International Journal of Development and Sustainability
Online ISSN: 2186-8662 – www.isdsnet.com/ijds
Volume 1 Number 3 (2012): Pages 714-742
ISDS Article ID: IJDS12091107

ISDS JOURNALS

Special Issue: Development and Sustainability in Africa – Part 1

Sustainability of smallholder tea production in developing countries: Learning experiences from farmer field schools in Kenya

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Abstract

A study to determine the impacts of farmers field schools (FFS) on smallholders' adoption of good agricultural practices in tea and to assess sustainability of smallholder tea production was conducted in the highlands of Kenya. Input-output data on tea management and on sustainability indicators (score 0-10) were collected from a sample of 120 FFS participants at the beginning of the study and from 60 randomly selected FFS participants and a comparison group of 60 non-FFS participants at the end of the study, 18 months later. The study showed that the smallholder tea systems are moving towards social sustainability and economic returns were positive. Sustainability indicator scores, for FFS members, increased by 4% from the base period. The FFS participants also attained a significantly higher level of farm sustainability, knowledge gains on good agricultural practices (GAP) and higher yields and farm and tea income than their non-FFS counterparts. These findings indicate that FFS methodology had a positive contribution to enhancing farmer learning and adoption of good agricultural practices in tea and improved farmers' livelihoods.

Keywords: Farmer field schools, Kenya, Smallholder tea, Sustainability, Farmer learning

Cite this paper as: Onduru, D.D., De Jager, A., Hiller, S. and Van den Bosch, R. (2012), "Sustainability of smallholder tea production in developing countries: Learning experiences from farmer field schools in Kenya", *International Journal of Development and Sustainability,* Vol. 1 No. 3, pp. 714-742.

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1. Introduction

Tea is the most popular and cheapest beverage next to water and is an important commodity in terms of jobs and export earnings for a number of tropical developing countries. While tea is produced in more than 35 countries, only a handful-China, India, Kenya and Sri Lanka are responsible for almost three-quarters of production and, indeed, more than half of the world's tea is produced in China and India alone (Sanne van der Wal, 2008). At global scale, tea is majorly produced in large plantations, but smallholder production is important in countries such as Kenya and Srilanka. Kenya is the third largest producer of tea (displacing Sri Lanka), after India and China and largest exporter of black tea in the World with smallholder production accounting for about 66% of total tea production (378 million kilograms in 2011), (Kariuki, 2012). Tea is the leading exchange earner (earned US$ 1.3 billion in foreign exchange in 2011) and contributes about 4% of Gross Domestic Product (GDP). The tea sectors also offers employment all-year-round to about 639,521 growers in the rural areas in addition to proving employment in other parts of the tea value chain. As a labour intensive industry, tea sector supports livelihoods of more than three million persons directly and indirectly (about 10% of Kenya's total population) (Tea Board of Kenya, 2008).

Despite its importance to developing countries, the tea sector is faced with a number of constraints. In a review of six major tea producing countries (India, Indonesia, Sri Lanka, Kenya, Vietnam and Malawi), Sanne van der Wal (2008) reported that tea production is hindered by rising production costs (labour, fuel and electricity), mismanagement, age of tea bushes, high overhead costs, bad agricultural practices, low labour productivity, climate change and dilapidated infrastructure. In real terms, prices of tea have gone down by about 35% in the past 25 years (Mulder, 2007). Also the sector's environmental footprint is considerable, with reduced biodiversity due to habitat conversion and high energy consumption (mainly using logged timber) among other factors. Additionally, for the smallholder sector, problematic issues include low farm gate prices, poor extension services, limited market channels, poor access to credit and low level of farmer organisation. Addressing the emerging issues requires adoption of alternative agricultural practices and philosophy that takes into account environmental, social and economic impacts of agricultural activities when making improvements in the current farming systems. Sustainable agriculture contributes to addressing this challenge (Francis, 1990).

Sustainable agriculture addresses environmental and social concerns, but also offers innovative and economically viable opportunities for growers, labourers, consumers, policymakers and many others in the entire food system. Concerns about sustainability focus on the necessity to adopt technologies and practices that do not have adverse effects on the environment, are easily accessible to and effective for farmers, can lead to improvements in food productivity and have positive side-effects on environmental goods and services (Pretty et al., 2008). The philosophy does not preclude any technology on ideological grounds, but embodies all technologies that are socially acceptable, improves productivity and does not cause harm to the environment. Going "sustainable" will transform the tea industry, which has been suffering for many years from oversupply and underperformance. Adding to the necessity of producing tea sustainably is the consumer voice willing to pay for tea produced in an ethical way guaranteed by third party bodies (Divney, 2007; Rainforest Alliance, 2007; Sanne van der Wal, 2008).

To enhance sustainability of smallholder tea production, farmers need to acquire skills and knowledge about good agricultural practices and how to implement them as well as on how to respond to new situation as farming environments change (Deugd et al., 1998). Application of good agricultural practices is knowledge intensive and requires a facilitated learning process that banks on the creativity and competence of farmers, extension workers and researchers. One such facilitated learning process is Farmer Field Schools (FFS). The FFS empowers farmers to learn principles and practical application of good agricultural practices through farmer-science knowledge linkages and through learning on and testing various technological options available, during which they are able to decide the best alternatives for their particular circumstances according to their agro-ecological settings, farm size, available capital and access to markets (Matata and Okech, 1998). FFS is based on adult learning principles. Although FFS has been applied to enhance farmer learning in a variety of enterprises, it has not been applied to the tea sector in Kenya.

The FFS approach empower farmers to be their own technical experts and to adapt potentially applicable technologies to their own particular conditions by enhancing farmers knowledge (technical and socio-economic), decision making and problem solving skills, and stimulating collective action. More recently FFS is being considered an appropriate vehicle for general empowerment of rural actors, in which life-long learning processes, strengthening of local institutions and networks, stimulating social processes and collective actions may lead to improvement in rural livelihoods (Hounkonnou et al., 2004).

This study therefore was undertaken in the highlands of Kenya to assess the impacts of FFS on adoption of good agricultural practices in tea (sustainable tea production practices) and on farmer livelihoods. The study also assesses the sustainability status of smallholder tea production and generates lessons learnt in adapting farmer field schools to smallholder tea production.

2. Methodology

2.1. Study sites

The study was conducted in four Counties in the highlands of Kenya, namely Nyamira and Kericho (West of the Rift Valley) and Muranga and Embu (East of the Rift Valley). The socio-economic characteristics of the districts are presented in Table 1. In terms of population density the districts are in the following decreasing order of magnitude Nyamira > Muranga > Kericho > Embu. High poverty levels are reported in the study districts west of the Rift Valley (Nyamira and Kericho) than those in the East (Muranga and Embu) of the Rift valley. In these highland areas, tea is grown between 4,500 (1500m) and 6750 feet (2250m) above sea level on tropical, red loam soil and decomposed volcanic deposits. The soils are well drained and have a pH in the range of 4.5 to 6.5. Straddling the equator, Kenya's tea-growing regions have an ample supply of sunlight and an even distribution of rain throughout the year, providing optimal conditions for tea growing. Rainfall in the highland areas are in the range of 1200 mm to 2500 mm annually while temperature ranges between 12°C and 28°C. Tea production goes on year-round, with two flushes, peak seasons of high crop-March to July, and

October to December, coinciding with the country's rainy seasons (Kinyili, 2003). However, in some tea growing areas such as Kericho County, rainfall pattern is unimodal.

