TEMPLATE TEA CLIMATE-SMART CREDIT PRODUCT

F3 Life

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1. Executive Summary

1.1. Introduction

The purpose of this document is to establish a generalised "climate-smart credit product" for small scale coffee growers (SSGs). A climate-smart credit product is a loan to a farmer, where the terms of the loan agreement require that the farmer implement a specified set of climate-smart and/or sustainable land management (CSA) practices on their farm, and that information about compliance with CSA loan terms informs borrower credit risks scores.

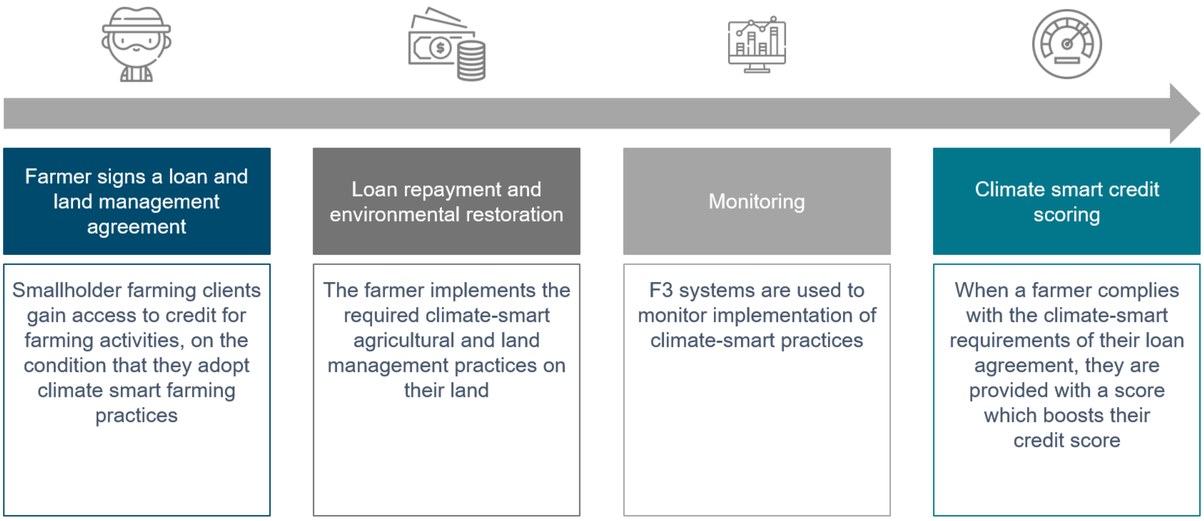

Figure 1: Climate-Smart Lending Process

Tea thrives in warm, humid, subtropical climates with acidic, well-drained fertile soils, requiring at least 1,300 mm of rainfall per year. Seedlings take 3-4 years after planting before they are ready for harvest and can survive up to 100 years. Tea will grow into a tree up to 16 metres in height, if left unpruned, but cultivated plants are generally pruned to waist height for ease of plucking. Almost all commercially-sold teas are a blend of teas from different areas and even different countries.

Tea provides employment to large numbers of people and supports the growth of several ancillary industries and is a major foreign currency earning commodity for most tea-producing countries. Globally there are more than 13 million smallholder farmers and plantation workers[1].

1.2. Climate risks to tea production

Tea growers are already feeling the impacts of climate change, with daily and seasonal unpredictability in weather creating challenges to effective tea management. Key concerns[2] include (i) changes in the timing of seasons causing delay in the onset of rainfall and extension of the cold season, (ii) increasing droughts both between and within seasons, (iii) heavy rains leading to landslides, which damage the tea and road infrastructure, (iv) cooler night temperatures and frost during the cold season damaging the green tea leaf, (v) higher temperatures during the daytime, (vi) and increasing incidence of hail. These changing weather patterns are creating challenging production difficulties resulting in loss in productivity.

[1] Faitrade, 2019. Fairtrade Impact for Small-scale Tea Farmers and workers https://www.fairtrade.net/products/tea.html accessed 15 February 2019.

[2] FAO, 2016. Report of the Working Group on Climate Change of the FAO Intergovernmental Group on Tea, a subsidiary body of the FAO Committee on Commodity Problems. Food and Agriculture Organization of the United Nations Rome.

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1.3. Tea green leaf production

- ***Propagation:*** Tea can be propagated by either seed or clonal cuttings. New high yielding varieties tolerant to drought and frost, resistant to pests and diseases and able to recover relatively fast from the effects of pruning and drought are increasingly becoming available and are recommended for new planting or infilling to replace traditional varieties.
- ***Planting:*** Land preparation prior to planting requires measures to prevent soil erosion and ensure safe drainage. Immediately after planting, plants should be staked to prevent wind damage. Shade is essential for regulating temperature, minimising the effects of drought and sun injury, serving as a windbreak, preserving soil moisture during the dry winter months and helping to reduce the incidences of pests.
- ***Training and Pruning:*** Regular pruning is required to maintain a suitable height for plucking as well as inducing further vegetative growth.
- ***Soil fertility practices:*** Regular replenishment of soil nutrients is important.
- ***Weed control:*** Weed management practices can include manual, chemical, cultural, and biological methods, with small scale growers usually depending on hand weeding, although use of chemical methods is becoming increasingly common due to labour constraints.
- ***Plant Protection:*** Many pests and diseases infect tea bushes and can cause economic losses, although in many cases no protection is provided.
- ***Harvesting or plucking:*** Harvesting is a labour intensive operation, which effects tea yield and quality. Generally, yields up to 2000 kg per ha of made tea are considered low, 2000-3000 kg per ha medium and above 3000 kg per ha as high[3].

1.4. Tea processing

Processing green leaf to produce black tea involves withering, rolling, fermentation, drying then grading to separate the teas into different grades. Thereafter tea blending involves combining different teas to ensure consistency and taste, to help in obtaining higher prices. 100kg of green leaf are generally estimated to make 25 kg of made tea, although this varies from 18-27 kg.

1.5. Tea value chain

The tea value chain involves thousands of companies around the world, including agri-input manufacturer and supply organisations, producers, primary processors, graders, auction houses, traders, secondary processors, wholesalers, and retailers through to shops and restaurants. The role of small scale growers (SSGs) is often restricted to the start of the chain, when they deliver green leaf to a tea processing factory. In Kenya in 2017, there were over 600,000 SSGs registered by the Kenya Tea Development Authority with a area per grower of 0.20 ha producing 0.45 tonnes of made tea equivalent to 2.21 tonnes per ha of made tea[4], or approximately 8000 kg of green leaf. A recent survey[5] in Rwanda showed the average SSG tea area was 0.59 ha, with over 50% having less than 0.28 ha of tea and 10% having 0.05 ha of tea.

3 https://www.indiaagronet.com/indiaagronet/horticulture/CONTENTS/tea.htm

4 KTDA Management Services Limited, 2018 Tea Growers Payment, June 2018 Financial Year. https://www.ktdateas.com/index.php/component/k2/item/125-tea-growers-payment-2018.html

5 Baseline Report, 2015. Rwanda Green Leaf Price Reform Impact Evaluation

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1.6. Challenges faced by small scale tea growers

While smallholder tea sector has exponentially increased its role in tea production, this has been mainly due to an expansion in the area grown rather than an increase in land productivity. Prices paid for green leaf are often low as quality is often lower than that of plantation produced leaf. Unfortunately SSGs may have limited information on improved agronomic practices and market prices, and lack the finance to purchase the necessary agricultural inputs to improve leaf quality. Consequently, SSG yields are considerably less than that achieved on plantations or estate grown tea.

1.7. Climate Smart Agriculture Practices

CSA strategies[6] include the need to establish:

- Planting new varieties or clones adapted to drier, warmer and/or cooler conditions with resistance to pests and diseases
- Integrated soil fertility management, through increased use of composts and manures, mulches and cover crops integrated where necessary with the use of inorganic fertilisers
- Integrated soil and water conservation and drainage measures using contour barriers or terracing especially on steeper slopes using grasses and trees on the terraces combined with rainwater harvesting techniques and improved irrigation, when available
- Agroforestry involving the planting of trees and hedges to mitigate sun, wind and water damage and improve soil fertility
- Integrated pest and disease management techniques

The integrated approach required for SSGs to derive optimum benefit from CSA tea practices dictate that loans advanced should be by the size of the area planted or to be rehabilitated, starting with an area of 0.03 ha, this being equivalent to 1/32nd of one hectare. This can be regarded as “Learner Level”, where CSA practices can be tried, tested and learnt from, before proceeding to progressively larger areas. These would be increased from 0.03ha to 0.06 ha, 0.13 ha, 0.25 ha, 0.5 ha, 0.75 ha and then one ha, a total of seven levels as detailed

Various CSA practices have been identified which can be monitored. These include (i) improved varieties of tea seedlings planted where this is undertaken, (ii) the use of manure/compost together with locally recommended rates of inorganic fertiliser, (iii) unless organic tea is to be marketed, (iv) the creation of contour terraces planted with a suitable grass with a cover crop planted between tea bushes, (v) the number of shade trees planted. Integrated pest and disease management practices would be initiated from the onset, provided through training rather than setting specific targets.

Rainwater harvesting structures can be introduced at the 0.25 ha level, since their construction will be opportunity driven and may not be possible on very small areas. They should also form part of a micro-watershed plan where contours/terraces and drainage lines from adjoining fields are linked to feed into natural watercourses. These can then be protected through afforestation or reforestation with indigenous trees and suitable grass species. Ideally, they should also be given protected status.

It should be noted that these targets can be adjusted according to locally-specific agro-climatic conditions and based on recommendations from local tea research organisations or extension agencies.

6 FAO, 2016 Report of the Working Group on Climate Change of the FAO Intergovernmental Group on Tea. Food and Agriculture Organization of the United Nations, Rome, 2016. ISBN 978-92-5-109279-8.

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		0.03ha	0.06ha	0.13ha	0.25ha	0.5ha	0.75ha	1ha
Contractual Requirements	Tree-planting	10 trees	19 trees	37 trees	76 trees	150 trees	226 trees	300 trees
	Rain-water harvesting ditches	0	0	0	1	2	3	4
	Green Manure & cover crop	0.03ha	0.06ha	0.13ha	0.25ha	0.5ha	0.75ha	1ha
	Mulching	0.03ha	0.06ha	0.13ha	0.25ha	0.5ha	0.75ha	1ha
	Contour terracing	13m	25m	50m	100m	200m	300m	400m
	Manure / compost	0.03ha	0.06ha	0.13ha	0.25ha	0.5ha	0.75ha	1ha
		Loan 1	Loan 2	Loan 3	Loan 4	Loan 5	Loan 6	Loan 7
Non-Contractual Requirements	Improved varieties (seedlings)	422	844	1,688	3,775	6,750	10,125	13,500
	Integrated pest management	Training	Training	Training	Training	Training	Training	Training

Figure 2: Climate-smart credit product for small scale tea growers

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1.8. Present Yield Levels

FAO data[7] for 2017 showed that of the 49 countries producing tea, the top ten producers grew 93% of the total area and produced over 90% of the total yield. Average yield across countries of 2.01 tonnes per ha, being highest in Asia (2.13 tonnes per ha), lowest in SSA (1.80 tonnes per ha) and 2.19 tonnes per ha in Latin / South America. Of the 18 countries producing tea in SSA, Kenya is responsible for nearly 60% of total production. SSGs registered under KTDA achieved a mean yield of 2.1 tonnes per ha. In Rwanda, where the mean was 1.6 tonnes per ha, this ranged from 0.1-2.1 tonnes per ha.

1.9. Tea prices

Tea is unusual among agricultural commodities in that it is sold through auction centres around the world with around 70% of the world's tea being traded through auctions. The World Bank forecast average auction prices of $2.83 per kg in 2019 and $2.84 in 2020. African teas averaged $2.39 per kg at auction in Mombasa, this being the major hub of Africa's tea trade. Teas grown in Burundi, Kenya, and Rwanda earn typically sell for around $2.50 per kg, compared with lower prices from other East African countries, their teas often being used as fillers. Malawi tea fetched $1.68 at auction in Limbe in Malawi.

1.10. The Impact of Sustainable Land-Management and Climate Smart Practices

Key features of the CSA approaches for sustainable tea production five strategy areas: (i) planting improved tea varieties, (ii) improving soil health, (iii) improving soil and water conservation, (iv) establishing trees for shade windbreaks, (v) mulching and erosion control and introducing integrated pest and disease management. The impact of these practices lies in four areas varying according to agro-climatic and market conditions: improving the resilience of natural resource use; reducing the risks associated with climate change. These include increased temperatures, droughts both between and within growing seasons, shortened growing seasons, increased rainfall intensity and more unpredictable seasons; mitigating the effects of some of the causes of climate change; and importantly increasing productivity. This includes increased yields with less yield variability and a reduction in input costs, but sometimes an increase in labour requirement.

Their impact will be cumulative, but dependent on deployment as integrated packages. Yield increase estimates are difficult to quantify. They will be location specific but can be achieved alongside a reduction in costs particularly for inorganic fertiliser and chemical applications in the control of pests and diseases, although an increase in labour will be required.

Progressive yield increases, based on research and practical experience in a number of countries, can occur from a base of less than one tonne per ha of made tea by more than 100% or more up to and exceeding three tonnes per ha and could be substantially higher. The impact will be greatest where soil health is presently poor and yield levels are already declining, often on steeper slopes with poor soil and water conservation practices and under rainfed conditions.

Research indicates that considerable cost savings can be made by adopting CSA practices, mainly by applying less inorganic fertiliser, a 20-100% reduction as soil health improves through application of manures, composts and mulching materials; and pesticide applications, a 20-100% reduction as integrated pest management methods are utilised.

CSA tea lending products can be used in any of the suitable environments especially where tea yields may have declined due to poor management practices and soil degradation. CSA lending for SSGs could be deployed in all those tea growing areas, where SSGs make an important contribution to total production.

[7] FAO, 2018 FAOSTAT. http://www.fao.org/faostat/en/#data/QC

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1.11. Farmer cost-benefit analysis

The key output of this exercise is two gross margin and farmer cost benefit analysis models for two scenarios of small scale tea growers adopting climate-smart and sustainable land management measures required under the proposed climate-smart credit product. The two scenarios are

- Firstly, where the grower has a mature tea garden of traditional varieties but is reluctant to uproot these and plant new varieties. In such circumstances the requirement of any loan would be to adopt all other CSA practices.
- Secondly, rehabilitating or planting all new existing tea with improved varieties as well as adopting the other CSA practices.

Results are summarised below, both showing net benefits to the farmer for implementation of a climate-smart tea system.

Table 1: Summary farmer cost benefit analysis results

Scenario	Yields at tea bush maturity	Gross margin	Labour required at tea bush maturity	Returns to labour at tea bush maturity	Returns to labour at tea bush maturity	Benefit/cost ratio
	kg per ha of green leaf	USD per ha	days per ha	USD per ha	USD per day	over 10 years
Existing tea without other CSA practices	5,000	1,650	160	2,050	13	-
Existing tea with other CSA practices	7,000	3,255	193	3,738	19	2.0
New tea without other CSA practices	6,500	2,800	190	3,275	17	-
New tea with other CSA practices	10,000	6575	268	7245	27	2.8
					Discount rate	10%

1.12. Tea "lender financial impact model"

A further component of the design of a climate-smart credit product is to build an impact model for the agri-lender offering the climate-smart credit product. The purpose of this exercise is to provide preliminary validation that business-as-usual agricultural loans are less profitable than climate-smart loans which incorporate requirements for climate-smart agricultural and land management practices into loan terms. From assumptions generalised from scientific and agricultural research, we believe that climate-smart lending is likely to have an appreciable effect on the cash position of the agri-lender.

	Loan 1	Loan 2	Loan 3	Loan 4	Loan 5	Loan 6	Loan 7
Yield loss scenario	30%	30%	30%	30%	30%	30%	30%
Number of clients	10,000	10,000	10,000	10,000	10,000	10,000	10,000
Loan book size (US$)	2,989,000	2,989,000	2,989,000	2,989,000	2,989,000	2,989,000	2,989,000
Portfolio loss with no climate-smart lending	**(720,000)**	**(720,000)**	**(720,000)**	**(720,000)**	**(720,000)**	**(720,000)**	**(720,000)**
Portfolio loss with climate-smart lending	**(725,046)**	**(637,369)**	**(567,227)**	**(509,838)**	**(462,014)**	**(421,548)**	**(386,862)**
Savings due to CSA practices	(5,046)	82,631	152,773	210,162	257,986	298,452	333,138
Cost of capital w/o climate-smart lending	20%	20%	20%	20%	20%	20%	20%
Cost of capital w climate-smart lending	8%	8%	8%	8%	8%	8%	8%
Annual interest savings (US$)	358,680.00	358,680.00	358,680.00	358,680.00	358,680.00	358,680.00	358,680.00
Cash position improvement with climate-smart-lending (US$)	**353,634**	**441,311**	**511,453**	**568,842**	**616,666**	**657,132**	**691,818**

1.13. Coffee "environmental cost-benefit analysis"

The final component of the design of a climate-smart credit product is an environmental cost benefit analysis which demonstrates that the terms of a climate-smart credit product creates valuable environmental benefits. We have completed the creation of this template, and run it with some preliminary data to show the benefits of implementing the CSA measures of the climate-smart credit product create a benefit with net present value of USD 1,365 over 7 years.

