A Logistic Analysis of Factors and Perception of Smallholder Rubber Farmers to Intercrop: A Case Study Involving Rubber and Plantain Intercropping System in Ghana

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Abstract

Even though rubber tree (Hevea brasiliensis) is a major tree crop and is lucrative for small holder' farmers in Ghana, the 6 years waiting period to maturity constraints its establishment. Intercropping of rubber with food crops has been found to be a solution to this production constraint in most rubber producing countries. The objective of this study was to empirically assess farmers' perception on rubber/plantain intercropping and factors that directly affect rubber farmers' decision to intercrop rubber plantations with plantain. A multistage sampling technique was used to select 200 rubber farmers from the Central and Western regions of Ghana. Both descriptive and logistic regression models were used to analyze the data. About 83% of the rubber farmers were males. Based on the logit model analysis, gender, level of education, household size, farm size, member of association and experience in rubber farming were found to have significant influence on the adoption of rubber/plantain intercrop. Respondents see the potential adoption of rubber/plantain intercropping system as a means to improve food security, farmers' income and livelihood. Non-governmental organizations, Ghana Rubber Estates Limited (GREL) and Government should focus on strengthening its extension arm to develop more interpersonal contacts with potential rubber farmers. Policy makers, researchers and extension providers should closely work together with rubber farmers in identifying suitable rubber/plantain spacing and varieties on a case by case basis to ensure effective adoption and scaling out.

Keywords: Food security, Ghana, GREL, Livelihood, Rubber and plantain intercropping

Analyse Logistique Des Facteurs Et Perception Des Petites Exploitants D'Hévéa À Intercaler: Cas d'Un Système De Culture intercalaire d'Hévéa et Plantain Au Ghana.

Résumé

Bien que l'hévéa (Heveabrasiliensis) soit une culture importante et qu'elle soit lucrative pour les petits exploitants agricoles du Ghana, le délai de six ans jusqu'à la maturité limite son établissement. La culture intercalaire d'hévéa avec des cultures vivrières s'est révélée être une solution à cette contrainte de production dans la plupart des pays producteurs de caoutchouc.

L'objectif de cette étude était d'évaluer de manière empirique la perception des paysans sur la culture intercalaire caoutchouc/plantain et sur les facteurs qui influent directement sur la décision de ces derniers de procéder à la culture intercalaire de plantations d'hévéa avec plantain. Une technique d'échantillonnage en plusieurs étapes a été utilisée pour sélectionner 200 producteurs de caoutchouc des régions centrale et occidentale du Ghana. Des modèles de régression descriptifs et logistiques ont été utilisés pour analyser les données. Environ 83% des producteurs de caoutchouc étaient des hommes. Fondé sur l'analyse du modèle logit, il a été constaté que le sexe, le niveau d'éducation, la taille du ménage, la taille de l'exploitation, le membre de l'association et l'expérience en caoutchouc avaient une influence significative sur l'adoption de la culture intercalaire caoutchouc/plantain. Les répondants voient dans l'adoption potentielle d'un système de culture intercalaire caoutchouc/plantain un moyen d'améliorer la sécurité alimentaire, le revenu et les moyens de subsistance des agriculteurs. Les organisations non gouvernementales, 'Ghana Rubber Estates Limited' (GREL) et le gouvernement devraient se concentrer sur le renforcement de vulgarisation afin de développer davantage de relations interpersonnelles contacts avec d'éventuels producteurs de caoutchouc. Les décideurs politiques, les chercheurs et les fournisseurs de services de vulgarisation devraient collaborer étroitement avec les producteurs de caoutchouc pour identifier sur une base de cas par cas les espacements et variétés appropriés de caoutchouc/plantain afin de garantir une adoption et une mise à l'échelle efficaces.

Mots-clés: sécurité alimentaire, Ghana, GREL, moyens de subsistance, culture intercalaire caoutchouc et plantain

Introduction

Rubber tree (*Hevea brasiliensis*), is becoming a major crop for smallholders in Ghana especially in the forest zones and an important commercial crop in most parts of the lowland humid tropics. Although rubber is not one of the major export commodities in Ghana like cocoa it is believed to be contributing significantly to the GDP of the agriculture sub sector with about 19,000 metric tons produced annually (MoFA SRID, 2011). In Ghana, trend in rubber plantation has improved and plantations have started to spread to new areas in the Eastern and Central Regions whilst the Western Region has the largest plantations. Rubber production has become a very lucrative farming venture and some cocoa and coconut farmers have been cutting down their cocoa and coconut trees to pave way for rubber plantations (www.peacefmonline.com). Global rubber consumption is forecast to rise 4.3 percent per year through 2015 to 30.5 million metric tons (Freedonia group, 2012). It is important to ensure a sustainable and sufficient future supply of rubber products while improving the productivity of farming systems in order to contribute to ensuring good income and food security for smallholder rubber farmers in Ghana. Rubber intercropping system is deliberately growing or retaining rubber with other food crops and/or other high value tree species. According to Joshi (2005), intercropping in rubber farming systems enhances the broadening of income through introducing food crops, timber trees or livestock in the rubber and it is a common practice in Southeast Asia. Rubber inter-cropping system is regarded as a triple-win practice as it can support food security, mitigate climate change and contribute to adaptation to these changes. In addition to reducing greenhouse gases by capturing carbon, rubber intercropping system also improves resilience to climate variability and extreme conditions, such as heavy rains or droughts (Global Climate Change News Brief, 2010).