Table 1. Characteristics of the study counties

Characteristics	County			
	Nyamira	***Kericho***	***Muranga***	***Embu***
Population (2009)	598 252	758 339	942,581	516,212
Surface area (km^2)	899	2479	2559	2,818
Density (people/km^2)	665	306	368	183
Poverty rate, based on KIHBS (%)[a]	48.1	44.2	29.9	42.0
Population with primary education (%)	64	69.8	69.5	71.3
Population with secondary education (%)	17.7	11.4	17.7	15.5
Good/fair roads (as % of total roads	64.9	58.5	45.0	33.7

[a] KIHBS: Kenya Integrated Household Budget Survey, 2005/2006

The farming system in the study sites is characterized by smallholders raising both crops and livestock. However, tea is the dominant cash crop. With over 562,000 smallholder tea growers in Kenya and land under tea of 115, 023 ha (KNBS, 2008; Kagira et al., 2012), the average land holdings in the smallholder sector is estimated to be 0.205 ha. According to Kavoi et al. (2002), the minimum economic tea farm unit for smallholder farmers is estimated to be 0.1 ha (0.25 acres).

2.2. General approach and farmer field schools

The study was carried out using a multi-institutional and multi-disciplinary approach with farmer field school methodology as the main framework for farmer learning and implementation of activities. The various institutions (extension, research and development institutions) participated in FFS process, bringing-in diverse expertise (technical and socio-economic) to increase farmer knowledge and skills. The FFS learning focused on basic agro-ecological processes through field observations, season-long field studies (trials/experimentation) and facilitated plenary discussion, experience sharing and training sessions.

Farmer Field Schools were first initiated in the FAO assisted Indonesian national Integrated Pest Management (IPM) programme in Central Java (1989) in rice growing areas to address a major threat to food security resulting from dramatic yield losses caused by the brown planthopper (Pontius et al., 2002). This study modified the classical IPM-FFS methodology to make it adaptable to the much more complex issues of rain-fed subsistence agriculture in Africa and, in particular smallholder tea systems. Experiences on tea-based FFS are limited in SSA. As far as we know this was the first time FFS was adapted for farmer learning in smallholder tea-based systems in SSA. Other initiatives have also adapted the methodology so as to enhance farmer learning on different themes such as integrated nutrient management, livestock and other enterprises among others (Onduru et al., 2002; FAO, 2008; Mweri and Dveskog, 2005). Despite these adaptations, the principles and the process of FFS has been maintained over time. Adaptations made in this study are presented in Table 2.

Table 2. Adaptations made to classical FFS approach

Mainstream (IPM-FFS) approach	**Adaptations made**
One cropping cycle (4-9 months)	The one-cropping-season FFS cycle was replaced by 18 months learning cycle. Tea being a perennial crop requires a longer period of study for farmers to be exposed to all phenological stages of tea as they occur
Focus on annual crops	Focus on perennial crop (tea)
FFS characterized by weekly meetings (to capture pest dynamics)	FFS meetings organized bi-monthly; other meetings organized as and when necessary
Experimentation in one central learning plot (Participatory Technology Development)	Experiments organized in five sub-group sites (five replicates) per FFS capturing diversity in tea farming system; Systematic experimentation given emphasis with experiments designed jointly in farmer-extension-research meetings and monitored by farmers at regular agreed-upon intervals.
Observations from agro-ecosystem analysis (AESA) shared each FFS meeting	In addition to sharing AESA observations in each meeting, the qualitative and quantitative data from experiments were further documented and analysed for wider dissemination
Lacks systematic in-built monitoring and evaluation system	Systematic in-built monitoring and impact assessments were included in the plan of activities
Formation of local farmer organizations for marketing and input supply	The project had inbuilt institutional linkages to address input supply and linkages to tea buyers and certification procedures that eventually allow farmers to earn premium price on tea

2.3. Formation of farmer field schools

Four tea processing factories with registered smallholders delivering tea to them were selected to participate at the beginning of the study, one in each of the study County. A tea factory has several tea buying centres (collection centres) under its designated geographical coverage (catchment). In each tea factory catchment, a representative tea buying centre with a number of smallholder tea growers delivering tea to the buying centre was selected for the study. One FFS was formed in each of the selected tea buying centre catchment and therefore, one FFs per factory catchment. This resulted in formation of four FFS (30 members per FFS). Meetings were held in each of the selected factories with prospective participants (tea growers) prior to formation of FFS. This was to gain rapport and collaboration and to enlist volunteer farmers into the FFS learning process. Volunteer farmers formed the respective FFS in each factory catchment at the start of the study.

The farms participating in the study were comparable in a number of characteristics such as distance to tea buying centre and land sizes typical of smallholdings (Table 3). However, total farm sizes tended to be larger in the West than East of the Rift Valley. This was the reverse for percentage of total land under tea.

Table 3. Distribution of farmer field schools and farm characteristics (standard deviation in parenthesis)

Description	**Pilot FFS characteristics**			
	West of Rift Valley		***East of Rift Valley***	
County	Nyamira	Kericho	Muranga	Embu
Tea factory	Nyansiongo	Momul	Ngere	Mungania
No. of FFS groups	1	1	1	1
No. of FFS farmers	30	31	30	30
Total farm size (ha)	1.3 (1.0)	1.2 (0.8)	1.0 (0.6)	0.7 (0.5)
Percent of total land occupied by tea	19	28	47	43
Distance to tea buying centre (km)	1.2 (0.6)	1.3 (0.7)	0.6 (0.4)	1.0 (0.7)

2.4. Assessment of sustainability status of smallholder tea system

Following the formation of the FFS groups, assessments of the sustainability of tea system was done using the following tools (i) baseline survey using Monitoring for Quality Improvement questionnaire (MonQI) and (ii) sustainability indicator questionnaire. The baseline survey, using MonQI questionnaire, diagnosed farmer's farm management practices and provided quantitative and qualitative information on the level of sustainability of smallholder tea production. Monitoring for Quality Improvement (MonQI) is a methodology for monitoring the management and performance of small scale farming systems world-wide (http://www.monqi.org). The MonQi toolbox consists of a set of questionnaires and computer software for data entry and processing. The MonQI questionnaires were administered to members of the various FFS in a one-time recall semi- structured interview covering the period July 2005 to June 2006 (here-after referred to as " before FFS" situation). A total of 120 farmers drawn from the four FFS were interviewed. The social, economic and environmental/ecological indicators covered by MonQI methodology are presented in are presented in tables 4a, 4b, and 4c.