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2. An introduction to tea and climate risks to production

2.1. Introduction

Tea is a perennial, non-alcoholic beverage crop that competes successfully with sodas and other soft beverages. What started as a medicinal crop in China 5,000 years ago, tea is now consumed around the world. The original species were *Camellia assamica* and *Camellia sinensis* with present day varieties and clones often being a mixture of both. There are four known species of tea and hundreds of cultivars that range in traits and environmental tolerances[8].

Tea thrives in warm, humid, subtropical climates with acidic, well-drained fertile soils. It requires at least 1,300 mm of rainfall per year with many high-quality tea plants being cultivated at elevations of up to 1,500 metres above sea level. Soil type, altitude, rainfall and variety or cultivar affects tea flavour, which in turn can affect price. New plants are propagated from either seed or cuttings, taking 3-4 years before they are ready for harvesting. A tea tree can survive up to 100 years. Tea will grow into a tree up to 16 metres in height, if left unpruned, but cultivated plants are generally pruned to waist height for ease of plucking. Plucking is the removal of buds and leaves, usually the top 2-5cm. A new flush of buds and leaves can normally be plucked every 7-15 days during the growing season. This is the green leaf which is transported to processing factories.

Tea processing involves oxidizing the tea leaves by macerating or crushing them, which introduces oxygen to cells and allows enzymes to facilitate a chemical reaction that results in “black made tea”, which is the name given to the end product. Steaming or pan-firing tea leaves denatures enzymes, which prevents oxidation and produces green teas. Almost all commercially-sold teas are a blend of teas from different areas and even different countries. This creates a well-balanced flavour using different origins and characteristics.

Tea traders buy tea primarily at three major international auction houses in Mombasa, Kenya; Colombo, Sri Lanka; and Kolkata, India. Price fluctuations at all auctions are common, as tea is a relatively volatile commodity, highly susceptible to changes in climate and management practices. Seasonality also affects the tea trade, as some growing regions are able to cultivate year round, but most are restricted to defined growing seasons.

Demand is growing through Asia, Africa, and Latin America due to rising per capita income levels. World predictions for 2027 indicate a demand for annual production of over eight million tonnes dry weight tea leaf, an increase of more than 30% over 2016 production levels. Although much of the world’s tea is produced on large tea plantations, small scale growers are making an increasingly important contribution, but yields are often considerably less than those achieved on plantations. Small-scale tea farmers and small producer organizations often rely on larger tea estates to purchase their green leaf.

Tea provides employment to large numbers of people and supports the growth of several ancillary industries. Globally there are more than 13 million smallholder farmers and plantation workers[9]. It is a major foreign currency earning commodity for most tea-producing countries. However, challenges associated with climate change and crop management threaten tea production in all the major growing regions.

8 Mainaak Mukhopadhyay and Tapan Kumar Mondal, 2017. Cultivation, Improvement, and Environmental Impacts of Tea. Agriculture and the Environment. DOI: 10.1093/acrefore/9780199389414.013.37. http://oxfordre.com/environmentalscience/view/10.1093/acrefore/9780199389414.001.0001/acrefore-9780199389414-e-373

9 Faitrade, 2019. Fairtrade Impact for Small-scale Tea Farmers and workers https://www.fairtrade.net/products/tea.html accessed 15 February 2019.

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2.2. Climate risks to tea production

Tea growers are already feeling the impacts of climate change, with daily and seasonal unpredictability in weather creating challenges to effective tea management. Key changes in weather patters which may affect production are[10]:

- Changes in the timing of seasons causing delay in the onset of rainfall and extension of the cold season.
- Increasing occasions of prolonged droughts both between and within seasons reducing the quality and quantity of tea production.
- Very heavy rains leading to landslides, which damage the tea and road infrastructure reducing accessibility to market.
- Extremely cold temperatures at night and during the cold season damaging the green tea leaf.
- Frost in areas that have never been affected by frost, reducing tea quality and in extreme circumstances killing tea bushes.
- Increasing temperatures during the day time adversely affecting yield and quality.
- Increasing incidence of hail, causing leaf damage, reducing yield and quality of the tea.

These changing weather patterns are creating challenging production difficulties resulting in loss in productivity. The livelihoods of tea producers and in particular those of smallholder farmers and their families are being adversely affected.

For example, a study, undertaken in Kenya in 2011[11], shows that there are some areas that will become unsuitable for tea. Others will remain suitable, but only if farmers adapt their agronomic management practices to the new conditions experienced. There will be further areas where suitability for tea increases and others will become suitable especially at higher altitudes. However, some of these may be protected as rainforest or areas of biodiversity.

Optimum tea-producing zones in Kenya are currently at 1,500-2,100 metres above sea level (masl). By 2050 this will increase to 2,000-2,300 with areas 1,400-2,000 masl declining in suitability and areas around 2300 masl becoming the most suitable. Clearly tea growers will need to adjust to changing environmental conditions, food safety regulations and economic pressures to meet growing demand.

3. CSA TEA CROP AND LAND MANAGEMENT REQUIREMENTS

3.1. Introduction

The purpose of this section is to propose a climate-resilient and sustainable land management system appropriate for implementation by smallholder tea farmers, based on best practice climate-smart and sustainable land-management practices. This section provides (i) context, (ii) the recommended CSA measures, and (iii) implementation detail.

10 FAO, 2016. Report of the Working Group on Climate Change of the FAO Intergovernmental Group on Tea, a subsidiary body of the FAO Committee on Commodity Problems. Food and Agriculture Organization of the United Nations Rome.

11 CIAT, 2011. Future Climate Scenarios for Kenya's Tea Growing Areas, Final report. CIAT, International Center for Tropical Agriculture (CIAT) A.A. 6713, Cali Colombia.

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3.2. Tea production12,13

Growth of tea is temperature-dependent, with tea bushes not growing when temperatures are either too low or too high, regardless of other climatic factors. The crop ideally requires temperatures of between 16-32°C with an annual rainfall of 1,250-1,500 mm distributed over 8-9 months with a humidity around 80% most of the time. Optimum pH is 4.5-5.0 on well-drained, permeable, and fertile soils, 1-2 metres deep. Most high-quality tea is grown at elevations of up to 1,500 metres above sea level. Although the tea grows more slowly at these altitudes, they acquire a better flavour and command higher prices.

The following is a summary description of key stages within the tea growing process. The purpose of this description is to provide context for the tea climate-smart agricultural land management recommendations which follow:

- **Propagation:** Tea can be propagated by either seed or cuttings. Seed germination occurs after 10-30 days, after which seedlings are transplanted into polythene bags and be ready for planting after 9-15 months. Cuttings also referred to as clones are collected from mother bushes and also grown in polythene bags. Prior to planting, seedlings are hardened by slow exposure to full sunlight. A narrow genetic base of tea varieties has in the past been a hindrance to improving productivity due to rapid vulnerability of genetically uniform cultivars. Notwithstanding new high yielding varieties or clones tolerant to drought and frost, resistant to pests and diseases and able to recover relatively fast from the effects of pruning and drought are increasingly becoming available and are recommended for new planting or infilling
- **Planting:** Land should be cleared of the roots of fallen trees and terraces/contours/drains made at suitable intervals depending upon slope to conserve soil and dispose of rainfall run-off safely. 9-15 month-old healthy plants (40–60 cm in height with some 10-12 mature leaves) are planted individually in holes (45 cm deep and 45 cm wide,) top soil being mixed with five kg of compost or well-rotted manure, together with recommended inorganic fertiliser, dependant on soil analysis.
- Contour planting can be undertaken either as a single row (1.2 m between rows and 0.75 m between plants) giving a plant population 10,800 per ha or alternatively as a double row (1.35 metres between double rows and 0.75 between plants) giving a higher plant population of 13,200 per ha. The latter method tends to give earlier and higher yields, better soil conservation, less weed growth and allows more efficient cultural practices especially in higher rainfall areas.
- **Staking:** Immediately after planting, plants should be staked to prevent wind damage and the soil surface around the plants mulched, about 25 tonnes of grass being required to mulch one hectare. Care must be taken to keep the mulch materials away from the stem of the tea plant to avoid stem diseases.
- **Shade management:** Shade is essential for regulating temperature, minimising the effects of drought and sun injury, serving as a windbreak, preserving soil moisture during the dry winter months and reducing the incidences of pests such as red spider mite. Shade trees will also improve soil fertility through recycling of nutrients add organic matter to the soil from shedded leaves.
- **Weed control:** Different varieties of annual and perennial weeds compete with tea plants for space, water and nutrients , especially when tea plants are young. Problem weeds include *Mimosa pudica, Borreriahispida, Cynodon dactylon, Sidaacut*a, and *Paspalum sp*. In mature tea, *Mikaniamicrantha, Paspalum, Axonopus, Lantana*, and *Mimosa*, among others, dominate. Weeds also increase the

12 Mainaak Mukhopadhyay and Tapan Kumar Mondal, 2017. Cultivation, Improvement, and Environmental Impacts of Tea. Agriculture and the Environment. DOI: 10.1093/acrefore/9780199389414.013.37. http://oxfordre.com/environmentalscience/view/10.1093/acrefore/9780199389414.001.0001/acrefore-9780199389414-e-373

13 https://www.indiaagronet.com/indiaagronet/horticulture/CONTENTS/tea.htm

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humidity around the bushes, creating conditions favourable for diseases, as well as hindering tea harvest.

- Weed management practices can include manual, chemical, cultural, and biological methods, with small scale growers usually depending on hand weeding, although use of chemical methods is becoming increasingly common due to labour constraints.

- **Training and Pruning:** When young tea plants have become established, the growing point is removed leaving 8-10 mature leaves. This induces growth of secondary branches, which are then pruned or tipped by removing 3- 4 leaves to induce growth of tertiary branches. It will take 18-20 months from planting to reach a stage for regular tea leaf plucking.

  Regular pruning should then be undertaken at 4-6 year intervals depending upon altitude and growth. This helps to maintain a suitable height for plucking as well as inducing further vegetative growth. Pruning includes a hard formative pruning in young tea, followed by a lighter pruning to encourage better frame development, and a medium pruning where tea frames are healthy. A hard rejuvenation pruning may be required in older bushes to remove dead or diseased wood, knots and interlaced branches to encourage new healthy branches.

- **Soil fertility management:** Regular replenishment of soil nutrients is important, the best time for fertiliser application being after the first rain often in split dressings. In case of recently pruned teas, fertilizer should be applied after the emergence of two new leaves. In mature tea, fertilisers are broadcast uniformly.

  The nutrient uptake from the soil of four tonnes of harvested green leaves is estimated to be 45–60 kg of nitrogen, 4–7 kg of phosphorus, 20–30 kg of potassium and four kg of calcium per hectare. Among micro-nutrients, zinc and manganese offers a consistent response, but others may need to be applied depending on soil analysis. Rates applied will depend on expected yields and existing soil fertility. Due to leaching and/or application of acid forming fertilizers, the soil pH is often reduced. Therefore, periodic application of lime may be required to maintain the optimum pH level. When applied it should be evenly broadcast before pruning once the pruning cycle has commenced.

  Application rates vary according to soil type and expected or target yields but typically to obtain 2000-3000 kg per ha of made tea (8000-12000 kg of green leaf) would be 250-350 kg per ha of N, 60-120, 60-120 of $P2O5$, 30-75 kg of $K2O$ as well as micronutrients. Higher yields would require higher rates of application. Fertiliser is often applied as a mixture of a suitable compound fertiliser, Ammonium Nitrate, Double or Triple Superphosphate and Muriate of potash according to local availability. In Kenya, the Kenya Tea Development Agency imports and recommends the use of a compound fertiliser 26N: 5P and 5K.

- **Plant Protection:** Many pests and diseases infect tea bushes and cause economic losses. The important ones, typical symptoms and some typical control measures, some using chemicals others biological are detailed in Annex 3. Pests include leaf suckers, stem borers, a number of different mites, thrips and nematodes which will cause leaf and stem damage. Fungal diseases include a blister blight affecting the leaves and others effecting roots and stems. Control methods include manual removal of pests, removal and burning of infected bushes as well as application of chemical pesticides. In many growing areas little control has been necessary, but the incidence is increasing.

- **Harvesting or plucking:** Harvesting is undertaken by plucking 2-3 leaves and a bud from the tea bush. It is a labour intensive operation, which effects tea yield and quality. Although machine plucking has been introduced on some larger plantations, tea quality often suffers. Bush height increases 5-10 cm each year after plucking, hence the need for pruning.

- **Yield**: The yield of "made" or dry tea depends upon elevation and climate, clonal or seedling varieties, management practices, severity of pruning and processing techniques. Generally yields up to 2000 kg

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per ha of made tea is considered low, 2000-3000 kg per ha medium and above 3000 kg per ha as high . 100kg of green leaf are generally estimated to make 25 kg of made tea, although this varies from 18-27 kg.

- **Tea processing:** Processing to produce black tea involves the following steps:

- *Withering:* This is undertaken to reduce the moisture content of leaves by spreading them in shallow troughs, which receive air from a fan fitted on one end.
- *Rolling or macerating:* This is undertaken by either a series or a single roller, during which the cells in the leaves are broken to liberate the sap and colour the tea.
- *Fermentation:* Rolled tea materials are spread in a high humidity environment to aid fermentation.
- *Drying:* This stops the fermentation process and removes moisture.
- *Grading:* This requires dried tea to be removed from any stalky fibres and then graded by passing through fibre separating machines with different sized meshes to separate the teas into different grades.

After basic processing, leaves are often subjected to additional processing before selling. This may include blending, flavouring, scenting, and decaffeination. Tea blending involves combining different teas to ensure consistency and taste, to help in obtaining higher prices. Flavoured or scented teas add new aroma and flavour. It can be undertaken through adding flavouring agents, such as ginger, cloves, mint leaves, bergamot (found in Earl Grey), vanilla, or spearmint. Alternatively, because tea easily retains odours, it can be placed in proximity to an aromatic ingredient to absorb its aroma, as in Jasmine tea.

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3.1. Tea value chain

The tea value chain involves thousands of companies around the world, including agri-input manufacturer and supply organisations, producers, primary processors, graders, auction houses, traders, secondary processors, wholesalers, and retailers through to shops and restaurants.

The role of small scale growers (SSGs) is often restricted to the start of the chain, when they deliver green leaf to a tea processing factory. Most value is added from point of sale either to secondary processing and marketing activities, which have the capacity to invest in the capital-intensive technologies needed to further process green leaf. A typical tea value chain is shown below, with Government often the Ministry of Agriculture or a state body being responsible for policy and the regulatory requirements for creating an enabling environment for production and marketing.

Table 2: Typical tea value chain

Improved varieties, land management & agronomic practices	**Agri-Input acquisition & production advice**	**Green leaf production**	**Transport and Primary processing**	**Secondary processing** (Domestic & international)	**Marketing and consumption**
– Researchers	**Production advice** – Extension agents (Govt & NGO) – Grower Associations – Cooperatives – Other farmers **Tea seedling production** – Research stations – Seed producers – Farmers **Fertilisers / pesticides** – Agri-input producers – Agro-dealers – Coops **Production credit** – Buyer credit (tea factories) – Micro-finance institutions, NGOs, Coops – Banks, Agri-banks	– Large Scale Farmers – Small scale growers – Community companies – Cooperatives – Plantation owning companies	**Transport** – Transporters – Farmers' groups or cooperatives – Tea factory **Initial processing** *Withering, rolling, fermentation, drying and grading* – Farmers – Cooperatives – Processing companies – State enterprises	**Tea production** *Blending, tasting, valuing, packaging and distribution* –Exporters –Tea companies	– Wholesalers – Supermarkets – Small retailers – Consumers

SSGs are usually regarded as those growing typically a few bushes up to two ha usually without irrigation. A recent survey[14] in Rwanda showed the average SSG tea area was 0.59 ha, with over 50% having less than 0.28 ha of tea and 10% having 0.05 ha of tea. The survey also showed that the area of land devoted to non-tea crops averaged 0.54 ha, confirming that most SSGs use their farms for other different crop enterprises, although tea is likely to be the most important cash crop. Other crops are primarily for home consumption.