Small holder plantation farmers especially in the western region of Ghana are shifting to rubber production due to the high financial returns compared to that of cocoa and other tree crops. Despite the upward trends in rubber production in the western and central regions, these farmers are faced with a kind of capital tired down in the cultivation due to the long gestation period of up to 6 years before it becomes due for tapping. Even though farmers are aware of the lucrativeness of establishing rubber plantation, their inability to wait for 6 years to see the benefits is constraining the establishment of rubber plantation by small holder farmers. To lessen the waiting time to the benefits, an option exist such as intercropping rubber with food crops like plantain (*Mussa spp*). This can be established together with the rubber for a period of one or two years and harvested during the immature establishment stages of the rubber. Plantain is considered as one of the food security crops in Ghana (FAO, 2014) and is compatible with most tree crops as an intercrop (Ngeleza et, 2011, Akinyemi et al., 2010).

Intercropping rubber with plantain comes with economic, environmental and sustainability benefits. According to Haggblade, *et al*., (2004), economic considerations and short-term profitability alone have not fully explained farmers' adoption behaviors. Rather, adoption decisions appear to be guided by level of household resource endowments and the prevailing social context such as customs, obligations and beliefs which are highly affected by factors such as farmers' education, age and family size. Age is a factor that has been extensively considered as a socio-economic factor influencing adoption of agroforestry (Ajayi *et al*., 2003). Other studied factors include membership in farmers' clubs and cooperative groups, availability of labour supply, the degree of innovativeness of individual farmers (Ajayi *et al*., 2006). Mercer (2004) indicated that socioeconomic and biophysical interactions greatly affect farmers' decisions in readily adopting some technologies more than others. One of the reasons why some intercropping development projects failed was lack of attention to socioeconomic issues in the development of such systems (Mercer, 2004). Thus, there is the need to focus on socioeconomic studies on rubber/plantain intercropping system for better understanding of the local bottlenecks in achieving desired adoption rates. Adoption of intercrop system depends on many factors such as access to information on intercrop, availability of good quality planting materials, availability of land, training opportunities, property rights on land, flexibility and compatibility of intercropping of rubber to existing farming systems. According to Rogers (2003), adoption occurs when one has decided to make full use of the new technology as a best course of action for addressing a need. Adoption is determined by several factors including socioeconomic, environmental, and mental processes that are governed by a set of intervening variables such as individual needs, knowledge about the technology and individual perceptions about methods used to achieve those needs (Thangata & Alavalapati, 2003). Rubber/plantain intercropping system is sustainable if fully adopted and have the potential to improve food security, reduce the rampant environmental degradation and restore degraded forest landscapes in Ghana.

Understanding farmers' decision making processes in ensuring sustainable food supply in rubber intercropping system is critical. Research frontiers in rubber/plantain intercrop need to be identified and better understand barriers to adoption and the development of strategies to support intercropping that enhance food security.

According to Rogers (2003), the adoption and diffusion model identifies five aspects that influence adoption: perceived attributes of the innovation; type of innovation decision; communication channel; nature of the social system; and the extent of change agent promotion efforts. He further indicated that adoption-diffusion of innovations model is a useful model for understanding farmers' decision making processes when they consider taking up and eventually adopting new technologies. Adoption is reached after an innovation-decision process that occurs in a five-step time-ordered sequence namely: knowledge; persuasion; decision; implementation; and confirmation (Rogers, 2003). Thangata and Alavalapati, (2003) found out that there are different types of models that have been used to explain adoption decisions of new technologies. However, no single model can embrace and explain all aspects of adoption and the traditional attitude of smallholder farmers towards technologies. There is an assumption in this model that research generates information that is inherently valuable, desirable and suitable for increasing farm production and productivity (Jangu, 1997). In this study rubber/plantain intercropping system is feasible, efficient and suitable for increasing productivity in Ghana and that it is the best option for use by resource-poor smallholder rubber farmers. The objectives of this paper are to evaluate farmers perception and factors that directly affect rubber farmers' decision to intercrop rubber with plantain.