Table 4a. Indicators of social sustainability used in the study

Indicator grouping	Meaning	Relevance	Parameters/measurements
Education of the household head	Refers to the number of years that the household head has spent in formal education system	• It is assumed that highly educated household heads are fast in adopting new technologies. • Education strengthens people's abilities to meet their needs and those of their families by increasing their productivity and potential to achieve high standards of living and thereby improving their quality of life. • Education (formal and non-formal) is a source of knowledge important for propelling the pace of agricultural development .	Education level of household head: Measured in complete years
Age of household head	Genetic age describing how long the household head has lived	• Measure of confidence and level of taking farming risk and or adoption of new technology. With age, a farmer can become more or less risk-averse to new technology. This variable can thus have a positive or negative effect on a farmer’s decision to adopt a new agricultural technology. • Labour provision: Persons within the age bracket 15-59 years are within the productive labour force and can effectively provide labour for farm operations (NCAPAD, 2005 District strategic plans 2005 – 2010).	Genetic age of household head: Reported in complete years
Farm labour (for mature tea)	A factor of production necessary for carrying out farm operations Labour allocated to various tea operations at farm	• Influences management of tea and its productivity • Labour as an input in tea production is considered a social factor of production, but with an economic dimension as labour productivity influences profitability of tea enterprise.	• Labour demand and intensity: measured in days/hectare • Farm labour self-reliance: Family labour as a percentage of total labour for tea production

	level excluding household labour allocated to off-farm activities		

Table 4b. Indicators of ecological sustainability

Indicator grouping	Meaning	Relevance	Parameters/measurements
Tea productivity	A measure relating quantity or quality of tea output to the inputs required to produce it in time and space.	• Tea green yields are a reflection of the quality of production resource base (soils, nutrients, moisture etc.) and farm management practices. • Tea green leaf yields are a reflection of the level of human manipulation of farm inputs and outputs and ecological processes.	• Green leaf yield kg ha^{-1} $year^{-1}$
Nutrient balance	A measurement of physical difference (surplus/deficit) between nutrient inputs into, and outputs from, an agricultural system	• Establishes linkages between agricultural nutrient use, changes in environmental quality and sustainable use of soil. • A negative nutrient balance indicates that “nutrient losses/uptake” exceeds nutrient inputs while a positive nutrient balance indicates the opposite. • Shortage of nutrients leads to soil mining and depletion of soil fertility, whereas superfluous application of nutrients may lead to leaching of nutrients to surface water and groundwater and jeopardize drinking water supplies and ecological functioning of water resources.	• Partial N PK balance (kg/ha/yr)

Table 4c. Indicators of economic sustainability

Indicator	Meaning	Relevance	Measurements
Gross margins	Financial indicator measuring profitability of crop enterprise calculated as the difference between gross value/revenue from tea enterprise and total variable costs for tea production	• Reflects the economic viability of tea • By proxy, it also reflects changes (improvement or decline) in land quality and degradation over the long term.	• Gross margins (Ksh ha^{-1} $year^{-1}$)
Net cash flow	Financial indicator measuring the difference between cash revenue and cash expenditure	• Reflects cash income from tea or cash (from tea) in the pocket of the farmer	• Net cash flow (Ksh ha^{-1} $year^{-1}$)

The results of the "before FFS situation" or diagnostic activities/baseline survey and performance of sustainability indicators were summarised for each farm (farm reports with graphics and tables) and shared with farmers in discussion meetings in which observed constraints and opportunities for addressing them were discussed.

2.5. Consolidation of FFS activities and formulation of curriculum

Farmer field schools were run on a curriculum formulated in a participatory manner with components including the following, among others: special topics (discussion topics), trials and demonstrations and group dynamic activities. The outputs of the diagnostic activities were used as an input into FFS curriculum building and in selecting topical issues for learning (special topics) and for field trials (participatory technology development, PTD). Group meetings were also held in each FFS to further inventorise constraints and opportunities of tea production and management and identify gaps in farmer knowledge. The farmer identified constraints, together with those emerging from facilitators and researchers, proposals were discussed alongside each other and prioritised for special topic sessions (Table 5) and for demonstrations and field trials (PTD) using pairwise ranking in meetings held with each FFS separately.

Table 5. Example of special topic sessions, Oburabo FFS (2006/2007)

Date	Special topic/ demonstration	Areas to be covered	Resource person
07.02.06	Farm planning and record keeping	• General farm layout • Importance of record keeping • Types of records	DAO
28.02.07	Land preparation, planting, infilling and clonal section	• Land preparation; tools • Preparation of planting materials • Clone types • Clone suitability	ESC and TESAs
7.03.07	Diseases and pests	• Types of diseases and pests/causes of diseases and pests • Effects of diseases and pests • Control and management	TRFK
28.03.07	Agroforestry	• Species and types • Recommended trees • Measures against planting	DFO
04.04.07	Tea payments	• Green leaf-made tea selling • Payment variations • Initial payment and bonus	ZM/ UNILEVER
25.04.07	Leaf collection Leaf handling	• Routing • Roles of farmer, LCC, drivers and TESAs at B/C • Spillages/loss of leaf before and on transit	FUM
02.05.07	Tea weighments	• At B/C and factory • Tare weight	FUM
30.05.07	Tea nursery preparation an management	• VP materials, soil, fertilizer types and quantity, cuttings, mother bushes • Nursery care and management	ESC and TESAs
6.06.07 & 27.06.07	Intercropping	• Types of intercropping • Effects of intercropping	TRFK
July	Fertiliser application	• Fertiliser types-favourable application time • Quantity to apply on different tea ages (young and mature plants)	AG KTDA
7.08.07	Fertiliser application		TRFK/UNILEVER
26.08.09	Sustainability in agriculture Pruning	• Importance of pruning • Proper pruning methods • Pruning tools • Types of pruning	
5.09.07	Clonal seedlings		TRFK
26.09.07	Intercropping boundary trees and weeding		TRFK
3.10.07	Farm planning		DAO
31.10.07	Record keeping		
7.11.07	Soil conservation	Effects of soil erosion	DAO
28.11.07	Tea marketing	How to conserve Tools to use	FUM
5.12.07	Mangerito	Effects of mangerito	Chairman/Director
26.12.07	Natural disasters	Effects of natural disasters	FSC/TESA

Prior to the implementation of the FFS curriculum, members of FFS prepared their own learning norms and rules, selected their own group leaders and prepared a learning contract covering 18-months learning cycle under the guidance of a facilitator. A field guide was also prepared jointly with FFS members to guide the FFS learning activities in the bi-weekly FFS meetings (Table 6). Key elements during the bi-weekly FFS meetings included agro-ecosystem analysis (observations on field trials), discussion topics (special topics) and group dynamic activities, details of which are presented here-after. Group dynamics, team building exercises, communication skills and building of local group structures, and field days and study tours were also included as part of the FFS curriculum.

Table 6. Example of an FFS field guide-Mungania Farmer Field School

Time	Duration	Activity	Reason	Who is responsible
9.50-10.00	10 Minutes	Arranging venue	Prepare venue	Host team
10.00-10.05	5 Minutes	Prayer	Commit day`s activities to God	Host team
10.05-10.10	5 Minutes	Roll call	Know attendance	FFS chairman
10.10-10.20	10 Minutes	Recap	Remind participants of previous meeting activities & lessons	Previous week host team
10.20 -10.25	5 Minutes	Programme for the day	Keeping participants informed of tasks ahead	Facilitator, Host team
10.25 10.50	25 Minutes	Discussions on trial	Exchange findings from AESA & share experiences	Subgroups
11.00-11.10	10 Minutes	Group dynamics (Break)	Building communication, leadership, social skills	Facilitator ,Host team
11.10-11.30	40 Minutes	Special topic (Discussions/Demonstrations)	Keep participants abreast with tea management technologies, knowledge & good agricultural practices, gender issues as well as social economic needs of a family.	Facilitator
11.40-11.45	5 Minutes	Summary & reactions	Reaffirming day`s learning points	Facilitator
11.45-11.50	5 Minutes	Announcements, Programme for next meeting	Prepare participants for next meeting	FFS chairman, Facilitator
11.50-11.55	5 Minutes	Prayer	Thanksgiving for the day	Host team
11.55-12.00	5 Minutes	End meeting, clear venue	Tidying up &returning FFS items	Host team, Facilitator

2.6. Farmer Field School trials (participatory technology development)

Trials or Participatory Technology Development (PTD) form an important component of the FFS curriculum and provides opportunity for farmers to make field observations, learn by doing and through self-discovery gain new skills in tea management. Trials were designed in a participatory process in meetings held separately for each FFS. The list of constraints delineated for trials during participatory diagnosis of constraints and opportunities by each FFS, with additional input from facilitators and researchers, formed the basis for discussions leading to selection of a priority theme/constraint to be addressed in field trials.