14 Baseline Report, 2015. Rwanda Green Leaf Price Reform Impact Evaluation

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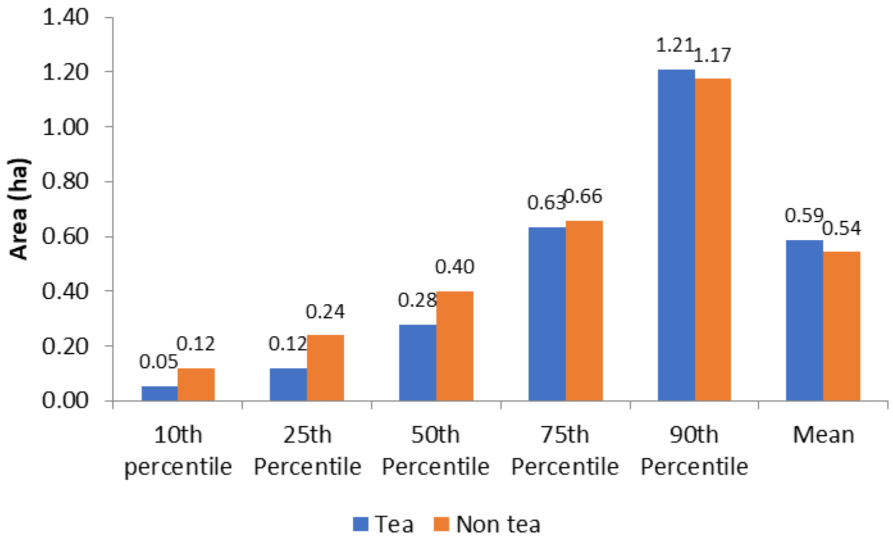

Figure 3: Small scale tea and non-tea grower farm sizes (Rwanda, 2015)

Apart from individual growers, other SSG models include farmer groups, cooperatives or community owned companies producing larger areas of tea typically 20-100 ha, possibly with an employed manager.

In Kenya in 2017, there were over 600,000 tea growers registered by KTDA growing 123,840 ha of tea, the mean area per grower being 0.20 ha producing 0.45 tonnes equivalent to 2.21 tonnes per ha of made tea[15], more than 8000 kg of green leaf, assuming four tonnes of green leaf being required for each tonne of made tea.

Many larger tea producing companies have well established supply chains directly linked to farmer groups or cooperatives. Under such schemes, some companies manage the entire system from advisory services, procurement, processing to export and final marketing and in some cases certification. In addition to such schemes, independent farmers and groups may also contribute a significant amount of tea. Much tea is exported to tea consuming countries where speciality or certified tea may be in high demand. Certification comes with costs, which can be profitable if there is a market that demands certified tea.

3.2. Challenges faced by small scale tea growers

Whilst the smallholder tea sector has exponentially increased its role in tea production, this is mainly due to an expansion in the area grown rather than an increase in land productivity. Improved agronomic production practices are urgently required[16]. Prices paid for green leaf are often low as quality is often lower than that of plantation produced leaf. Unfortunately SSGs may have limited information on improved agronomic practices and market prices, and lack the finance to purchase the necessary agricultural inputs to improve leaf quality[17]. They often compete with plantations and tea factories, to which they sell their green leaf tea. Other challenges faced by SSGs include deficient transport infrastructure, unreliable and high cost energy supply, delayed payments, an increase in pests and diseases and the high costs of tea production, which many farmers cannot afford.

15 KTDA Management Services Limited, 2018 Tea Growers Payment, June 2018 Financial Year. https://www.ktdateas.com/index.php/component/k2/item/125-tea-growers-payment-2018.html

16 Monroy L., Mulinge W., Witwer M., 2012. Analysis of incentives and disincentives for tea in Kenya. Technical notes series, Monitoring African Food and Agricultural Policies project, Food and Agriculture Organization of the United Nations, Rome.

17 Ibid

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Well-organised SSGs as typified by Kenya´s smallholder tea farmers organized under the Kenya Tea Development Authority (KTDA) are considered successful. They often receive higher prices than less organised tea farmers, but still complain of low returns.

It is however important to take into account socially responsible and sustainable tea production practices promoted by some NGOs and multinational companies. For instance, "Fair Trade" and "Rain forest" certification play a positive role in raising SSGs incomes and ensuring sustainable production[18][19].

3.3. Climate Smart Tea Production

Climate-smart agriculture (CSA) contributes to the achievement of the sustainable development goals[20], through integrating three dimensions of sustainable development (economic, social and environmental) by jointly addressing food security and climate challenges. It is an approach that requires site-specific assessments to identify suitable agricultural production technologies and practices.

The table ollowing summarises the main climate change threats to sustainable tea production, the likely impact and six broad mitigation strategies[21]. These include the need to establish: (i) planting new varieties or clones adapted to drier, warmer and/or cooler conditions with resistance to pests and diseases, ii) integrated soil fertility management (ISFM), through increased use of composts and manures, mulches and cover crops integrated where necessary with the use of inorganic fertilisers, iii) integrated soil and water conservation (SWC) and drainage measures using contour barriers or terracing especially on steeper slopes using grasses and trees on the terraces combined with rainwater harvesting techniques and improved irrigation, when available, (iv) agroforestry involving the planting of trees and hedges to mitigate sun, wind and water damage and improve soil fertility, including protection of areas of high biodiversity, and (v) integrated pest and disease management, through improved scouting and biological control methods.

18 Faitrade, 2019. Fairtrade Impact for Small-scale Tea Farmers and workers https://www.fairtrade.net/products/tea.html accessed 15 February 2019.

19Reiko Enomoto, 2011. Tea Implementation Guide for smallholders in Africa. Sustainable Agriculture Division, Rainforest Alliance. Based on the Sustainable Agriculture Standard of the Sustainable Agriculture Network.

20 FAO, 2013. Climate Smart Agriculture Sourcebook. ISBN 978-92-5-107720-7 (print), E-ISBN 978-92-5-107721-4 (PDF). www.fao.org/climatechange/climatesmart

21 FAO, 2016 Report of the Working Group on Climate Change of the FAO Intergovernmental Group on Tea. Food and Agriculture Organization of the United Nations, Rome, 2016. ISBN 978-92-5-109279-8.

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Climate change threats	Impact	Mitigation strategies
1. Changes in the timing of seasons 2. Increasing occasions of prolonged droughts both between and within seasons 3. Very heavy rains leading to landslides 4. Extremely cold temperatures at night and during the cold season 5. Frost in areas that were never affected by frost 6. Increasing temperatures during the day 7. Increasing incidence of hail causing	– Delay in the onset of rainfall and extension of the cold season. – Reduced quality and yields .and in extreme circumstances killing tea bushes – Damage to road infrastructure reducing accessibility to market – Increased soil erosion, soil fertility loss and reduced soil moisture availability – Arrival or increase in pests and diseases not previously experienced – Sun damage – Increased risk of damage by frosts – Declining suitability for growing tea and consequential move to more suitable areas – Biodiversity loss	i) Planting new varieties / clones on suitable land ii) Integrated soil fertility management iii) Soil and water conservation iv) Agroforestry including Protection of areas of high biodiversity v) Integrated pest and disease management

Figure 4: Climate change threats, impact and mitigation strategies[22]

The strategies identified in the table above involve important management practices, designed to improve productivity and mitigate the effects of climate change. These include[23,24,25]:

- **Planting improved tea varieties / clones on suitable land.** Seedlings and cloned plants tolerant to adversities of weather (drought, water logging, and warm/cold weather conditions) and pests and diseases should be used, gradually replacing older traditional varieties. Unfortunately, many existing varieties or clones are not drought or cold sensitive and are likely to suffer stress or even die as a result of temperature changes. At the same time it is important that land unsuitable for tea cultivation should be removed and replaced with new areas with suitable ecological conditions for new tea. New clones are being or have recently been developed by Tea Research Institutes that are improving performance under drought and frost conditions as well as demonstrating resistance to pests and disease. For instance in Kenya, key new clones include:
  - TRFK 301/4 and TRFK 301/5 clones are 'tolerant' to drought and to harsh adverse abiotic and biotic stress factors. TRFK 301/5 is a high yielding tea clone and is thus good for infilling.
  - TRFK 430/90 and TRFK 371/3 are both considered to be drought 'tolerant', out yielding locally planted clones by more than 68%. They are also resistant to mites and root knot nematodes and recover relatively fast from pruning and drought.
  - TRFK 306/1 is a new purple tea with higher medicinal properties than green and black tea varieties. It is also drought and frost resistant, pest and disease resistant, high yielding and grows in similar weather conditions to green tea species. If the right markets can be found, it can fetch 3- 4 times the revenue of standard black teas.

22 ibid

23 GIZ, undated. Extension officer training manual: Adapting to Climate Change in the Tea Sector. Deutsche Gesellschaft für Internationale Zusammenarbeit, in collaboration with the Tea Research Foundation of Kenya and the Kenyan Tea Development Agency.

24 UNIDO, 2017. Adaptation and mitigation in the Kenyan tea industry. Country Report. United Nations Industrial Development Organisation. Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria.

25 Reiko Enomoto, 2011. Tea Implementation Guide for smallholders in Africa. Developed in collaboration with Partner Africa, the Kenya Tea Development Agency (KTDA) and the Ethical Tea Partnership. Rainforest Alliance, Sustainable Agriculture Division.

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- **Integrated soil fertility management (ISFM):** Emphasis should be placed on ensuring healthy soils with good soil structure, high soil organic matter content with soil organisms and nutrients available for plant uptake. Inorganic fertilisers can improve soil fertility by adding nutrients to the soil. However, they do not improve soil organic matter content, microorganisms or soil structure. Hence adding organic matter in the form of compost, well matured animal manure, or mulching material is an essential component of ISFM. Adding compost is a beneficial way to increase soil fertility and improve growth of young immature tea bushes. It provides both nutrients and increases soil moisture holding capacity and will lead to a reduced need for inorganic fertilisers.

- **Improvement of soil organic matter content**: This should be undertaken through applications of compost, tea waste, animal manure (3-5 tonnes per ha) both when new tea is planted as well as established tea. For newly planted tea, it is best to mix compost with top soil and apply it into the planting holes at a rate of at least 5 kg per plant. For already planted tea the best time to do this is after pruning when space is available between rows. The compost should be lightly dug into the soil. Compost should also be added to the soil when infilling gaps with new tea bushes.

- **Mulching, green manures and cover crops:** These form an integral part of both ISFM and soil and water conservation (SWC), where they are fully described.

- **Soil and water conservation:** The following measures are the considered the standard measures of integrated soil and water conservation management.

- **Contour terraces/banks** planted with grass and/or trees should be established with appropriate measures for safe removal of water (micro-watershed management) especially on steep slopes, the distance between terraces depending on the slope of the land, but typically 25 m apart.

- **Suitable grass species** such as vetiver (Vetiver zizanioides), napier grass (Pennisetum purpureum) and guinea grass (Panicum maximum), Bahia grass (Paspulum notatum) should be planted along the contour at intervals across the slope to slow down run-off of water. In addition to reducing soil erosion, the grasses can provide material for mulch or feed for livestock. The grass can be mixed or replaced with hedgerows of leguminous fodder trees such as *Leucaena diversifola*, *Calliandra calothyrsus*, *Sesbania sesban* and *Gliricidia sepium*.

- **Mulching** is the process of covering the topsoil with dead plant material including pruning from tea bushes and shade trees, leaves, grass, twigs or crop residues and thus providing it with a layer of protection from the elements. This assists in keeps the soil moist and preventing soil erosion as well as the growth of weeds. As the mulch decomposes, it serves as an organic fertilizer for the soil. Mulching should be undertaken in both in the early stages of plant establishment as well as in established tea bushes. It should be applied between the rows of tea and if possible around the edge of the tea fields, wherever there is exposed soil. However, it should not be placed too close to the tea as this can stunt the development of feeder roots making the plant more susceptible to drought. Also, mulching in this way will help to prevent attack by ants and termites. Tea bush pruning material is a useful mulch and should not be removed for other purposes and never burnt unless it is diseased.

- **Green manures and cover crops** are particularly important on steep slopes. Species planted should match local climatic and soil conditions, but not compete with the tea for nutrients, water or light. Common species include: *Crotalaria spp*, *Desmodium intortum*, *Canavalia ensiformis*, *Dolichos lablab*, *Medicago sativa*, *Mucuna pruriens* and *Macroptilium atropurpureum*.

- **Rain water harvesting and low cost irrigation**: Harvesting rain water is an economic and efficient way to obtain water and can be incorporated into a micro-watershed plan of contour terraces.

- **Irrigation:** this has many benefits including helping to increase crop yields, easier and more accurate fertiliser application through the irrigation system, thus reducing fertiliser requirements.

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The establishment of a low cost drip irrigation system can be a low cost option, where water is available. When combined with rainwater harvesting, it promotes effective crop growth during dry spells and consequently better control over harvesting green leaf and market timing.

- **Agroforestry shade trees:** Shade trees provide both advantages and disadvantages for tea production. However, they help to combat some of the impacts of climate change through regulating climatic conditions. When temperatures are high, the shade trees provide protection to the tea leaf. They have also demonstrated benefits during incidents of frost. This is due to their ability to create a micro-climate which reduces the ability for frost to form on the tea leaves. This is particularly useful in frost prone valley bottoms. During times of drought, shade trees help to reduce evapotranspiration from both the soil and tea bushes, which reduce the risk of the tea drying out and dying. Similarly, shade trees protect soil and crops from the drying effects of wind as well as improving soil fertility, particularly if leguminous varieties are grown.

- Unfortunately shade trees can slightly reduce tea yields especially at high altitude, competing with tea bushes for soil water and if incorrect varieties are grown can encourage pests and disease

- Hence it is important to use the recommended shade trees for the area, seed for which can be often be obtained from Tea or Forestry Research Institutes. Recommended spacing of tree rows should be approximately ten times the standard height of the tree that is being used. For example, if the tree size is 6m at its maximum, then the rows should be planted at 60m intervals. Again, advice should be sought from research institutes on the most appropriate intervals.

- The establishment and management of shade trees and shelter belts to modify micro-climate and provide organic matter are critically important. *Grevillea robusta* and *Albizzia moluccana* or *Albizzia chinensis* are often recommended as high shade species. Leguminous faster growing trees and shrubs include: *Calliandra spp, Gliricidia sepium, Sesbania sesban, Tephrosia candida*.

- **Protecting water sources and areas of biodiversity:** If the tea area has a water course running along the edge or within its boundary, neither tea nor other crop should be cultivated near it. Natural vegetation should be encouraged and if necessary additional protection provided by planting indigenous trees and a suitable grass. Such areas should be given protected status where possible in order to protect the biodiversity and avoid serious environmental damage, through loss of endangered or indigenous species, soil erosion and water contamination.

- **Integrated pest and disease management:** Suitable practices to improve bush vigour are described below[26].

- **Pest management**

- Plant resistant varieties to prevent

- Helopeltis, a pest that sucks on young soft tea leaves leaving dark brown spots from its saliva and damaged distorted leaves.

- Mites, which cause leaf damage and discolouration.

- Prune diseased branches and leaves to cut the life cycle of pests.

- Plucking hard and reduce harvesting intervals to control aphids. Also by not spraying an insecticide, ladybirds are protected and will help in natural control of Aphids.

- Adequate fertilizer application to create a healthy and strong the tea bush, able to fight mites.

26 Reiko Enomoto, 2011. Tea ImplementationGuide for smallholders in Africa. Developed in collaboration with Partner Africa, the Kenya Tea Development Agency (KTDA) and the Ethical Tea Partnership. Rainforest Alliance, Sustainable Agriculture Division.

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- **Disease control**

- Armillaria, a fungal disease that spreads through the root system. Uproot the entire bush including roots and destroy by exposing it on the ground.
- Phomopsis, a fungal disease that enters through open wounds on stems and branches. Plant resistant clones. Also be careful when hoe weeding to avoid accidental damage to the tea stem.
- Hypoxylon, a fungal disease that attacks primary branches, remove affected branches and if necessary apply copper-based fungicide to the wounds. During pruning, make sure to prune above 60 cm to prevent the pathogen from reaching the wounds.

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4. THE CLIMATE SMART TEA CREDIT PRODUCT

The purpose of this section is to identify how climate-smart land-management measurements will be progressively built out over progressive loan cycles as requirements of those loans.

The integrated approach required for SSGs to derive optimum benefit from CSA tea practices dictate that loans advanced should be by the size of the area to be planted, filled-in or rehabilitated, starting with an area of 0.03 ha or 1/32nd ha. This can be regarded as "Learner Level", where CSA practices can be tried, tested and learnt from, before proceeding to progressively larger areas. These would be increased from 0.03ha to 0.06 ha, 0.13 ha, 0.25 ha, 0.5 ha, 0.75 ha and then one ha, a total of seven levels as detailed on on the next page. The reason for having seven levels is the large numbers of growers with very small field sizes as illustrated for Rwanda. Not only will this support the learning process of individual growers, but learner and starter plots are then available for demonstration, learning and, if necessary, modification through experience by relevant stakeholders. The process lends itself to both new tea establishment as well as gradual rehabilitation of old tea fields.

