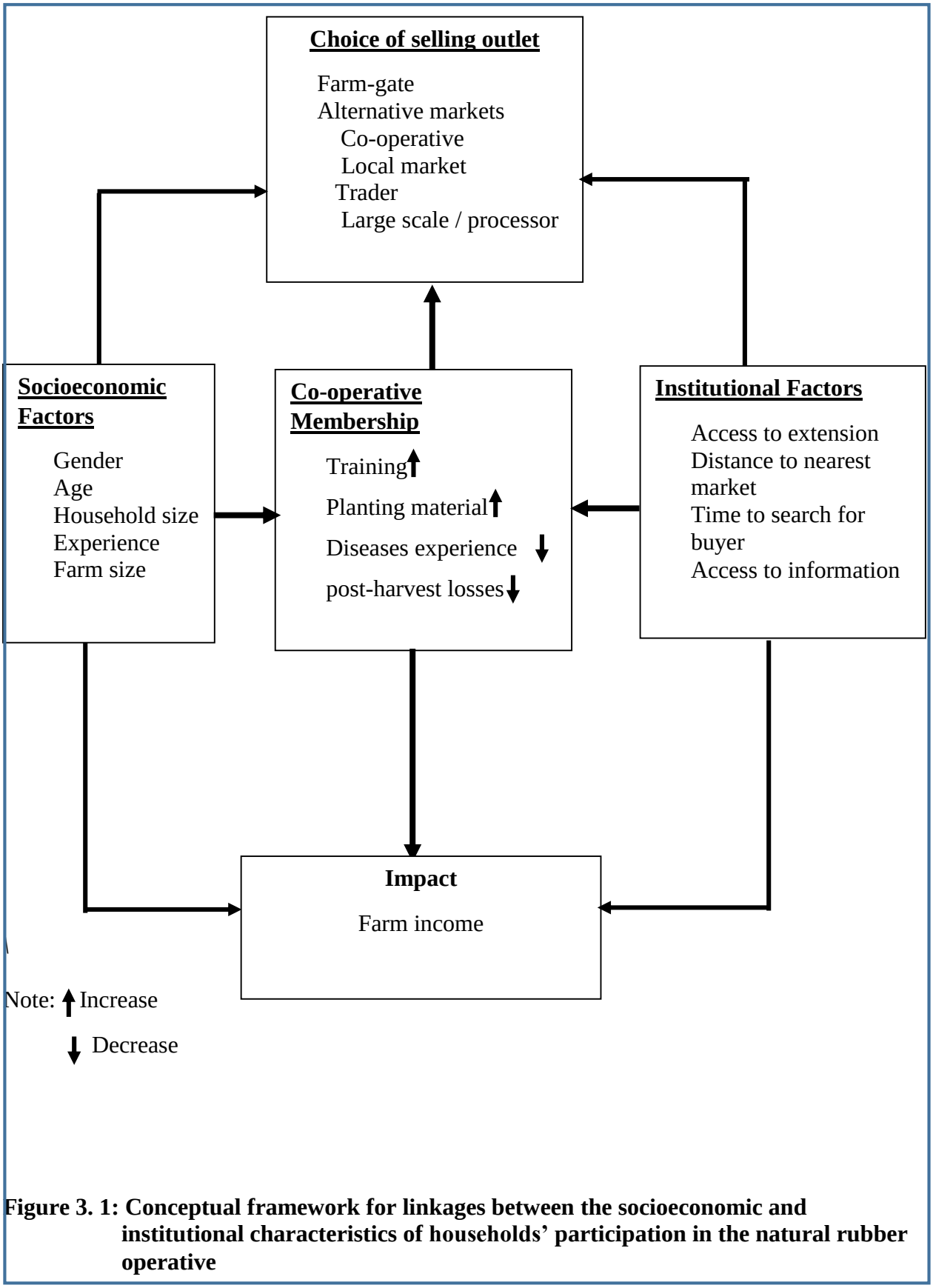


Figure 3. 1: Conceptual framework for linkages between the socioeconomic and institutional characteristics of households' participation in the natural rubber operative

Source: Author conceptualization

The decisions made by the farmer will either enhance or reduce their production and market participation leading to improve income or not. Hence, farmers are expected to participate in the NR co-operative if the expected utility of participation is higher than the utility without participation. The choice made by the farmers is a function of socio-economic, farm, and institutional characteristics. The utility of choice made is a latent variable that is only known to the farmer and observed through the choices (participation or not) made (Wooldridge, 2015).

U_{ij}=U_i X_i…….. [3.1]

Where, U_i is the expected utility of the farmer and X_i is the characteristics related to alternative j and farmer who is the decision-maker. The probability that a farmer will choose alternative j from inside (B) is given as;

P_{ij} (B) = P_i ($U_{ij} > U_{ik}$)…….... [3.2]

P_{ij} is the probability of the NR farmer choosing alternative j from inside B to become a member of the NR co-operative and sells at farm-gate or alternative markets, U_{ij} is the expected utility of a NR choosing alternative j, while U_{ik} is the expected utility of a NR farmer choosing alternative k.

Following Lancsar and Savage (2004), the utility a farmer derives from participating in the NR co-operative U_{ij}, and the choice of selling outlets can be specified as a summation of a deterministic component V_{ij} in equation 3.3, which is made up of the set of observable characteristics of the utility function and the random error term ε_{IJ} that accounts for components of the utility not observed by the researcher. In other words, it accounts for all the unobservable factors that influenced the choices made by a NR farmer and is express in equation 3.3 as;

$U_{ij} = V_{ij} + \varepsilon_{ij}$ ……. [3.3]

Where:

V_{ij} = observable explanatory variables such as gender or farm size farm and the parameter to be estimated

The model assumes that a NR farmer will choose the option that maximizes the highest utility. If a NR farmer chooses the alternative that gives the highest utility, then the probability of the choice of alternative *j* over alternative *k* is expressed as:

$P_{ij}\ (B) = Prob\ (\ V_{ij} - V_{ik}\ >\ \varepsilon_{ik} - \varepsilon_{ij}\ )$ ..... [3.4]

Where:

$Prob$ = Probability

The rest of the variables are defined in equation 3.2 and 3.3

3.3 Empirical methods used for impact of natural rubber co-operative and selling outlets

Different binary models have been used to estimate the decisions made by households. The linear probability model, probit, and logit models are the most commonly used model binary outcomes. In these models, farmers either participate in the NR co-operative or not. The dependent variable takes the value of 1 for participants and 0 for non-participants. The linear probability model (LPM) is a regression approach used when the dependent variable is binary and discrete, but this approach has some drawbacks that make it inefficient, the probability can be more than one and the partial effect of the explanatory variable is constant, and it produces unrealistic R^2 (Wooldridge, 2015). This means that the LPM violates the OLS assumption of homoscedasticity due to the binary nature of the dependent variable and cannot be used to make causal inference about farmers participation in the NR co-operative and the choice of selling outlets used.

Limitations of the LPM can be overcome by using the logit or probit model because the probability of participating in the NR co-operative or selection of the choice of selling outlets

is between 0 and 1 and are non-linear. The Logit model is based on cumulative logistics distribution function, while the probit model has a normal cumulative distribution function. The logit model has one practical advantage over the probit models, the inverse linearizing transformation of the Logit model is straightly interpretable as log-odds, (Klieštik et al., 2015). Hence, with this advantage, the logit model was preferred for this study.

Different methods have been used to measure the impact of participation in a program or project on participants to know the outcomes. Generally, all the methods used are categorized into two; randomization of treatment and non-random treatment. Randomization of treatment involves randomly assigning NR farmers to treatment and control groups, while non-random treatment involves assigning NR farmers to treatment and control groups based on specific conditions. The treatment is farmers in the NR co-operative, while the control is non-co-operative farmers (Khandker *et al.,* 2009). In this study, we look at the impact of farmers participating in the NR co-operative on farm income using non-random treatment because of farmers self and conditional selection in the NR co-operative.

According to the Gertler *et al.* (2011**),** the most widely used non-random treatment effect methods are difference-in-differences (DD), instrumental variable (IV), regression discontinuity (RD) and propensity score matching method (PSM). RD accounts for observed and unobserved heterogeneity such as gender, managerial skills, and it requires collecting data on NR farmers before participating in the NR co-operative and while participating in the co-operative. Though the cutoff eligibility threshold can be defined non-parametrically, and the drawback is that there is a possibility that eligibility rules will not adhere consistently. The IV Method allows for endogeneity in individual participation and finds a variable that is highly correlated with farmers participation in the NR co-operative, but uncorrelated with

unobservable characteristics affecting outcomes. The demerit of the IV method is the selection of the instruments or variables. To find a variable that affects farmers' participation in the NR co-operative, but not the outcome variable, farm income is difficult. Using a variable that influences farmers participation in the NR co-operative and the outcome leads to bias estimates (Martens *et al*., 2006). The DD method is mostly used when all the NR farmers in the study area participate in the co-operative. It requires collecting data before their participation, and while participating in the NR co-operative. The DD method requires panel data. It assumes that the unperceivable heterogeneity in participant is present and is time-invariant. The demerit is the assumption of the presence of the unobservable selection and the availability of data on the treated and control groups at two or more points in time. The unobservable selection and time-invariant lead to upward or downward bias.

The PSM method uses cross-sectional data to match participant and non-participant with similar observable characteristics to measure the impact of a program. This method assumes that treated and untreated observation must have a similar propensity score to ensure comparable control in the propensity score distribution. Additionally, PSM reduces selection bias caused by farmers' self or conditional selection in the NR co-operative. The demerit of this method is that matching can only be performed on observable characteristics (Gertler *et al*., 2016). The current study uses cross-sectional data and it does not have data on participants before the intervention. Therefore, the PSM method introduced by Rosenbaum and Rubin (1983) was used to compare the observed outcome of participants and non-participants in the NR co-operative.

3.4 Empirical model

3.4.1 Effect of Co-operative and other factors on the choice of selling outlets

Past studies used the logit model only or with two-stage models to determine the decisions made by households. For instance, Osebeyo and Aye (2014) and Supaporn and Supawadee (2017) determined factors influencing the choice of marketing outlets for tomato farmers in Nigeria and rubber farmers in Thailand using a logit model. Similarly, Asefa *et al*. (2016), used a multinomial logit model to determine factors determining coffee market outlets preference in Ethiopia. In order to determine the effect of co-operative and other institutional and socioeconomic factors on smallholder NR farmers' choice of selling outlets, respondents were asked whether they sell their NR at the farm-gate or alternative markets. The dependent variable is discrete and binary, and this makes the use of a logit model suitable for achieving this objective.

3.4.1.1 Estimating equation for the logit model

The binary dependent variable Y_i takes the value as given below.

$$Y_i = \begin{cases} 1 \;\; if\ a\ farmer\ sells\ at\ farm-gate \\ 0 \;\; if\ a\ farmer\ sells\ at\ alternative\ markets \end{cases} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots [3.5]$$

Following McFadden (1973) and Wooldridge (2015), the probability that individual i selling at farm-gate is given as;

$$\text{prob}\,[y_{ij} = 1] \;\; \frac{\exp \theta' X\prime}{1+\exp \theta' \mathrm{X}_\iota} = \Lambda(\theta' X_i) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots [3.6]$$

Where;

i = Individual farmer

j = Choice of selling outlet (1= farm-gate, 0=alternative markets)

X = A vector of explanatory variables such as gender and other socioeconomic factors

θ = The parameter to be estimated

Λ = Logistic distribution function

exp = Exponent

Equation 3.5 is the reduced form of the logit model. The model is assumed to follow a logistic distribution whose cumulative density function (F) is specified as:

$F'(\theta' X_i) = \Lambda(\theta' X_i)[1 - \Lambda(\theta' X_i)$ ..... [3.7]

Where; F' represents the cumulative distribution function of the logistic distribution (Λ). The rest of the variables are defined in equation 3.6

The probability of individual i selling at farm-gate can be estimated as:

$P_r[Yi = 1] = X_i \theta_i + \varepsilon_i$ .....[3.8]

Y_i is the decision made by individual households, whether to sell at farm-gate or alternative markets; θ is the parameter to be estimated and ε_i is the unobserved error term of farmers.

The parameter estimates of the logit model provide only the direction of the effect of the explanatory variables on the dependent variable, but they do not represent the real magnitude of change (Demeke and Haji, 2014). In order to measure the size of the effect of the explanatory variables on the predicted probability of household choice of selling outlet (sell at farm-gate or alternative markets), marginal effects were estimated (Anderson and Newell, 2003).

$$\theta_m = \left[\frac{\partial(\theta_\iota X_\iota + \varepsilon_\iota)}{\partial\, \theta_\iota X_\iota}\right]\theta$$ Marginal effects for continuous explanatory variables [3.9]

$$\theta_m = P_r\,[Y_{i=1}] - P_r[Y_{i=0}]$$ Marginal effects for dummy variables ..... [3.10]

Where m is the marginal effect, the rest of the variables are defined in equation 3.6

3.4.2 Impact of participation in the NR co-operative on farm income

Abebaw and Haile (2013), Ahmed and Mesfin (2017), and Shumeta and Haese, (2016) determined the impact of agricultural co-operative on technology adoption and income in Ethiopia using PSM. A logit model was employed in the first stage to determine the propensity scores.

