African Journal of Agricultural Research Vol. 7(16), pp. 2560-2568, 26 April, 2012
Available online at http://www.academicjournals.org/AJAR
DOI: 10.5897/AJAR11.1647
ISSN 1991-637X ©2012 Academic Journals

*Full Length Research Paper*

# Socio-economic constraints to adoption of yield improving tea farming technologies: A study of small holder tea farmers affiliated to estates in Nandi Hills, Kenya

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Accepted 27 February, 2012

**Tea farming technical packages tailored to improve productivity have been developed by the Tea Research Foundation of Kenya and availed to farmers for adoption where the estate subsector has demonstrated that these packages can double the current small holder tea production of 1,800 kg made tea per hectare. Despite this potential, there exists an alarmingly low uptake of these technologies by small holder tea farmers which points to significant gaps in the current tea sector policies and technology transfer worth exploring in the small holder tea sector. Lack of knowledge on socio-economic factors that constrain the adoption of these packages by smallholder tea farmers could be the cause of the wide gap that exist on the rate of adoption within the estate and small holder tea sub sectors. This is clearly demonstrated by low productivity in the latter over the years. Understanding these factors may provide explanations to the low adoption rates, which in turn could be used to formulate policies and offer research recommendations. This study is aimed at estimating how socio economic factors influence smallholder farmers' decision to adopt the available tea farming technologies. Descriptive statistics and logistic regression were employed with socio-economic factors as independent variables being regressed against the dependent variable of recommended yield improving tea farming technology in the Logistic Regression Model. The study was carried out among smallholder tea farmers affiliated to estates in the Nandi hills tea growing zone in Kenya. A questionnaire was randomly administered to 190 smallholder tea farmers who supplied green leaf to estate factories. The results generally showed that although, 99% of small holders grow potentially high yielding TN14/3 and C12 tea varieties, they do not apply the recommended practices needed to maximize the potential of these varieties. Only 45.8% of the small holder farmers were found to use the technologies. The logistic model analysis of the survey data showed that head gender, benefits awareness, costs awareness, and extension services significantly affected adoption. The implied significance on extension contact could be explained by lack of information on these packages among smallholder farmers who may be willing to adopt the technology. Policies that focus on transfer of information and reduction in cost of production based on these packages to smallholder farmers may help to boost the adoption. The evidence from the study also suggests that management skills seem to be lacking among the tea farmers in Nandi hills and calls for its inclusion in the training package. An organization to specifically represent the interests of estate smallholders would also be welcomed and useful.**

**Key words:** Estate smallholder tea farmers, tea, technology adoption, Nandi hills, Kenya.

## INTRODUCTION

Tea, *Camellia sinensis* (L) O. Kuntze is a perennial plant, whose buds and/or leaves are used to produce tea beverage and other products. Kenya is a major tea-producer and remains the world's largest tea exporter.

In addition, the tea industry in Kenya is fully liberalized and is composed of the estate and the smallholder sub sector with the small-scale farmers producing about 70% of total tea production. Small holder tea production provides meaningful employment to over 500, 000 households in the rural areas of the country. The estate sub-sector comprises of large-scale plantations that operate under Kenya Tea Growers Association (KTGA), while the smallholders on the other hand are farmers whose holdings have less than eight hectares on tea (Nyangito, 2001). Majority of smallholders fall under Kenya Tea Development Agency (KTDA) whose services include providing a link and transfer of recommended tea farming practices from the Tea Research Foundation of Kenya (TRFK) through the agency's elaborate extension system. Within the small holder sub-sector, a parallel system to KTDA exists where farmers sell green leaf directly to estate factories. Interestingly, small holder tea farmers linked to estates operate under the plantation based KTGA where the membership is based on affiliation to specific estate factories. Despite this linkage, most tea estates have no elaborate extension system to cater for smallholder operations partly because tea farms are small and widely scattered and at times difficult to access. In addition, estates are likely to be reluctant to invest in extra personnel and other resources to provide extension services apart from group demonstrations and general advisory services.