A number of CSA practices have been identified which can be monitored. Typical targets for each are based on those required for one ha and proportionately scaled down for smaller areas. For an area of 0.03 ha (12 m x 25 m) the "Learner level", the following targets would be required.

Table 3: Climate-smart lending targets

#	Targets for 0.03 ha
1	422 (say 400) new tea seedling plants.
2	Each planted with five kg of manure/compost together with locally recommended rates of inorganic fertiliser, unless organic tea is to be marketed.
3	25 metres of contour terraces planted with a suitable grass with a cover crop planted between tea bushes, the biomass from both being used as mulch material for temperature, soil moisture and weed control.
4	8 shade trees selected for their suitability to the area.
5	Integrated pest and disease management practices would be initiated from the onset, provided through training rather than setting specific targets.

Rainwater harvesting structures can be introduced at the 0.25 ha level, since their construction will be opportunity driven and may not be possible on very small areas. They should also form part of a micro-watershed plan where contours/terraces and drainage lines from adjoining fields are linked to feed into natural watercourses. These can then be protected through afforestation or reforestation with indigenous trees and suitable grass species. Ideally, they should also be given protected status.

It should be noted that these targets can be adjusted according to locally-specific agro-climatic conditions and based on recommendations from local tea research organisations or extension agencies.

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Table 4: Practices required under the tea climate-smart credit product

					CSA requirements per unit						
					Loan 1	**Loan 2**	**Loan 3**	**Loan 4**	**Loan 5**	**Loan 6**	**Loan 7**
			units	No. per ha	**0.03**	**0.06**	**0.13**	**0.25**	**0.5**	**0.75**	**1**
Plant improved tea cultivars on suitable land	1	Seedlings and grafted plants tolerant to adversities of weather (drought, water logging, warm/cold weather conditions) and pests and diseases	Seedlings	13500	422	844	1,688	3,375	6,750	10,125	13,500
Integrated soil fertility management	2	Improvement of soil organic matter content through applications of compost, tea prunings, animal manure leading to a reduction in inorganic fertiliser applications	tonnes	5	0.2	0.3	0.6	1.3	2.5	3.8	5
Soil and water conservation	3	Establish contour terraces/banks planted with grass and/or trees with appropriate measures for safe removal of water (micro-watershed management)	metres	400	13	25	50	100	200	300	400
	4	Mulching with vegetative matter (such as Napier or Guatemala grass grown on contour terraces)	sq. metres	5000	156	313	625	1,250	2,500	3,750	5,000
	5	Retaining of pruning litter and shade tree droppings/loppings	-	-	-	-	-	-	-	-	-
	6	Use of green manure and cover crop (such as Crotalaria and Sesbania)	sq. metres	5000	156	313	625	1,250	2,500	3,750	5,000
	7	Rain water harvesting incorporated in the micro-watershed plan	number	4	-	-	-	-	-	-	-
Agroforestry	8	Establish trees for shade, windbreaks, mulching, and erosion control between trees and on field boundaries	seedlings per unit of land	250	8	16	31	63	125	188	250
	9	Afforestation, reforestation and establishment of indigenous trees in areas surrounding tea farms. These areas should be given protected status where possible.	-	50	2	3	6	13	25	38	50
Integrated pest and disease management	10	Use of multiple pest management tactics to prevent economically damaging out-breaks, while reducing risks to human health and the environment	-	-	-	-	-	-	-	-	-

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		0.03ha	0.06ha	0.13ha	0.25ha	0.5ha	0.75ha	1ha
Contractual Requirements	Tree-planting	10 trees	19 trees	37 trees	76 trees	150 trees	226 trees	300 trees
	Rain-water harvesting ditches	0	0	0	1	2	3	4
	Green Manure & cover crop	0.03ha	0.06ha	0.13ha	0.25ha	0.5ha	0.75ha	1ha
	Mulching	0.03ha	0.06ha	0.13ha	0.25ha	0.5ha	0.75ha	1ha
	Contour terracing	13m	25m	50m	100m	200m	300m	400m
	Manure / compost	0.03ha	0.06ha	0.13ha	0.25ha	0.5ha	0.75ha	1ha
		Loan 1	Loan 2	Loan 3	Loan 4	Loan 5	Loan 6	Loan 7
Non-Contractual Requirements	Improved varieties (seedlings)	422	844	1,688	3,775	6,750	10,125	13,500
	Integrated pest management	Training	Training	Training	Training	Training	Training	Training

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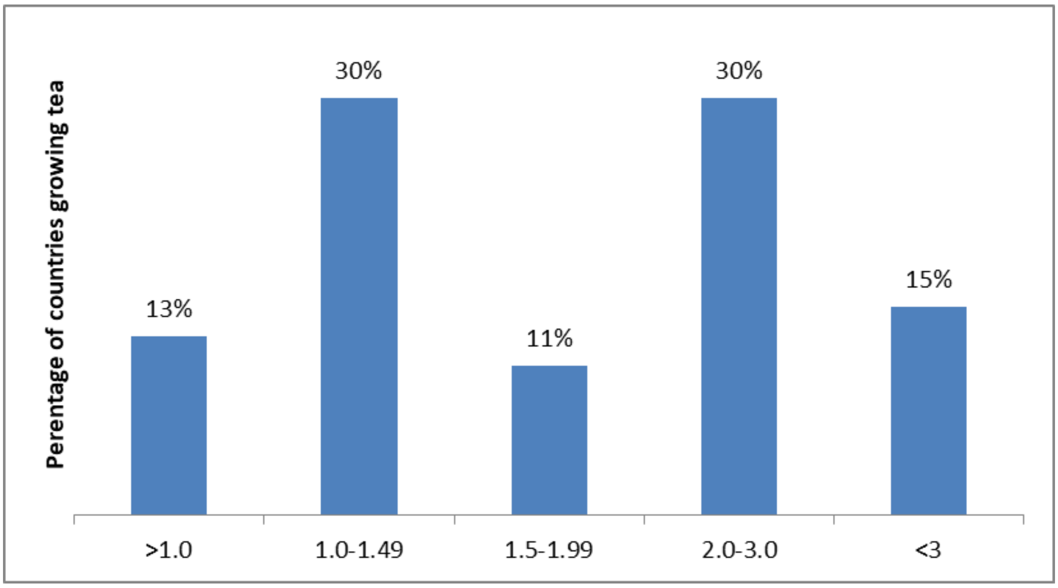
5. Yield and Mitigation Benefits

With reference to the academic literature where possible, provide justifiable estimates for the impact of the proposed sustainable land-management and climate-smart measures in terms of impact on explanation of the agronomic mechanism whereby the yield increase is achieved for example drought or excessive rain with explanation of the agronomic mechanism whereby the yield increase is achieved.

5.1. Present Yield Levels

FAO data[27] for 2017 showed that of the 49 countries producing tea, the top ten producers grew 93% of the total area and produced over 90% of the total yield. Detail for all producers is shown in Figure 2. The total tea area grown was 4,087,597 ha, producing 6,114,441 tonnes of processed or made tea, with an average yield across countries of 2.01 tonnes per ha. However differences between countries are large. Yields of less than two tonnes per ha are generally regarded as low, 2-3 tonnes as medium and over three tonnes as high[28]. Using these criteria more than 50% of countries can be regarded as low yielding, 30% medium and 15% high yielding.

Table 5: Average tea yields (tonnes per ha)



89% of the global tea area is in Asia, 10% in sub Saharan Africa (SSA) and 1% in Latin / South America. Yields are highest in Asia (2.13 tonnes per ha), lowest in SSA (1.80 tonnes per ha) and 2.19 tonnes per ha in Latin / South America.

The areas grown and yields per ha for the top ten producers is shown in below.

Although China grows over 50% of the total area, yields per ha are comparatively low compared to other major producers

[27] FAO, 2018 FAOSTAT. http://www.fao.org/faostat/en/#data/QC
[28] https://www.indiaagronet.com/indiaagronet/horticulture/CONTENTS/tea.htm

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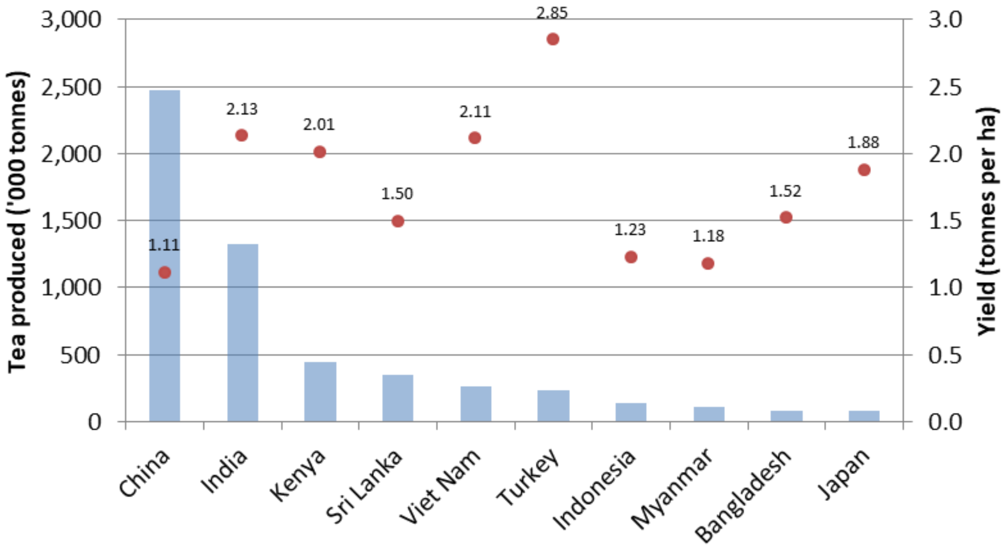

Figure 5: Areas grown and mean tea yields (tonnes per ha) for the top ten global producers[29]

Country	ha grown	%	Rank in terms of area grown	Yield (tonnes)	%	Tonnes/ha	Rank in terms of yield per ha
China	2,224,261	54%	1	2,473,443	40%	1.11	10
India	621,610	15%	2	1,325,050	22%	2.13	2
Kenya	218,538	5%	4	439,857	7%	2.01	4
Sri Lanka	233,909	6%	3	349,699	6%	1.50	7
Viet Nam	123,188	3%	5	260,000	4%	2.11	3
Turkey	82,108	2%	8	234,000	4%	2.85	1
Indonesia	113,692	3%	6	139,362	2%	1.23	8
Myanmar	88,806	2%	7	104,743	2%	1.18	9
Bangladesh	53,856	1%	9	81,850	1%	1.52	6
Japan	43,245	1%	10	81,119	1%	1.88	5
Total	3,803,213	93%	-	5,489,123	90%	1.75(mean)	-

Table 6: Area of tea, yields and rank in terms of area grown and yields, 2017[30]

29 FAO, 2018 FAOSTAT. http://www.fao.org/faostat/en/#data/QC

30Ibid

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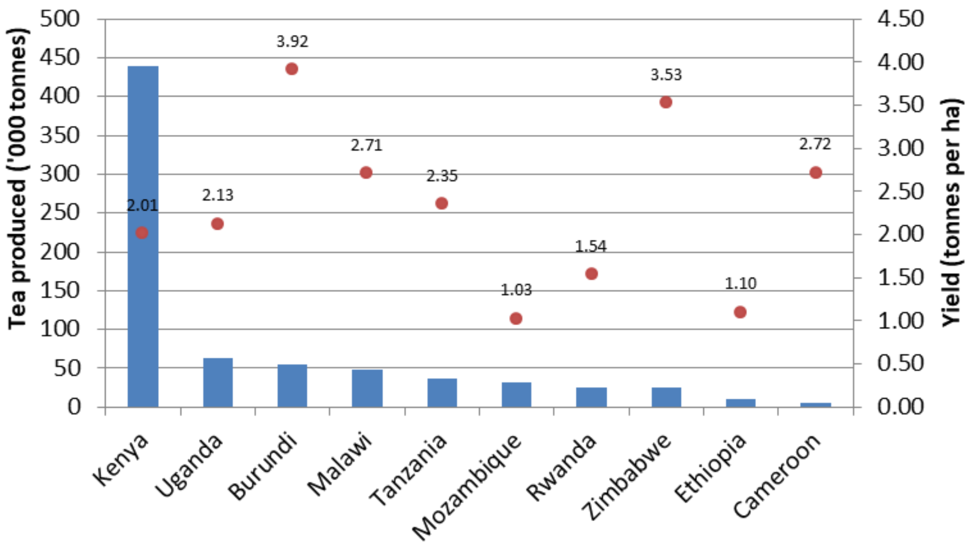
There are 18 countries producing tea in SSA. The areas grown and mean yields for the top ten producers are shown below. Kenya is by far the largest responsible for nearly 60% of total production within SSA, although a number of smaller producers achieved higher yields.

Table 7: Areas grown and mean tea yields (tonnes per ha) for the top ten SSA producers[31]



5.2. Tea Prices

While world tea consumption has increased over the last decade, traditional importing European countries, with the exception of Germany, have seen a decline in consumption levels. Overall, the European tea market is largely saturated and per capita consumption has been declining for more than a decade. In the UK, tea consumption is projected to decrease as black tea struggles to maintain consumer interest amid increased competition from other beverages, including coffee.

Notwithstanding global tea consumption and production are projected to keep rising over the next decade, driven by strong demand from developing countries. Tea consumption has grown particularly rapidly in China, India and other emerging economies, driven by a combination of higher incomes and efforts to diversify production including specialty herbal teas, fruit fusions and flavoured gourmet teas.

World production of black tea is projected to rise annually by 2.2% to reach 4.4 million tonnes in 2027, reflecting major output increases in China, Kenya and Sri Lanka. At the same time global output of green tea is also foreseen to increase, but at an even faster rate of 7.5% annually to reach 3.6 million tonnes in 2027, largely dominated by China, where the production of green tea is expected to more than double from 1.5 million tonnes to 3.3 million tonnes in 2027. This will create new rural income opportunities and improve food security in tea-producing countries[32].

International tea prices for processed or made tea, as measured by the FAO Tea Composite price, have remained firm over the last decade. Important drivers of tea prices include not only demand and supply but also the potential effects of changing climatic conditions, market access, pests and diseases and changing dynamics among multinationals, wholesalers, and retailers.

31 Ibid

32 FAO, 2018. Intergovernmental Group on Tea, 2018. Current Market Situation and Medium Term Outlook. Hangzhou, the People's Republic of China, 17-20 May 2018 www.fao.org/3/BU642en/bu642en.pdf

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Tea is unusual among agricultural commodities in that it is sold through auction centres around the world with around 70% of the world's tea being traded through auctions. Unlike coffee and cocoa, there is no futures market for tea. Although the system appears to be a fair market in which prices are determined solely by supply and demand, a small number of companies dominate sales at each auction. The World Bank forecast average auction prices of $2.83 per kg in 2019 and $2.84 in 2020.

Tea sold at auction in Colombo, Sri Lanka often lead the world in pricing, averaging $4.21 per kg for high altitude-grown teas[33], while Jakarta tea averaged $1.73 per kg. African teas averaged $2.39 per kg at auction in Mombasa, this being the major hub of Africa's tea trade. This includes tea from Burundi, the DRC, Madagascar, Mozambique, Rwanda, Tanzania, and Uganda. Teas grown in Burundi, Kenya, and Rwanda earn typically sell for around $2.50 per kg, compared with lower prices from other East African countries, their teas often being used as fillers. Malawi tea fetched $1.68 at auction in Limbe in Malawi. Kenya tea is regarded as essential in making popular brands including PG Tips, Lipton, Tetley, and Twining's tea.

Annual price variations for processed tea are shown for a number of countries (Annex 5), for which FAO data is available.

Approximately four kilos of green leaf are required to make one kilo of made tea. In Kenya farmers receive approximately 25% of auction prices of made tea[34]. In Sri Lanka the green leaf price is calculated at 21.5% of the average made tea price[35]. The table below shows the average annual price of tea green leaf in Kenya over the period 1980 to 2017[36], assuming farmers were paid 25% of made tea prices.