3.4.2.1 Estimating equation

The impact of a program or project is evaluated by estimating the average treatment effect (ATE) of the participatory variable (NR co-operative membership) on the outcome variable, farm income (Rosenbaum and Rubin 1983; Gertler *et al.*, 2016). This can be done by comparing the outcome of the same unit with and without the treatment. For instance, the ATE in this study could be estimated by comparing the income when a farmer participates in the NR co-operative and before participating. The effect is estimated as:

$ATE = E\ [Y_{i1}/D = 1]\text{-}E\ Y_{i0}\ /\ D = 0]$ ……. [3.11]

Where;

E = Expected

Y_{i1} = Outcome of interest after joining the co-operative

Y_{i0} = Outcome of interest before joining the co-operative

D = Binary indicator, D = 1 for member, D = 0 for non-member

However, the impact of the intervention for the same household with, and without the intervention, cannot be observed simultaneously using cross-sectional data. Estimating the impact of NR co-operative membership on the i^{th} farmer in equation 3.11 would be misleading due to the problem of missing data. Since only one of the two outcomes (income) Y_{i1} or Y_{i0} for a household is observable at a time, the observed outcome is expressed as:

$Y_i = D_i\ Y_{i1} + (\ 1 - D_i)\ Y_{i0}$ ……. [3.12]

Where all the variables are as defined in equation 3.11, unless otherwise stated.

However, following Smith and Todd (2005), Caliendo and Kopeinig (2008), and Rosenbaum and Rubin (1983), the average treatment on the treated (ATT) the parameter of interest, can be defined as the difference in the mean expected outcome of co-operative members while participating in the NR co-operative and the expected outcome if they had not participated. This can be expressed as:

$ATT = E(\ Y_{i1} D_i = 1) - E(Y_{i0} |\ D_i = 1) = E(Y_{i1} - Y_{i0} |\ D_i = 1)$ ..... [3.13]

Where all the variables are as defined in equation 3.11, unless otherwise stated

Data on the co-operative members are available and the equation is specified as $E(\ Y_{i1} | D_i = 1)$ but data on the counterfactual outcome are not observed for a given household and the equation is also specified as $E(Y_{i0} |\ D_i = 1)$. Due to the unavailability of data on counterfactual, average treatment effect (ATE) mentioned in equation 3.11 is generally observed and can be written as:

$ATE = E(\ Y_{i1} |D_i = 1) - E(Y_{i0} |\ D_i = 0)$

$ATE = [E(\ Y_{i1} |D_i = 1) - E(Y_{i0} |\ D_i = 1)] + [E(\ Y_{i0} |D_i = 1) - E(Y_{i0} |\ D_i = 0)]$ ..... [3.14]

$ATE = ATT + E(\ Y_{i0} |D_i = 1) - E(Y_{i0} |\ D_i = 0)$

$(\ Y_{i0} |D_i = 1) - E(Y_{i0} |\ D_i = 0)$ is the level of selection bias that arises when the ATE is used to estimate the impact of NR co-operative membership on farm income.

With $ATE = ATT + E(\ Y_{i0} |D_i = 1) - E(Y_{i0} |\ D_i = 0)$, ATE may be estimated, but the estimates are likely to be biased. However, the focus of impact evaluation dwells in the estimation of $(Y_{i0} |\ D_i = 1)$ and not $(Y_{i0} | D_i = 0)$. Hence, $(Y_{i0} |\ D_i = 0)$ cannot be used as a proxy for $(Y_{i0} |\ D_i = 1)$ because the treated and the control may be different before the intervention, therefore the difference between these households may not completely be due to the intervention but unobservable factors such as managerial skills and technical ability (Pan, 2014) . To overcome the selection bias caused by farmers self-selection into the NR co-operative, PSM proposed by Rosenbaum and Rubin (1983) was used to construct a statistical comparison group

(counterfactual) by matching co-operative members to non-members with similar observable characteristics in order to provide an unbiased estimation of the treatment effect.

According to Rosenbaum and Rubin (1983), Ali and Abdulai (2010), and Hoken and Su (2015) the validity of the PSM results such as the absence of hidden biases in the form of managerial skills that influence participation in the NR co-operative and the outcome variable simultaneously and selection based on observable characteristics depends on the fulfillment of two essential requirements: the conditional independence assumptions (CIA) also called unconfoundedness assumption and the common support assumptions (CSA). The CIA assumes that given a set of observable characteristics, X, the outcome Y_{i1} and Y_{i0} are independent of actual program participation condition D. This means that selection into the NR co-operative is strictly based on observable characteristics. The notation for the assumption can be expressed as:

$(Y_{i1}, Y_{i0}) \perp D \; p\,(\boldsymbol{X})$ …… [3.15]

Where;

$\perp$ = independence

$\boldsymbol{p}$ = propensity score to participate in NR co-operative

X = observable covariates

D = Binary indicator, D = 1 for member, D = 0 for non-member

The CIA allows use of non-co-operative members with similar observable characteristics to measure how co-operative members would perform without being members that is without receiving treatment. The propensity score, which is the conditional probability that a household participates in the NR co-operative, is the first step in PSM approach and it was estimated using a logit model. Under the CIA, the propensity score can be expressed as:

$p(X) = \Pr(D = 1|X) = E(D|X); p(X)$ ……. [3.16]

Where;

Pr = Probability

All the variables are as defined in equation 3.11 and 3.15, unless otherwise stated.

After obtaining the predicted probabilities of participating in the NR co-operative based on observable characteristics, different empirical studies, Fischer and Qaim (2012), Abebaw and Haile (2013), and Abate et al. (2014) indicated that the Nearest Neighbor Matching (NNM), Radius Matching (RM) and Kernel-based Matching (KBM) algorithms are the most commonly used matching algorithms to match co-operative members (treated) and non-co-operative members (control). The NNM involved matching co-operative members and non-members with similar propensity scores, RM involved choosing an individual from the control group as a matching partner for the treated individual that lies within the propensity range and closet in terms of propensity score, while the KBM involved matching each individual in the treatment group with the weighted averages of individuals who have similar propensity scores with greater weight in the control group (Caliendo and Kopeinig, 2008).

The CSA helps in ensuring that every household has a positive probability of being a participant or non-participant of the NR co-operative, therefore ruling out the reality of perfect predictability. Without CSA, it is impossible to construct a counterfactual to estimate the impact of NR co-operative on farm income because every NR farmers will not have an equal chance of participating in the NR co-operative.

The CSA is expressed as:

$0 < \Pr(D = 1|X) < 1$ …… [3.14]

Where all the variables are as defined in equation 3.15

Under the CIA and CSA, the ATT is expressed as follows:

$$ATT = E\ (Y_{i1} \mid D_i = 1) - E\ Y_{i0} \mid D_i = 1)$$

$$= E((\ Y_{i1} - Y_{i0} \mid D_i = 1))$$

$$= E\{E[(\ Y_{i1}\ - Y_{i0}\ ) \mid D_i\ = 1, p(X)]\}$$

$$= E\{E[(\ Y_{i1} \mid\ D_i = 1,\ p(X)] - E[Y_{i0} \mid D_i = 0,\ p(X)] \mid D_i\ = 1\} \ldots\ldots\ldots\ldots\ldots\ldots\ldots [3.15]$$

Where all the variables are as defined in equation 3.11 and 3.15

Table 3. 1 : Description of variables hypothesized to influence households choice of selling outlets for natural rubber

Variable	Description of variables	Measurement of variables	Hypothesized Sign
Dependent variable			
Sell at farm-gate or alternative markets	A binary variable indicating the decision to sell at farm-gate or alternative markets	Dummy (1= farm-gate, 0 = alternative markets)	
Independent variables			
Gender	Gender of the household head (the farmer)	Dummy: (1= male, 0 = female)	+
Household size	number of people living in the same house and making common provision for food		-
Access to extension service	Household received extension services during 2017-2018	Dummy: (1=Yes, 0 =No)	-
Training	Received training on NR production and marketing during 2017-2018	Dummy(1=Yes, 0= No)	-
Time taken to find buyers per hour	Number of hours taken to find buyer for NR	Dummy (1= <8 hours, 0 = > 8 hours)	+/-
Access to market information	Household received production and marketing information from 2017-2018	Dummy (1 =Yes, 0 = No)	-
Co-operative member	Member of NR co-operative	Dummy (1=Yes, 0=No)	-
Farm size	Size of land occupied by NR production	Dummy(1= 0-10 acres, 0=10> acres)	+/-
Distance to the nearest market	Average distance to the nearest market for sales of NR	Kilometer	+
Ownership of transport means	Ownership of vehicle, motorbike, and bicycle	Dummy (1=Yes, 0=No)	-

Natural rubber (NR)

Note: Farm size was captured as a categorical variable, but was later transformed to binary variable for the model

Natural rubber latex takes 8 hours to coagulate after tapping.

Table 3. 2: Description of variables hypothesized to influence farmers participation in the NR co-operative

Variable	Description of variables	Measurement of variables	Expected sign
Dependent variable			
Member of the NR co-operative or not	Binary variable indicating if a household is a member of NR co-operative or not	Dummy (1=Yes, 0= No)	
Independent variables			
Gender	Gender of the household head (the farmer)	Dummy (1=male, 0= female)	+/-
Age group	Age group of household head	Dummy (1=18-35 years, 0=35> years)	-
Experience	Experienced in NR farming	Years	+
Household size	number of people dependent on the household head for food		+
Dependency ratio	Household members below 15 and above 64 years		-
Access to extension service	Household received extension services during 2017-2018	Dummy(1=Yes, 0=No)	+
Training	Access to training in NR production and marketing during 2017-2018	Dummy(1=Yes, 0= No)	+
Access to information	Household received production and marketing information during 2017-2018	Dummy(1=Yes, 0= No)	+
Planting material	NR variety used for production	Dummy (1=budded stem, 0= seedling)	+
Farm size	Size of land occupied for NR production	Dummy(1= 0-10 acres, 0=10> acres)	+
Disease type	Type of NR disease experienced	Dummy (1= root type of disease, 0= stem type of disease	+
Post-harvest losses	losses from tapping, rain, and plant materials	Dummy (1=Yes, 0=No)	+
Payment delays	Payment delay from the sales of NR	Dummy (1=Yes, 0=No)	-

Natural Rubber (NR)

Note: Root and stem type are diseases specific to the root and stem of the NR tree

3.5 Study areas

Margibi County was purposively selected as it is the major area for rubber production in Liberia and it has the largest industrial natural rubber plantation (Firestone natural rubber company) in the world. The county is located on the north of the central coast of Liberia along the Atlantic Ocean in the south and bordering Montserrado, Bong, and Grand Bassa Counties on the East, north and northeast and west, respectively (Republic of Liberia, 2012). The county has four districts, Kakata, Gibi, Firestone, and Mambah-kaba and has a total population of 209,923. The climate is hot and humid with an annual temperature of 80°F and the average annual rainfall of 510cm. The soil is sandy clay loam and has a lot of nutrients (Republic of Liberia, 2011)

The main cash crops produced are natural rubber 52 percent, followed by plantain and banana 34 percent, sugarcane and pineapple 14 percent, respectively, palm nuts 14 percent and cacao 10 percent. The primary food crops produced in the area by households are cassava 79 percent, followed by rice and maize 33 and 12 percent, respectively. The primary livelihood activities in the county are natural rubber and charcoal production. The county has an approximated land area of 2866.67 square miles, and 6.4 percent is used by NR plantations (Republic of Liberia, 2012; UNMIL, 2006) The population is of Kakata and Gibi districts is 88,704 and 14,250, respectively (Republic of Liberia, 2011).

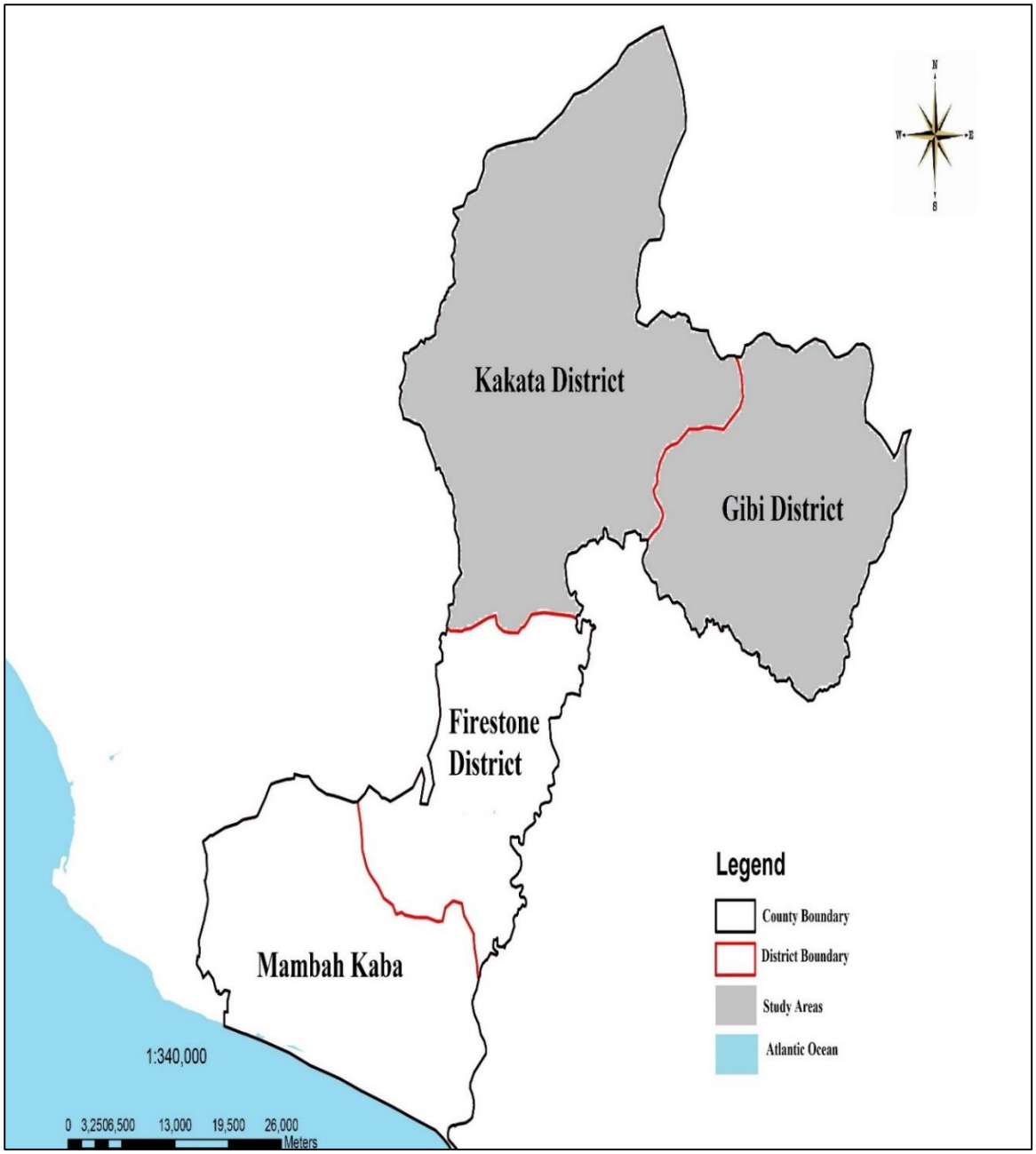


Figure 3. 3: Map of Margibi County showing the study districts

Source: Republic of Liberia (2016).