Technological packages for improved productivity have been developed and disseminated to the tea industry by the TRFK which receives most of its research funding from all tea growers. Although, these recommendations are available for all farmers, the estate sub-sector has undergone the most improvements in productivity as compared to the small holder farmers. Tea productivity in the smallholder sub-sector has been relatively lower compared to the estates sub-sector over the years and the yields are still well below potential. For example, in the year 2008, the Tea Board of Kenya (TBK) reports that smallholders had 107,115 ha of land under tea and produced 210 million kilograms of made tea while the estates had 50, 605 ha and 135 million kilograms of tea (TBK, 2008). This translates to an output level of 1, 960 and 3, 023 kg made tea per hectare per year respectively. This is despite the fact that small holders grow potentially high yielding vegetatively propagated tea varieties (clonal teas) as compared to estates that grow diverse cultivars including the low yielding types propagated from seed (seedling teas). This disparity in tea production and the large gap in productivity between the smallholders and estates is a major source of concern which needs to be addressed since tea in Kenya is grown on prime agricultural land with very good soils and climate capable of producing over 6,000 kg of made tea per hectare per year (Kavoi et al., 2000). One way of improving agricultural productivity among smallholder tea farmers is through the introduction of improved agricultural technologies to farmers. This can only be done successfully if socio-economic factors that constrain farmers from adopting them are determined and corrective measures instituted. It was therefore important to identify and examine these factors as any new technology can only be useful if adopted by farmers (Pandey, 1988). Previous studies on smallholder tea growers are mainly targeted farmers under the management of Kenya Tea Development Agency (Kavoi et al., 2000, Etherington, 1973) thus, creating a dearth of information on estate smallholder tea farmers in Kenya. Studies on smallholder farmers affiliated to tea estates are few, Von Bülow and Sorensen (1993) linked low productivity among smallholder farmers to conflict between spouses over the control over land. There is thus, no existing study that focuses on technology adoption by estate based smallholder farmers.

## Objectives of the study

The aim of this study is to improve on the current state of knowledge by contributing to better understanding of this fairly new segment of smallholder farmers not directly captured by existing institutions governing the tea industry in Kenya. The study seek to establish the level and socio-economic constraints to adoption of recommended tea farming technology by smallholder farmers in the Nandi hills tea growing zone, Nandi county, Kenya. The findings of this study will be useful in the formulation of better policies on tea production in the country and in particular, the emerging estate smallholder tea growers. We employed descriptive statistics and logistic regression model for the analysis to achieve this objective.

## MATERIALS AND METHODS

### Study area

This study was conducted among smallholder tea farmers supplying green leaf to estate factories in the Nandi hills tea growing zone in Nandi East district, Nandi County, Kenya. The area has a cool and wet climate with temperatures between 18 and 24°C which coupled with the rich volcanic soils make the area ideal for growing tea. The zone is dominated by large estate plantations and small holder participation is mainly based on the supply of tea to estate factories either individually or via out grower farmer organizations. There is an estimated number of over 6, 000 smallholder tea growers supplying tea to private tea processing companies that buy, process and market the tea at fee in the Mombasa tea auction.

### Sampling and data collection

The study used multistage cluster sampling to identify a survey sample in the district. Nandi hills area was purposely selected as it has the majority of small holder tea farmers within the district. 70% of

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**Table 1.** Sampling statistics for the groups.

| Cluster | Number smallholders tea farmers | Sample proportion |
|---|---|---|
| Chebarus | 211 | 22 |
| Chematich | 463 | 47 |
| Chemomi | 432 | 44 |
| Kaplelmet | 414 | 42 |
| Taito | 343 | 35 |
| Total | 1863 | 190 |

farmers in Nandi East district grow tea. To identify the tea farmers for the study, names were systematically picked from registers in various tea collection centers. The smallholders were then put into five groups per selected tea collection centre. Tea growers were also grouped based on the factories buying their tea into Chebarus, Chematich, Kaplelmet, Chemomi and Taito (Table 1). The number of respondents in each group was determined based on the proportion to the total number of smallholder farmers supplying their green leaf to estate tea factories within the district. Farm household is considered an appropriate unit for analysis because decisions on allocation of land, labour and other farm activities among the Nandi community are done at household level with the household head as the ultimate decision maker. Consequently, household heads or their representatives were the key respondents.