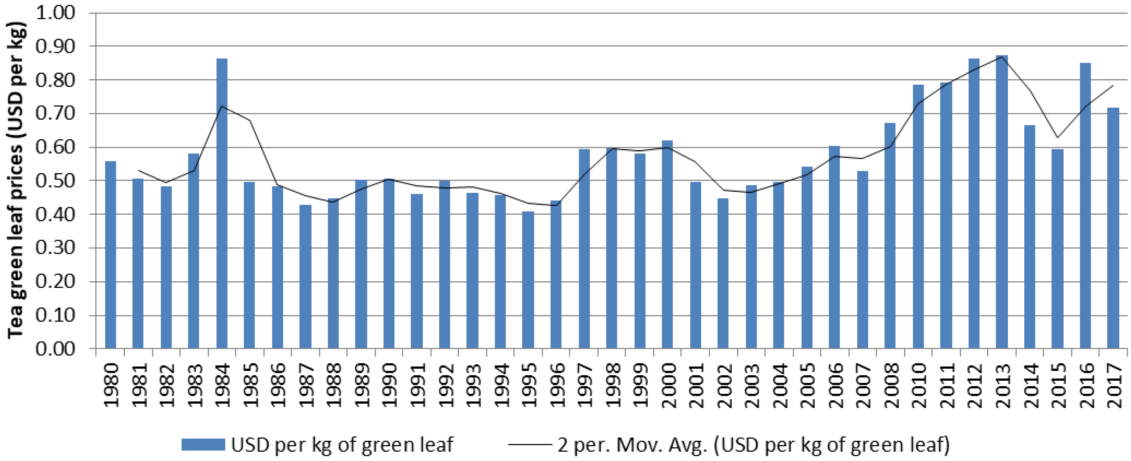

Figure 6: Average annual price of tea green leaf in Kenya 1980-2017 (USD per kg)

It should be noted that average monthly prices vary from month to month. In Kenya the average for a 13-month period (June 2016-June 2017) was USD 0.87 per kg but varied from USD 0.67-0.95 per kg.

33 the International Tea Committee

34 KTDA Management Services Limited, 2018 Tea Growers Payment, June 2018 Financial Year. https://www.ktdateas.com/index.php/component/k2/item/125-tea-growers-payment-2018.html

35 Sri Lanka Tea Board, 2018. www.gov.lk/services/sltb_rp/es/reasonableprice/index.action

36 International Monetary Fund, Global price of Tea, Kenyan [PTEAUSDA], retrieved from FRED, Federal Reserve Bank of St. Louis; https://fred.stlouisfed.org/series/PTEAUSDA. February 13, 2019.

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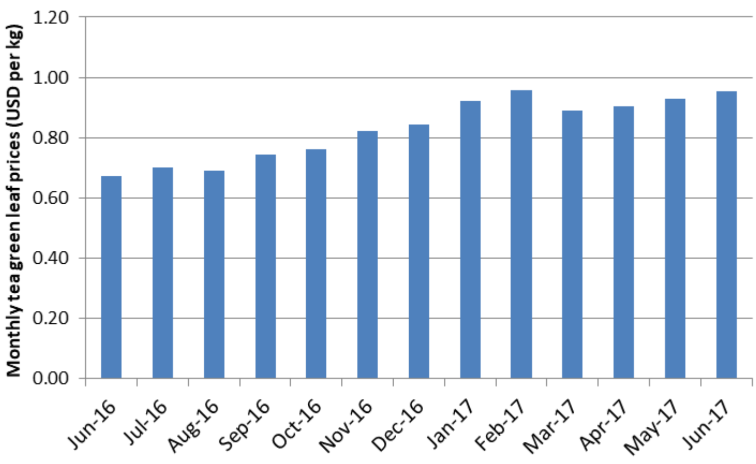

Figure 7: Average monthly price of green leaf in Kenya June 2016-June 2017 (USD per kg)[37]

5.3. The Impact of Sustainable Land-Management and Climate Smart Practices

Key features of the CSA approaches for sustainable tea production five strategy areas:

- ***Planting improved tea varieties*** tolerant to the adversities of drought, weather conditions and pests and diseases. At the same time it will be important to encourage removal of land unsuitable for tea from cultivation and ensure new areas have suitable agro-climatic and marketing conditions.
- ***Improving soil health*** through integrated soil fertility management practices, including application of composts and manures combining this with mulching and use of green manure cover crops. This will over time reduce the requirements for inorganic fertilisers.
- ***Improving soil and water conservation*** thus reducing or eliminating soil erosion, through the establishment of contour terraces on which grass and / or trees are planted. In addition rainwater harvesting and irrigation where available will increase soil moisture facilitating longer growing periods.
- ***Establishing trees for shade, windbreaks, mulching, and erosion control*** between tea bushes and on field boundaries. At the same time afforestation, reforestation and establishment of indigenous trees in areas adjoining water course and low lying areas will increase biodiversity as well as providing further protection against soil erosion and flooding.
- ***Introducing integrated pest and disease management*** practices to prevent economically damaging out-breaks, while reducing risks to human health and the environment
- The impact[38,39] of these practices, lies in four areas varying according to agro-climatic and market conditions. Their impact will be cumulative, but dependent on deployment as integrated packages.
- ***Improving the resilience of natural resource use.*** This includes increasing farm level biodiversity; increasing groundwater availability, reducing soil erosion, increasing availability of plant nutrients from the soil, increasing infiltration of water into the soil, increasing soil microbial diversity, improving soil aggregation and increasing soil water holding capacity

37 Ibid

38 Bell P, Namoi N, Lamanna C, Corner-Dollof C, Girvetz E, Thierfelder C, Rosenstock TS. 2018. A Practical Guide to Climate-Smart Agricultural Technologies in Africa. CCAFS Working Paper no. 224. Wageningen, the Netherlands: CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS). Available online at: www.ccafs.cgiar.org

39 B Campbell, 2107. Climate Smart Agriculture What is it? Rural 21 4:14-16. CGIAR Research program on Climate Change, Agriculture and Food Security (CCAFS)

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- ***Reducing the risks associated with climate change***. These include increased temperatures, droughts both between and within growing seasons, shortened growing seasons, increased rainfall intensity and more unpredictable seasons

- ***Mitigating the effects of some of the causes of climate change***. These include encouraging changes in land use, reducing emissions from inputs used in cane production, sequestering carbon both in the soil and in increased biomass, and N20 emissions through reducing fuel use

- ***Increasing productivity.*** These include increased yields with less yield variability and a reduction in input costs, but sometimes an increase in labour requirement. Consequently incomes will be increased.

Details of the impact of each of these components are shown qualitatively (- no effect, + some effect, ++ intermediate effect and +++ large effect) in Annex x, with that on productivity shown in Figure 7.

Climate smart agricultural practice			Yield	Yield variability	Labour increase	Income increase
Plant improved tea cultivars on suitable land	1	Seedlings and grafted plants tolerant to adversities of weather (drought, water logging, warm/cold weather conditions) and pests and diseases	+++	++	++	+++
		Selection of lands with suitable growing (ecological) conditions for new tea cultivation	+++	+++	+	+++
		Removing land unsuitable for tea from cultivation	+++	+++	+++	+++
Integrated soil fertility management	2	Improvement of soil organic matter content through applications of compost, tea waste and/or cattle manure leading to a reduction in inorganic fertiliser applications	+++	+++	++	+++
Soil and water conservation	3	Establish contour terraces/banks planted with grass and/or trees with appropriate measures for safe removal of water (micro-watershed management)	+++	+++	++	+++
	4	Mulching with vegetative matter (such as Napier or Guatemala grass grown on contour terraces)	+++	+++	++	+++
	5	Use of green manure and cover crop (such as Crotalaria and Sesbania)	++	++	++	++
	6	Rain water harvesting incorporated in the micro-watershed plan	+++	+++	+++	+++
	7	Irrigation during dry spells	+++	+++	+++	+++
Agroforestry	8	Establish trees for shade, windbreaks, mulching, and erosion control between trees and on field boundaries	++	++	++	+++
	9	Afforestation, reforestation and establishment of indigenous trees in areas surrounding tea farms. These areas should be given protected status where possible.	+++	+++	++	++
Integrated pest and disease management	10	Use of multiple pest management tactics to prevent economically damaging out-breaks, while reducing risks to human health and the environment	+++	+++	+	+++
		** greatest on steeper slopes*	-	*no effect*		
		*** especially on areas without irrigation*	+	*small effect*		
			++	*intermediate effect*		
			+++	*large effect*		
Note 1:		Yields will increase over a period of time from a base of one tonne per ha-1 as soil health is improved, soil organic matter builds and soil conservation measures become effective.				

Figure 8: Impact of CSA practices on productivity

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5.4. Yields Increases through Adoption of CSA Tea Practices

Yields will increase over time as soil health is restored, soil organic matter builds and soil and water conservation measures become effective. This is likely to involve a step-wise process through farmer learning and knowledge increase, but also dependent on agro-climatic potential.

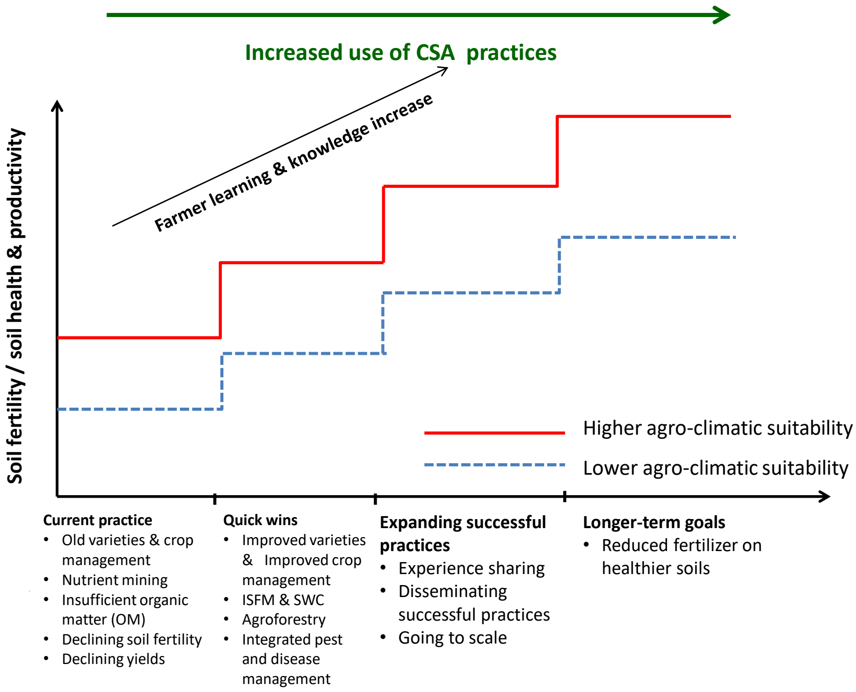

Figure 9: Step wise productivity yield in responsive and less responsive soils[40]

Research and experience in a number of countries shows that yield increases from less one tonne ha^{-1} to over three tonnes ha^{-1} of made tea are achievable and could be substantially higher given good management. The impact will be greatest where soil health is presently poor and yield levels are already declining, often on steeper slopes with poor soil and water conservation practices and under rainfed conditions. Unfortunately, mistakes made during establishment of the tea can mean that attainable yields are not reached and low yields may persist throughout the life of the crop. Common causes of include the use of inferior planting materials, incorrect plant spacing as well as a failure to apply good agronomic practices.

Yield increase estimates through the adoption of CSA tea production practices are difficult to quantify and depend on existing base yields and will depend on adoption of an integrated package, rather than individual components. They will also be location specific, dependent on local agro-climatic conditions, but can be achieved alongside a reduction in costs particularly for inorganic fertiliser and chemical applications in the control of pests and diseases, although an increase in labour will be required. Variation can be expected dependent on agro-climatic conditions, market opportunity and most importantly farmer capacity.

40 Adapted from Vanlauwe B, Desceemaeker K, Giller K et al, 2015. Integrated soil fertility management in SSA: Unravelling local adaptation. Soil, 1, 491-508.

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5.5. Cost Increases and Reductions through Use of CSA Tea Practices

Research indicates that considerable cost savings can be made by adopting CSA practices, mainly by applying less inorganic fertiliser, a 20-100% reduction, as soil health improves through application of manures, composts and mulching materials; and pesticide applications, a 20-100% reduction as integrated pest management methods are utilised. The larger reductions are for speciality teas where organic certification is required and the use of inorganic fertiliser and pesticides is not permitted. There is considerable scientific argument about the pros and cons of this, especially for coffee but likely to be true for tea as well, with argument that use of inorganic fertiliser and pesticides are necessary to attain sustainable yields[41].

The table below**Error! Reference source not found.** quantifies the impact of the CSA practices on tea the a dditional inputs required for the CSA practices as well as their likely costs. These have been determined on a per ha basis and scaled down for the smaller area, these being 0.03, 0.06, 0.12, 0.25, 0.5, 0.75 and one ha.

The table below quantifies the impact of the CSA lending practices, the additional labour requirements in both days and cost per ha, again scaled down for the smaller areas.

Climate smart agricultural practice		% yield increase	Agronomic reasons for benefit
New varieties	1 Plant improved varieties -	20%	Great genetic potential with resistance /tolerance to drought as well as pests and diseases
Integrated soil fertility management	2 Make compost and apply 5 kg to each coffee plant annually together with balanced inorganic fertilisers	20%	Improving soil organic matter content increases soil moisture holding capacity, improves soil health allowing a reduction in time of the need for inorganic fertiliser
Soil and water conservation	3 Construct contour barriers and/or terraces with grass planted on them	25%	Reduced soil erosion and consequential increase in soil fertility, Stabilisation of contour banks and use as mulch material
	4 Cut grass and mulch around coffee trees		Protect the soil against raindrop action, soil erosion and reduce soil temperature
	5 Plant cover crops, where appropriate		as above, but also saves labour and herbicide requirement for weed control
	6 Establish rainwater harvesting structure linked to contours/terraces		Harvest and store rain water to increase soil moisture availability for the crop
Agroforestry	7 Establish trees between the coffee bushes	25%	The provision of shade, windbreaks, mulching, and erosion control
	8 Afforestation, reforestation and establishment of indigenous trees in areas surrounding tea farms. These areas should be given protected status where possible.		
Integrated pest and disease management	9 Use of multiple pest and disease management tactics to prevent economically damaging out-breaks, while reducing risks to human health and the environment	10%	Biological control will help reduce the costs of using purchased pesticides
	Total	100%	

Notes: *1. Although % increases are attributed to each CSA practice, integration/coordination of all practices at the same time is required to derive full impact.*
2. Yields will increase over a period of time from a base of one tonne per ha-1 as soil health is improved, soil organic matter builds and soil conservation measures become effec

Table 8: Quantification of the impact of CSA practice on tea yield levels over time:[42]

41 VAN DER VOSSEN H. A. M.,2005. A Critical Analysis of the Agronomic and Economic Sustainability of Organic Coffee Production. Expl Agric., volume 41, pp. 449–473, Cambridge University Press.