Methodology of the study

Data collection and description

The data for the analysis were collected between January to March in the year 2014. Data were obtained from 200 rubber farmers from Western and Central regions of Ghana. Western and Central regions lie within latitudes 4°80′ and 5°21 North and Longitudes 2°35′ and 3°07 West and latitudes 5°30′and 6°02 North and Longitudes 1°15 and 2°45 West respectively. The total land size for western region is about 23,921 square kilometers which is about 10% of Ghana's total land size. The total land size of central region is 9,826 square kilometers, which is about 4.1% of total land size of Ghana. The detailed hydrometerological characteristics

Table 1: Hydrometerological characteristics of the study area

	Western Region	Central Region
Mean temperature	Maximum: 31 °C Minimum: 26 °C	Maximum: 31 °C Minimum: 28 °C
Climate	Tropical rainforest	Forest dissected
Average humidity	Dry season: 50–75 % Rainy season: 85–90 %	Dry season:55-75 % Rainy season: 83-90 %
Average rainfall	1500–1800 mm	1300-1800
Topography	Undulating	Undulating
Soil condition	loamy	Sandy loam
Average elevation	150 m	250 m

of the study areas are provided in Table 1.

A stratified random sampling technique was employed in the selection of the 200 rubber farmers interviewed for the study. In the first stage, Western and Central Regions were purposively selected because they are the two main rubber production regions in Ghana. In the second stage of selection, twelve districts, with eight from the Western Region and four from the Central Region were considered. The districts were Ellemblle, Jomoro, Nzema East, Ahanta West, Wassa West, Mporhor, Wassa East and Tarkwa Nsuaem all in the Western Region; and Agona West, Ajumako-Enyan-Essiam, Upper Denkyira East and Upper Denkyira West in the Central Region. In the third stage, 200 rubber farmers were randomly selected from the twelve districts. Both primary and secondary data were employed in the study. The primary data consisted of qualitative data and household survey interviews. Specifically, the primary data were collected through focus group discussions (FGD), stakeholder interviews, and field observations. The household survey interviews employed both open-ended and close ended survey instruments, whilst the secondary data were obtained from the FAO Statistical Yearbook and other relevant sources like GREL Annual Reports.

Conceptual and analytical framework

The decisions to adopt various methodologies by rubber farmers are influenced by a range of factors: from government policies, technological change, market forces, environmental concerns, demographic factors, institutional factors and delivery mechanisms. The logistic regression model or the logit model, is a special case of a generalized linear model and analyzes models where the outcome is a nominal variable. The logistic regression model which was used as the dependent variable is categorical. The model includes probit and logit – probabilistic dichotomous choice qualitative models. According to Agresti, (2007), analysis for the logistic regression model assumes the outcome variable is a categorical variable. It is common practice to assume that the outcome variable, denoted as Y, is a dichotomous variable having either a success or failure as the outcome. For logistic regression analysis, the model parameter estimates $(\alpha, \beta_1, \beta_2, \delta, \beta_P)$ should be factors in our model. For our purposes, significant combinations of factors have large given values greater than 1. For our ordinal regression model to hold, we need to ensure that the assumption of parallel lines of all levels of the categorical data is satisfied since the model does not assume normality and constant variance (Bender and Benner, 2000). Logistic regression does not assume a linear relationship between the dependent and independent variables, the dependent variables do not need to be normally distributed, there is no homogeneity of variance assumption, in other words, the variances do not have to be the same within categories, normally distributed error terms are not assumed and the independent variables do not have to be interval or unbounded (Wright, 1995). Since we fit a logistic regression model, we assume that the relationships between the independent variables and the logits are equal for all logits. The regression coefficients are the coefficients $\alpha, \beta_1, \beta_2, \delta, \beta_P$ of the equation:

$$Logit\,[\pi(X)] = \alpha + \beta_1 X_1 + \beta_2 X_2 + \delta + \beta_P X_P)$$

The results would therefore be a set of parallel lines for each category of the outcome variables. This assumption can be checked by allowing the coefficients to vary, estimating them and determining if they are all equal. So our maximum likelihood parameter estimates, diagnostic and goodness of fit statistics, residuals and odds ratios were obtained from the final fitted logistic regression model. However, the estimation rests on the strong assumption that the latent error term is normally distributed and homoscedastic. The maximum likelihood estimate is the value of the parameter that is most consistent with the observed data that if the parameter equaled to that of the estimate, the observed data would have a greater chance of occurring than if the parameter equalled any other possible value.

Results and Discussions

Descriptive statistics of variables examined in the study are presented in Table 2. The average age of rubber farmers was 48 years, close to the national average age for cocoa farmers in Ghana of 50 years (Ghana Statistical Service, 2012). About 83% of the rubber farmers were males. The mean year of schooling of rubber farmers was 8 years, which is below the national average of 15 years for universal and compulsory basic education (Education System, 2015).

The predominant activities of rubber farming such as land clearing, brushing of undergrowth, manual felling of small trees and bushes, crosscutting as well as tapping are mostly done by men.

Rubber growing is very labour-intensive and tapping has to be done at dawn or in the mornings. Table 3 shows the processes involved in rubber cultivation as well as gender roles in the respective processes.