A sample size of 190 small holder farmers (103 non adopters and 87 adopters) was randomly selected based on the population of each group from a target population of about 1,863 smallholder tea farmers within the Nandi hills tea growing zone. A sample of at least 20 farmers was picked from each group and this was considered adequate to capture any variability in the data set while at the same time, allowing for manageable data in terms of cost and logistics. The distribution of each group is as shown in Table 1. The number of sampling units was determined according to the population and was carried out in such a way to reflect the number of smallholder farmers from each of the five groups within the study area. Smallholder tea households owning less than 8 ha of land on tea production were purposively surveyed. Both the primary and secondary data were used in the study, while the primary data was analyzed and used for discussions and conclusions, the secondary data obtained from agricultural reports from the district agriculture office, tea cooperatives, and tea out growers' organizations was used to beef up literature and discussions. Information on tea farming was collected through a pre-designed questionnaire which had earlier been tested and improved in a pilot survey. Data collected included household characteristics and tea farming practices. The interviews were mainly focused on the knowledge and adoption of the recommended tea production practices in the farms especially, activities that impacted directly on yields and green leaf quality. Additionally, problems encountered in the adoption were also outlined. Before the data collection, the questionnaire was pre-tested in the study areas and then adjusted to collect data appropriately.

The mode of communication with most farmers was the local Nandi dialect which is the predominant language spoken in Nandi county.

The questionnaire consisted of two main sections, the first section was on socio-economic characteristics of farmers and the rest was on tea farming and tea farming practices. Among the selected production practices were types of tea grown, weeding, fertilizer application, pruning and plucking. In the socio-economic section variables such as gender, household size, cooperative membership, house hold size, cost and benefits awareness and extension services were tested. Interviews were carried out at the farm site by enumerators, the researcher and extension agents. It was important to physically observe the farms so as to verify whether the farmer has indeed applied the recommended tea farming practices. Selected farmers were informed on the intended survey in advance, usually at the tea collection centers, or green leaf weighing shed through a local intermediary. This was in order to establish the willingness of the farmer to participate, as well as organize for the interview time.

To select adopters and non adopters, those farmers who practiced recommended plucking, weeding, fertilizer application, correct pruning regimes and growing of modern tea varieties or clones were considered as adopters. The other information sought was related to the general knowledge of existing tea farming practices for green leaf production. In tea, the factors that comprise recommended tea farming technology are to be adopted in combination of good yields that are to be realized. Although, most literature on technological adoption concentrates on single practices for example, fertilizer application (Green and Ng'ong'ola, 1993). Other studies like Nkonya et al. (1997) suggest that the adoption of technologies may in effect be enhanced because of synergies that exist between them. Experience however shows that immediate and uniform adoption of innovations in agriculture is quite rare (Feder et al., 1985). The selection of the most important factors was based on recommendations from the Tea Research Foundation and a similar study on small holder tea growers supplying tea to factories owned by KTDA (Mwaura and Muku, 2008).

Those farmers that had good tea plucking tables with correct plucking intervals of between 8 to 11 days as recommended for Nandi Hills area and those applying at least 100 N per ha of fertilizer were considered as adopters. Generally, the recommended fertilizer rates in Kenya range between 100 and 250 kg nitrogen per hectare per year depending on yield performance of a field. Equally, farmers who carried out chemical and/or manual weeding, and having plots with no weeds above the plucking table were considered as adopters. The type of tea grown determines both the yields and quality with clonal teas giving better yields and brewing quality than seedling teas, therefore, farmers with clonal as opposed to seedling tea were considered as adopters. Finally, pruning of tea is critical in commercial production where a pruning interval of 3 or 4 years is considered ideal at recommended pruning heights and by use of a standard pruning knife. Farmers following this pruning regime were also considered as adopters. Based on findings and virtual observations on the growers' farms, these recommendations from the Tea Research Foundation of Kenya were considered the most important as far as yields and quality of tea were concerned and were therefore, considered together as "yield improving tea farming technology". Details of these recommendations are found in the Tea Farmers' Handbook 5$^{th}$ edition (TRFK, 2008). SPSS software version 16.0 was used for the econometric analysis.