Technologies for field trials, addressing the prioritized theme/constraint, were proposed by farmers, facilitators and researchers and discussed alongside each other, resulting in the choice of one technology for field trials. Priority was given to technologies that fit well in the target season of field trials. Trial objectives, treatments, trial lay-out, replication and indicators for monitoring, frequency of monitoring and duration of trials were discussed in FFS group meetings and agreed upon, including an action plan for implementation. A field trial typically consisted of three treatments, including a control (farmer practice), on plots of land with 30 bushes of mature tea each (uniform bushes), Table 7. Each FFS was divided into five sub-groups with each sub-group hosting a trial; thus there were five replications for the same field trial in an FFS. Each field trial was implemented over a period of 6 months. Plucking of tea was done using a plucking stick except in trials where the use of the plucking stick was part of the treatment.

2.7. Agro-ecosystem analysis

Farmer learning and monitoring of the trials was done through agro-ecosystem analysis. Agro-ecosystem analysis chart/recording tool, with monitoring indicators, was used by sub-groups (host teams) of farmer field schools to study the field trials, learn from them and collect relevant data. Each sub-group made observations in their own "block" of trials at agreed upon frequency and set dates. The observations made and data collected by the sub-groups were analysed at sub-group level, and later presented in plenary in the bi-weekly FFS meetings for further critique and sharing of results. The plenary discussions were for building consensus on the performance of the various treatments, exchange of learning experiences and for deciding on actions required to address emerging issues.

2.8. Graduation, impact assessment and post-FFS activities

At the end of the 18-months FFS learning cycle, a graduation ceremony was held for the FFS members. This was followed by impact assessment of FFS activities, "after FFS situation" conducted by independent enumerators. In the impact assessment study, half of the FFS farmers (60) spread equally across four tea factory catchment areas, were selected to be interviewed for the longitudinal comparison (before versus after participation in FFS). The farmers were selected using a stratified (random) sampling procedure. Similarly, another 60 non-FFS farmers were also selected to enable a latitudinal comparison (participation versus non-participation in FFS). Half of the non-FFS participants were selected from same tea buying centres where the FFSs are situated while the other half were selected in neighbouring tea buying centres within the respective tea factory catchment area. Data was collected from the selected FFS and non-FFS participants using a semi-structure questionnaire, which captured various areas of impact assessment (Table 8).

Table 7. Examples of field trials conducted by different FFS during the study period

Trial description	Treatments	Indicators/observations to be made
Tea plucking intervals	T_1: 7-8 days plucking interval	Green leaf yields; breakbacks; time taken to pluck each plot; table rise; weeds; pests and diseases; weather factors; leaf appearance and damage
	T_2: 9-10 days plucking interval	
	T_3: 14-15 days plucking interval	
	Plucking done using a plucking stick	
Tea plucking intervals	T_1: 7-8 days plucking interval	
	T_2: 9-10 days plucking interval	
	T_3: 13-14 days plucking interval	
	Plucking done using a plucking stick	
Tipping-in height	T_1: 0 inches	Green leaf yields; Ground coverage; table height development; shoot density; weed type; pruned stem coverage; bush size; wounds coverage; pests and diseases; weather factors
	T_2: 4 inches	
	T_3: 6 inches	
	Plucking done every 7 days using a plucking stick	
Tipping in height	T_1: 1 inch	
	T_2: 4 inches	
	T_3: 6 inches	
	Plucking done every 7 days using a plucking stick	
Tipping-in height	T_1: 2 inches + no plucking stick	
	T_2: 4 inches + plucking stick	
	T_3: 6 inches + plucking stick	
	Plucking done every 7 days using a plucking stick	
Pruning height	T_1: 16 inches from ground	Green leaf yields; Leaf colour; tenderness of leaves; weed density; bud breaking; wound coverage; decay of pruning/branches; ground coverage; canopy size; gaps in tea; leaf resetting; tipping frequency; length of shoots; shoot size; no of dormant shoots; time taken to pluck a plot; no of breakbacks; pests/disease; weather conditions; weeds incidence
	T_2: 20 inches from ground	
	T_3: 24 inches from ground	
	Plucking done every 7 days using a plucking consultants	

In addition, the “sustainability questionnaire” which was administered to farm households at the “before FFS situation” was also administered again to the households (after FSS situation). In this “sustainability questionnaire”, were 10 indicator clusters each with measurable parameters (Table 9). Each of the parameters was quantified by asking farmers specific questions related to good agricultural practice. Farmer response to each question was given a score with the total scores for all questions and parameters under each indicator cluster adding up to 10 (score scale of 0-10).The scores were averaged for all respondents, grouped by FFS and by tea factory catchment.

Table 8. Data captured in the impact assessment study

Description	**Data captured**
Household characteristics	For example name of the household head, name, age and gender of the respondent
Knowledge on good agricultural practices (GAP) on tea	Farmer's knowledge on good agricultural practices (GAP) on tea; The more correct answers given by the farmer, the more points a farmer scored on that question. The scores on the different GAP were aggregated to a score on knowledge (0- 10).
Implementation of good agricultural practices	This part identifies which of the GAPs have been actually implemented by FFS and non-FFS farmers on their individual tea fields
Farm level impacts	This part of the questionnaire collected data to determine the effects of FFS on tea farming and the farming system in general
Impacts on livelihood	Assesses the effects of the FFS on different aspects of farmer livelihoods such as access to information and markets, empowerment, leadership skills, self-help activities etc.
Sustainability of tea production	See Table 9
Farmer field school process	Farmer assessment and grading of the different aspects of FFS and their usefulness.

Table 9. Indicator clusters and measurable parameters used in the study

Indicator cluster	**Parameters**
1. Product value	1. Product waste
	2. Product profitability
	3. Product contaminants
2. Soil and human capital	1. Human capital
	2. Social capital
3. Local economy	1. Reduction in imported goods and services
	2. Money spent locally
4. Soil fertility	1. Soil organic matter
	2. Soil compaction
	3. Soil acidity
5. Soil loss	1. Soil erosion
	2. Soil cover index
6. Nutrients	1. Nutrient balance
	2. Loss of nutrients to water
7. Water and effluent	1. Water supply
	2. Irrigation
	3. Effluent management
8. Pest and weed management	1. Active ingredients per hectare
	2. Ecotoxicity
	3. Operator safety
9. Biodiversity	1. Genetic diversity
	2. Habitat quality
	3. Habitat quantity
	4. Landscape and off-site effects
10. Energy	1. "Renewerability" of sources

Source: Adapted from Pretty et al. (2008)

3. Results and discussion

3.1. Sustainability of current tea production system

3.1.1. Social sustainability

So far there is no universal consensus on adequate criteria and indicators for social sustainability (Lütteken and Hagedorn, 1999; Moldan and Dahl, 2007; Syers et al., 1995). Social sustainability focuses on the personal assets like education, skills, experience, consumption, income and satisfaction in basic needs, labour and employment (social and human capital) and is strongly linked to institutional aspects which aims at interpersonal processes like democracy and participation, ethics and equity (inter-and intragenerational equity, gender equity, ethical trade/practices), security and independent and pluralistic sources of information (Omann and Spangenberg, 2002). The study used education level, age of household heads and family labour self reliance to assess social sustainability of smallholder tea production systems (Table 10).