According to Pearson (1992) gender relations are social relations, referring to ways in which the social categories or men and women, male and female, relate over the whole range of social organization, not just interactions between individual men and women, or in terms of biological reproduction, gender relations describes the social meaning of male and female, thus what is considered appropriate behavior or activity for men and women. Gender relations in a way govern how men and women behave in a society and defines the role of men and women. In the new era of globalization period rubber plantation can be compared to other large scale plantation of monocrop in the world, for

Table 2: Variable definition and descriptive statistics

Variable	Variable definition	Mean	Standard Deviation
Adoption of RPI	Adoption of RPI dummy = 1 if household adopted RPI, 0 otherwise		
Explanatory variables			
GENDER	1 if females, 0 otherwise	0.170	0.377
AGE	Age of respondent (Years)	48.18	11.72
EXTENCONT	1 Extension contact, 0 otherwise	0.885	0.319
EDU	Years in schooling (Years)	7.935	4.24
HHSIZE	Household size	6.94	3.09
FARMSIZE	Farm size (ha)	6.820	3.380
FARORG	1 if farmer is a member of armers' organization, 0 otherwise	0.905	0.294
FARMEXP	Number of years in rubber farming	13.77	11.48

example plantation for cocoa or oil palm plantation, which are regarded as cash crop. The negative effects of cash crop can be explained with an example from Sub-Saharan Africa in a study conducted by Berhman *et al.* (2011), where the lucrative cash crops are understood to be 'male crops' whereas crops for home consumption to be 'female crops'. This does not mean that women do not take part in the whole process of production of the cash crop rather, women make the major share of contribution in the work and also in taking care of the household work which goes unaccounted. Women are mostly regarded as being particularly vulnerable when land is converted to plantation of monocrop. Table 3 shows the processes involved in rubber cultivation as well as the various roles played by men and women in the cultivation of rubber. It can be inferred from the table as reminiscent from the study that the land preparation processes in rubber cultivation are done solely by men except lining and pegging which is done by both sex. The maintenance of rubber farms (weeding, pruning, line opening, line cleaning and agro inputs application (fertilizer and termiticide application) are done by both men and women.

Table 3: Processes involved in rubber cultivation and gender roles

Processes involved in rubber cultivation	**Role by Men**	**Role by Women**
Land preparation		
Land clearing /Brushing of undergrowth	●	
Manual felling of small trees and bushes	●	
Felling and lopping of big trees with chainsaw	●	
Stacking of the vegetated debris	●	
Controlled burning of the dried vegetated matter	●	
Crosscutting and packing of the woods/logs	●	
Piling and burning of all the debris around the tree stumps	●	
Construction of channels to drain excess water where necessary	●	
Lining and pegging	●	●
Holing	●	
Planting	●	●
Agro-inputs	●	
Fertilizer application	●	●
Termiticide application	●	●
Farm maintenance	●	
Pruning	●	●
Weeding	●	
Line opening	●	
Line Cleaning	●	●
Harvesting/tapping	●	●
Selling of farm produce	●	●

Planting of rubber seedlings in rubber cultivation is also done by both men and women after the seedlings which are mostly supplied by Ghana Rubber Estates Ltd (GREL) are acquired by farmers.

The average rubber farm size was about 7 hectares, which is relatively higher than the national average of 3.0 hectares for small-scale farmers. It was found out that out of the 200 respondents, 166 (83%) of them said that the husband was the household head, while 34 (17%) said that it was the wife for the 34-female respondents. From the study, it was observed that household headship was an important variable in relation to decision making process at the household level, control and allocation of resources, and the general management of the household's affairs, which include land use. The area of study is a patrilineal society; thus, land and other properties are inherited or transmitted from one generation to the next through the male line. This put the males in the forefront in decisions making about land use and by the fact that men are the household heads in the general management of household affairs. It was found out that decision making on land use and the use of the land products are mostly made by men. The level of formal education is an important variable because it does not only influence the demographic but also socio-economic characteristics of the population. The 200 respondents interviewed had varied levels of education. It came out that 65(32.2%) of them had reached Middle School Leaving Certificate Level (MSLC), 19 (9.5%) had reached secondary level, 30 (15%) had primary level, 35(17.5) had Junior High School level, 18 (9%) had reached tertiary level, while 33 (16.5%) had not had formal education. Most (83.5%) of the respondents had had a basic form of education, reached at least primary level of education. The study observed that education level of the household head was important in understanding and interpretation of information to make an informed decision on adoption of rubber/plantain practices.

Rubber plantations are usually established using budded seedlings. The successful establishment of rubber plantation is essentially dependent on the planting materials thus the source of the planting material is very important. The main source of rubber planting materials for farmers is GREL. About 1% is being raised by other private individuals and organizations within the rubber growing communities.

Plantations of fast-growing exotic tree species is gaining prominence in recent years and is become increasingly important land use in the tropical regions. The fertility status of most soils in the humid tropics, particularly under low input agricultural systems, depends largely upon previous land use and soil organic matter (SOM), both quantitatively and qualitatively. Results from Figure 1, showed that about 30% of the respondents converted their coconut farmlands to the planting of rubber. Foodcrops land followed with 27.5%, fallow lands (25.9%) and least among them was farmers (5.2%) converting cocoa farms into rubber plantation.