**The model**

The study focuses on a small holder's decision to adopt the yield improving tea farming technology (YIT), it further quantifies the probability of the factors that may significantly constrain or influence the decision to adopt the technology. The logistic model is the

**Table 2.** Respondent classification based on adoption level of the recommended yield improving tea farming technology.

| Adoption status | Adoption frequency | Adoption percent (%) |
|---|---|---|
| Non-adopter farmers | 103 | 54.2 |
| Adopters farmers | 87 | 45.8 |
| Total farmers interviewed | 190 | 100.0 |

standard method of analysis when the outcome variable is dichotomous (Hosmer and Lemeshow, 2000). The dependent variable was dichotomised with a value of 1 if a farmer was a yield improving tea technology adopter (following the TRFK recommendations) and 0 if not (non adopter). To assess the relative contribution of significant factors, a binary logistic analysis was employed and a predictive model with simple indicators was developed. This model predicts the probability that an individual with certain socio-economic characteristics chooses one of the alternatives (Gujarati, 2003; Green and Nangola, 1993). According to the logistic model, the probability, $P_i$, of a smallholder adopting yield improving tea technology is given by:

$$P_i = \frac{\exp^{zi}}{1+\exp^{zi}} \quad (1)$$

Where $Z_i$ = a random variable that predicts the probability of the $_i$th farmer adopting yield improving tea technology. For an individual farmer, the model can be expressed in Equation 2 as:

$$Z_i = \ln\frac{P_i}{1-P_i} = \beta_0 + \sum_{n=1}^{n} \beta_n X_{ji}, \quad (2)$$

Where; Pi = Probability of the event occurring; $\beta_o$ = Constant term; $B_n$ = Coefficients; $X_{ji}$ = Independent variables. The coefficients demonstrate the effect of each explanatory variable on log of odds and could be expressed through the following linear relationship in Equation (3):

$$Z_i = \beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} + \ldots\ldots\ldots\ldots + \beta_n X_{ni} \quad (3)$$

The model specification for this study can therefore be summarized in Equation (4) as:

$$Z_i = Y = \beta_0 + \beta_1 X_1 + \beta_1 X_1 + \ldots\ldots + \beta_n X_n + \varepsilon \quad (4)$$

The estimated model therefore was:

$$Y = YIT = \beta_0 + \beta_1 GEN + \beta_2 EDU + \beta_3 SIZ + \beta_4 BA + \beta_5 CAB + \beta_6 EXTN + \beta_7 COM + + \varepsilon \quad (5)$$

The qualitative dependent variable is yield improving tea farming technology (YIT), which takes on the value of 1 if the farmer adopts its variants and 0 if no adoption occurred.

Where: Y = Adoption level (1= Adopters; 0 otherwise) or proportion of farmers adopting the technology for particular values of independent variables $X_1$, $X_2$……$X_n$ that influence the adoption of yield improving tea farming technology, $\beta_1$, $\beta_2$……denote the regression coefficients, $\varepsilon$ is the error term. The explanatory variables are:

$X_1$ = Gender of Household head (GEN) (1 = Male; 2 = Female), $X_2$ = Household head education (EDU) (1 = Primary; Secondary = 2; College = 3), $X_3$ = Household size (SIZ)(measured in persons living under the care of the respondent), $X_4$ = Benefits Awareness (BA) (1 = Aware; 0 otherwise), $X_5$ = Costs Awareness ( CA) (1= Aware; 0 otherwise) $X_6$ = Extension Services(EXTN) (1= Yes; 0 otherwise), $X_7$ = Cooperative Membership (COM)(1 = Yes; 0 otherwise) , Ɛ = Error term.