Table 10. Average parameter values for indicators of social sustainability (standard deviation in parenthesis)

Tea factory catchment	No of FFS	No of farmers	Education of household head (no of years spent)	Age of household head (years)	Total labour (days/ha/yr)	Farm labour self-reliance (%)
Ngere	1	30	8 (4)	51 (8)	146 (74)	68
Mungania	1	30	9 (4)	45 (15)	121 (71)	98
Nyansiongo	1	30	11 (3)	47 (11)	72 (54)	100
Momul	1	31	8 (5)	52 (13)	93 (58)	52
All	4	121	9 (4)	49 (12)	120 (122)	80

The average number of years spent in the "formal education system" was calculated per FFS and factory grouping. The results show that there was low variability in the average number of years spent in education system as reflected in the low standard deviations observed from the study. Previous studies in Kenya have indicated that literacy levels (education level) of the household heads can influence the adoption of agricultural practices (Ohsson et al., 1998). The average years (≥ 8 years) spent in the education system by household heads in the study implies that most of them were literate and could potentially be receptive to new technologies.

The average age of the household heads was within the productive labour bracket of 15-64 years (NCAPD, 2005). This indicates that the household heads are potentially able to provide labour and are potentially receptive to new agricultural technologies. Previous studies in Kenya have indicated that the older the household head becomes, the less receptive they become to new agricultural technologies (Makhokha et al., 2001).

The farm labour self reliance stood at 68-100% for the FFS studied. The high self reliance (a reflection of dominance of family labour), has been corroborated by previous studies in Kenya (Tallontire, 2001). However, the results further show that smallholders, sometimes, employ hired labour to supplement family labour during peak seasons (peak flush). The hired labourers are paid at a piece rate, with a fixed price per kilogram of green leaf plucked. The result is that worker income varies according to factors such as skill, working hours, health, and strength and high and low tea production season (Sanne van der Wal, 2008).

3.1.2. Ecological/environmental sustainability

The ecological dimension of agricultural sustainability deals with the conservation of production/natural resources, reduction and avoidance of environmental degradation, conservation of biodiversity and minimisation of damages to the ecological system caused by agricultural production (Lütteken and Hagedorn, 1999). The indicator groupings used include tea productivity and nutrient balances (Table 11).

Table 11. Average parameter values for indicators of ecological sustainability (standard deviation in parenthesis)

Tea factory catchment	**No of farmers**	**No of FFS**	**Tea green leaf yields (t $ha^{-1}yr^{-1}$)**	**N Partial Balance [kg/ha/year]**	**P Partial Balance [kg/ha/year]**	**K Partial Balance [kg/ha/year]**
Ngere	30	1	7.2 (3)	225 (82)	25 (26)	33 (42)
Mungania	30	1	7.2 (4)	194 (67)	22 (31)	27 (11)
Nyansiongo	30	1	4.6 (3)	220 (190)	19 (17)	33 (32)
Momul	31	1	8.2 (7)	139 (89)	13 (9)	17 (16)
All	121	4	6.8 (5)	194 (121)	20 (23)	28 (29)

The average green leaf tea yields reported in this study was below the national average yields, estimated at 2658 kg made tea ha^{-1} (≈ 13290 kg green leaf ha^{-1}) (KNBS, 2008). The yields were also lower than those from the Estates. For example in the year 2007, the national average yields in the Estates was 3105 kg made tea ha^{-1} (≈15528 kg green leaf ha^{-1}) versus 2658 kg made tea ha^{-1} for smallholders (KNBS, 2008). Similarly, a previous review of tea yields in Kenya has reported yields in the range of 700-2300 and 1700-3700 kg made tea ha^{-1} for smallholders and estate plantations, respectively, over the last three decades (Kamau, 2008). The potential yields of currently available clones in Kenya are in excess of 4000 kg made tea ha^{-1} (≈20000 kg green leaf ha^{-1}) (Njuguna, 1989; Oyamo, 1992; Wachira, 2001). Some of the factors contributing to the differences in yield gaps include; nutrient management (farm inputs), human resource and labour, processing factory capacities especially during peak seasons, proximity to farms thereby maximising on harvesting and lowering costs of transportation, road infrastructure and maintenance among others (M'Imwere, 1997; Owuor et al., 2005). Thus, there is room for improvement of tea yields among the smallholder growers studied.

In this study, the partial nutrient balance was calculated as follows:

NPK balance = Σ (NPK inputs via mineral fertilizers + NPK inputs via organic fertilizers – NPK withdrawal via crop uptake in harvestable crop products – NPK withdrawal via crop uptake in crop residues)

Tea production practices in the study sample resulted in positive NPK balances (Table 12), but with variability from one FFS to another. This demonstrates the diversity of nutrient management practices among the smallholder tea growers studied. However, nutrient balances need to be interpreted with care and within the context of local conditions. Although NPK balances close to zero are preferable (indicates minimum losses), there is no "universal threshold" that one should aim at in all situations as there is need to relate nutrient balances to environmental, economic and production targets as well as to soil nutrient stocks. A common characteristic shown by soils is the acidity (pH 4 pH 6) in which the tea plant grows best (Othieno, 1992). However at low pH, phosphorus is strongly adsorbed into the soil and a farmer may partly have good reasons to apply surplus P. Most fertiliser formulations usually take into account the rate of nutrient leaching and thus in some cases, nutrient applications may be slightly higher than crop requirement to offset expected nutrient losses but within limits that do not result in overfertilisation/massive nutrient losses.

An example of the rate of nitrogen nutrient application is given in Table 12. The rate of nitrogen application (through mineral fertilizers) was in the recommended range of 100-250 kg N ha^{-1} for mature tea (> 3 years) in Kenya (Othieno, 1988). Other studies by Kamau (2008) have further indicated that the response of tea bushes to N in Kenya increases up to when a tea bush has an age of about 30 years and then seems to stagnate. Hence higher rates of up to 200 kg N ha^{-1} yr^{-1} should be confined to the more productive tea bushes (≤ 30 years) while younger tea bushes should receive not more than 150 kg N ha^{-1} yr^{-1}.