3.5 Sample size determination

Following Anderson et al. (2011) the sample size of an unknown population is determined as follows:

$$n = \frac{p\,(1-p)Z^2}{E^2}$$

Where:

N = is the sample size being determined

P = is the proportion of the target population of interest that is unknown. In this case farmers

Z = z-statistics (the confidence interval)

E = is the allowable margin of error

The recommended proportion of the target population to use when the standard deviation of the sample is unknown is 0.5 (Anderson *et al.*, 2011) Hence, the study used 0.5 because the target population was not known.

P = 0.5, Z= 1.96, E = 0.0703

$$\frac{0.5(1-0.5)\ (1.96)^2}{(0.0693)^2} = 200$$

3.6 Sampling design and data collection

3.6.1 Sampling design

Multi-stage stratifying sampling procedure was used as follows. First the county and districts were purposively selected because it has a well-functioning NR co-operatives and a large number of smallholder rubber farmers. Second, a list comprising of co-operative farmers and non-co-operative farmers were obtained from the county agricultural coordinator and the head of the co-operative in the study area. The list produced 200 and 80 households belonging to co-operative and 185 and 65 non-co-operative in Gibi and Kakata districts respectively. Respondents were randomly selected from the two districts based on a probability proportional to size using a random number table. The exercise resulted in the selection of 70 and 30 co-operative farmers and 76 and 24 of the non-co-operative farmers in Gibi and Kakata districts, respectively.

3.6.2 Data collection procedure

Primary data used in this study was collected between April and May 2018 in Kakata and Gibi districts. The structured questionnaire was designed and pretested during the training of enumerators. To qualify as an enumerator, the person had to be residing in the study area, fluent in the local language Kpelle, trained in basic agriculture, and experienced in conducting surveys. Cross-sectional data on household was collected by interviewing the head of smallholder rubber farmer household on specific factors, mainly distance from farm to market, access to market information, access to extension, and ownership of transport equipment, household size, and time spent searching for buyers. In the absence of the household head, family member 18 years or older who participate in decision making in the household served as a proxy for the household head. The data was entered directly into Open Data Kit tool (ODK) during face to face interview. The data collected was exported to Microsoft Excel and analyzed using STATA 14

3.6.3 Problems experienced during data collection

Harvesting of latex is done early in the morning, from 4:00 to 9: 00 am, when the turgor pressure in the tree is high to enable production of more latex, farmers leave for harvesting early in the morning. The majority of the sample farmers were also engaged in other agricultural activities like rice, palm, and cassava farming. After harvesting latex they usually go to their other farms to tend to other crops. Even though farmers were contacted by mobile phone a day before the interview, many were not available during the day, therefore the enumerators had to go to the villages in the evenings for the interviews. Since the villages were not easily accessible using public commercial transport, the enumerators spent the night in the villages and took the opportunity to interview willing farmers during the night and early morning hours before they went out to tap latex. Since the farms in the study area were

dispersed over a wide area and the roads connecting them were very inaccessible, the task of data collection was arduous.

3.7 Diagnostic tests of the model

To ensure that the basic assumptions of the econometric models were met, heteroscedasticity, multicollinearity and pairwise correlation matrix tests were performed

3.7.1 Heteroscedasticity test:

Heteroscedasticity (variance of the of the error term varying across observations) is one of the violations of the basic assumption of OLS. It results in inefficient estimators, incorrect confidence interval, and incorrect *t*-statistics. According to Wooldridge (2015), the OLS estimates are biased and inconsistent, meaning that they are no longer best linear unbiased estimator (BLUE). To test for the presence of heteroscedasticity, the Breusch-Pagan / Cook-Weisberg test was used with the null hypothesis of homoscedasticity meaning that the variance was constant across the observation. The use of the "hettest" STATA command for the determinants of the choice of selling outlets resulted in

Chi^2 (1) = 17.86

Prob > Chi^2 = 0.000

This led to the rejection of the null hypothesis of homoscedasticity and to the conclusion that heteroscedasticity problem existed, necessitating correction using of the robust logit model.

Similarly, the heteroscedasticity test for factors influencing farmers' participation in NR co-operative resulted in

Chi^2 (1) = 1.29

Prob > Chi^2= 0.2567

The chi-square value of 0.2567 was not statistically significant, therefore the null hypothesis of homoscedasticity was not rejected leading to the conclusion that heteroscedasticity was not a problem.

3.7.2 Multicollinearity test

Multicollinearity is when there is a high linear relationship among the independent variables used in the OLS model. Severe collinearity between the explanatory variables in the model leads to a large standard error leading to wider confidence intervals, acceptance of the "zero null hypothesis" (that is the true population coefficient is zero) more readily. The variance inflation factor (VIF), which is computed for each of the explanatory variables, was used to check for multicollinearity. The VIF for each variable was computed as follows:

$$VIF = \frac{1}{1-{R_i}^2}$$

Whereas; R^2 is for auxiliary regression and i^{th} is the independent variable.

According to Gujarati (2004), If the VIF of a variable exceeds ten, it should not be included in an econometric model, therefore it should be dropped. None of the variables in the logit model and the PSM model had a VIF greater than 10 (Appendix I) suggesting there is no perfect collinearity among the explanatory variables used in the model. Pearson and Spearman correlation matrix was performed to ascertain whether there is a strong linear relationship between the continuous and categorical variables used in the model. The results in Appendix II showed that none of the variables were close to ± 1 indicating no strong linear relationship between the variables in the model.

CHAPTER 4: RESULTS AND DISCUSSION

4.1 Socioeconomic, Institutional and Farm characteristics of co-operative and non-co-operative members

4.1.1 Socioeconomic characteristics of households

About 50 percent of the respondents interviewed were members of the NR co-operative (Table 4.1). About 17 percent of the co-operative farmers were youth (18-35 years), while 34 percent of the non-co-operative farmers were in the same age range. The result shows that the percentage of age differs significantly between the two groups at 1 percent. The reason is that older farmers have access to resources such as land, which increase their participation in formal groups. For instance, older farmers in the study area have bigger farm sizes than younger farmers. Similarly, Fischer and Qaim (2012) found that farmers in banana co-operatives in Kenya were older, contrary to Simelane (2011), who found that dairy co-operative farmers in Swaziland were younger. Co-operative members had five more years of experience compared to non-cooperative counterparts. This implies that farmers who were members of the co-operative had better knowledge about agriculture. This result is consistent with Abebaw and Haile (2013), who found that farmers with more years of experienced in Ethiopia were more likely to participate in agricultural co-operatives. On average, the dependency ratios (that is household members under 15 and above 64 years) were found to be 3.7 and 3.1 for co-operative and non-co-operative farmers, and the difference was significant at 5 percent level. The age groups can explain this, more than half of the farmers in the study area were older. They likely have access to resources that helped overcome entry barriers in the NR co-operative.

Table 4. 1 Socioeconomic characteristics of sample households by co-operative membership

Variables	Co-operative farmers (n= 97)	Non-co-operative farmers (n=97)	Total sampled (n=194)		Significant differences
		Means		***t- ratio***	**(P-value)**
Farming experience (years)	23.1	18.3	20.7	-3.43	0.00***
Household size	7.9	7.2	7.6	-1.53	0.12
Dependency ratio	3.7	3.1	3.4	-2.25	0.02**
		Percentages		***z- ratio***	
Gender (Male)	86.6	89.6	88.1	0.66	0.66
Age group (years) (18-35)	16.5	34	25.3	2.81	0.00***
Access to extension (Yes)	6.2	3.1	4.6	-1.02	0.31
Access to training (Yes)	21.6	6.19	13.92	-3.11	0.00***
Access to production and market information (Yes)	56.7	49.48	53.09	-1.007	0.31

***, ** Significant at 1 and 5 percent respectively.
Source: Survey data, (2018). In all tables and figures that follow, the source is the survey data, (2018), unless otherwise stated.

About 21 percent of the co-operative farmers had access to training compared to non-co-operative farmers 6 percent, and the difference was significant at 1 percent. Discussion with the farmers revealed that the co-operative had provided more training opportunities for members in agronomic practices, latex tapping, and processing to improve the production and marketing of NR. This is consistent with one of the basic principles of co-operation, training, and education to enhance members capacity to increase production and access better selling outlets (Kumar *et al*., 2015).

4.1. 2 Access to training by co-operative membership

Figure 4.1 shows that farmers in co-operative access more training in different aspects of NR production than non-co-operative farmers. The training offered by the co-operative mainly focuses on tapping of latex, agronomic practices, and latex processing. Training in latex tapping is very crucial to natural rubber production. Improved tapping techniques and recommended tapping time increase the production of NR latex, which consequently increases farmers income. Improved agronomic practices such as brushing of the farm, application of agrochemicals and panel protectant help control for pests and diseases on the farm. This also helps to increase the production of latex. The results indicate that the NR co-operative is mostly focus on increasing the production of NR than marketing.

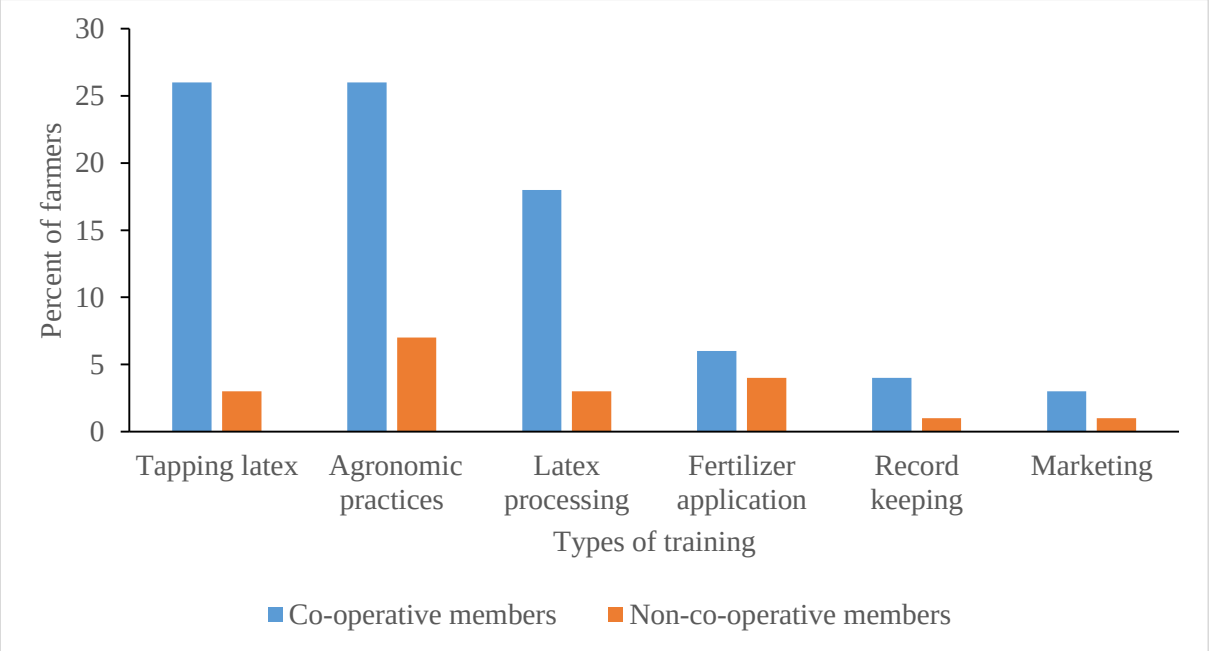


Figure 4. 1: Types of training access by co-operative membership

4.1. 3 Institutional and farm characteristics

Table 4.2 indicates that on average, co-operative farmers were seven more kilometers away from the nearest local market compared to their non-co-operative counterparts. The results show that the mean distance away from the nearest local market varies significantly between the two groups at 1 percent. A plausible explanation is that farmers joined co-operative to reduce the high transaction costs in accessing markets by collective marketing their NR. Co-operative farmers owned more transport means (15percent), such as bicycle, motorbike, and vehicle than non-co-operative farmers (3percent). The results show that ownership of transport means was significantly different between the two groups at 1 percent. This is attributed to the large farm size (11-20 acres), which is associated with higher production and farm income that can be invested in farm activities. Ownership of transport means reduce the transaction costs of waiting for commercial vehicles to access both input and output markets.