41 Markus Giger , Hanspeter Liniger, Caspar Sauter, Gudrun Schwilch,. 2015. Economic Benefits and Costs of Sustainable Land Management Technologies: An Analysis of WOCAT's Global Data. Land Degrad. Develop. 29: 962–974 (2018). Published online 7 October 2015 in Wiley Online Library DOI: 10.1002/ldr.2429

42 Yield levels in excess of 100% are possible and dependent on the adoption of the packages as a whole rather than the individual components

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Table 9: Quantification of the impact of CSA practice on tea input costs

CSA practices	#	#	units	No. per ha	CSA requirements per ha							USD/ unit	CSA input requirements (USD)						
					Loan 1	Loan 2	Loan 3	Loan 4	Loan 5	Loan 6	Loan 7		Loan 1	Loan 2	Loan 3	Loan 4	Loan 5	Loan 6	Loan 7
					0.03	**0.06**	**0.13**	**0.25**	**0.5**	**0.75**	**1**		**0.03**	**0.06**	**0.13**	**0.25**	**0.5**	**0.75**	**1**
Plant improved tea cultivars on suitable land	1	Seedlings tolerant to adversities of weather (drought, water logging, warm/cold weather conditions) and pests and diseases	Seedlings	13500	422	844	1,688	3,375	6,750	10,125	13,500	**0.1**	42	84	169	338	675	1013	1350
Integrated soil fertility management	2	Improvement of soil organic matter content through applications of compost, tea waste, cattle manure (3-5 tonnes per ha) leading to a reduction in inorganic fertiliser applications	kg	4000	125	250	500	1000	2000	3000	4000	0	0	0	0	0	0	0	0
Soil and water conservation	3	Establish contour terraces/banks planted with grass and/or trees with appropriate measures for safe removal of water (micro-watershed management)	metres	400	13	25	50	100	200	300	400	0	0	0	0	0	0	0	0
	4	Mulching with vegetative matter (such as Napier or Guatemala grass grown on contour terraces)	sq. metres	5000	156	313	625	1,250	2,500	3,750	5,000	0.01	2	3	6	13	25	38	50
	5	Use of green manure and cover crop (such as Crotalaria and Sesbania)	sq. metres	5000	156	313	625	1,250	2,500	3,750	5,000	0.01	2	3	6	13	25	38	50
	6	Rain water harvesting incorporated in the micro-watershed plan	number	4	-	-	-	1	2	3	4	0	0	0	0	0	0	0	0
Agroforestry	7	Establish trees for shade, windbreaks, mulching, and erosion control between trees and on field boundaries	seedlings per unit of land	250	8	16	31	63	125	188	250	0.5	4	8	16	31	63	94	125
	8	Afforestation, reforestation and establishment of indigenous trees in areas surrounding tea farms. These areas should be given protected status where possible.	-	50	2	3	6	13	25	38	50	0.5	1	2	3	6	13	19	25
Integrated pest and disease management	9	Use of multiple pest management tactics to prevent economically damaging out-breaks, while reducing risks to human health and the environment	-	Integrated pest and disease management practices would be initiated from the onset, provided through training rather than setting specific targets.								–	-	–	–	–	–	–	–
												Total	**50**	**100**	**200**	**400**	**800**	**1200**	**1600**

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Table 10: Quantification of the impact of CSA practice on tea labour requirements

CSA practices	#	#	Labour requirement (days)									Labour costs (USD)						
				Loan 1	Loan 2	Loan 3	Loan 4	Loan 5	Loan 6	Loan 7		Loan 1	Loan 2	Loan 3	Loan 4	Loan 5	Loan 6	Loan 7
			Days per ha	**0.03**	**0.06**	**0.13**	**0.25**	**0.5**	**0.75**	**1**	Costs per day	**0.03**	**0.06**	**0.13**	**0.25**	**0.5**	**0.75**	**1**
Plant improved tea cultivars on suitable land	1	Seedlings tolerant to adversities of weather (drought, water logging, warm/cold weather conditions) and pests and diseases	**60**	1.9	3.8	7.5	15	30	45	60	2.5	5	9	19	38	75	113	150
Integrated soil fertility management	2	Improvement of soil organic matter content through applications of compost, tea waste, cattle manure (3-5 tonnes per ha) leading to a reduction in inorganic fertiliser applications	10	0.3	0.6	1.3	3	5	8	10	2.5	0.8	1.6	3	6	13	19	25
Soil and water conservation	3	Establish contour terraces/banks planted with grass and/or trees with appropriate measures for safe removal of water (micro-watershed management)	30	1	2	4	8	15	23	30	2.5	2.3	4.7	9	19	38	56	75
	4	Mulching with vegetative matter (such as Napier or Guatemala grass grown on contour terraces)	2	0.1	0.1	0.3	1	1	2	2	2.5	0.2	0.3	1	1	3	4	5
	5	Use of green manure and cover crop (such as Crotalaria and Sesbania)	5	0.2	0.3	0.6	1	3	4	5	2.5	0.4	0.8	2	3	6	9	13
	6	Rain water harvesting incorporated in the micro-watershed plan	4	0.0	0.0	0.0	1	2	3	4	2.5	0.0	0.0	0	3	5	8	10
Agroforestry	7	Establish trees for shade, windbreaks, mulching, and erosion control between trees and on field boundaries	20	0.6	1.3	2.5	5	10	15	20	2.5	1.6	3.1	6	13	25	38	50
	8	Afforestation, reforestation and establishment of indigenous trees in areas surrounding tea farms. These areas should be given protected status where possible.	5	0.2	0.3	0.6	1	3	4	5	2.5	0.4	0.8	2	3	6	9	13
Integrated pest and disease management	9	Use of multiple pest management tactics to prevent economically damaging out-breaks, while reducing risks to human health and the environment	2	0.1	0.1	0.3	1	1	2	2	2.5	0.2	0.3	1	1	3	4	5
			Total	**4**	**8**	**17**	**34**	**68**	**102**	**136**	**Total**	**10**	**21**	**42**	**86**	**173**	**259**	**345**

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5.6. Mitigation of Crop Loss in the Event of Weather Shock

The risks to tea associated with climate change and associated weather shocks include increased droughts both between and within growing seasons and consequently shortened growing seasons; increased rainfall intensity; increased temperatures and more unpredictable seasons.

These mean that tea yields are likely to become more unpredictable and be reduced. Unfortunately no robust data is available detailing possible yield losses due to adverse weather, although in extreme circumstances 100% losses are likely to be experienced. For instance, during drought in Kenya in 1997 production dropped by 15%. The drought in 2000 was worse and in 2006, Unilever Tea Company temporarily closed three of its eight factories and run others at reduced capacity because as a result of drought[43]. Such events are likely to increase in the future. The CSA lending practices, which give emphasis to improving soil health, are designed to reduce the risks associated with climate change, are designed to reduce such losses but are unlikely to eliminate them.

43 Elias Kiarie Kagira, Sarah Wambui Kimani & Kagwathi Stephen Githii, 2012. Sustainable Methods of Addressing Challenges Facing Small Holder Tea Sector in Kenya: A Supply Chain Management Approach. Journal of Management and Sustainability; Vol. 2, No. 2; 2012. ISSN 1925-4725 E-ISSN 1925-4733

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6. AGRO-CLIMATIC AND MARKET PARAMETERS WITHIN WHICH CSA LENDING CAN BE DEPLOYED

6.1. Introduction

This section provides a brief and concise identification of the quantitative and qualitative parameters in which the credit product can be deployed, which will be dependent on the conditions in which the crop can be profitably grown and sold

6.2. Agro-climatic conditions

Section 2.2 sets out the management conditions where tea flourishes. Growth of tea is temperature-dependent, with tea bushes not growing when temperatures are either too low or too high, regardless of other climatic factors. Ideally the crop requires temperatures from 16-32ºC with an annual rainfall of 1250-1500 mm distributed over 8-9 months with a humidity around 80% most of the time. Optimum pH is 4.5-5.0 on well-drained, permeable, and fertile soils 1-2 metres deep. Most high-quality tea is grown at elevations of up to 1,500 metres above sea level. Although the tea grows more slowly at these altitudes, they acquire a better flavour and command higher prices.

CSA tea lending products can be used in any of the suitable environments especially where tea yields may have declined due to poor management practices and soil degradation. CSA products are specifically intended to build soil health through ISFM practices supported by soil and water conservation and agroforestry practices.

6.3. Market parameters

Tea is one of the world’s most widely consumed beverages, supporting a multibillion-dollar industry spanning a lengthy value chain from farmer to consumer. Demand is growing through Asia, Africa, and Latin America due to rising per capita income levels. World predictions for 2027 indicate a demand for annual production of over eight million tonnes, an increase of more than 30% percent over 2016 production levels. Much of the world’s tea is produced on large tea plantations, with small scale growers making an increasingly important contribution. Globally more than 13 million smallholder farmers and plantation workers produces around five million tonnes of tea.

Many tea companies have well established supply chains directly linked to farmer groups or cooperatives. Under such schemes, some companies manage the entire system from advisory services, procurement, processing to final marketing and in some cases certification. In addition, independent farmers and groups also contribute a significant amount of tea. Certification comes with costs, which will be profitable if there is a market that demands certified tea. To reduce certification costs, individual farmers may either join an existing certification scheme or organise themselves into a new group, especially during postharvest handling.

CSA lending for SSGs could be deployed in all those tea growing areas, where SSGs make an important contribution to total production.

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7. Farmer cost-benefit analysis

7.1. Introduction

The purpose of this section is to present the findings of a generalised cost benefit analysis for tea production under the terms of a climate-smart credit product. The purpose of this is to firstly demonstrate that the terms of a climate-smart credit product will be beneficial for a small scale tea grower, and secondly to provide a cost benefit analysis model template for creation of climate-smart credit products in specific contexts.

7.2. Why undertake cost benefit analysis?

Ecologically sustainable tea production is possible by applying best practices of agronomy and crop protection. These include planting of temperature, drought and disease resistant varieties or clones, improving soil health applying organic and inorganic fertilizers to maintain optimum soil quality and crop nutrient levels, soil and water conservation measures, including using agroforestry to plant trees to reduce crop losses due to biotic stress factors, and using integrated pest management techniques. Full commitment of all stakeholders in the Tea Sector will be required in helping to ensure economic and social sustainability of tea production.

Perceived profitability has been recognised as a key factor in explaining farmers' decisions to adopt or not adopt sustainable land management (SLM) technologies[44]. It was concluded that a wide range of existing SLM practices generate considerable benefits not only for land users, but for other stakeholders as well. However high initial investment costs associated with some practices may constitute a barrier to their adoption; and short-term incentives for land users can help to promote these practices where appropriate.

7.3. Cost benefit analysis assumptions

Many factors in a farmer cost benefit analysis will vary according to location, agro-ecological and economic context, as well as farmer perceptions of the advantages and disadvantages of each. Those variables used to inform this template analysis are summarised in the table below, with a tea farm gate price of US$0.50 per kg for green leaf, this being 25% of the made tea price together with an opportunity cost for labour of US$ 2.50 per day. The tables below set out the variables affecting base-line and CSA output and input prices.

44 Markus Giger, Hanspeter Liniger, Caspar Sauter, Gudrun Schwilch, 2015. Economic benefits and costs of sustainable land management technologies: an analysis of WOCAT's global data. Land Degrad. Develop. 29: 962–974 (2018). Published online 7 October 2015 in Wiley Online Library (wileyonlinelibrary.com) DOI: 10.1002/ldr.2429

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Table 11: Variables affecting the base-line tea production practices

Base case Outputs	**Year**	**Unit**	**No.**	**Value per kg**
Tea green leaf yield (existing tea, no CSA)		kg/ha	5000	0.5
Tea green leaf yields (new planting, no CSA)	% increase on base		30%	0.55
% of mature bush for new plantings	Y1 - Y2	% mature tree	0%	
	Y3	% mature tree	25%	
	Y4	% mature tree	50%	
	Y5	% mature tree	75%	
	Y6 on	% mature tree	100%	

Base case Inputs		**Unit**	**No.**	**Cost (USD)**
Compound fertiliser (mature tea)	Y1-on	50 kg bags/ha	10	30
Compound fertiliser (new plant)	Y1+Y2	50 kg bags/ha	5	30
Compound fertiliser (new plant)	Y3-on	50 kg bags/ha	10	30
Pesticides and herbicides (if used)	Y3-on	litres/ha	15	10

Base case labour requirments			No	USD / day
Land preparation (new tea)	Y1	days/ha	20	2.5
Seedling planting (new tea)	Y1	days/ha	5	
Apply inputs	Y1-on	days/ha	10	
Canopy management (Pruning)	Y1-on	days/ha	20	
Hand weeding	Y1-on	days/ha	30	
Harvesting (Plucking) and loading	Y1	days/1000 kg	20	

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Table 12: Variables affecting the CSA production practices

CSA practice Outputs	Year	Unit	#	Value per kg
No bush replacment, with CSA		% base case	40%	0.6
Bush replacement plus CSA		% base case	100%	0.75
% of mature tree for new plantings	Y1 - Y2	% mature tree	0%	
	Y3	% mature tree	25%	
	Y4	% mature tree	50%	
	Y5	% mature tree	75%	
	Y6 on	% mature tree	100%	

CSA additional input costs	Year	Units	No.	Cost (USD)
Alt 1. Seedlings (full new plant)	Y1	seedlings/ha	13500	0.10
Green manure cover crops (seed)	Y1	kg/ha	5	2.00
Planting grass on contour terraces (plant material	Y1	kg/ha	10	2.00
Agroforestry shade trees (seedlings)	Y1	trees/ha	250	0.20

CSA Input cost savings	Year	Units	No.	Cost (USD)
Inputs (fertiliser and pesticides)	Y2-	% of base case	15%	

CSA additional labour costs	Year	Units	No.	Cost (USD/day)
Alt 1. Plant seedlings (full new plant)	Y1	days/ha	30	2.5
ISFM compost	Y1-on	days/ha	3	
SWC contour terraces	Y1	days/ha	8	
SWC cover crops	Y1	days/ha	3	
SWC grass vegetation	Y1	days/ha	3	
SWC rain water harvesting	Y1	days/ha	4	
Agroforestry trees	Y1	days/ha	25	
Harvesting		days/1000 kg	20	

CSA labour saving over base	Year	Units	No.	Cost (USD)
Input application	Y3-	% of base case	10%	

7.4. Results

The key output of this exercise are two gross margin and farmer cost benefit analysis models for two scenarios of small scale tea growers adopting climate-smart and sustainable land management measures required under the proposed climate-smart credit product. These are

- **Scenario 1:** where the grower has a mature tea garden of traditional varieties but is reluctant to uproot these and plant new varieties. In such circumstances the requirement of any loan would be to adopt all other CSA practices.
- **Scenario 2:** rehabilitating or planting new tea with improved varieties as well as adopting all the other CSA practices.

Results from the analysis are shown in the following two sets of comparative tables. These demonstrate, in generalised cases, the positive financial return to the climate-smart and sustainable land-management measures required under the climate-smart credit product. This conclusion may not apply in all cases, and the model will need to be adapted for specific use-cases.

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Scenario 1: Mature bushes, no tea replacement, but all other CSA practices adopted

Table 11 shows a base situation where the grower has mature trees and is not using CSA practices. This is compared with tea bushes remaining and all other CSA practices being. Results are presented over two years to reflect the additional input required by CSA in the first year and ongoing input in the second and further years.

Table 13: Base case gross margin analysis of mature tea (existing bushes, no CSA practices)

	#		Units	Qty/ha	Price/unit USD	Y1	Y2	Y3	Y4	Y5	Y6 on
Income	Yield		kg/ha			5,000	5,000	5,000	5,000	5,000	5,000
	Value		USD/kg			0.50	0.50	0.50	0.50	0.50	0.50
Gross Income			**USD per ha**			**2,500**	**2,500**	**2,500**	**2,500**	**2,500**	**2,500**
Input costs											
	Fertiliser	26N: 5P: 5K	50 kg bag/ha	10	30	300	300	300	300	300	300
	Herbicides and pesticides		litres per ha	15	10	150	150	150	150	150	150
			sub-total			**450**	**450**	**450**	**450**	**450**	**450**
Margin over input costs before labour costs, loan repayments or levies			**USD / ha**			**2,050**	**2,050**	**2,050**	**2,050**	**2,050**	**2,050**
Labour costs	Apply inputs		days	10	2.50	25	25	25	25	25	25
	Canopy management		days	20	2.50	50	50	50	50	50	50
	Hand weeding		days	30	2.50	75	75	75	75	75	75
	Harvesting and loading		days/1000 kg	20	2.50	250	250	250	250	250	250
			sub-total	**80**		**400**	400	400	400	400	400
Total variable costs			**USD per ha**			**850**	**850**	**850**	**850**	**850**	**850**
Gross Margin over inputs and labour costs before loan repayments or levies			**USD per ha**			**1,650**	**1,650**	**1,650**	**1,650**	**1,650**	**1,650**
Total labour input			**days**			**160**	**160**	**160**	**160**	**160**	**160**
Returns to labour			**USD /ha**			**2,050**	**2,050**	**2,050**	**2,050**	**2,050**	**2,050**
Returns to labour			**USD/ day**			**12.8**	**12.8**	**12.8**	**12.8**	**12.8**	**12.8**

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Table 14: Gross margin analysis of mature tea (existing bushes, all other CSA practices adopted)

			Units	Qty/ha	Price/unit USD	Y1	Y2	Y3	Y4	Y5	Y6 on
Income	Yield		kg/ha			7,000	7,000	7,000	7,000	7,000	7,000
	Value		USD/kg			0.60	0.60	0.60	0.60	0.60	0.60
Gross Income			**USD per ha**			**4,200**	**4,200**	**4,200**	**4,200**	**4,200**	**4,200**
Input costs	Base costs		USD per ha			450	450	450	450	450	450
	Savings on base input costs			15%		-68	-68	-68	-68	-68	-68
	Additional costs										
	Seedlings (10% of tea plants replaced each year)		No.	0	0.10	0	0	0	0	0	0
	SWC (plant grass on contour)		kg/ha	10	2.00	20	20	20	20	20	20
	SWC (cover crops)		kg/ha	5	2.00	10	10	10	10	10	10
	Agroforestry (trees)		seedlings	250	0.20	50	50	50	50	50	50
			sub-total			**463**	**463**	**463**	**463**	**463**	**463**
Margin over input costs before labour costs, loan repayments or levies			**USD / ha**			**3,738**	**3,738**	**3,738**	**3,738**	**3,738**	**3,738**
Labour costs	Base costs		USD/ha			400	400	400	400	400	400
	Savings on base costs		%	10%		-40	-40	-40	-40	-40	-40
	Additional costs										
	ISFM (compost)		days	3	2.5	8	8	8	8	8	8
	SWC (contour/ terraces)	Y1	days	8	2.5	20	-	-	-	-	-
		Y2-	days	0	2.5	-	-	-	-	-	-
	SWC (use grass as mulch)		days	3	2.5	8	8	8	8	8	8
	SWC (cover crop management)		days	3	2.5	8	8	8	8	8	8
	SWC rainwater harvesting	Y1	days	4	2.5	10	-	-	-	-	-
		Y2-	days	1	2.5	-	-	-	-	-	-
	Agroforestry (trees)	Y1	days	25	2.5	63	-	-	-	-	-
		Y2-	days	0	2.5	-	0	0	0	0	0
	Additional harvesting and loading	Y3-	days/1000 kg	20	2.50	100	100	100	100	100	100
			sub-total			**575**	**483**	**483**	**483**	**483**	**483**
Total variable costs			**USD per ha**			**1,038**	**945**	**945**	**945**	**945**	**945**
Gross Margin over inputs and labour costs before loan repayments or levies			**USD per ha**			**3,163**	**3,255**	**3,255**	**3,255**	**3,255**	**3,255**
Total labour input			**days**			**230**	**193**	**193**	**193**	**193**	**193**
Returns to labour			**USD /ha**			**3,738**	**3,738**	**3,738**	**3,738**	**3,738**	**3,738**
Returns to labour			**USD/ day**			**16.3**	**19.4**	**19.4**	**19.4**	**19.4**	**19.4**

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Scenario 2: Rehabilitating or planting new tea with improved varieties and adopting all other CSA practices.