Table 12. Example of nitrogen flows and partial nutrient balances for mature tea in farmers' fields disaggregated by tea factory (kg/ha/year; standard deviation in parenthesis)

	Momul		**Nyansiongo**		**Ngere**		**Mungania**	
	No of farmers	Mean	No of farmers	Mean	No of farmers	Mean	No of farmers	Mean
N IN1: Mineral fertilizer [kg/ha]	31	159.7(91)	30	231.9 (190)	30	238.4 (78)	30	211.3 (69)
N IN2: Organic fertilizer [kg/ha]	31	0.0 (0)	30	0.0 (0)	30	10.9 (28)	30	0.9 (3)
N OUT1: Harvested products [kg/ha]	31	20.7(19)	30	11.6 (7)	30	24.7 (23)	30	18.1 (10)
N OUT2: Crop Residues [kg/ha]	31	0.0 (0)	30	0.0 (0)	30	0.0 (0)	30	0.0 (0)
N Partial Balance [kg/ha]	**31**	**139.0 (89)**	30	**220.4 (190)**	30	**224.6 (82)**	**30**	**194.2 (67)**

The tea industry in Kenya has experienced changes in fertilisation practice from the use of straight N-fertilizers especially sulphate of ammonia at high rates of about 400 kg N ha^{-1} in the 1960s which led to lack of yield response due to potassium deficiency, to the use of the compound NPK(S) formulation (Othieno, 1994; Wanyoko, 1997). There has also been a change from the application of the compound NPK(S) (25:5:5:5S) to NPK 25:5:5 and to NPK 26:5:5 formulations. Kenya Tea Development Agency (KTDA) currently recommends an application of 1 bag (50kg) 26:5:5 for 700 bushes. This translates into about 200 kg N ha^{-1} and 160 kg N ha^{-1} for bushes planted at a spacing of 4 ft x 2.5 ft and 5 ft x 2.5 ft respectively. On average, the rates of N applications by smallholder tea growers were still within safe ecological limits. High N applications (of $NH4^{+}$-based fertilisers) in tea may result in increased soil acidification, nutrient imbalances and nitrogen losses (Newbould, 1989; Owino-Gerroh, 1991) as well as lower black tea chemical quality parameters (Cloughley, 1983; Owuor et al., 1990).

3.1.3. Economic sustainability

Economic sustainability deals with saving the economic basis of livelihood, safeguarding and improving employment in agriculture, food security and food quality and contributing to the productivity of the whole economy (Lütteken and Hagedorn, 1999). In the study, gross margins and net cash flows were selected as indicators for assessing the economic dimension of sustainability of tea enterprise (Table 13).

Table 13. Average parameter values for indicators of economic sustainability (standard deviation in parenthesis)

Tea factory catchment	No of farmers	No of FFS	Gross margins (Ksh $ha^{-1}yr^{-1}$) x 1000	Net cash flow (Ksh $ha^{-1}yr^{-1}$) x 1000
Ngere	30	1	111.2 (58.6)	133.9 (69.9)
Mungania	30	1	107.5 (75.0)	138.4 (89.5)
Nyansiongo	30	1	26.5 (51.7)	66.8 (55.9)
Momul	31	1	101.3 (110.4)	137.0 (141.1)
All	121	4	86.8 (84.1)	119.2 (98.7)

1 US$ = Ksh 68 during the study period

Tea production was economically viable as indicated by the positive gross margins (GM) and net cash flows (NCF) (Table 13). Previous studies on other tea growing areas of Kenya have reported positive economic performance of smallholder tea at farm level (De Jager et al., 1998). The highest cost of production was attributed to labour and inorganic fertilisers. Labour (family labour + hired labour) accounted for 58-71% of the total costs of tea production. This appears slightly higher than 50-60% reported for tea production in Asian countries (Hicks, nd; Sivaram, nd).

3.2. Impacts of farmer field schools

3.2.1. Knowledge on good agricultural practices

The respondents were asked questions relating to their knowledge on good agricultural practices in tea over the study period. Farmer response to each question was given a score (0-10); the higher the number of correct answers given, the higher the total score/points for the particular question. The FFS approach significantly increased the knowledge of the FFS farmers ($p < 0.01$; t-test) with FFS farmers having an average score of 6.5 *versus* 5.1 for their non-FFS counterparts. The knowledge gains on good agricultural practices (GAP) on tea were higher for FFS members than their non-FFS counterparts irrespective of whether the non-FFS were close to FFS site (same tea buying centre) or further away.

3.2.2. Adoption and dissemination of good agricultural practices

The study investigated whether the knowledge gained by FFS members led to the adoption of GAPs in tea production and also whether such knowledge was disseminated to non-FFS members. A comparison made before and after FFS, indicated that the rate of adoption of GAPs increased over the study period, but with high rates among FFS members (Table 14). It is perceived that knowledge gains in FFS could have contributed to this trend above the conventional extension messages to which non-FFS were exposed to.

Asked whether they disseminate information gained from FFS to other farmers, relatives and or neighbours, all FFS members answered in the affirmative. In about 81% of the cases, the information was disseminated through conversations between FFS and non-FFS members while in the rest, it was through visit to FFS field trials/experiments. The most frequently disseminated information was on plucking rounds (plucking every 7-8 days), use of plucking stick, and pruning, weeding and fertilizer application in tea. About 65% of non-FFS respondents affirmed that they have heard about FFS activities; and by time of study 30% of the non-FFS members interviewed had implemented new tea management practices as a result of information received from FFS members, further corroborating the fact that the FFS members did disseminate knowledge they acquired from the FFS sessions.

3.2.3. Productivity and sustainability of tea production

This study explored whether farmers participation in FFS, and exposure to GAPs led to changes in productivity of tea. A comparison made between the “before FFS” and “after FFS”, revealed a significant positive change in tea productivity for FFS members (mean increase of 1297 kg ha^{-1}, $p < 0.01$; t-test) but separately also for non-FFS members (mean increase of 1121 kg ha^{-1}, $p < 0.05$; t-test). However, the overall increase in productivity above the baseline year (“before FFS”) tended to be higher for FFS (19% increase) than non-FFS members (15% increase). While there could be other factors influencing the outcome (e.g. climatic factors), participation in FFS possibly played a role in enhancing productivity increases.

Table 14. Share (%) of FFS farmers that implemented GAP after graduation and prior to start of the FFS compared with non-FFS farmers in a similar period

Management practices	Farmer Field school respondents		Non-Farmer field school respondents	
	Implementation rate after FFS (2007; n=60)	Implementation before FFS (2005;n=60)	Implementation rate in 2007 (n=60)	Implementation rate in 2005 (n=60)
Retain prunings in field	100	40	87	62
Apply fertilizer short rains	98	43	98	74
Prune at 20 inches	97	30	57	35
Indigenous trees	93	40	48	38
Soil conservation	92	53	63	48
Tipping-in at 4-6 inches	90	30	57	32
7-8 day plucking intervals	82	29	45	10
Infilling	83	32	53	37
Rain storage	80	48	60	52
Renewable energy	78	37	72	55
Records	75	32	20	18
Pruning knife	67	47	77	69
Pruning machine	52	7	2	0
Worker circumstances	52	27	40	32
Manure	35	18	14	4
Protective equipment	34	20	29	23
Sleeves (polypots)	31	17	30	24
Riparian strip	28	20	25	15

The study further explored whether participation in FFS led to an increase in sustainability of tea production based on 10 clusters of indicators in “sustainability questionnaire”. The average scores of FFS respondents showed that the level of sustainability of tea production increased by 0.3 scores (4%) between the “the before FFS” and the “after FFS period”. The increase was partly due to increase in scores on product value, biodiversity and soil loss after participation in FFS. Overall, the impact of FFS activities on increase of sustainability, though positive, appears limited within the FFS cycle of about two years. The increase could have been masked by the fact that the FFS members already had high scores at the beginning of the study and the variability in the data collected and by the fact that tea is a perennial crop and may take long time for changes in some of the indicators to be realised.