The average output of farmers in co-operative was significantly more (7071kg) than non-co-operative members, and the difference was significant at 5 percent. This is attributed to co-operative farmers having more training in NR production and having bigger farm sizes compared to their counterparts. The co-operative provided training in latex tapping and agronomic practices. This contributed to the high production. The average annual income of co-operative members was more (US$ 276) than non-members (US$ 231), but there was no significant difference. Similarly, the results also show no significant difference in the income from other crops between co-operative and non-co-operative members. These results indicate that NR is more profitable than other corps, and most of the farm income is derived from the sales of NR.

Table 4. 2 Comparing the institutional and farm characteristics of natural rubber farmers

Variables	Co-operative farmers (n=97)	Non-co-operative farmers (n=97)	Total sampled (n=194)		Significant Differences
		Means		***t- ratio***	**(P-value)**
Distance to the market (km)	25	17	21	-3.11	0.00***
Annual output of NR (Kg)	7071	5681	6376	-1.96	0.05**
Annual income from NR (US$)	276	231	253	-1.48	0.14
Annual income from other crops (US$)	23	18	20	-1.14	0.25
		Percentages of household		***z- ratio***	
Planting material (Budded stem) [a]	28.87	29.9	29.38	0.15	0.87
Disease type (root type of disease experienced) [b]	45.4	70.1	57.30	-3.49	0.005***
Post-harvest losses (Yes)	69.1	49.5	59.20	-2.77	0.00***
Payment delays from sales of NR (Yes)	53.6	46.30	55.20	0.43	0.66
Ownership of transport means (Yes) [c]	15.46	3.09	9.28	-3.02	0.00***
Time taken to find buyer (1= < 8 hours) [d]	75.3	30	52.60	-6.33	0.00***
		Percentages of household		χ^2	
Farm size (acres)					
5 < acres	10.31	29.9	20.1	21.18	0.00
5-10 acres	15.5	27.8	21.7		
11-20 acres	74	42.3	58.3		

***, ** Significant at 1 and 5 percent respectively.

Natural rubber (NR)

a = budded stem is a form of bud grafting that is done with NR.

b = Root type of disease are diseases specific to the root of NR tree.

c = Ownership of transport means are motorbike, bicycle, and vehicle.

d = NR latex takes 8 hours to coagulate.

Kg= Kilogram

About 69 percent of the co-operative farmers incurred post-harvest losses caused by contamination by rain, plastic sacks, leaves, and flaking of the tree bark when securing the cup for tapping compared to 49 percent of non-co-operative farmers. The difference was significant

at 1 percent. Post-harvest losses can also be incurred by improper application of acid to coagulate the latex. The high losses may be attributed to the co-operative being unable to provide farmers with rain guard to use during the wet season. This result contradicts Simelane (2011), who found that non-co-operative dairy farmers incurred more losses in processing milk compared to co-operative farmers in Swaziland. The author noted that the co-operative provided training in milk handling practices. About 70 percent of non-co-operative farmers experienced diseases that affect the roots compared to 45 percent of co-operative farmers. The results show that the proportion of households experiencing root type of disease varies significantly between the two groups at 1 percent. This is likely that the co-operative has trained farmers in good agricultural practices that curtailed roots type of disease. Natural rubber latex has to be sold within in eight hours to maintain quality. Results show that only 30 percent of the non-co-operative members found buyers before eight hours from harvest compared to 75 percent of co-operative members. The difference was significant at 1 percent. Social capital among co-operative farmers enables easy access to marketing information.

A significantly higher percentage of the co-operative farmers have bigger farm sizes (11-20 acres) compared to non-members, and the difference was significant at 5 percent level. Large farms have the potential to increase agriculture production. They need co-operative to sell their produce since the co-operative provides access to market and other inputs at a lower cost. This is consistent with Francesconi and Heerink (2010) who found that in Ethiopia, co-operative farmers were large scale farmers.

4.1.4 Selling outlets of smallholder rubber farmers by co-operative membership

Appendix V shows that there are seven selling outlets used for smallholder NR farmers in Lao PDR and other NR producing countries in Asia. However, in Liberia, only a few of the outlets

mentioned in Appendix V are used by smallholder farmers. The selling outlets depend on the latex processing method used. For instance, farmers processing latex into cup lump are more likely to sell at farm-gate or to trader and processor, while farmers processing into technical specified rubber and ribbed smoked sheet mostly use international markets. The selling of NR at the farm-gate, local market and to traders requires less quality control compared to the selling of NR to processors or large scale holder that requires checking for quality such as if the right acid is used and not infuse with impurities. Results in Table 4.3 show that majority of the co-operative farmers (59 percent) sold NR to processors and large scale farmers, while 20 percent sold at farm-gate.

Table 4. 3: Selling outlets by co-operative membership

Variables	Co-operative farmers (n=97)	Non-members (n=97)	Total (n=194)	χ^2	Significant differences	Mean price at various outlets
		Percentages of household				
Selling outlets				7.34	0.062*	
Farm-gate	20.62	32.99	26.80			0.37
Trader	9.28	3.09	6.19			0.40
Local market	11.34	15.46	13.40			0.43
Large scale/ processor	58.76	48.45	53.61			0.48

Average prices offered per 1kg of natural rubber in April 2018 at various selling outlets in Gibi and Kakata Districts

* Significance at 10 percent

The results indicate that more co-operative farmers significantly used alternative markets (Trader, local market, large scale/ processors) compared to their counterpart. The difference is significant at 10 percent. This suggests that access to training in processing NR and social capital among co-operative members have helped minimize quantity and quality constrained faced by members. Co-operative farmers mostly come together and sell their NR to processors to get high prices. This helps overcome the high transportation cost constraint caused by long distant.

4.1.5 Reasons for the selection of selling outlets

In selecting the selling outlets, majority of the farmers 42 percent revealed using better price as selection criteria followed by direct payment, less quality control, receiving inputs and loan from traders, lower transaction costs in accessing the outlets and proximity as selection criteria (Table 4.4). Farmers who sold NR to processors profited high prices compared to those who sold at farm-gate, local markets and to traders. As mentioned in the preceding section, the selling outlets in Table 4.4 were group into two: farm-gate and alternative markets.

Table 4. 4: Reasons for the choice of selling outlets

Selling outlets	Reason	Percentage
Farm-gate	Instant cash received from sales. Low production. Lack of information about other selling outlets. No ownership of transport means. Received inputs and loans from traders. Less quality control measures.	33.69
Large scale or processor	Better price offered.	41.66
Trader	Lower transaction costs in accessing the outlets.	6.41
Local market	Closer to farm.	18.18

4.1.6 Farm characteristics by choice of selling outlets

The average output of farmers selling at alternative markets was significantly higher 647 kg than those selling at farm-gate 425kg (Table 4.5). This is likely that alternative markets sellers have bigger farm sizes compared to their farm-gate counterparts. The mean household size for farmers selling at the farm gate was lesser (7) than farmers selling in alternative markets (8). The result shows 1 percent significant difference between the two groups of farmers in term of

household size. This is because less family labor is available for farm-gate sellers to produce enough bulk quantities of NR that can be sold in high price markets.

Table 4. 5 Farm characteristics by selling outlets

	Farm-gate sellers (n=64)	(Alternative markets)[a] (n=130)		Significant Differences
Variables	**Means**		***t*-ratio**	**(P-value)**
Monthly yield of NR (Kg)	425.47	647.96	3.45	0.00***
Household size	7	8	2.18	0.03***
	Percentages of household		***z*-ratio**	
Farm size (1= 0-10 acres)	50	37.7	-1.63	0.10*
Ownership of transport means (Yes)	5	17	2.39	0.02***

***, ** Significance levels at 1 and 5, percent respectively
Natural rubber (NR)
Kilogram (Kg)
[a] = Alternative markets are trader, local market, large scale / processors

Alternative market sellers significantly owned bigger farms than farm-gate sellers.

Almost 17 percent of the farmers selling through alternative markets owned transport means compared to 5 percent of farm-gate sellers. Ownership of transport means was significantly different between the two groups at 1 percent. Ownership of transport means increase access to distant markets and helps in the reduction of transportation costs.

4.2 Factors affecting households choice of selling outlets

The results in Table 4.6 indicate that distance to the nearest market, ownership of transport means, time taken to find buyers, household size, access to market information and access to extension services significantly influenced households selling outlets.

Table 4.6 Determinants of household choice of selling outlets at farm-gate or at Alternative outlets

Dependent variable: Household choice of selling outlets (1= Farm-gate, 0= Alternative markets)[a]			
Variables description	**Coefficient**	**Robust Std. error**	**Marginal Effect (dy/dx)**
Member of NR co-operative (1=yes, 0= no)	-0.156	0.063	-0.020
Gender (1= male, 0= female)	0.485	0.088	0.063
Household size	- 0.146	0.008	-0.019 **
Access to extension (1= yes, 0= no)	3.714	0.155	0.483***
Training in latex production (1=yes, 0= no)	-0.935	0.083	-0.121
Access to market information (1=yes, 0=no)	-0.836	0.052	-0.109**
Time taken to find buyers(1= < 8 hours, 0=>8)	0.867	0.053	0.113**
Farm size (1= 0-10 acres, 0=10> acres)[b]	-0.351	0.054	-0.046
Distance to the nearest market (km)	-0.084	0.001	-0 .011***
Ownership of transport means (1=yes, 0=no)[c]	-1.516	0.104	-0.197 *
Log Likelihood = -78.82			
Pseudo R^2 = 0.36			
Prob >χ^2 = 0.000 (test for overall significance of the model)			
LR $\chi^2(10)$ = 49.41			

Natural rubber (NR)

***, **,* Significance levels at 1, 5 and 10 percent respectively

a = Alternative markets are trader, local market and large scale / processors

b= The distribution of the farm size were 20, 21 and 58 percent for 5 < acres, 5- 10 acres and 11-20 acres, respectively. For the model, 5 < acres and 5- 10 acres were combined into one to have some level of equal distribution in the model.

c = Ownership of transport means are motorbike, bicycle, and vehicle

Results show that co-operative membership has a negative but no significant effect on the decision to sell at farm-gate. Table 4.6 indicates that the decision to sell at farm-gate or alternative markets is not dependent on whether a farmer is a member of the NR co-operative or not. A plausible explanation is that smallholder farmers in the study areas depend on the

sales of NR for daily sustenance. Therefore, farmers may opt to use a selling outlet that will provide direct payment.

A unit increase in household size reduced the probability of selling at farm-gate by 2 percent. A plausible explanation is that large household size is an indication of more family labor available to produce bulk quantities of NR to access distant markets with a high price and markets that require a specific quantity. This result corroborates with the finding of Kadigi (2013), who found that an increase in household size in Tanzania reduced the probability of dairy farmers selling at farm-gate. The author indicated farmers used family labor to help in the milking of the cow to increase production.

The likelihood of selling at farm-gate was 48 percent higher for household who have received extension services. The result is contrary to priori expectation. This is because the extension services provided in the study area are mostly oriented towards other agricultural activities such as tapping of NR latex than marketing, hence, farmers received more information about increasing the yield of NR than marketing it. Additional discussion with farmers revealed that the extension services provided are mainly toward reducing of NR diseases. This is demonstrated in the descriptive results. Similarly, Alemu *et al.* (2011) who studied determinants of vegetable channels selection in Ethiopia, found that access to extension negatively influenced market participation. The author indicated that extension officers provided more training toward production than marketing.

Access to market information about price, selling outlets and buyers reduced the probability of selling at farm-gate by 11 percent. Access to market information enables farmers to analyze the market situation and information about prices and the quantity of NR to supply to the

market. Access to information reduces the transaction costs of searching for buyers and storage. Further, it reduces the risk of oversupplying NR to the market that results in the acceptance of lower price. The result concurs with Osebeyo and Aye (2014), who found that access to market information increased smallholder tomatoes farmers market participation in Nigeria. The authors revealed that access to information helps farmers to know the demand for their crops and help farmers avoid selling for unwanted prices.

Taking less than 8 hours to find a buyer for NR increased the probability of selling at farm-gate by 11 percent. This is attributed to the long distance in accessing markets, quantity, and costs as well. Farmers mostly look at the quantity of NR they have and the cost they will incur in accessing the market. If the quantity is low and the cost of accessing the market is almost equivalent to the price the NR will be sold, the farmer will prefer selling at the farm-gate where buyers are available than going to the market.

A kilometer increase in the distance from the nearest local market to the farm reduced the probability of selling at farm-gate by 11 percent. This means that households closer to the nearest local market are more likely to sell at farm-gate compared to households' distant from the market. A reasonable explanation is that farm-gate sellers mostly have a lower quantity that restricts them from accessing alternative markets, though they are closer to the market. Additionally, there are less quality restrictions in selling at farm-gate than to alternative markets to processors who demand a specific NR quality. Randela *et al.* (2008) made similar observations in South Africa, where cotton farmers were most likely to travel long distances for commercialization.