## RESULTS AND DISCUSSION

Adoption levels of improved technology were measured by the proportion of farmers who adopted the technology. The status on the adoption of recommended yield improving tea farming technology in Nandi hills tea growing zone in Kenya showed that adopters in Nandi hills Tea growing zone are less than non-adapters (Table 2).

Table 2 reveals that the majority of the respondents (54.2%) did not adopt the yield improving tea production technology package as recommended by TRFK packages. The poor adoption result in the study area probably explains the reasons why there is low productivity among smallholder farmers. Although, a considerable number of smallholder farmers (45.8%) have been able to adopt the technologies but most of them (54.2%) are still constrained by numerous factors and hence, are incapacitated. Various reasons for failure to adopt were given, for example, on failure to adopt fertilizer application recommendations, some non adopters were not aware of TRFK recommendations, while others complained that they were not getting adequate quantities of fertilizer from estate companies. This is because fertilizer from the estate is pegged on tea deliveries per month. This criterion tended to favor only the progressive farmers who were mainly the adopters while the resource poor farmers with low leaf deliveries to factories received below the recommended levels. Likewise depending on which of the competing enterprises is profitable, farmers tend to divert fertilizer meant for tea to other crops. This together with the fact that smallholder farmers sometimes sell the tea to middlemen, a practice locally referred to us as "*mangirito"* is a topic of an ongoing study. Accordingly, there is the need to carry out on-farm demonstrations and educational seminars on benefits of fertilizer use on tea.

Social economic and demographic statistics for adopter and non adopters among the sampled households are as shown in Table 3. Majority (89%) of the households that adopted the technology were headed by men. Similarly, most of the smallholder tea farmers were male (85%), all from the Nandi community. The low number of female

**Table 3.** Descriptive statistics for socio- economic and demographic characteristics of non-adopter and adopter.

| Characteristic | Average | | Adopter | Non-adopter |
|---|---|---|---|---|
| Age (years) | 48 | | 48 | 47 |
| Household size (number) | 5 | | 5 | 5 |
| Farm size (ha) | 3.1 | | 5.4 | 1.1 |
| Average under tea (ha) | 1.2 | | 2.6 | 0.3 |
| Farmers experience (years) | 16 | | 20 | 12 |
| | **Frequency** | **Percent (%)** | | |
| **Gender** | | | | |
| Male | 161 | 85 | 78 | 83 |
| Female | 29 | 15 | 9 | 20 |
| **Education** | | | | |
| Primary | 102 | 54 | 15 | 87 |
| High school | 76 | 40 | 65 | 11 |
| College | 12 | 6 | 7 | 5 |
| **Cooperative membership** | | | | |
| Yes | 84 | 44 | 68 | 16 |
| No | 106 | 56 | 19 | 87 |
| **Extension contact** | | | | |
| Yes | 82 | 38 | 66 | 16 |
| No | 108 | 62 | 21 | 87 |