Although the increase in level of sustainability of tea production was limited among FFS members in the period of study, there was a significant difference ($p < 0.01$; t-test) in level of tea sustainability between FFS farmers and their non-FFS counterparts in 2007 (Table 15). The FFS members scored highly on indicators such as product value and biodiversity and soil loss, contributing to significantly high aggregate scores. This indicates that participation in FFS played a role in increasing the level of sustainability of tea production.

Table 15. Average sustainability score for FFS and non FFS farmers (0-low; 10-high)

Tea factory	Farmer Field School			Non Farmer field school	
	Pre-FFS; Year 2005 (n=60) (a)	Post FFS; Year 2007 (n=60) (b)	Difference (b-c)	Non FFS; Year 2007 (n= 60) (d)	Difference (b-d)
Momul	7.0	7.8	0.8	7.6	0.2
Mungania	7.4	7.9	0.5	7.0	0.9***
Ngere	8.0	7.9	0.0	7.2	0.7***
Nyansiongo	8.3	8.4	0.1	7.7	0.8***
Average	**7.7**	**8.0**	**0.3**	**7.4**	**0.6*** **

*** Significant difference at $p < 0.01$, t-test

3.2.4. Impacts of farmer field schools on farm level impacts and livelihoods

The study investigated the effects of FFS on farm level impacts. Farmers were asked to mention general changes that have taken place in their farming practices since joining FFS (FFS members) or over the last two years (an equivalent period for non-FFS) on a number of issues related to farming activities (Table 16). Majority of farmers reported increases in tea yields, income from tea and total farm income. However, a higher percentage of FFS respondents reported positive changes on these indicators of farm performance than their non FFS counterparts, probably pointing to the fact that FFS could have had an effect in bringing the changes. Participation and or non participation in FFS did not, however, influence farmers to increase land under tea as reported by 68% and 65% of FFS and non-FFS members respectively. This is probably due to the fact that farmers have small holdings and most of the land is already under tea. A higher percentage of FFS farmers reported increased labour use for production of other crops than their non-FFS counterparts. This, partly, indicates that FFS does not hinder diversification to other income sources and to maintenance of biodiversity.

Table 16. Estimation of the change of the farm-level indicators between 2005 and 2007

	FFS (n=60)			**Non-FFS (n=60)**		
	% of farmers that increased	% of farmers that remained stable	% of farmers that decreased	% of farmers that increased	% of farmers that remained stable	% of farmers that decreased
Tea yield	98	0	2	68	10	22
Size of tea field	32	68	0	32	65	3
Number of bushes	55	45	0	37	55	8
Labour used for tea	42	47	12	28	53	18
Income from tea	98	0	2	62	13	25
Labour-other activities	52	45	3	25	65	10
Income-other activities	78	18	3	57	28	15
Total farm income	98	2	0	68	15	17

Farmer field schools, directly or indirectly, attempts to improve farmer's livelihoods, for example empowering farmers for collective action and to gain access to agricultural information. Both FFS and non-FFS respondents were positive that their livelihoods have improved. However, a higher percentage of FFS than non-FFS respondents were positive that their livelihoods have improved with regards to empowerment (9% higher), access to information (21% higher), personal development (8% higher), conflict resolution (12% higher) and relations with tea factory (7% higher) and leadership ability (14% higher). About 70-92% of FFS farmers were of the opinion that participation in FFS positively influenced the changes observed in livelihood aspects.

3.2.5. Farmer evaluation of the FFS process

The study explored the opinion of FFS members on the FFS process by investigating how the farmers rate the different aspects or elements of FFS methodology adopted in the project activities (Table 17). About 73-98% of FFS farmers rated the various aspects of FFS approach as "good", probably indicating that they were beneficial to the learning process. Farmers were also asked to give opinion on the usefulness of FFS field trials (field experiments). About 55% of the FFS respondents felt they had learned more from the field trials than special topics while 18% of the respondents had learned more from the special topic sessions than field trials; and the rest (22%) had learnt equally both from field trials and special topics.

Table 17. Perception of FFS members on different aspects of FFS methodology (% of farmers interviewed; n=60)

	Not so good	*Neutral*	*Good*
Curriculum development	2	0	98
Facilitators	8	2	90
Organization	8	0	92
Meeting frequency	13	2	85
Time necessary	7	5	88
Special topic sessions	12	0	88
AESA subgroup	17	0	83
AESA plenary	15	3	82
Commercial activities	16	11	73
Group dynamics	8	0	92

According to FFS participants, improvements in the future functioning of FFS on tea should include new income generating projects (rearing silk worm, goats), scaling- up FFS to more farmers, organisation of more field trips/study tours, reducing frequency of meetings per month and establishing more field trials.

3.3. Lessons learnt

3.3.1. Experiences with sustainability assessment

Although the use of the multiple indicator sets proved useful and synergistic in providing insight into the sustainability of smallholder tea production system, nutrient balances could only be partially interpreted as local thresholds in tea systems are not established or available from literature. While there is a consensus that a near neutral, neutral or positive nutrient balances are desirable, the interpretation attached to such outcomes depends on local farm conditions, nutrient management practices, crops grown, soil types and agro-ecological conditions.

The study used farm labour self reliance as an indicator of self-reliance and social sustainability. The estimates of family labour could not be done with required accuracy as smallholder tea farmers rarely keep records of time duration they spent in carrying out various tea activities. Family labour allocation to various tea activities were estimated through indirect means involving dialogue with the farmers and type of tea activity to which the labour was allocated to.

Measurements of parameters related to the sustainability indicator sets relied on farmers recall and field observations made by enumerators. Thus, the data collected could only be reliable within limits of farmers recall period, especially in situations where the farmers were asked to remember activities carried out in the past one year.

The sustainability assessment in this study involved a wide range of indicators and measurable parameters. While it holds true that multiple indicators and parameters are needed to diagnose the various dimensions of agricultural sustainability, in practice, measurements of some parameters may be either time consuming or expensive. Thus, a minimum number of indicator parameters may be desirable. In this study, however, such minimum set of best indicator parameters could not be established within the study time-frame for it could have required long-term monitoring of “parameter performances” before such a decision is made.

3.3.2. Experiences with farmer field school process

The application of FFS as a methodology of extension and stimulating farmer learning on good agricultural practices on smallholder tea production in Kenya is relatively new. The adaptations made to the initial IPM-FFS methodology and used in this study appeared to have yielded good fruits. The prolonged learning duration and flexible FFS meeting frequency (twice in a month) enabled FFS farmers to learn and experiment on tea practices, some of which require longer periods of learning and experimentation to appraise the full range of costs and benefits. The participation of about 30 tea growers per FFS presented wide choices for learning and carrying out practical demonstrations in selected FFS members fields where such activity was due, for example pruning, tipping in, fertilizer application etc. This meant that the FFS participants could learn practices associated with tea growing at various stages of tea production without necessarily having to plant a separate “new tea” block and wait for it to mature after 3 years to learn practices like good methods of plucking.