A household owning transport means (bicycle, motorbike, and vehicle) reduced the probability of selling at farm-gate by 20 percent. Ownership of transport means helps lower the transaction costs such as transportation cost in accessing markets and time spent waiting for commercial vehicles. This helps increase the quantity of NR traded on the market and make farmers more efficient in marketing. Additionally, it provides greater insight into the marketing choices made by farmers in selling NR. The result is consistent with Sigei *et al*. (2015) who find that in Kenya, ownership of transport means increased small-scale pineapple farmers market participation. Similarly, Key *et al.* (2000) find that ownership of transport means increased farmers likelihood of participating in alternative markets.

4.3 Impact of participation in the natural rubber co-operative on farm income

4.3.1 Factors influencing farmers participation in the natural rubber Co-operative

The results of the logit model in Table 4.7 indicate that household size, access to production and market information, NR disease type, post-harvest losses, training in NR production and marketing, payment delays, farm size, and age group significantly influenced households participation decisions in the NR co-operative. The probability of participating in NR co-operative reduced by 23 percent if a farmer is younger. A plausible explanation is that younger farmers in the study areas are not interested in farming activities, thus, preferred traveling to urban areas to find employment outside agriculture. This result is consistent with Fischer and Qaim (2012), who found that older banana farmers in Kenya were more likely to participate in agricultural co-operative.

Table 4. 7: Propensity scores estimates for farmers participation in the natural rubber co-operative using a logit model

Dependent variable: Household member of a natural rubber co-operative (1=Yes, 0= No)			
Variables description	**Coefficient**	**Std. error**	**Marginal propensity scores (dy/dx)**
Age group (1=18-35 years, 0=35> years)	-1.335	0.074	-0.227***
Gender (1=male, 0= female)	-0.790	0.092	-0.134
Household size (continuous)	-0.152	0.016	-0.028*
Dependency ratio (continuous)	0.195	0.022	0.033
Farming Experienced (years)	0.017	0.003	0.004
Access to Extension (1=yes, 0= no)	1.617	0.153	0.274
Training in NR production (1=yes, 0= no)[a]	2.322	0.094	0.395***
Access to market information (1=yes, 0= no)	-0.979	0 .083	-0.167**
Farm size (1= 0-10 acres, 0=10> acres)[b]	-1.348	0.069	-0.229***
Planting Materials (1= budded stem, 0= seedling)[c]	-0.118	0.071	-0.020
NR disease experienced (1= root, 0= stem)[d]	1.754	0.081	0.298***
Post-harvest losses in NR production(1=yes, 0=no)	0.743	0.068	0.126*
Payment delays from the sales of NR (1=yes, 0= no)	-0.682	0.065	-0.116*
Log Likelihood = -99.27			
Pseudo R^2 = 0.26			
Prob > χ^2 = 000 (test for overall significance of the model)			
LR χ^2 (13) = 70.40			

***, **, * Significance levels at 1 , 5, and 10 percent respectively

a = Training such as tapping of latex, planting of NR, bud grafting, diseases and pest management

b =The distribution of the farm size were 20, 21 and 58 for 5 < acres, 5-10 acres and, 11-20 acres respectively. For the model, 5 and 5-10 acres were combined into one to have some level of equal distribution in the model

c = budded stem is a form of bud grafting that is done with NR.

d = Root and stem type of disease are diseases specific to the root and stem of NR tree

The findings contradict Karl *et al*. (2006) who found that in Turkey, the probability of participating in rice co-operative declines with increases in the age of the household head.

A unit increase in household size reduces the propensity scores of participating in NR co-operative by about 3 percent. This is attributed to the fact that the larger households' have more family labor for NR production and marketing activities. Also, large households have more people that are likely to earn off-farm income that can be invested in NR production. For instance, Musafiri (2016) found that large household size in Rwanda is associated with an increase in agricultural productivity and net farm income per hectare. The result concurs with Karl *et al*. (2006), who found that an increase in household size increased the probability of participating in rice co-operative in Turkey.

Access to training in latex production, tapping, processing latex, agronomic practices and record-keeping by government and non-government organizations increased the propensity score of participating in NR co-operative by 40 percent. The likely reason is that trained farmers know the benefits of group production and marketing as provided by co-operative. Moreover, trainers disseminate information about the benefits of farming organization and encourage farmers' participation. For instance, Grace (2011), found that access to training in Rwanda by dairy farmers influenced farmers decision to join co-operative.

Access to market information reduced the propensity scores of participating in NR co-operative by 17 percent. This suggests that farmers who accessed market information through extension officers, radio program, and fellow farmers had a lower probability of participating in the NR cooperative compared to their counterpart. A plausible explanation is that information about production and marketing is mostly provided by processors, therefore farmers go to the offices of the processors or contact their fellow farmers nearest to the processors' office to get information about price. Additionally, information is also obtained through radio programs. Conversely, Abebaw and Haile (2013), who studied the impact of co-operative on technology

adoption in Ethiopia, noted that access to information increased the probability of participating in agricultural co-operatives.

Farmers owning smaller farm size, less than ten acres reduced the propensity scores of participating in NR co-operative by 23 percent. Smaller farms mostly lack access to productive resources such as cash that serves as entry barriers in formal groups. For instance, farmers revealed that the co-operative charge 1,000 Liberian dollars for registration. Farmers complained that the amount was high, therefore, serving as an entry barrier for their participation in the NR co-operative. Fischer and Qaim (2012), note that an increase in farm size increased the probability of participating in banana co-operatives in Kenya, contrary to Awotide *et al*. (2015), who find that an increase in farm size reduced the probability of participating in rice co-operative in Nigeria.

Experiences of diseases that affect the root of the NR tree increased the propensity scores of participating in the NR co-operative by 30 percent. A plausible explanation is that farmers joined co-operatives with the intention of learning agronomic practices that curb diseases. Moreover, farmers can benefit from the collective bulk purchase of pesticides, and fungicides carried on by the co-operative. This brings about economies of scale and disease prevention, which subsequently increase production.

Farmers who experienced post-harvest losses have a higher propensity score of participating in NR cooperatives by 13 percent. A plausible explanation is that NR latex harvesting and management requires specialized skills. Wrongful tapping of the NR tree destroyed the cambium and reduced the yield of NR latex. Hence, farmers joined cooperative in order to

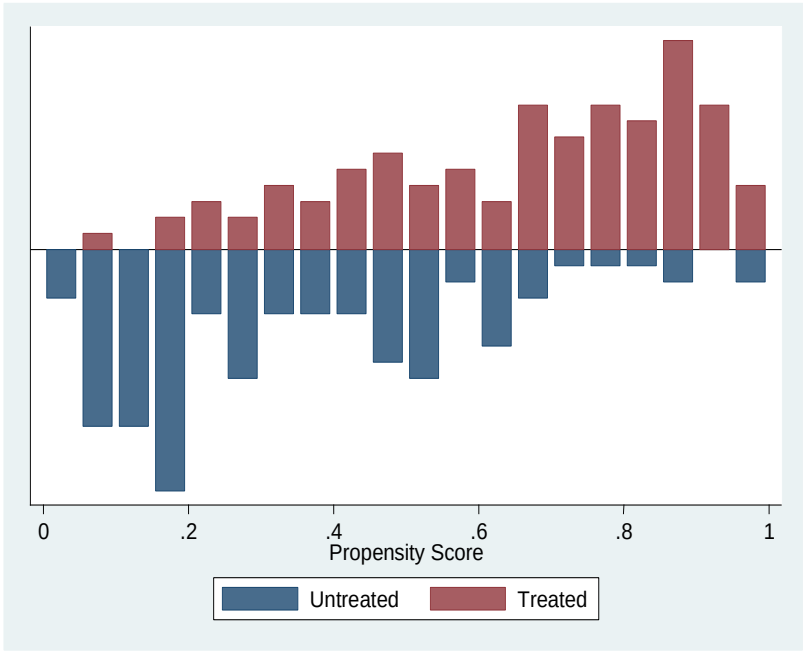
access training on better farming methods such as cleaning of the tapping knife and the NR tree with agrochemical after tapping and also the management of the latex.

Delays in payment reduced the propensity score of participating in NR co-operative by 12 percent explaining why farmers preferred to sell NR to the market directly or itinerant traders who pay immediately. Shiferaw *et al*. (2009) reported similar findings in Kenya, where grain marking co-operative took more than four weeks to pay farmers. However, the results contradict Bakucs *et al.* (2012) who found that in Hungary, agricultural co-operative members benefited from direct payment.

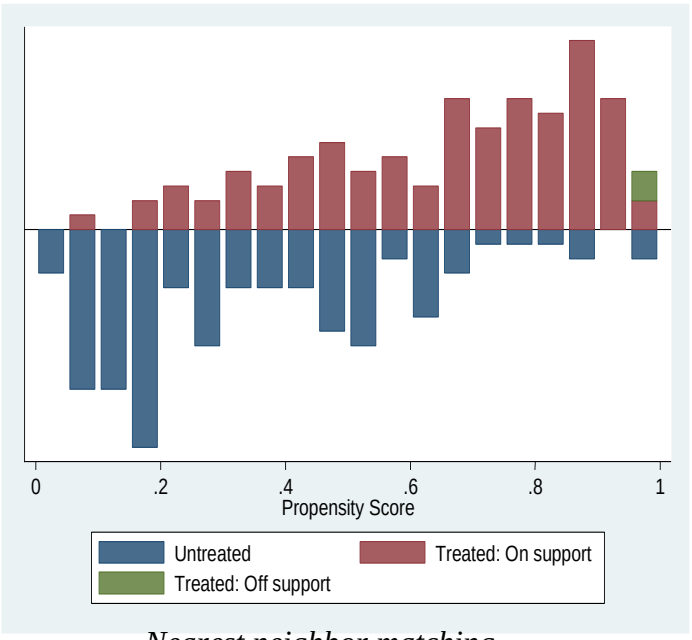
4.3.2 Validating the PSM results: Testing for common support requirement

Figure 4.2 presents the pairing of similar estimated propensity scores of the treated (co-operative members) and untreated (non-co-operative members) and the region of common support. The common support region is the area within the minimum propensity score of the treated and the maximum propensity score of the untreated. The horizontal and vertical axes show the estimated propensity scores and the observed frequency, respectively. The treated on support indicates the matching of observation with similar propensity scores in the two groups, while treated off support shows unmatched observation who propensity scores are smaller than the minimum of the treated and greater than the maximum of the untreated. The distribution is unbalanced because those observations whose propensity scores are smaller than the minimum propensity score of the treated and greater than the maximum propensity scores of the comparison group (untreated) are eliminated from the estimation of the average treatment effect on the treated (ATT) to restrict the observation to the region of common support to avoid bad match. For instance, treated households who do not have similar observable characteristics like the control.

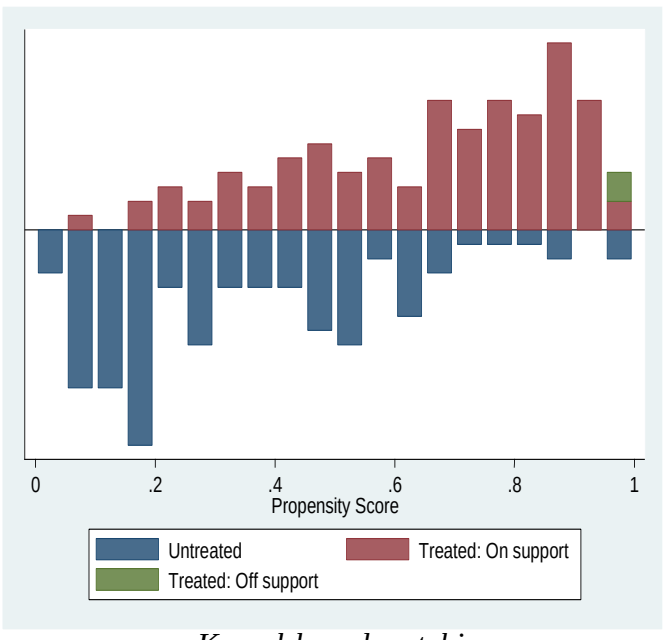
As mentioned in the methodology, the Nearest Neighbor Matching (NNM), Radius Matching (RM), and Kernel-Based Matching (KBM) are the most widely used matching algorithms. These algorithms provide a visual assessment of the density function of the two groups (Caliendo and Kopeinig, 2008). Figure 4.2 shows that two households were excluded using the NNM and KBM due to lack of common support. This means their propensity scores lied outside the region of common support. Hence, they are dropped from the sample in estimating the average treatment effect on the treated (ATT). The result is that each individual in the remaining sample now had a positive probability of being either a member of the NR co-operative or non-member. This implies that the common support assumption, which requires for each treated household to have a corresponding untreated household as a match was satisfied (Austin, 2011).



Radius matching algorithm



Nearest neighbor matching



Kernel-based matching

Figure 4. 2: Pairing of propensity scores among treatment and control groups in the region of common support using nearest neighbor, radius matching, kernel-based matching

4.3.3 Covariate balancing test

The balancing test shows whether or not the differences in the covariates between the participants and non-participants have been removed. If they have been removed, the untreated can be considered as plausible counterfactual (Caliendo and Kopeinig, 2008). The three algorithms, NNM, KBM, and RM, were employed by Francesconi and Heerink (2010) and Ogutu *et al*.(2014), who studied the impact of co-operative membership on commercialization and the impact of information and communication technology in Ethiopia and Kenya, respectively were used for the balancing test which involves verifying the quality of the match.