The largest farmland converted into rubber cultivation especially in the Western region is coconut farmland. Coconut farms are the worst affected in terms of conversion of farmlands to rubber cultivation.

The least of the lands converted to rubber production is cocoa farmlands. Cocoa farming, coconut farming and foodcrops farming were the predominant landuse before the conversion of lands into rubber cultivation. It follows that, 62.8% of lands previously used for other farming activities have been converted to rubber cultivation.
Results from the study showed that GT1,

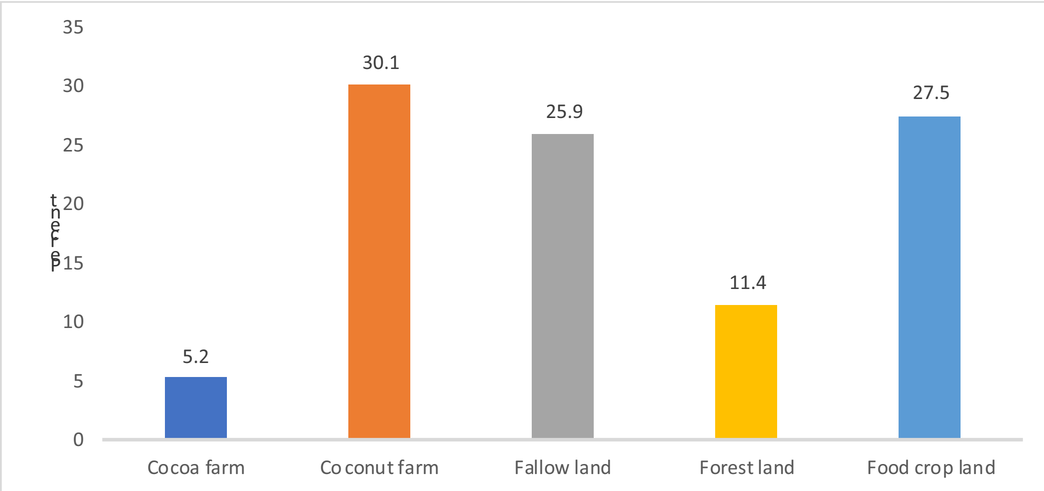

Figure 1: Previous land-use before rubber plantation

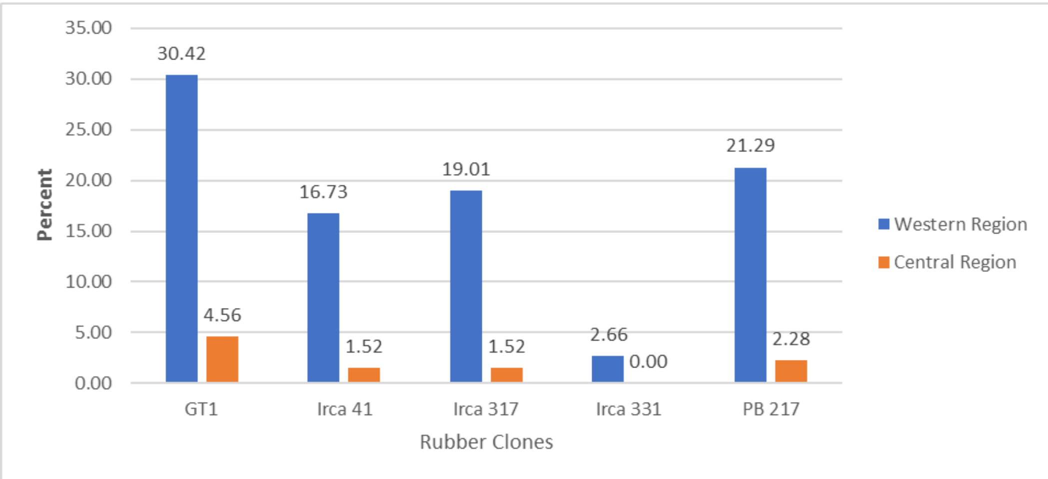

Figure 2: Rubber clones used per region

IRCA41, IRCA317, IRCA331 and PB217 were the clones of rubber planted by farmers in both Central and Western regions of Ghana (Fig.2). In the Central region, 4.56% of farmers planted clone GT1, 1.52% of farmers planted IRCA41 and IRCA317 clones, 2.28% of farmers planted clone PB217 with no farmer planting IRCA331 clone. In the Western region 30.42% of farmers planted clone GT1, 16.73% of farmers planted IRCA41 clone, 19.01% planted IRCA317, 2.66% planted IRCA331 and 21.29% of farmers planted PB217 clone. GT1 clone was the most preferred in the Western region to the other four clones being used by rubber farmers.