The test and validation of technologies under farmer field schools have tended to use one central plot for learning and experimentation. However, for a perennial cash crop with high labour demand such as tea in this study, there was need to adapt the set up of the FFS field trials (experimentation) for them to be implemented and monitored by FFS sub-groups. The setting up and running of the same set of experiments/trials in five sub-groups of the same FFS proved useful in capturing diversity that exists in the farming community, encouraging farmers to be innovative, spreading out the risks associated with field trials on a high value cash generating crop, reducing walking distance to field trial site and in arranging labour as and when required. For example tea plucking on the trial plots, although done at agreed upon intervals and at specified dates, requires that sub-group members allocate labour for the activity regularly on days which may not necessarily coincide with FFS group meetings.

It was learnt from this study that the FFS approach encourages members to learn from one another and to exchange their views. This was evident from the fact that some of the women members of FFS who were initially shy to express themselves during FFS group meetings begun to express and exchange their views with other FFS members as the FFS activities continue progressing. Also team spirit began emerging during group and sub-group work activities. The latter was more evident during agro-ecosystem analysis (AESA), reporting results of AESA and when a sub-group plays the role of “a host” (e.g. time keeping, arranging FFS meeting venue and group dynamic activities etc) during FFS group meeting. In these activities it was evident that there was horizontal flow of information among FFS participants, sharing of tasks and resources, a sense of positive competition, improving communication skills and an emergence of local leadership abilities.

Although the theme of the FFS was on good agricultural practices in tea and on enhancing sustainability of tea production, during curriculum development it became clear that farmers’ needs spanned beyond just the technical issues of tea production into other socio-economic and broader livelihood issues. Thus, the curriculum contents were expanded to include other issues beyond the technical ones, especially in the second year of the FFS cycle; the first year of the FFS cycle addressed mainly the technical issues on good agricultural practices in tea and other tea-production-marketing related issues. Participatory formulation of an integrated curriculum proved useful in meeting farmers’ needs (technical and socio-economic).

The community-based farmer field school platforms create opportunity for linking extension services with community activities in addition to supporting broader planning and priority setting for demand driven and market oriented services. The FFS contributed to building up a closer working relationship between tea growers and personnel from the Agricultural Services (extension service) of Kenya Tea Development Agency (KTDA). However, initially, it appeared that there was some dissonance in the present work description of tea extension assistants, TESAs, (extension workers) and the demands of FFS as the TESAs were required to attend to both FFS and still meet targets set in the “conventional extension service” offered by KTDA. Furthermore, FFS demanded new ways of working from top-down to bottom up sharing of information and creating farmer-science knowledge linkages. The dissonance was, however, resolved through workload re-allocation and setting of new targets, thus allowing TESAs to dedicate the required time and efforts to FFS.

Emanating experiences from this study further demonstrate that there is a promising future with regards to FFS as a starting point for implementing sustainable tea practices and in creating production-market linkages for smallholder tea production. Although, LIPTON has been purchasing tea produced by smallholder farmers through KTDA, there has never been a direct linkage and interaction between the buyer (LIPTON) and the producer (smallholder tea farmers). The interaction created through this project offered an opportunity for farmers to directly interact with tea buyers and to understand buyer (and consumer) requirements during the FFS sessions.

Experiences from this study further indicate that farmer field schools, as adapted in this project, can contribute positively to addressing sustainability of smallholder tea production by drawing from experiences of multiple institutions. Coming from a range of institutional backgrounds, the multi-disciplinary teams and institutions working on the project benefited from the diverse skills, knowledge and resources of their colleagues, as well as gaining insight into participatory methodologies, the dynamics of smallholder tea farming systems and how to overcome challenges when “converting” to sustainable tea production. Furthermore, due to the multi-institutional framework and emerging ideas from project partners, an opportunity to increase tea value arose as compliance with standards for Lipton Good Agricultural Practices (GAP) became an enabler for certification by Rainforest Alliance.

It is seemingly clear from lessons learnt from this project that policy dimensions, commitment to farmer field school concept and participatory approaches, and initiation of support activities (marketing and premium prices etc) among other factors would be necessary for long term survival of farmer field school groups and for effective scaling up of the FFS process piloted in this project. By the time of the study, a roll-out of the FFS activities to other KTDA factories was under way.

4. Conclusions

One of the practical dilemmas is to address the social, economic and environmental/ecological impacts of agricultural activities while conserving the natural resource base. Social sustainability assessment of the smallholder tea systems using proxy indicators such as education level, age of household head and labour self reliance has indicated that the studied farming systems are moving towards social sustainability. The household heads were literate and in their productive age bracket implying that they could be “socially stable”, open to new ideas and can provide labour for farming activities into the future. The study observed a high labour self reliance, an indication that the studied smallholder tea growers have a low dependency on external labour inputs.

Tea productivity and nutrient balances were used as proxy indicators of ecological sustainability. The average tea yields observed in this study were lower than average national yields and potential yields of the currently available clones in the study areas. Thus, the studied systems can be considered to have room for improvement with regards to this indicator. However, nutrient balances, which monitor land quality and establishes linkages between nutrient use, changes in environmental quality and sustainable use of soil were positive. Their effect on the production environment, however, could not be quantified within the study period; requires relating them to soil nutrient stocks and to environmental, economic and production targets.

The smallholder tea farming systems studied returned a positive economic performance indicating that the studied tea system was economically viable. The gross margins and net cash flows for tea were positive. However, there is need to relate these findings with socio-economic indices, for example of poverty levels and household income, to further shed light on the impacts of tea on smallholder livelihoods.

Assessment of the status of sustainability of smallholder tea production using locally adapted sustainability indicators (on a score of 0-10) showed an increase in scores of 4% from the base situation (before FFS) to the post-FFS situation (after FFS situation) indicating that FFS activities had some positive impacts on enhancing the sustainability of smallholder tea. The FFS participants also attained a high level of sustainability scores than their non-FFS counterparts, especially on product value, biodiversity and soil loss indicators.

The adaptations made to FFS approach compared to the original IPM-FFS methodology (longer FFS cycle, flexibility in type and frequency of activities, experimentation strategy and producer-buyer market linkages) appeared more appropriate in farmer learning and adoption of good agricultural practices in smallholder tea production than the conventional extension methodology. The study has shown that knowledge gains on good agricultural practices (GAP) on tea and implementation of the same were higher for FFS members than their non-FFS counterparts. Also a higher number of FFS participants, than their non-FFS counterparts, returned a positive improvement in their livelihoods in terms of high yields, income from tea and total farm income. However, a limitation of this study was that the impact assessment was done shortly after the FFS graduation, thus no information could be gathered about farmers long-term experiences with practices learnt in the FFS, adoption-disadoption processes and or long term group processes in the post-FFS graduation period. Another assessment after 2-3 years could provide valuable information about the sustainability of the adoption of GAPs and the dissemination of the same.

Acknowledgements

The authors of this paper would like to thank tea growers and members of FFS affiliated to Nyansiongo, Momul, Ngere and Mungania KTDA factories for having participated in the study. We are sincerely grateful for Maureen and Peter Mbadi (KTDA headquarters); Factory Unit Managers, Extension Service Coordinators and Tea Extension Service Assistants (TESAs) who participated in this study. The role of Tea Research Foundation, and the KTDA/LIPTON Project Steering and Technical Committees are sincerely acknowledged. We are also thankful for Zak Mitei, Winfred Mwaniki and Andrew Mwaniki (Unilever, Kericho); and Gail Smith (LIPTON, UK) for the invaluable role in implementation of project activities and the facilitation and guidance they offered during the study. The paper is based on farmer field schools set up in the period 2006 to 2008 (KTDA/LIPTON Project) under DFID funding.

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