The matching quality determines whether or not the matching algorithms or methods used balanced the distribution of relevant covariates in both treatment and control groups. Several covariate balancing tests can be used to balance the distribution of variables in the control and treatment groups. The main ideas of all the tests have been to compare the variables before and after matching to check if there is stay any significant differences. For this study, the standardized bias test was first calculated to check if matching reduces bias after matching and a two-sample t-test was used to check if the significant differences between participants and non-participants have been removed after matching. Additionally, a pseudo R^2 test was performed to compare the pseudo R^2 from the logit model before and after matching. Lastly, the absolute mean bias test was performed to check for a reduction in mean bias between participants and non-participants after matching and if the balancing property is satisfied (Caliendo and Kopenig, 2005). According to Rosenbaum (2002), Sianesi (2004), and Haji and Legesse (2017), after matching there should be a large number of insignificant variables, reduction in bias and low pseudo R^2 to show no systematic differences in the distribution of covariates between participants and non-participants to indicate a good comparison group (counterfactual).

The results of the covariate balancing test using the RM, NNM, KBM algorithms are given in Appendix III. The results in Appendix III, Table 1 show a reduction in bias for all the covariates after matching using the RM. From the two tail t-test in column 6, we observed that before matching seven variables show statistically significant differences, while after matching we have only three variables significantly different indicating a good counterfactual because of the large number of insignificant variables.

Similarly, the results in Appendix III Table 2, using NNM, show that 7 of the p-value in column 6 before matching exhibit statistically significant differences and after matching, we have only one variable significantly different. This also indicates a good counterfactual because of the many insignificant differences between participants and non-participants. Lastly, the results in Appendix III, Table 3 using KBM indicates that 7 of the p-value in column 6 before matching show statistically significant differences, while after matching we have only 3 of the variables significantly different.

The evaluation of the matching algorithms in Table 4.8 shows a substantial reduction in standardized mean bias after matching for NNM, RM and KBM. The estimates indicate that the mean bias reduced from 30.7 percent before matching for the three matching algorithms to 12.6, 15.9, and 15.7 percent after matching for NNM, RM, and KBM, respectively. This implies that after matching, there are no observable differences in characteristics between co-operative and non-co-operative farmers. This suggests that the non-co-operative farmers (control) were a good counterfactual or comparison group. The percentage reduction in the absolute mean bias is 74, 1.22 and 95 percent using the NNM, RM, and KBM algorithms, respectively.

Table 4. 8 Statistical test to evaluate the quality of the matching estimators with nearest neighbor, radius and kernel-based matching algorithms

	Mean bias			Pseudo-R^2		P-value of LR	
Matching algorithms	**Before**	**After**	**% Absolute bias reduction (mean bias)**	**Unmatched**	**Matched**	**Unmatched**	**Matched**
NNM	30.7	12.6	74	0.26	0.060	0.00	0.297
RM	30.7	15.9	1.22	0.26	0.066	0.00	0.163
KBM	30.7	15.7	95	0.26	0.064	0.00	0.209

NNM: Nearest neighbor matching, RM: Radius matching, KBM: Kernel-based matching

The percentage reduction in NNM and KBM is greater than 20 percent. This conforms with Rosenbaum and Rubin (1985), who proposed 20 percent or greater is sufficiently large for absolute or standardize bias reduction. This showed that matching substantially reduced the selection bias caused by farmers' self-selection in the NR co-operative.

After matching, there is no systematic difference in the distribution of covariates between co-operative and non-co-operative farmers showing that matching reduced selection bias. The Pseudo-R^2 of the estimated logit model was high before matching at 0.26 as indicated in Table 4.8 and low afterward for all matching algorithms at 0.06, 0.066 and 0.064 for NNM, RM, and KBM, respectively. Also, the p-value of the likelihood ratio tests was statistically significant at all levels before matching for the three matching algorithms, but insignificant at all levels after matching. The results corroborate with Sianesi (2004), who said that after matching the pseudo-R^2 should be low to show significant at all levels and the p-value of the likelihood ratio should be insignificant to reflect that there is no complete difference in the distribution of covariates between the two groups of farmers. In conclusion, the matching estimators indicate that co-operative and non-co-operative members were significantly different in terms of certain pretreatment characteristics such as age and training before matching, however, after matching the insignificant p-value of the likelihood ratio, low pseudo-R^2, reduction in bias after matching

in Table 4.8 and the insignificant p-values with the various algorithms in Appendix III indicates that the differences were removed, showing a good counterfactual and well distribution of covariates between the two groups.

These results suggest that there was no systematic difference in covariates distribution between co-operative member and non-member with regards to the outcome of interest in this study, farm income. This means that any difference in farm income that may arise between the two groups would be due to farmers' participation in the NR co-operative. Therefore, the balancing property was satisfied. From the results, the NNM is the best matching algorithm because it has a large number of insignificant variables and an absolute bias reduction of more than 20 percent, hence, the sensitivity of the result was checked using the NNM.

4.3.4 Testing for hidden bias with sensitivity analysis

The conditional independence assumption (CIA) involves the inclusion of all observable explanatory variables expected to simultaneously influence farmer participation in the NR co-operative and farm income that serves as the outcome variable (Caliendo and Kopenig, 2005). In other words, the estimation of the treatment effect with the matching algorithms is based only on observable characteristics.

However, excluding entry barrier, participation in the NR co-operative is not random, there may be initial differences or unobservable characteristics such as managerial skills, social network and technical ability that influence participation and outcome variable (farm income) simultaneously. If this happens, the issue of hidden bias or selection on the unobservable may arise, leading to inconsistency and lack of robustness of the estimator. PSM does not control for this hidden bias because it assumes participation in the NR co-operative is based only on

observable characteristics. The sensitivity analysis test shows whether the treatment effects of participating in the NR co-operative that is based on observable characteristic has been altered by the unobservable characteristics previously mentioned (Rosenbaum, 2002). Several sensitivity analysis tests can be used to check for selection bias or the influence of unobservable variables on participation and average treatment effect on the treated (ATT). This study employed Rosenbaum bounds test (rbounds) to check the sensitivity of the results.

The results of the sensitivity analysis to unobservable heterogeneity in appendix IV indicate that the critical level of gamma (**γ)** for the impact of NR co-operative on farm income varies between 2.0 and 2.1. This indicates that the unobservable variable would have to increase the odds ratio of participation in the NR co-operative by 100 -110 percent before it would nullify the estimated impact. Similarly, Ogutu *et al*. (2014), studied the impact of ICT based market information services in Kenya and reported a critical value of gamma **γ** close to this study. The study concludes that the estimated treatment effect of participation in the NR co-operative on farm income remains unchanged even in the presence of substantial amounts of unobserved heterogeneity. Hence, the CIA was satisfied.

4.3.5 Impact of farmer's participation in the natural rubber co-operative on farm income

Table 4.9 Summarized the estimation results of the average treatment effect on the treated (ATT) of the outcome variable (farm income) using the NNM, RM, and KBM matching methods. The impact estimates indicate that the NR co-operative has a positive and significant impact on the income of its members using the matching algorithms above. This indicates that the average farm income for co-operative farmers was significantly more (138.3 US$) than non-co-operative farmers.

Table 4. 9 Impact of rubber co-operative on farmer income from natural rubber production under different matching algorithms from 2017-2018

Outcome variable: farm Income in US$ from 2017-2018

Matching algorithms	Co-operative members	Non-co-operative members	ATT (Difference)	Std. Error	t-value
NNM	277.2 US$	168.6 US$	108.6 US$	52.6	2.07**
RM	275.6 US$	137.4 US$	138.3 US$	44.7	3.09***
KBM	277.2 US$	139.7 US$	137.6 US$	45.2	3.04***

***, * Significance levels at 1 and 5 percent respectively

ATT = Average Treatment Effect on the Treated

US$ = United States Dollar.

NNM: Nearest neighbor matching, RM: Radius matching, KBM: Kernel-based matching

Based on the finding, we reject the null hypothesis that there is no difference between the farm income of NR co-operative members and non-members and conclude that the NR co-operative had a significant influenced on the income of its members.

The average treatment effect on the treated (ATT) for participation in the NR co-operative is US$ 108.6, 138.3 and 137.6 with the NNM, RM and KBM algorithms, respectively. The treatment effect is significantly different at 1 and 5 percent for RM, KBM, and NNM, respectively. This shows that participation in the NR co-operative increased farm income by between US$ 108.6 and US$ 138.3 per year. The finding implies that the co-operative in the study areas have offered training in good agronomic practices such as weeding, fertilizer application and farm sanitation, coupled with training in the tapping of latex and processing among members. This has increased the production of co-operative farmers and provided additional income for members. This result is consistent with the finding of Verhofstadt and Maertens (2014) and Ito *et al*. (2012) who revealed that agricultural co-operatives in Rwanda and China increased members income through the provision of quality inputs and adoption of

production technology. The difference in farm income between co-operative member and non-member is between 108.6 US$ to 138.3 US$ for the three matching methods. The difference in farm income is mainly attributed to co-operative farmers having higher production of NR, more accessed to training and mostly selling to outlets that offered better prices which have enabled members to earn more income from the sales of NR compared to their counterpart.

CHAPTER 5: SUMMARY, CONCLUSION, AND RECOMMENDATIONS

5.1 Summary

Natural rubber is the most important cash crop in Liberia, ranked second to iron ore in value of export. About 10.3 percent of the rural households in Liberia grow NR. Rural households depend on the income for livelihood. Despite the importance of NR to the Liberian economy, small and medium farmers that dominate the sector are faced with production and marketing constraints, particularly poor agronomic practices, lack of training in latex tapping and processing and limited selling outlets. To overcome some of the constraints faced by farmers, the Government, civil society organizations, and donors, introduced co-operatives as a medium through which farmers can improve the production and marketing of NR for better livelihoods.

However, little attention has been given to NR and the farmer co-operative handling it, even though it is the highest contributor to GDP and foreign exchange earner in the agricultural sector. The role of NR co-operatives in Liberia in increasing smallholder NR farmers income by enhancing skills in good agronomic practices and improving market access is not clear. Therefore, the overall objective of this study was to determine the impact of the NR co-operative on the choice of selling outlets and farm income in Liberia. The specific objectives were to compare the socioeconomic and farm characteristics of co-operative and non-co-operative members, to determine the effect of co-operative membership and others socioeconomic factors on the choice of selling outlets, and to evaluate the impact of co-operative membership on farm income.

Multi-stage stratifying sampling procedure was used as follows. First, the county and districts were purposively selected because it has a well-functioning rubber co-operatives and a large number of smallholder rubber farmers. Second, a list of co-operative farmers and non-co-

operative farmers were obtained from the county agricultural coordinator and the head of the co-operative in the study area. The lists produced 280 households belonging to co-operative and 250 non-co-operative in Gibi and Kakata districts, respectively. Respondents were randomly selected from the two districts based on a probability proportional to size using a random number table. Descriptive statistics were used to compare the socioeconomic and farm characteristics of the two groups of farmers. The logit model was used to determine the effect of co-operative membership, institutional and other socioeconomic factors on farmers choice of selling outlets. Finally, the propensity score matching method was used to determine the impact of co-operative membership on farm income.

5.2 Conclusion and recommendations

Socioeconomic and farm characteristics of households

The result shows that a significantly lower percentage of the co-operative farmers were youth (18-35 years) compared to non-co-operative members. Farmers in the rubber co-operative had significantly five more years of experience compared to their non-cooperative counterparts. This suggests that experienced and older farmers are more resourceful, which increase their participation in formal groups. A significantly higher percentage of the co-operative farmers had access to training compared to non-co-operative farmers. The results indicate that the NR co-operative provided more training opportunities for members in agronomic practices, latex tapping, and processing to improve the production and marketing of NR.

The study found that on average, the distance in kilometers to the nearest local market was significantly higher for co-operative farmers compared to non-co-operative farmers. This observation suggests that farmers joined co-operative to minimize the high transaction costs in accessing market and information by collectively transporting their NR to the market. Co-

operative farmers significantly owned bigger farms compared to non-co-operative farmers, suggesting that bigger farms need co-operative to sell their produce since the co-operative provides access to market and other inputs at a lower cost. A significantly higher percentage of co-operative farmers owned more transport means compared to non-co-operative farmers. This is probably attributed to the large farm sizes owned by co-operative farmers, which is associated with high production and income.

Farmers in co-operative access more training compared to non-co-operative farmers. The training offered by the co-operative mainly focuses on tapping of latex, agronomic practices, and latex processing. Training in latex tapping is very crucial to NR production. Improved tapping techniques and recommended tapping time increase the production of NR latex, which consequently increases farmers income. The results indicate that the NR co-operative is mostly focus on increasing the production of NR than marketing.

It was found that a significantly higher percentage of the co-operative farmers (59 percent) sold NR to processors and large scale farmers, while 20 percent sold at farm-gate. The results indicate that more co-operative farmers use alternative markets (Trader, local market, large scale/ processors) compared to their counterpart. In selecting the selling outlets, majority of the farmers 42 percent revealed using better price as selection criteria followed by direct payment, less quantity and quality control, receiving inputs and loan from traders, lower transaction costs in accessing the outlets and proximity as selection criteria. The training in tapping, processing of NR and social capital among co-operative members have helped minimize quantity and quality constrained faced by members.

The effect of co-operative membership, institutional and other socio-economic factors on smallholder farmers choice of selling outlets.