This compares the situation where new varieties are planted firstly without other CSA practices and secondly with all other CSA practices.

In both cases results are shown up to and including the sixth year (Y6), when yields will have stabilised and continue at these levels.

Table 15: Gross margin analysis of new plant tea no CSA practices adopted

	#			Units	Qty/ha	Price/unit USD	Y1	Y2	Y3	Y4	Y5	Y6 on
Income	Yield			kg/ha					1,625	3,250	4,875	6,500
	Value			USD/kg					0.55	0.55	0.55	0.55
Gross Income				**USD per ha**					**894**	**1,788**	**2,681**	**3,575**
Input costs												
	New tea planting	Y1		seedlings	13,500	0.10	1,350	-	-	-	-	-
	Fertiliser	Y1-Y2	26N: 5P: 5K	50 kg bag/ha	5	30.00	150	150	-	-	-	-
	Fertiliser	Y3-on	26N: 5P: 5K	50 kg bag/ha	10	30.00	-	-	300	300	300	300
				sub-total			**1,500**	**150**	**300**	**300**	**300**	**300**
Margin over input costs before labour costs, loan repayments or levies				**USD / ha**			**-1,500**	**-150**	**594**	**1,488**	**2,381**	**3,275**
Labour costs	Land preparation	Y1		days	30	2.50	75	0	0	0	0	0
	Coffee seed planting	Y1		days	10	2.50	25	0	0	0	0	0
	Apply inputs	Y1-		days	10	2.50	25	25	25	25	25	25
	Canopy management	Y1-		days	20	2.50	50	50	50	50	50	50
	Hand weeding and roguing	Y1-		days	30	2.50	75	75	75	75	75	75
	Additional harvesting and loading	Y3-		days/1000 kg	20	2.50	-	-	81	163	244	325
				sub-total			250	150	231	313	394	475
Total variable costs				**USD per ha**			**1,750**	**300**	**531**	**613**	**694**	**775**
Gross Margin over inputs and labour costs before loan repayments or levies							**-1,750**	**-300**	**363**	**1,175**	**1,988**	**2,800**
Total labour input				**days**			**100**	**60**	**93**	**125**	**158**	**190**
Returns to labour				**USD /ha**			**-1,500**	**-150**	**594**	**1,488**	**2,381**	**3,275**
Returns to labour				**USD/ day**			**-15.0**	**-2.5**	**6.4**	**11.9**	**15.1**	**17.2**

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Table 16: Gross margin analysis of new plant tea, with all CSA other practices

			Units	Qty/ha	Price/unit USD	Y1	Y2	Y3	Y4	Y5	Y6 on
Benefits	Yield tea		kg/ha	-	-			2500	5000	7500	10000
	Value		USD/kg	-	-			0.75	0.75	0.75	0.75
	Tea income		**USD**	**-**	**-**			**1875**	**3750**	**5625**	**7500**
Input costs	Base costs		USD/ha			1500	150	300	300	300	300
	Savings on base costs		%	15%		-225	-23	-45	-45	-45	-45
	SWC (plant grass on contour)	Y1	metres	10	2.00	20	-	-	-	-	-
	SWC (cover crops)	Y1	metres	5	2.00	10					
	Agroforestry (trees)	Y1	seedlings	250	0.20	50	-	-	-	-	-
	sub total					**1355**	**128**	**255**	**255**	**255**	**255**
Margin over inputs						**-1355**	**-128**	**1620**	**3495**	**5370**	**7245**
Labour costs	Base costs		USD/ha	-	-	250	150	231	313	394	475
	Savings on base costs		Y3-	10%				-23	-31	-39	-48
	ISFM (compost)	Y1-	days	0	2.5	0	0	0	0	0	0
	SWC (contour/ terraces)	Y1	days	8	2.5	20	-	-	-	-	-
		Y2-	days	0	2.5	-	0	0	0	0	0
	SWC (use grass as mulch)	Y3-	days	2	2.5	-	5	5	5	5	5
	SWC rainwater harvesting	Y1	days	4	2.5	10	-	-	-	-	-
		Y2-	days	0	2.5	-	0	0	0	0	0
	Agroforestry (trees)	Y1	days	25	2.5	63	63	63	63	63	63
		Y3-	days	0	2.5	-	0	0	0	0	0
	Harvesting and loading	Y3-	days/1000 kg	20	2.50	-	-	44	88	131	175
	sub total					**343**	**218**	**319**	**436**	**553**	**670**
Total variable costs per ha			**USD per ha**			**1698**	**345**	**574**	**691**	**808**	**925**
Gross Margin over inputs and labour costs before loan repayments or levies						**-1698**	**-345**	**1301**	**3059**	**4817**	**6575**
Total labour input			**days**			**137**	**87**	**128**	**175**	**221**	**268**
Returns to labour			**USD /ha**			**-1355**	**-128**	**1620**	**3495**	**5370**	**7245**
Returns to labour			**USD/ day**			**-9.9**	**-1.5**	**12.7**	**20.0**	**24.3**	**27.0**

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Benefit cost ratios

Benefit cost ratios for the three scenarios have been compared based on a 10 year horizon and a 10% discount rate.

Table 17: Benefit cost Ratio comparisons of the three scenarios

			Year										
	Scenario	#	**Y1**	**Y2**	**Y3**	**Y4**	**Y5**	**Y6**	**Y7**	**Y8**	**Y9**	**Y10**	**Total**	Benefit cost ratio
No new plant	**Base**	Gross margin	1650	1650	1650	1650	1650	1650	1650	1650	1650	1650	16500	
		Discounted gross margin	1650	1500	1364	1240	1127	1025	931	847	770	700	11152	
	CSA	Gross margin	3163	3255	3255	3255	3255	3255	3255	3255	3255	3255	3255	
		Discounted gross margin	3163	2959	2690	2446	2223	2021	1837	1670	1518	1380	21908	2.0
		B:C ratio	1.9	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	**2.0**	
100% new plant	**Base**	Gross margin	-1750	-300	363	1175	1988	2800	2800	2800	2800	2800	15475	
		Discounted gross margin	-1750	-273	300	883	1357	1739	1581	1437	1306	1187	7767	
	CSA	Gross margin	-1698	-345	1301	3059	4817	6575	6575	6575	6575	6575	40009	
		Discounted gross margin	-1698	-314	1075	2298	3290	4083	3711	3374	3067	2788	21676	2.8
		B:C ratio	1.0	1.2	3.6	2.6	2.4	2.3	2.3	2.3	2.3	2.3	**2.8**	
	Discount rate	10%												

Results are summarised below.

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Table 18: Results summary

Scenario	Yields at tea bush maturity	Gross margin	Labour required at tea bush maturity	Returns to labour at tea bush maturity	Returns to labour at tea bush maturity	Benefit/cost ratio
	kg per ha of green leaf	USD per ha	days per ha	USD per ha	USD per day	over 10 years
Existing tea without other CSA practices	5,000	1,650	160	2,050	13	-
Existing tea with other CSA practices	7,000	3,255	193	3,738	19	2.0
New tea without other CSA practices	6,500	2,800	190	3,275	17	-
New tea with other CSA practices	10,000	6575	268	7245	27	2.8
					Discount rate	10%

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8. LENDER FINANCIAL IMPACT MODEL

8.1. Introduction

The key hypothesis of the climate-smart lending model is that business-as-usual agricultural loans are less profitable than climate-smart loans which incorporate requirements for climate-smart agricultural and land management practices into loan terms. Although this will always need to be assessed on a case-by-case basis, the purpose of this section is to create a generalised lender financial impact model which demonstrates the impact of climate-smart lending on bottom line performance and which can be extrapolated to new use cases.

8.2. Model assumptions

The underlying assumptions of this model are as follows:

- CSA farming practices improve farm yield
- CSA buffer or mitigate losses in the event of weather shock

Farmers take out loans against anticipated post-harvest profit (before input loan repayment), and must repay all loans, including input cost loans, from realised profit In the event of a yield shock, meaning a farmer may not have enough revenue to repay all loans and must therefore allocate available income uniformly across all creditors, resulting in a default experienced by all a farmer's creditors pro rata to the size of the credit issued to the farmer

8.3. Model outputs

Whilst the output of this exercise is the general model template for climate-smart lending for tea, below are the summary outputs of the model showing improved cash position in the event of a 30% yield shock. The model projects both (i) reduced savings on portfolio losses over time, and (ii) savings due to improvements in cost of capital due to the environmental return.

	Loan 1	**Loan 2**	**Loan 3**	**Loan 4**	**Loan 5**	**Loan 6**	**Loan 7**
Yield loss scenario	30%	30%	30%	30%	30%	30%	30%
Number of clients	10,000	10,000	10,000	10,000	10,000	10,000	10,000
Loan book size (US$)	2,989,000	2,989,000	2,989,000	2,989,000	2,989,000	2,989,000	2,989,000
Portfolio loss with no climate-smart lending	**(720,000)**	**(720,000)**	**(720,000)**	**(720,000)**	**(720,000)**	**(720,000)**	**(720,000)**
Portfolio loss with climate-smart lending	**(725,046)**	**(637,369)**	**(567,227)**	**(509,838)**	**(462,014)**	**(421,548)**	**(386,862)**
Savings due to CSA practices	(5,046)	82,631	152,773	210,162	257,986	298,452	333,138
Cost of capital w/o climate-smart lending	20%	20%	20%	20%	20%	20%	20%
Cost of capital w climate-smart lending	8%	8%	8%	8%	8%	8%	8%
Annual interest savings (US$)	358,680.00	358,680.00	358,680.00	358,680.00	358,680.00	358,680.00	358,680.00
Cash position improvement with climate-smart-lending (US$)	**353,634**	**441,311**	**511,453**	**568,842**	**616,666**	**657,132**	**691,818**

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9. Environmental cost benefit analysis

9.1. Introduction

Whilst the output of this exercise is the general model template for climate-smart lending for sugar this section presents the findings of a generalised or template environmental cost benefit analysis for sugar cane production under the terms of the proposed climate-smart credit product. The purpose of this is to (i) demonstrate that the terms of a climate-smart credit product creates valuable environmental benefits, and (ii) to provide a cost benefit analysis model template for creation of climate-smart credit products in specific contexts.

9.2. Model assumptions

Environmental cost benefit analysis estimates market and non-market values for ecosystem goods and services. We do not undertake this valuation, but instead use the accepted practice of value transfer to estimate values created by the implementation of land-use practice required by the climate-smart credit product. These values are obtained from the academic environmental economic research literature, which provides the ability to provide a dynamic set of environmental values in a dollar metric. Where the environmental economic literature does not provide adequate data, we conservatively assign a zero value.

We do not include yield benefits of the required measures to avoid double-counting.

9.3. Model outputs

The table opposite provides the summary outputs for the environmental cost benefit analysis. The net present value (NPV) of implementing the system is nearly US$ 1,365 over 7 years. Please note that as a template, this model uses dummy variables ahead of a site specific analysis, and excludes farmer benefits which would be included in a full public cost benefit structure methodology.

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#	Benefits	Year 0	1	2	3	4	5	6
1	Plant trees	13	13	13	13	13	13	13
2	Rainwater harvesting structures	40	40	40	40	40	40	40
3	Cover crops	12	12	12	12	12	12	12
4	Mulching with crop residues	30	30	30	30	30	30	30
5	Contour terracing	40	40	40	40	40	40	40
6	Manure and compost spreading	24	24	24	24	24	24	24
7	Introducing an Integrated pest management programme	14	14	14	14	14	14	14
	Total Benefits (US$/ha)	173	173	173	173	173	173	173
	Additional Labour Costs	(128.00)	(90.00)	(90.00)	(90.00)	(90.00)	(90.00)	(90.00)
	Loan discounts	14.95	14.95	14.95	14.95	14.95	14.95	14.95
	Total Costs (US$/ha)	**(113.05)**	**(75.05)**	**(75.05)**	**(75.05)**	**(75.05)**	**(75.05)**	**(75.05)**
	Net Benefits (US$/ha)	**285.84**	**247.84**	**247.84**	**247.84**	**247.84**	**247.84**	**247.84**
	Discounted Net Benefits (US$/ha)	**285.8**	**225.3**	**204.8**	**186.2**	**169.3**	**153.9**	**139.9**
	NPV (US$/ha)	**1,365.3**						

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Annex 1: Area and average Tea yields for cane sugar producing countries[45][46]

Country	Area (ha)	%	Total yield (tonnes)	%	Yield (tonnes/ha)
China	2,224,261	27%	2,473,443	20%	1.11
India	621,610	8%	1,325,050	11%	2.13
Kenya	218,538	3%	439,857	4%	2.01
Sri Lanka	233,909	3%	349,699	3%	1.50
Viet Nam	123,188	2%	260,000	2%	2.11
Turkey	82,108	1%	234,000	2%	2.85
Indonesia	113,692	1%	139,362	1%	1.23
Myanmar	88,806	1%	104,743	1%	1.18
Bangladesh	53,856	1%	81,850	1%	1.52
Japan	43,245	1%	81,119	1%	1.88
Argentina	39,600	0%	80,608	1%	2.04
Mozambique	31,190	0%	32,000	0%	1.03
Uganda	29,929	0%	63,633	1%	2.13
Nepal	28,522	0%	24,653	0%	0.86
Malawi	17,849	0%	48,412	0%	2.71
Rwanda	16,889	0%	25,931	0%	1.54
Iran	15,848	0%	100,580	1%	6.35
Tanzania	15,548	0%	36,614	0%	2.35
Burundi	13,836	0%	54,210	0%	3.92
DR Congo	12,000	0%	3,585	0%	0.30
Taiwan	11,511	0%	13,443	0%	1.17
Ethiopia	9,782	0%	10,777	0%	1.10
Thailand	8,819	0%	58,015	0%	6.58
Zimbabwe	7,201	0%	25,434	0%	3.53
Lao	3,990	0%	7,660	0%	1.92
Papua New Guinea	3,952	0%	5,729	0%	1.45
Georgia	2,302	0%	2,300	0%	1.00
Republic of Korea	2,256	0%	2,505	0%	1.11
Cameroon	2,075	0%	5,639	0%	2.72
Malaysia	1,845	0%	10,385	0%	5.63
Peru	1,578	0%	2,177	0%	1.38
Guatemala	1,238	0%	525	0%	0.42
Madagascar	1,206	0%	390	0%	0.32
South Africa	773	0%	1,585	0%	2.05

[45] FAOSTAT, 2017. Statistical data base. Food and Agriculture Organisation of the United Nations, Rome, Italy. http://www.fao.org/faostat/en/#data/PP/ accessed 10th February 2018

[46]

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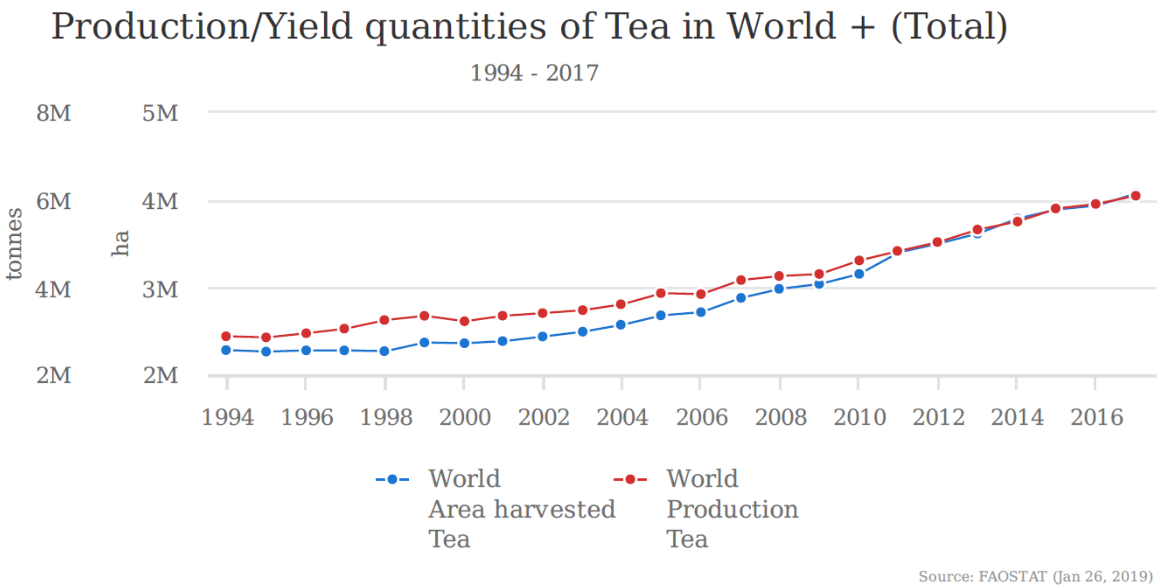
Country	Area (ha)	%	Total yield (tonnes)	%	Yield (tonnes/ha)
Zambia	659	0%	948	0%	1.44
Azerbaijan	642	0%	775	0%	1.21
Mauritius	622	0%	1,379	0%	2.22
Reunion	587	0%	853	0%	1.45
Ecuador	566	0%	1,356	0%	2.40
Russian Federation	470	0%	554	0%	1.18
El Salvador	337	0%	669	0%	1.99
Bolivia	272	0%	1,177	0%	4.33
Brazil	185	0%	459	0%	2.48
Montenegro	124	0%	100	0%	0.81
Mali	93	0%	96	0%	1.03
Colombia	60	0%	149	0%	2.48
Seychelles	28	0%	13	0%	0.46
Total/mean	4,087,597		6,114,441		2.01
				Max	6.58
				Min	0.30



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Annex 2: Tea industry country profiles: Kenya, Rwanda, Uganda

Indonesia

Indonesia, also known as the world's largest palm oil producer, is among the world's top tea producing countries. Despite due to the growth of the more lucrative palm oil business, land devoted to tea plantations is shrinking; Indonesia is still one of the leading producers of tea in the world with half of its tea being exported to the world.