headed households should not be misconstrued to imply that tea farming is exclusively a male dominated activity (15% were women), however, the culture of land ownership in the region may have had some influence. Under the traditional land tenure practices of the local Nandi community, women tend not to inherit or own land (Snell, 1986). This practice is however, slowly changing with modernization and now more women are able to own and in some cases inherit land. On the average, adopters were slightly older (48years) than non adopters (47years). The average age for both was 48 years which also shows that the respondents interviewed are still very active and at the same time old enough to have accumulated enough tea farming experience. The average farm sizes of 5.4 ha were higher for adopters than non adopters (1.1 ha). Correspondingly, the area under tea was quite low for non adopters at 0.3 ha when compared to that of adopters at 2.6 ha. The average farm size for both categories was however 3.1 ha while that under tea was 1.2 ha. Kavoi et al. (2005) indicated that an economical tea farm size in Kenya should be about 0.13 ha; therefore, any tea farm below this hectarage can conveniently be referred to as an uneconomic farm unit. Based on this criterion, tea farm sizes for both adopters and non adopters can therefore, be termed as economical. Generally, literacy levels are low (54%) with many having primary education. Adopters level of education was high with about 82% having attained a high school level of education. Majority of non adopters (84%) had primary level of education. Most adopters (77%) had contact with extension agents as compared to only 16% of non adopters. The study also revealed that most farmers became aware of these research recommendations mainly through personal observation and experience while working in the tea estates, few cited visits by extension personnel from the ministry of Agriculture, while others credited attending demonstration field days in the estate farms as their means of acquiring tea production information. A large percentage of the farmers had worked in the estate farms at some point mostly as casual workers with most of the respondents revealing that at least one member of the family was employee in tea estates on off farm employment. Adopters and non adopters did not differ appreciably with respect to age and household size where the mean household size was about 5 persons for both categories. Since tea farming is labor intensive, activity increased productivity is expected from households with more family labor. However, due to the high labor requirements in tea production, family labor may not be adequate for those with larger tea farms and thus, some smallholder farmers engage hired labor to augment household labor supply. Lack of adequate family labor accompanied by the inability to hire labor can seriously constrain the adoption of tea farming practices. 80% of the adopters indicated that they

**Table 4.** Tea varieties grown by smallholder tea farmers in Nandi Hills, Kenya.

| Type of tea | Number | Percent (%) |
|---|---|---|
| Seedling | 2 | 1 |
| Clonal | 188 | 99 |
| **Clone types** | | |
| TN14/3 | 112 | 59 |
| C12 | 48 | 26 |
| TRFK6/8 | 6 | 3.2 |
| TRFK14/3 | 8 | 4.3 |
| Mixed | 14 | 7.5 |

**Table 5.** Parameter estimates of the logistic model analysis of socio-economic factors.

| Variable | Coefficient | Standard error | P-values |
|---|---|---|---|
| Head gender | 0.917 | 0.534 | 0.071* |
| Head education | 0.290 | 0.505 | 0.572 |
| Household size | 0.449 | 0.484 | 0.390 |
| Benefits awareness | 1.018 | 0.384 | 0.035** |
| Costs awareness | 1.012 | 0.376 | 0.003*** |
| Extension services | 1.736 | 0.377 | 0.085* |
| Cooperative membership | 0.383 | 0.504 | 0.595 |
| Constant | -2.000 | 0.373 | 0.012* |

Overall estimate = 78.1%; Chi-square test = 62.619. Where: *, **, *** refer to significance at P = 10, 5 and 1% respectively.

relied on hired labor in tea production especially, on weeding and plucking during peak harvesting periods. Non adopters did not use hired labor but instead majority sought off farm employment in the adjacent tea estate. The role of different genders in tea farming was found to be clearly distinct in the Nandi community where men were mainly involved in planting, pruning and weeding while women participated in weeding, plucking and carrying of greenleaf to the collection centres. Adopters on the average had accumulated farming experience of 20 years compared to non adopters at 12 years. Tea is a perennial crop and has a life of over 50 years. It takes about 4 years to become fully matured and to start giving returns to investment. Most of the activities in tea production therefore, require more farming experiences.

## Tea varieties grown by adopters and non adopters

The farmers' varietal preferences as deduced in the study are as shown in Table 4. 99% of smallholder tea farmers in the study area grow recommended clonal tea or vegetative propagated varieties as opposed to seedling types.

The most adopted tea clone was TN14/3 (59%) followed by C12 (25.2%). Other tea clones grown were TRFK31/8 (4.2%) and TRFK6/8 (3.2%), while about 8.4% of the farmers grow a mixture of different tea clones in their farms. The variation in adoption rates of different types of tea clones is a reflection in the clones grown in the adjacent tea estate companies where they are provided with young seedlings for planting in their farms. Discussions with local leaders revealed that most of the farms were initially part of the large multinational tea plantations that were hived and redistributed to local population mostly in the early 1980's when most plantations had started growing clonal tea varieties.