The logit results showed that the decision to sell at farm-gate or alternative markets is not dependent on whether a farmer is a member of the NR co-operative or not. A plausible explanation is that smallholder farmers in the area depend on the sales of NR for daily sustenance. Therefore, farmers may opt to use a selling outlet that provides direct payment. The results indicated that distance to the nearest market had a significant influence on farmers' decision to sell at farm-gate. Similarly, time taken to find potential buyers had a significant influence on farm-gate sales, while access to market information and ownership of transport means had a significant influence on farm-gate sales. Additionally, access to extension services had a significant influence on farm-gate sales, while household size also had a significant influence on farm-gate sales.

Households having access to market information, mainly price information, and information about potential buyers are less likely to sell at farm-gate. The likelihood of selling at farm-gate increased as a household received extension services. The result is contrary to priori expectation. The study concluded that access to market information enables farmers to analyze the market situation and information about prices and the proportion of NR to supply to the market. The extension services provided in the study area are mostly oriented towards other agricultural activities such as tapping of NR latex than marketing. Hence, farmers received more information about increasing the yield of NR than marketing it. Additional discussion with farmers revealed that the extension services provided are mainly toward reducing NR diseases.

Therefore, the study recommends the establishment of market support services by the Government of Liberia in the form of a market information system, mainly information on price, buyers, processing of latex and accessible markets and transportation means. This will provide up to date and reliable information on potential trading partners and prices, which will reduce the transaction costs of accessing information. The positive influence of access to extension services on the decision to sell at farm-gate calls for extension officers to be more versatile in the services provided to farmers. Extension agents could provide training in marketing and help farmers choose marketing outlets that offer higher prices. This can be done through a village-based field trip, social learning, organizing a weekly radio talk show about the marketing of natural rubber that farmers can listen to or use information communication technology to disseminate marketing information.

Evaluating the impact of participation in the natural rubber co-operative on farm income

The results validate the contribution of co-operative to improving the livelihoods of smallholder farmers. The results of the logit model showed that age, household size, farm size and payment delays, access to market information, training, disease type, and post-harvest losses significantly influenced farmers' decision to participate in the NR co-operative. Younger farmers are less likely to participate in the NR co-operative. Probably the youths prefer migrating to urban places to find jobs off the agricultural sector. Experiences of NR diseases increased the probability of participating in the NR co-operative, probably with the intention of learning agronomic practices that curb the disease. The PSM results showed a significant and positive impact of the NR co-operative on farm income by US$ 108.6, 138.3 and 137.6, respectively for nearest neighbor matching, radius matching, and kernel-based matching algorithms. The finding implies that the co-operative in the study areas have offered training in good agronomic practices coupled with training in the tapping of latex and

processing among members. This has increased the production of co-operative farmers and provided additional income for members.

Participation in the NR co-operative had positively and significantly increased farmers' income. However, participation is very low among smallholder farmers. There is a need to create awareness among non-co-operative farmers about the importance of collective action. This can be done through the Co-operative Development Agency of Liberia, Government extension officers, and civil society organizations. Moreover, training in organization development, especially educating farmers about group membership enables farmers to know the importance of collective action, media advertisement and talk shows on co-operatives can also increase the awareness of co-operatives among farmers. The Government could strengthen and support co-operative as a rural organization that can help reduce poverty and improve the livelihood of rural farmers by encouraging the planting of bud graft rubber and setting up a general processing facility for latex. Since access to training was found to influence farmers participation in the NR co-operative significantly. The Government and donors need to provide technical and institutional support services for farmers in the form of policy that will enable farmers' access training in agronomic practices, tapping and processing of latex. During the training, the importance of collective action for production and marketing of NR can be underscored using examples of existing well run co-operatives.

Suggested research area

Natural rubber is produced in almost all the counties in Liberia, but this study was undertaken only in one county. It is recommended that a similar study be undertaken in other counties in Liberia to compare the impact of NR co-operative. This will inform the Government and policymakers in designing policy and programs directed toward improving the NR sector. Additionally, the study only focus on agriculture income. It is recommended that similar study be undertaken on household income.

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APPENDICES:

Appendix I: Multicollinearity tests results

Table 1: Variance inflation factor for the explanatory variables used to model household choice of selling outlets

Variables	VIF
Gender of the household head	1.05
Household size (number)	1.13
Access to extension services	1.07
Access to market information	1.14
Training in latex production	1.14
Co-operative membership	1.60
Time taken to find buyers	1.49
Farm size (acres)	1.24
Distance to the nearest market	1.18
Ownership of transport means	1.13
Mean VIF	**1.22**

Source: Author's computation, survey data (2018)

Table 2: Variance inflation factor for the explanatory variables used to influence household participation in natural rubber co-operative

Variables	VIF
Gender of the household head	1.07
Age	1.28
Farming experience	1.59
Household size	1.21
Dependency ratio	1.95
Access to extension	1.08
Training in NR production	1.13
Access to information	1.83
Planting material	1.23
Farm size	1.22
Disease type experienced	2.04
Post-harvest losses	1.34
Payment delays from sales of NR	1.25
Mean VIF	**1.48**

Source: Author's computation, survey data, (2018)

Natural rubber (NR)

Appendix II: Results of the Spearman and Pearson correlation matrix tests.

Table 1: Spearman correlation matrix for binary explanatory variables hypothesized to influence household choice of selling outlets

	Transport means	Extension access	Farm size	Training	Time taken to find buyer	Co-operative membership	Gender	Access market information
Transport means	1.0000							
Extension access	-0.085	1.000						
Farm size	-0.107	0.062	1.000					
Training	-0.110	0.053	-0.038	1.000				
Time taken to find buyer	0.180	0.111	-0.054	-0.006	1.0000			
Cooperative membership	0.077	0.074	-0.324	0.223	0.454	1.000		
Gender	-0.002	0.005	-0.078	0.101	-0.093	-0.048	1.000	
Access market information	0.045	0.154	-0.018	-0.168	0.244	0.052	-0.049	1.000

Pearson correlation matrix for continuous explanatory variables hypothesized to influence household choice of selling outlets

	Market distance travel	Household size
Market distance travel	1.000	
Household size	0.093	1.000

Source: Author's computation, survey data, (2018)

Table 2: Spearman correlation matrix for binary explanatory variables hypothesized to influence household participation in the natural rubber co-operative

	Age group	Training	Farm size	Payment delays	Post-harvest losses	Disease types	Extension Access	Planting material	Access market information	Gender
Age group	1.000									
Training	0.109	1.000								
Farm size	0.037	-0.038	1.000							
Payment delays	0.071	0.093	0.091	1.000						
Post-harvest losses	-0.074	-0.000	-0.149	0.349	1.000					
Disease types	-0.041	-0.163	-0.132	0.205	0.327	1.000				
Extension access	0.040	0.053	0.062	-0.048	0.033	0.059	1.000			
Planting material	-0.036	0.133	-0.156	-0.101	-0.064	-0.346	-0.089	1.000		
Access to market information	-0.048	-0.129	-0.021	0.149	0.293	0.437	0.158	-0.278	1.000	
Gender	0.029	0.101	-0.078	-0.010	0.118	-0.074	0.005	-0.009	-0.057	1.000

Pearson correlation matrix for continuous explanatory variables hypothesized to influence household participation in the natural rubber co-operative

	Farming experience	Household size	Dependency ratio
Farming experience	1.000		
Household size	- 0.465	1.000	
Dependency ratio	0.337	0.456	1.000

Source: Author's computation, survey data, (2018)

Appendix III: Results of the covariate balancing tests

Table 1: Covariate balancing tests for selection bias before and after matching using Radius matching

Independent Variables	Sample	Mean		Bias	Significance
		Treated (n= 97)	Control (n=97)	% Bias reduction	t-test P-value
Age (years)	Before matching	0.164	0.340		0.005
	After matching	0.165	0.237	58.8	0.212
Gender of the household head	Before matching	0.865	0.896		0.508
	After matching	0.866	0.773	-200	0.094
Household size	Before matching	7.918	7.288		0.127
	After matching	7.918	7.402	18	0.179
Dependency ratio	Before matching	3.711	3.041		0.017
	After matching	3.711	3.526	72.3	0.516
Farming experience(years)	Before matching	23.155	18.351		0.001
	After matching	23.155	23.474	93.3	0.839
Access to extension	Before matching	0.062	0.030		0.308
	After matching	0.062	0.010	-66.7	0.055
Training in NR production	Before matching	0.216	0.061		0.002
	After matching	0.216	0.226	93.3	0.864
Access to market information	Before matching	0.567	0.494		0.316
	After matching	0.567	0.536	57.1	0.667
Farm size (acres)	Before matching	0.257	0.577		0.000
	After matching	0.258	0.206	83.9	0.398
Planting material (NR variety)	Before matching	1.288	1.299		0.876
	After matching	1.289	1.371	-700	0.224
NR Disease type experienced	Before matching	0.546	0.298		0.000
	After matching	0.546	0.485	75	0.391
Post-harvest losses in NR	Before matching	0.690	0.494		0.005
	After matching	0.691	0.588	47.4	0.136
Payment delays from sales of NR	Before matching	0.536	0.567		0.667
	After matching	0.536	0.371	-433.3	0.021

Source: Survey Data, (2018)
Natural rubber (NR)

Table 2:Covariate balancing tests for selection bias before and after matching using Nearest Neighbor

Independent variables	Sample	Mean		Bias	Significance
		Treated (n= 97)	Control (n=97)	% bias reduction	t-test P-value
Age	Before matching	0.165	0.340		0.005
	After matching	0.158	0.232	58	0.202
Gender of the household head	Before matching	0.865	0.896		0.508
	After matching	0.863	0.789	-138.2	0.182
Household size	Before matching	7.918	7.289		0.127
	After matching	7.863	7.805	90.8	0.888
Dependency ratio	Before matching	3.711	3.041		0.017
	After matching	3.663	3.742	88.2	0.813
Farming experience (years)	Before matching	23.155	18.351		0.001
	After matching	23.116	24.995	60.9	0.262
Access to extension	Before matching	0.0619	0.0309		0.308
	After matching	0.042	0.016	14.9	0.282
Training in NR production	Before matching	0.216	0.062		0.002
	After matching	0.200	0.168	79.6	0.577
Access to market information	Before matching	0.567	0.494		0.316
	After matching	0.557	0.542	78.1	0.828
Farm size (acres)	Before matching	0.258	0.577		0.000
	After matching	0.263	0.221	86.8	0.501
Planting material (NR variety)	Before matching	1.289	1.299		0.876
	After matching	1.294	1.384	-767.9	0.195
Disease type experienced	Before matching	0.546	0.299		0.000
	After matching	0.537	0.505	87.2	0.665
Post-harvest losses	Before matching	0.691	0.495		0.005
	After matching	0.695	0.679	91.9	0.816
Payment delays from sales of NR	Before matching	0.536	0.567		0.667
	After matching	0.547	0.374	-461.6	0.016

Source: Survey Data, (2018)

Natural rubber (NR)

Table 3:Covariate balancing tests for selection bias before and after matching using Kernel-Based matching

Independent variables	Sample	Mean		Bias	Significance
		Treated (n= 97)	Control (n=97)	% bias reduction	t-test P-value
Age (years)	Before Matching	0.165	0.340		0.005
	After matching	0.158	0.242	52	0.148
Gender of the household head	Before Matching	0.866	0.897		0.508
	After matching	0.863	0.768	-206.3	0.093
Household size	Before Matching	7.918	7.289		0.127
	After matching	7.863	7.410	28	0.241
Dependency ratio	Before Matching	3.711	3.041		0.017
	After matching	3.663	3.495	74.9	0.559
Farming experience (years)	Before Matching	23.155	18.351		0.001
	After matching	23.116	23.716	87.5	0.706
Access to extension	Before Matching	0.062	0.030		0.308
	After matching	0.042	0.01	-2.1	0.176
Training in NR production	Before Matching	0.216	0.061		0.002
	After matching	0.2	0.210	93.2	0.858
Access to market information	Before Matching	0.567	0.495		0.316
	After matching	0.557	0.526	56.2	0.664
Farm size (acres)	Before Matching	0.258	0.577		0.000
	After matching	0.263	0.211	83.5	0.396
Planting material (variety)	Before Matching	1.289	1.299		0.876
	After matching	1.294	1.358	-512.6	0.356
Disease type experienced	Before Matching	0.546	0.298		0.000
	After matching	0.537	0.474	74.5	0.387
Post-harvest losses	Before Matching	0.690	0.495		0.005
	After matching	0.695	0.579	40.9	0.098
Payment delays from sales of NR	Before Matching	0.536	0.567		0.667
	After matching	0.547	0.358	-512.6	0.009

Source: Survey Data (2018)
Natural rubber (NR)

Appendix IV: Results of sensitivity analysis with Rosenbaum bounds

Table 1. Sensitivity analysis with Rosenbaum bounds.