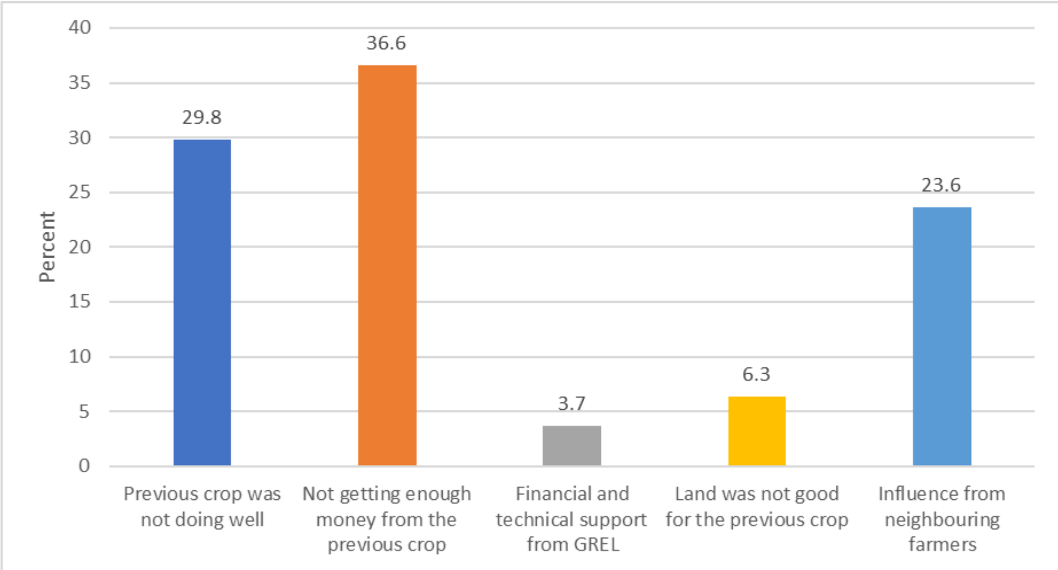

Figure 3: Reasons for starting rubber plantation

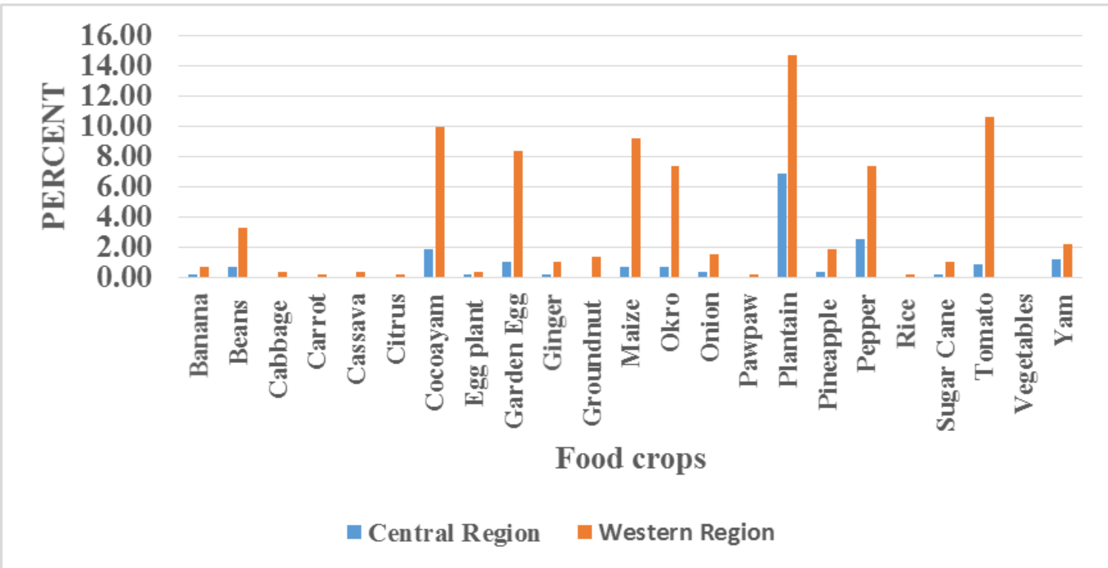

Figure 4: Food Crops Intercropped in Rubber Plantations

However, PB217 clone was the most planted by farmers from the two major rubber growing regions of Ghana.

The following are reasons given by farmers for preferring rubber cultivation to other tree crop farming systems: previous crops were not doing well, they were not getting enough money from the previous crops, financial and technical assistance from GREL, Land was not good for the previous crops and influence from neighboring farmers.

Among these reasons, the topmost according to the farmers were: they were not getting enough money from their previous crops like coconut, cocoa and oil palm. This view represented 36.6% of the entire farmers interviewed and it is a sign that farmers were moved to take new decisions based on financial reasons. About 23.6% of farmers were influenced by their neighbours whom they saw venturing into rubber cultivation and seeing the industry as more lucrative.