## Logistic model analysis estimates

The results of the logistic regression estimates are presented in Table 5. The results indicated that in the overall model estimate, 78.1% of the total variation in the sample was explained by the logistic regression model. This shows that the explanatory variables are relevant in explaining the adoption decision.

The logistic model analysis (Table 5) from survey data showed that household head gender benefits awareness, costs awareness, and extension services were significant at 1, 5 and 10% levels respectively. However, household head education; household size and cooperative membership do not influence the adoption. Education was not a significant factor as expected in the study area possibly because almost all of the farmers interviewed had acquired formal primary education (Table 3) that could enable them to read and write and eventually follow

technical recommendations. Furthermore, a modest farmer's expererience on tea farming can adequately compensate for deficiencies in education. Yaron et al. (1992) showed that the influence of extension can counter balance the negative effect of lack of years of formal education in the overall decision to adopt some technologies. This study found that household size was not significantly related to technology adoption decisions. Even though family labor constitutes a bulk of the labor used in agriculture in Kenya, it is not always available for farm operations. Most of the poor farmers who are often non adopters also tend to seek alternative employment in the neighboring estate farms.

Gender of the farmer was found significant and positively related to adoption of recommended tea yield improving farming technology. This suggests that men are more likely to engage in tea farming and take up the recommendations on their fields than women. Some studies have argued that where there is a problem of secured land rights, women may be less likely to adopt it because of lack of rights to grow tea (Adesina et al., 2000). As stated earlier, the culture of land ownership among the Nandi community may have had some influence. Although, Kenyan inheritance laws allow for equal inheritance of land by both male and female dependants under the traditional land tenure practices of the Nandi community and control of household resources including land is held by men. This result may reflect the traditional bias against women in inheriting land. Gender relations have also been cited (von Bulow and Sorensen, 1990) to negatively affect smallholder tea production that leads to low productivity and neglected tea fields especially, when tensions arise as a result of conflicts over the control of proceeds of tea sales.

Benefits awareness and cost awareness were found to significantly affect adoption. This might be attributed to the fact that, the perception of increased benefits gives incentive to the farmers to adopt more productive technologies. The high gross-margins attributed to tea production and lifestyle in the neighboring estates may have been an incentive to smallholders to engage in the cash crop production. Costs awareness centres on the fact that tea plant takes about 4 years to reach economical harvesting period after planting. Adoption can be expected to be dependent on the cost of a technology and on whether farmers possess the required resources. Once the farmer is assured of profit maximization, he or she would definitely invest in it. A study by Danish Development International Authority (DANIDA) in Mauritania in 1984 and 1986 showed that project success and support from affected communities depend on how well the project costs and benefits are perceived by local communities. The positive relationship may be due to the fact that, if the tea farmer is aware of the costs involved in adopting a particular technology, he would assess the ability of realizing optimal gross margins. This clearly shows that awareness of benefits and burdens of the project by the concerned farmers should not be taken for granted because it can determine the future of such project.

Contact with extension was significant and positively related to adoption and confirms that farmers on contact with extension and research agencies have greater likelihood of take-up recommended tea farming practices. Contact with extension services gives farmers the access to information on recommendations, advice on inputs and their use, and management of technologies. Furthermore, in most cases, extension workers establish demonstration plots where farmers get hands-on learning and can experiment with new farm technologies. Adoption of any innovation, technology or agricultural practice will be accelerated if farmers have an accurate understanding of the principles underpinning extension recommendations. The key factor in explaining adoption is the neighboring estate farms who act as role models to smallholder farmers. Most of the tea farming practices is knowledge-intensive, therefore, formal schooling may enhance managerial ability, and this would imply that extension will make up for low levels of educational attainment, perhaps through emphasis on management training and actual participation in tea technology demonstrations (Marenya and Barret, 2002). Low levels among the non adopters may be explained by poor resource endowment among the lowly educated household heads as educated farmers are likely to be employed have more income and are also able to assimilate farm management techniques in addition to being in a position to hire the most experienced farm hands around. The scale of production may also be a factor that influences the desire to seek the assistance of an extension officer. There is a possibility that the majority of tea growers never attend training sessions offered to out grower farmers by the tea estates companies. Meanwhile, it has been found that the ratio of frontline extension staff to smallholder tea farmers is low in Kenya (Kavoi et al., 2005). Similar studies on factors influencing agricultural marketing amongst smallholder tea farmers in South Africa (Jari and Fraser, 2009) and on maize technology adoption (Bisanda et al., 1998) found extension services as an important factor. Non adoption (54.2%) by farmers may be explained by the poor access to extension services. Lack of significance on the impact of cooperative membership on the adoption of technologies could possibly be explained by previous poor management of cooperatives within the study area.