Gamma (γ)	Sig+	Sig-
1	.000017	.000017
1.05	.000041	6.7e-06
1.1	.000089	2.6e-06
1.15	.000182	1.0e-06
1.2	.000348	4.0e-07
1.25	.000628	1.5e-07
1.3	.001075	5.9e-08
1.35	.001758	2.3e-08
1.4	.002762	8.7e-09
1.45	.004183	3.3e-09
1.5	.006131	1.3e-09
1.55	.008724	4.8e-10
1.6	.012085	1.8e-10
1.65	.016339	6.9e-11
1.7	.021607	2.6e-11
1.75	.028002	9.9e-12
1.8	.035626	3.7e-12
1.85	.044564	1.4e-12
1.9	.054884	5.2e-13
1.95	.066633	2.0e-13
2	.079836	7.4e-14
2.05	.094494	2.8e-14
2.1	.110588	1.0e-14
2.15	.128078	3.9e-15
2.2	.146901	1.4e-15
2.25	.16698	5.6e-16
2.3	.188219	2.2e-16
2.35	.210511	1.1e-16
2.4	.233739	0
2.45	.257776	0
2.5	.282492	0
2.55	.307753	0
2.6	.333425	0
2.65	.359376	0
2.7	.385478	0
2.75	.411606	0
2.8	.437645	0
2.85	.463485	0
2.9	.489023	0
2.95	.514169	0
3	.538839	0

Source : Survey Data (2018)

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APPENDIX V: QUESTIONNAIRE

Farmer's Questionnaire

Effect of Co-Operative on Smallholder Rubber Farmers Choice of Selling Outlets and Farm Income in Liberia

Household Survey Questionnaire, April 2018

Introduction:

This questionnaire will be used to interview smallholder rubber farmers' household heads; spouse or family members aged 18 years and above who participate in decision making in the household.

Objective of the Survey

The objective of this survey is to gather information about the production and marketing of smallholder farmers in co-operative and non-co-operative farmers in Kakata and Gibi districts. Only farmers that are currently tapping or harvesting latex will be interviewed. The responses from this survey will be treated confidentially and will only be used to inform policymakers about the impact of co-operatives and the constraints farmers faced in marketing natural rubber. The interview will not last more than one hour.

For any clarification or information concerning this survey, please contact: Francis F.B. Mulbah on +231886639382/ +231770420506 / +254796140531 or Francismulbah@gmail.com

General Information

Enumerator's Name: _____

Name of Farmer: _____

Date of Interview: _____

County: _____ District: _____ Village: _____

I am a member of co-operative: [ ] Yes [ ] No

If yes, please provide the name of the co-operative: _____

No	**Section 1: Household Characteristics**	**Codes**
1	What sex is the head of the household?	[ ] 1= Male [ ] 0= Female
2	Age group (years)	[ ] 1= 18-35 [ ] 2= 36– 45 [ ] 3= 46 – 55 [ ] 4= 51 – 65 [ ]5= > 65
3	What is your Education level?	[ ]1= No formal education [ ] 2= Primary education [ ] 3= Secondary education [ ] 4 = Post-secondary education [ ] 5= Tertiary education
4	What is the size of the household?	
5	Do you have access to credit?	[ ] 1= Yes [ ] 0= No
6	Number of household members between 15-64 years old	
7	Number of household members between 15 and 64 years old	
8	Number of household members 65 years and above	
9	Number of household members between 18-64 working off-farm	
10	How many years of Experience do you have in rubber farming?	
11	What are your main source of farm income?	[ ] 1 = Rubber farming [ ] 2= Other agricultural activities
	Which of the following assets do you have on the farm?	[ ] 1= Platform balance [ ] 2= Electric oven [ ] 3= Chemical balance [ ] 4= Other (specify)

No.	**Section 2:Farm Characteristics**	**Codes**
1	Do you own a plot of farming land for rubber?	[ ] 1= Yes [ ] 0 = No
2	How was the Land acquired?	[ ]1 = Co-operative [ ] 2 = Purchased [ ] 3 = Rented [ ] 4= Inherited
3	What size of rubber farm do you have (acres)	[ ]1= <5 [ ] 2= 5-10 [ ] 3= 11-20

Section 3: Input used. Non-labor inputs

	Type of inputs	Which of the inputs you used in rubber production? (Tick as appropriate) √	Place of purchase? [ ]1= Co-operative [ ] 2= From fellow farmers 3[ ]= Agriculture store	Source of funding for inputs? [ ] 1= Co-operative [ ] 2 = Credit [ ]3= Personal cash [ ]4 = Others (specify)	Payment method [ ]1= Cash [ ] 2= Credit [ ] 3= Other (specify)	Challenges faced when accessing inputs: [ ]1= Distance travel [ ]2= Accessibility [ ] 3= High cost [ ] 4= Time taken to acquire inputs	Unit cost	Approximated quantities used Dec 2017-Feb 2018
1	Fertilizer							
2	Herbicides							
3	Polythene sheet							
4	Adhesive for rain guarding							
5	Plastic cup							
6	Spray oil							
7	Power sprayers							
8	Headlights							
	Fungicides							
9	Ammonium Acid							
10	Total quantity and input used: Dec 2017 – Feb 2018							
11	Total cost per unit used: Dec 2017-Feb 2018							

Section 3.1: Input used. Labor input used		
Activities	What is the Labor cost in US$ per-person for the following activities?	
Weeding and spraying of farm		
Tapping of latex		

			Section 4: Production					
	Planting Material	√	Average Latex Yield		Average Latex Sales		yearly yield and sales	
1	Seedling		Per week kg	Per month (kg)	Per week (kg)	Per month (kg)	Yearly yield of latex (Kg)	Yearly sales of latex (kg)
2	Seedling							
3	Budded stem							
4	Clonal seedling							
5	Annual Latex yield							
6	Total amount of latex sold per year							

No.	Section 5: latex Marketing Activities	Code
1	How do you process your latex?	[ ] 1=Ribbed smoke sheet [ ] 2= Technical specified rubber [ ] 3=Cup lump [ ] 4 = Condense latex [ ] 5= Liquid latex [ ] 6=Latex concentrate [ ] 7= Unsmoked sheet [ ] 7= Crumb rubber [ ] 8= Others (specify)
2	Where do you mainly sell your latex?	[ ] 1= Co-operative [ ] 2 = Farm gate [ ] 3= Trader [ ] 4= Local market [ ] 5= large scale holder [ ] 6 = international market [ ] 7 = other (specify)
3	Why did you choose this market outlet?	[ ] 1= Closer to farm [ ] 2= Closer to house [ ] 3= Instant cash received from sales [ ] 4= Better price offered [ ] 5= Processing center near [ ] 6= Collection center near [ ] 7= Lower cost in accessing the selected outlet [ ] 8 = Other (specify)
4	What distance do you travel to the nearest market (km)?	
5	Are you satisfied with the choice of marketing channel you use?	[ ] 1= Yes [ ] 0= No
5 (a)	If no or yes, why? Explain	
6	Time taken to search for buyers	[ ] 1= <8 Hours [ ] 2 = >8 Hours

7	How many hours or days do you spend to get information about the price of latex?	[ ] 1= <8 Hours [ ] 2 = 8-24 Hours [ ] 3= 48-336 Hours [ ] 4=336 Hours <
8	What is the average communication cost in US$ incurred in getting information about the price of rubber?	
9	Do you experience delays in payment?	[ ] 1= Yes [ ] 0= No
(a)	If yes, how many days?	

	Section 5.1 Quantity of latex sold at each market outlets			
Market outlets	Tick √	Price / kg	Quantity of latex sold per month in kg	Income from sales per-month
Co-operative				
Farm gate				
Traders				
Local market				
International market				
Large scale				

Section 5.2 Proportional Transaction Cost	Codes
Do you owned a transport equipment? a) If no, How latex is transported to the market?	[ ] 1= Yes [ ] 0= No [ ] 1= commercial transport [ ] 2= head load [ ] 3= other (specify)
Major constraints faced in transporting latex to the market?	[ ] 1= long distance [ ] 2= bad road networks [ ] 3= high cost of transportation [ ] 4= no access to commercial vehicle [ ] 5= other (specify)

No	**Section 6: Agronomic practices**	Tick √
	Which of the following agricultural activities is practiced on your farm?	
	Weeding	
	Fertilizer Application	
	Herbicides; Agrochemical ;spraying; Insecticides; farm sanitation	

No.	**Section 6.1 : Latex Management and farm record**	**Codes**
1	Is there any quality measure put in place within 8 hours after tapping to maintain the quality of latex before it coagulates naturally?	[ ] 1 = Yes [ ] 0 = No.
	(a) If yes, explain…	
	(b) What is the cost incurred in maintaining such quality (US$)	
2	What are some of the problems encountered in ensuring that the latex is of good quality?	
3	Do you keep farm records?	[ ]1= Yes [ ] 0= No
4 (a)	If yes, what type of record do you keep?	[ ] **1**=Inputs used and cost [ ] 2= Latex production [ ] 3= Latex sold [ ]4= Latex processed [ ] 5= Income from sales [ ] Others (specify)

Section 6.2: Disease Management			
What are the types of rubber diseases you experienced on your farm and what are the control mechanisms you employed?			
Name of Disease	√	Period of attack: embryonic or matured	Control mechanism
Root disease			
Panel disease			
Stem disease			
Other (specify)			

2. Do you experience any post-harvest losses? [ ] 1= Yes [ ] 0= No

a) If yes, what are the causes of the post-harvest losses? [ ] 1= Lack of processing facilities [ ] 2= Long distance to market [ ] 3= Poor latex management [ ] 4= Lack of information on potential buyer [ ] 5= other (specify):

b) What is the monthly income forgone from the post-harvest losses?

No.	Section 7: Farm Income			
1	Sources of Income	√	Monthly amount	Yearly amount
5	Rubber farming			
6	Other agricultural activities			
7	Other (specify)			

Section 8: Services provided

Training

1. Have you attended any training for rubber production and marketing in the last one year? [ ] 1= Yes [ ] 0= No. If no skip question 2

If yes, what type of training and which institution offered it?

No.	Types of training	√	Institutions
1	Tapping of latex		
2	Farm management		
3	Latex processing		
4	Fertilizer application		
5	Record Keeping		
6	Marketing		
7	Other (Specify)		

1. The selected training improved your production and marketing of latex? [ ] 1= Yes [ ] 0= No

3 (a) If yes, in what way?

Section 9: Extension Services

1. Willing to adopt new technology [ ] 1=Not willing [ ] 2= Less willing [ ] 3= Very willing
2. Do you have access to market information? [ ] 1= Yes [ ] 0= No

a) If yes where do you get your market information? [ ] 1= Multinational or large scale companies [ ] 2= Extension officers [ ] 3= Radio [ ] 4 = Co-operative [ ] 5= Internet [ ] 6= community members [ ] 7 = fellow farmers [ ] 8 = other (specify)

3. Do you have access to extension services? [ ]1= Yes [ ]0= No
4. Do you have an assigned extension officer in the area? [ ]1= Yes [ ]0= No

a) If yes, what is the frequency of visit in a year? [ ] 1= < 2 times [ ] 2=2-5 times [ ] 3= 5-8 times [ ] 4= >11 times [ ] 6= do not visit

5. Has the visit help improve your production and marketing of latex? [ ] 1= Yes [ ] 0= No

a) If yes, how has it improved it?

6. Please state the type of services that have been provided by the following institutions to farmers.	
Institutions	Code
Government of Liberia (GoL)	[ ] 1= Training [ ] 2 = Credit [ ] 3= Inputs [ ] 4=Processing of latex [ ] 5= Marketing of latex [ ] 6= Provision of land [ ] 7= Other (specify)
Co-operative	[ ] 1= Training [ ] 2 = Credit [ ] 3= Inputs [ ] 4=Processing of latex [ ] 5= Marketing of latex [ ] 6= Provision of land [ ] 7= Other (specify)
NGOs	[ ] 1= Training [ ] 2 = Credit [ ] 3= Inputs [ ] 4=Processing of latex [ ] 5= Marketing of latex [ ] 6= Provision of land [ ] 7= Other (specify)
Microfinance Institutions	[ ] 1= Training [ ] 2 = Credit [ ] 3= Inputs [ ] 4=Processing of latex [ ] 5= Marketing of latex [ ] 6= Provision of land [ ] 7= Other (specify)
Rubber planter Association of Liberia	[ ] 1= Training [ ] 2 = Credit [ ] 3= Inputs [ ] 4=Processing of latex [ ] 5= Marketing of latex [ ] 6= Provision of land [ ] 7= Other (specify)
Rubber Development Authority	[ ] 1= Training [ ] 2 = Credit [ ] 3= Inputs [ ] 4=Processing of latex [ ] 5= Marketing of latex [ ] 6= Provision of land [ ] 7= Other (specify)

Section 10: Members of co-operative only	
1. What are the reasons that motivated you to join the rubber co-operative?	[ ]1= Access to ready market [ ] 2= Latex processing [ ] 3= Lower price of inputs and timely provision [ ] 4= Extension services, [ ] 5= Farm management [ ]6= Access credit [ ] 6= Others (specify)

1. For how long have you been member of the co-operative?
2. Do you sell your latex to the co-operative? [ ] 1= Yes [ ] 0= No If yes, how long?

No.		Code
5	What are some of the ways in which the cooperative has help you improve the production and marketing of your rubber?	[ ] 1= Extension services [ ] 2= Latex marketing [ ] 3= Provision of inputs [ ] 4= Training [ ]5 = Latex processing [ ] 5= Credit access [ ] 6= Improvement in grades of latex [ ] 7= other (specify)
6	Are there any positive changes in the following since you joined the co-operative	[ ] 1= Production level [ ] 2= Income [ ] 3= Credit access [ ] 4 = Other (specify) Please explain
7	Being a member of a co-operative is more beneficial than being an independent farmer?	[ ] 1= Yes [ ] 0= No Please explain:
8	Have you adopted new technology or accessed any new information relating to rubber production and marketing technology?	[ ]1= Yes 0= No [ ]
9	2. The rubber co-operative have helped minimized the challenges faced by farmers?	[ ]1= Yes [ ] 0= No

10. What are the main problems faced by the rubber co-operative		
Problems	Less important	Very important

Are you going to continue your membership with the co-operative? [ ] 1= Yes [ ] 0= No

a) If yes or no, why? ……..