The results indicate that plantain, cocoyam, maize, garden egg, pepper, tomatoes and beans are the major food crops farmers intercrop with rubber. This is consistent with the submission of Gouyon *et al*. (1993) who found out that food crops were grown with the rubber seedlings for the first few years and then the natural vegetation was left to regenerate. Many studies (Masea and Cramp, 1995; Esekhade et al, 2014) have recommended rubber intercropping systems involving intercropping rubber with other economic crops especially arable crops as way of effectively utilizing the resource base in the plantation and ensure early returns on investment. Plantain was found out to be the most frequently intercropped with rubber in both Central and Western Regions of Ghana as a result of its compatibility and profitability. This confirms a study by Banful, (2013) who found out that plantain is a very important food crop in Ghana because the fruit of plantain is eaten in every household in Ghana.

Perception of Farmers on Rubber/Plantain Intercrop

Figure 6 indicates farmers' perception on rubber/plantain intercropping systems. Farmers have various levels of perception on certain characteristics of intercropping plantain in rubber plantation at the initial stages of growth. The results indicate that about 24% percent of rubber farmers strongly perceive that plantain grown on rubber plantation provides food for the household. Most often people grow food crops for the purposes of making money this was made clear from the results of the study, which showed that about 22% grow plantain in the rubber plantation to make income at the early stages of the plantation. This income is mostly used to argument other income sources for the household. Also, money from plantain sales are used to offset management cost in the rubber plantation. Other perception held by farmers for intercropping plantain on rubber plantation includes the control of weeds, enhancing rubber growth, protecting young rubber trees from pest and diseases and conserving soil moisture.

The income from smallholder farmers could be diversified using rubber agroforestry and especially rubber cultivation integrated with plantain. The extent of rubber farmers intercropping rubber with plantain depends on a number of factors. Table 4 shows the maximum likelihood estimate of the parameters of Logit regression model characterizing factors that influence farmers to adopt rubber/plantain intercrop. The maximum likelihood ratio test showed that the estimated model with the set of explanatory variable for the data was better. There was therefore a significant relationship between the odds and the probability of farmers' adoption of rubber/plantain intercrop

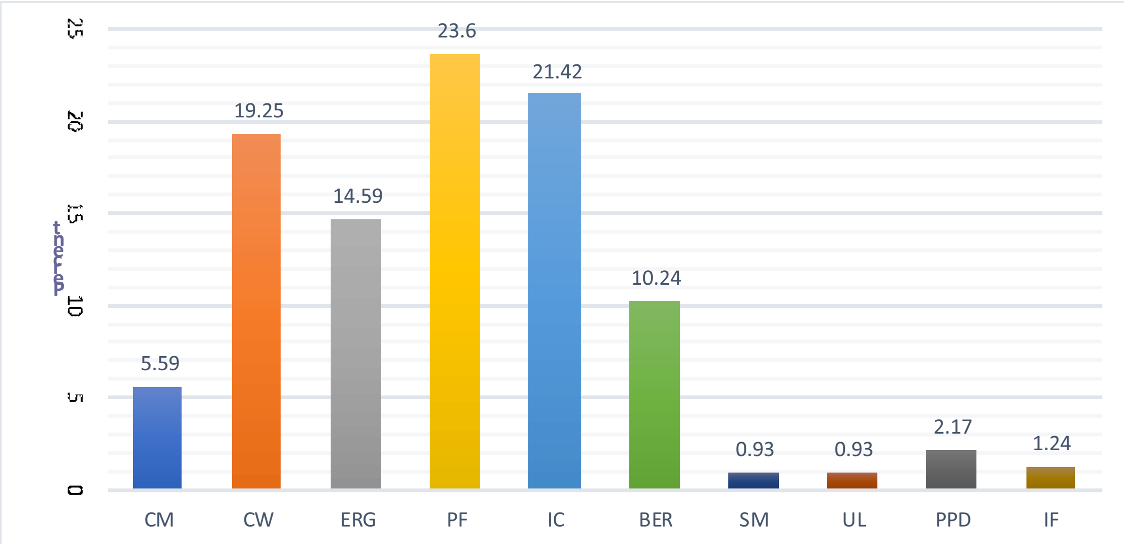

Figure 5: Farmers' perceptions of Rubber/Plantain Intercrop

CM: Conservation of moisture, CW: Control of weeds, ERG: Enhance Rubber Growth, PF: Provides Food, IC: Income, BER: Provide shade, SM: Serves as mulch, UL: Utilize land, PPD: Protection against pest and diseases, IF: Improves soil fertility

system and the explanatory variables included in the model; suggesting that these variables contribute significantly as a group to the explanation of the factors that influence rubber farmers to adopt rubber/plantain intercropping system.