## Conclusion

The study examined the factors that constrain estate smallholder tea farmers from adopting recommended yield improving tea farming technology. Tea is an important crop for this group of farmers with the evidence showing that most of them dedicated large parts of their total farm

holdings to tea. The study showed that modern high yielding tea clones have been taken up by almost all farmers (99%), and with Nandi hills tea growing zone being a prime agricultural land suited to growing of tea, the yield potential in the farms is achievable if farmers adopted the recommended tea farming practices to boost yields. The logistic model analysis of survey data showed that head gender, benefits awareness, costs awareness, and extension services were significant at 1, 5 and 10% levels respectively. However, head education, household size and cooperative membership do not influence the adoption of yield improving tea farming technology. Low adoption could possibly be explained by the fact that most farmers tend to select only affordable packages. Learning from Malawian experiences (Chirwa et al., 2006), it is evident that greater emphasis be placed on institutional and economic factors in the improvement of tea production by small holder tea farmers. In Malawi, it was found that tea farmers under well drawn private contracts can access extension service, low cost and high quality inputs provided by estates factories and receive their proceeds on time. Similarly, estates should encourage the small holder tea farmers in Nandi hills to form strong out grower organization which will enable them have stronger bargaining power in contractual arrangements with estates factories. This will facilitate easier access to technology, extension services, and farm input credits and may improve the adoption levels of recommended tea farming technologies hence, boosting farmer's yields and income. The influence of gender differences, particularly, as they are linked to culture and differential labour demands between sexes in tea farming as seen among the Nandi community should be considered in technology adoptions issues related to tea farming among small holders.

Finally, for estate small holder farmers, potential yields that can match those observed in the estate sub-sector will not be realized under the constraints discussed in this study and thus, ways of addressing these drawbacks have to be mooted and implemented. We can also conclude that socio-economic constraints are responsible for the low technology adoption by tea farmers in Nandi hills tea growing zone.

## RECOMMENDATIONS

Technologies are to be disseminated to the smallholder farmers through on farm courses based on practical demonstrations in which the farmers have contact with the trainers, like in farmer training schools.

Benefits and costs in tea farming should be comprehensively studied in relation to competing enterprises like maize, horticulture and dairy in Nandi hills tea growing zone to allow the farmers make informed choices on whether tea farming is profitable or not and this should be based on actual gross margins with benefit and cost analysis and availed to farmers for decision making. Estate companies should encourage and support the farmers in forming strong out grower schemes and cooperatives by buying tea only from registered farmers from these groups so as to avoid the exploitation of farmers by middle men. These groups should be able to negotiate for better contractual terms with the estates and benefit from cheap bulk buying of fertilizers and other farm inputs.

## ACKNOWLEDGEMENTS

This study was supported by the Priority Academic Program Development of Jiangsu Higher Education Institutions, China; the Program of Suzhou Engineering Research Center for Modern Ecological Tea Industry, China (SZGD201067, WZC65); the Earmarked Fund for Modern Agro-industry Technology Research System of China (CARS-23) and the PhD Gathering Program of Jiangsu and special thanks to David Kosgei (Department of Agricultural Economics, Moi University, Kenya) for his helpful advice.

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