Data from review shows that there were 7 biophysical aspects that had an influence on the level of adoption of the rubber/plantain intercropping system as compared to 8 socio-economic factors. Based on the Logit model analysis, gender, level of education, household size, farm size, member of association and experience in rubber farming were found to have significant influence on the adoption of rubber/plantain intercrop. The positive sign on gender implies that both male and females have the tendency to adoption of rubber/plantain intercropping. Farm size has a positive implication on the adoption of rubber/plantain intercropping system. Limited land availability limits the type of technology that farmer can put into practice thereby negatively affecting adoption of rubber/plantain intercropping. The significantly positive sign on the education and years in rubber farming variables might be attributed to the high level of knowledge and experience farmers had in the multiple benefits derived from rubber/plantain intercropping. Household size of respondents is also a major determinant for adopting rubber/plantain intercrop. Large household size would mean they need more food and income to meet their daily upkeep. It is of no surprise that farmers perceived food and income as their topmost priority in intercropping rubber and plantain in the study area. It came out clear that the contact with extension officers had a positive impact on adopting rubber/plantain intercropping system due to the frequent lessons they received from the extension officer and other

Table 4: Regression analysis of factors that influence Rubber/Plantain Intercropping System

Variable Name	Estimate	SE	Wald	p (Sig.)	Odds ratio
Gender	0.667	.476	1.963	.011**	1.948
Age of respondent	0.006	.014	.214	.644	1.006
Contact with extension	0.250	.522	.299	.032*	1.284
Education level	0.095	.031	9.259	.002***	0.909
Household size	0.041	.053	0.586	.044*	0.960
Farm size	-0.042	.046	.832	.012**	0.959
Member of Association	0.078	0.545	0.021	.086*	1.081
Experience in rubber farming	0.013	0.015.	.857	.005***	1.014
Constant	0.864	1.044	7.686	.008**	2.373
Model chi-square	66.35 p<0.000				
–2 log likelihood	237.305[a]				
Nagelkerke (R Square)	. 780				

*** Significant at 1%, ** Significant at 5%, * Significant at 10%
Source: Authors' computation

training staff from GREL. Frequent contacts with extension agents may increase knowledge acquisition by rubber farmers through demonstration plots on farmers' fields and this increases their understanding of the technology and improves rate of adoption. This is in agreement with Matata *et al*. (2010), who argued that extension contact is a key variable in developing a favorable attitude among farmers towards adopting a technology.

Lastly, age was not to have any significant influence on farmers' adoption of rubber / plantain intercropping system. This might be due to the fact both the young and old in one way or the other know of the multiple benefits of rubber/plantain intercropping. Regarding age, it was learnt that younger households are more risk takers relative to older households and thus likely to adopt rubber/plantain intercropping system. This may be because younger people have longer planning horizons and may be more willing to take risks than older people. In addition, management of this system is labour demanding in the initial stages thereby not favouring the category of old farmers.

Adoption of an intercrop system is always limited by national and international policies that promote crop monocultures and input subsidies (Dorward, 2009). In Ghana and most part of Africa, input subsidies and rural credit programmes are usually tied to 'modern' seeds and chemical inputs (Adjognon, 2017). For instance, in Ghana the Cocoa Hi Tech Programme is an important government policy where selected small holder cocoa farmers are provided with subsidized fertilizer, herbicide and hybrid cocoa seed; this has a direct bearing on adoption of intercropping system and other integrated soil fertility management practices.

Conclusions and Recommendation

The potential adoption of rubber/plantain intercropping system in Western and Central region of Ghana seen as a means to improve food security as well as farmers' income and livelihood. Rubber/plantain Intercropping system generates income, food and significant public environmental services such as biodiversity and carbon sequestration. Without government involvement in providing enabling policy and greater incentives, the level of adoption of rubber/plantain intercrop will be very minimal. The level of adoption of this intercropping system are influenced by both biophysical and socioeconomic factors. However socioeconomic factors are more crucial for adoption. Some of the factors that can limit wide-scale adoption of rubber/plantain intercropping system are level of formal education, age, experience in rubber farming, extension capacity and farm size. The increased understanding among rubber farmers, of the connection between land productivity and land quality can be an opportunity that could lead to wide scale adoption of rubber/plantain intercropping system. Farmer-centered approach to research and development in rubber/plantain intercropping system remains the key to wide-scale adoption of the system. This therefore implies that practices recommended for any region should be tailor-made to conforming to the prevalent socio-economic conditions of the rubber farmers. Although some facts about the collected data are unique to Western and Central Region of Ghana, the publications reviewed show a high potential of applicability of these findings in most parts of rubber growing regions. Factors analyzed and discussed have some policy implications in that if adoption of rubber / plantain intercropping system in Ghana has to be enhanced by increasing extension services to improve contacts with rubber farmers, policy would play significant role. Also, Non-governmental organizations, GREL, and government should focus on strengthening its extension arm to develop more interpersonal contacts with potential rubber farmers. The application of these results is that policy makers, researchers and extension providers should closely work together with rubber farmers in identifying suitable rubber/ plantain spacing and varieties on a case by case basis to ensure effective adoption and scaling out.

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