Kenya[47] [48]

Currently tea is the leading export crop with Kenya being the third largest producer of black tea after India and Sri Lanka. The tea production in Kenya reached 473,300 tonnes in 2016, increasing by over 18 percent from the previous year. The sector is divided in to production systems or sub-sectors: the smallholder farmers and the integrated multinationals with their own plantations and factories. Smallholders are integrated by law under the Kenya Tea Development Agency that groups, coordinates, process and market the entire smallholders' production. KTDA account for sixty percent of the total tea production, while the multinational sector and large scale growers account for the remaining forty percent. From one initial factory serving 19,000 growers and only 4,700 ha of tea, today KTDA now has 51 factories spread in 24 districts. The KTDA is the country's biggest private company with over 15,000 employees and 63 tea factories. The factories are owned by 380,000 growers who cultivate 92,800 ha of tea. Although the tea industry has been completely liberalized, government control still exists under the Tea Board of Kenya, whose directors are directly elected by key stakeholders in the industry. Both smallholders and plantations sell most of their tea through the Mombasa Tea Auction, the second biggest tea auction in the world, operated by the East African Tea Trade Association

During recent years, the industry has been facing several challenges including high dependence on a few export markets; low yields of smallholder farmers, high costs of production and lack of credit facilities; low participation of the stallholders in the upper segment of the value chain and in the regulatory bodies; deficient governance and management by the KTDA, with levies paid by the farmers not returning to their benefit; lack of innovation, research and extension service; and weak local marketing and limited value adding.

Rwanda[49]

Tea growing in Rwanda started in 1952 and has contributed immensely to foreign exchange earnings over years. Tea is planted on hillsides at a high altitude between 1,900m and 2,500m, and on well drained marshes at an altitude of between 1,550m and 1,800m. Production of tea has increased steadily, from 60MT of black tea in 1958 to 25,410MT in the year 2015. Most tea processed in Rwanda is black tea (CTC), however green tea and orthodox tea is also processed in small quantities.

Eleven out of the country's 30 districts are active tea producing regions with over 30,000 smallholdings and 60,000 households making a living out of tea farming.. Just like in most tea producing areas in East Africa, tea in Rwanda is grown on large plantations owned by both the government and private sectors. The Rwanda Tea Authority, a government department within the Ministry of Agriculture, brought together the nation's

[47] R.M. Gesimba, M.C. Langat , G. Liu and J.N. Wolukau , 2005. The Tea Industry in Kenya; The Challenges and Positive Developments. Journal of Applied Sciences, 5: 334-336
[48] Monroy L., Mulinge W., Witwer M., 2012. Analysis of incentives and disincentives for tea in Kenya. Technical notes series, MAFAP, FAO, Rome.
[49] Rwanda Development Board. http://rdb.rw/export/export/products-directory/tea-sector/

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growers, blenders, packers, tea co-ops, factory and industrial captains. Most of Rwanda's tea is sold by auction in Mombasa.

The Government has undertaken a number of reforms of the tea sector in recent times including a program to privatize tea estates in order to improve production output and quality levels in the sector. The intended beneficiaries of these programs are farmers and private sector investors, who would benefit from higher productivity, output and income levels, and ultimately, the Government of Rwanda with its balance of payments targets. At the end of 2012, the reform of green leaf pricing came into force, linking green leaf prices to international market prices for 'made tea'. as part of a broader effort to increase exports and investment in the tea sector[50].

Sri Lanka[51][52]

Tea production is one of the main sources of foreign exchange for Sri Lanka contributing over US $1.5 billion in 2013 to the economy of Sri Lanka. It employs, directly or indirectly, over 1 million people. In addition, tea planting by smallholders is the source of employment for thousands whilst it is also the main form of livelihoods for tens of thousands of families. Sri Lanka is the world's fourth-largest producer of tea, the highest production of 350 million kg was recorded in 2016. It was the world's leading exporter of tea with 23% of the total world export, but has since been surpassed by Kenya. The tea industry showed its greatest year-on-year crop shortfall in recent times, as the subsector faces various challenges due to severe weather conditions, coupled with restrictions on fertilizer subsidies. The tea small holders continued to be dominant amongst producers by contributing over 72% of national production.

Despite the tea industry employing a large number of people, poverty levels on plantations have consistently been higher than the national average

Uganda[53]

Tea is Uganda's third most important export earner. The current production in the country is 59,000 tons of made tea per year, earning 104 million USD to the Uganda's economy. Despite its importance to Uganda, the tea sector is faced with a number of constraints that include rising production costs, age of tea bushes, high overhead costs, bad agricultural practices, low labour productivity, climate change and dilapidated infrastructure. These challenges can be addressed through sustainable agriculture. Since the collapse of Tea Research Institute of East Africa, tea research in Uganda has been dormant for three decades, due to limitations in tea experts, finance and infrastructure. Tea research is primarily based on plant improvement, soil nutrient management, pest and disease management, transfer of technology.

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[50] www.worldbank.org/en/programs/competitiveness-policy-impact-evaluation-lab/brief/rwanda-tea-pricing-impact-evaluation
[51]: https://www.bizvibe.com/blog/top-tea-producing-countries/
[52] SRI LANKA TEA BOARD, ANNUAL REPORT, 2015, Sri Lanka Tea Board, 574, Galle Road, Colombo 03 Sri Lanka. www.pureceylontea.com
[53] Ronald Kawooya, Venansio Tumwine, Vivian Namutebi, Charles Mugisa Racheal Naluugo and Robert Kajobe ,2015. Tea research in the year 2015 in Uganda: An overview. African Journal of Agricultural Science and Technology (AJAST), Vol. 3, Issue 12, pp. 505-513. December, 2015. http://www.oceanicjournals.org/ajast ISSN 2311-5882

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ANNEX 3: PESTS AND DISEASES OF TEA, TYPICAL DAMAGE AND ALTERNATIVE TREATMENTS

Pests and diseases	Description of damage	Treatment
Pests		
Helopeltis antonii (tea mosquitoes)	Small adult bugs and hairy orange nymphs suck the sap from fresh leaves and tender shoots; leaves curl up, dry and die.	Collect and destroy bugs during the initial stages; spray Malathion or Lindane
Xyleborus fornicates (stem borer)	Grubs make a typical short-hole on the branches. A serious problem in low and mid elevation areas	Badly affected branches are pruned off. Heptachlor is sprayed on the pruned frames and prunings
Oligonychus coffea (red spider mite)	Infests upper surface of mature leaves.	
Brevipalpus californicus (scarlet mite)	Discolouration of leaves often leads to defoliation.	Tetradifon Dicofol or Ethion.
Calacarus carnatus (purple mite)	Leaves exhibit smoky grey colour.	
Acaphylla theae (pink mite)	Young leaves turn pale and get twisted.	
Polyphagota rosnemus latus (yellow mite)	Attack young shoots, leaves become rough, brittle and corky under the surface.	
Scirtothrips bispinosus (thrips)	Leaf surface becomes uneven and curly, exhibiting parallel lines of feeding marks on either side of the midrib	Phosalone or endosulfon
Meloidogyne javanica, M. incognita (nematodes)	Occur in tea nursery, infested roots develop galls.	Pre heat treatment of soil and application of carbofuran.
Diseases		
Exobasidium vexans (blister blight)	Infects tender leaves and stems and develops translucent spot. Cloudy and wet weather favour infection.	Copper oxychloride spray for pruned field at 3-4 days interval. In the plucking Oxychloride + 210g Nickel chloride in 45lit of water/ha at 7 days interval.
Rosellinia arcuate (black root disease)	Infected roots show black mycelium, white star shaped mycelium between bark and wood and black lead shot like perithecia seen on stems.	Dithane.
Poria hypolateritia (red root disease)	Infected roots exhibit blood red mycelium. It spreads fast and slowly kills the bush.	Uproot and burn infected plants. Soil fumigation with methyl bromide carbon-di-sulphide
Fomes noxius (brown root disease)	Infected root wood turns soft and spongy; it spreads slowly but kills quickly.	Rehabilitate soil with Guatemala grass.

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ANNEX 4: CLIMATE SMART MANAGEMENT PRACTICES FOR TEA PRODUCTION

CSA Practice for Tea			Detail	Benefits for the environment	Benefits for the grower	Challenges for the grower
Plant improved tea cultivars on suitable land	1	Seedlings and cloned plants tolerant to adversities of weather (drought, water logging, warm/cold weather conditions) and pests and diseases	Improved seedlings can be self grown or purchased from an approved nursery. These might be grown from improved seed, cloned or grafted material	Many farmers continue to use traditional and old low yielding old varieties, unsuitable for changing climate conditions	Improved yields, improved quality, better pest and disease control	Sourcing suitable material as it may be unavailable or in short supply
		Selection of lands with suitable ecological growing conditions for new tea cultivation	Careful selection of suitable lands is key to ensuring sustained productivity		Improved productivity	Growers may be unwilling to uproot traditional varietis as it may still give them an income on a low input low output basis
		Removing land ecologically unsuitable for tea from cultivation	Growers may have planted tea on very steep slopes which have become eroded or in watercourses or wetlands where productivity is low			
Integrated soil fertility management	2	Improvement of soil organic matter content through applications of compost, tea waste, cattle manure (3-5 tonnes per ha) leading to a reduction in inorganic fertiliser applications	5 kg of compost should be mixed with the soil when each tea seedlings is planted. Basal fertiliser can be applied at the same time	Many soils are showing signs of decreasing soil health due to low organic matter content	Increased production with a reduced need for inorganic fertiliser	Biomass and labour availability
Soil and water conservation	3	Establish contour terraces/banks planted with grass and/or trees with appropriate measures for safe removal of water (micro-watershed management)	These are especially important when tea is grown on steep or sloping land. The distance between contours will be smaller on steeper fields and will not be necessary of slopes less than 2%.	Designed to reduce soil erosion and increase capture of run-off rainfall during high rainfall intensity events	Increased production through improved soil fertility and soil moisture availability	Plant availability and labour requirement
	4	Mulching with vegetative matter (such as Napier or Guatemala grass grown on contour terraces)	As the grass mature, it can be cut in and used as mulch material. If there is insufficient mulch can be brought from outside the field	Designed to stabilise the contours/terraces as well as providing biomass that can be used for compost, livestock feed and mulch material	Can be used as a mulch as well reducing labour for weeding	Labour availability
	5	Use of green manure and cover crop (such as Crotalaria and Sesbania)	Alternative species of cover crops can be planted between tea plants to provide a ground cover that will suppress weeds. Care must be taken to ensure that the cover crop does not compete with the tea bush	Cover crops will protect against soil erosion, reduce soil temperatures as well as suppressing weed growth, but may compete with the tea for soil moisture in dry periods.	Mulch is available in situ and need to be carried to the field	Labour requirement
	6	Rain water harvesting incorporated in the micro-watershed plan	Opportunity should be used to divert rainfall from run-off areas such as paths and roads to water to storage structures within the coffee field.	Designed to provide opportunity to collect run-off rainfall to increase soil moisture availability during dry periods	Increased production	Labour availability
	7	Irrigation during dry spells	Different means of irrigation can be investigated. Low cost drip systems are effective if water is avalable.	Increase soil mositure during dry spells	Increased productivity	Water, equipment and finance availability
Agroforestry	8	Establish trees for shade, windbreaks, mulching, and erosion control between trees and on field boundaries	A number of different tree species are suitable for planting in coffee fields or on field boundaries designed to provide shade, windbreaks, erosion control and biomass for fuel, fodder. Some fruit trees are also suitable.	Improved micro-climate for coffee production	Biomass availability increased and more sustainable production	Plant and labour availability
	9	Afforestation, reforestation and establishment of indigenous trees in areas surrounding tea farms. These areas should be given protected status where possible.	Such areas are often not suitable for tea production. They may have been abandoned and rehabiliation and/or protection may be required			
Integrated pest and disease management	10		Use of multiple pest management tactics to prevent economically damaging out-breaks,	Reduced risks to human health and the environment	Reduced costs of pest and disease control	Lack of knowledge

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ANNEX 5: THE IMPACT OF CSA TEA PRACTICES[54]

- Improving the resilience of natural resource use (farm level biodiversity, groundwater availability, soil erosion, plant available nutrients, infiltration of water into the soil, soil microbial diversity soil aggregation and soil water holding capacity)
- Reducing the risks associated with climate change (increased temperature, intra-seasonal droughts, in season droughts, shortened growing season, increased rainfall intensity and unpredictable seasons)
- Mitigating the effects of some of the causes of climate change (change in land use, emission from inputs, carbon sequestered in the soil, carbon sequestered in biomass, N20 emissions, and CH4 emissions)
- Increasing productivity (yield, yield variability, labour and income)
- Quantification of the impact of CSA practice on productivity (farmer benefits and costs)

54 Derived from Bell P, Namoi N, Lamanna C, Corner-Dollof C, Girvetz E, Thierfelder C, Rosenstock TS. 2018. A Practical Guide to Climate-Smart Agricultural Technologies in Africa. CCAFS Working Paper no. 224. Wageningen, the Netherlands: CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS). Available online at: www.ccafs.cgiar.org

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1.

1. The impact of tea CSA practices on the resilience of natural resource uses

CSA practice			Farm level biodiversity	Groundwater availability	Soil erosion	Plant available nutrients	Infiltration of water into the soil	Soil microbial diversity	Soil aggregation	Soil water holding capacity
Plant improved tea cultivars on suitable land	1	Seedlings and grafted plants tolerant to adversities of weather (drought, water logging, warm/cold weather conditions) and pests and diseases	-	-	-	-	-	-	-	-
		Selection of lands with suitable growing (ecological) conditions for new tea cultivation	+	+	+	+	+	+	+	+
		Removing land unsuitable for tea from cultivation	+	+	+	+	+	+	+	+
Integrated soil fertility management	2	Improvement of soil organic matter content through applications of compost, tea waste, cattle manure leading to a reduction in inorganic fertiliser applications	-	+	++	+++	+++	+++	+++	+++
Soil and water conservation	3	Establish contour terraces/banks planted with grass and/or trees with appropriate measures for safe removal of water (micro-watershed management)	++	++	+++	++	+++	++	++	++
	4	Mulching with vegetative matter (such as Napier or Guatemala grass grown on contour terraces)	-	-	+++	++	++	++	++	++
	5	Use of green manure and cover crop (such as Crotalaria and Sesbania)	+		+++	++	++	++	++	++
	6	Rain water harvesting incorporated in the micro-watershed plan	-	++	++	+	+++	-	-	+++
	7	Irrigation during dry spells	-	-	+	-	-	+	-	-
Agroforestry	8	Establish trees for shade, windbreaks, mulching, and erosion control between trees and on field boundaries	+++	++	++	+++	+++	++	+	++
	9	Afforestation, reforestation and establishment of indigenous trees in areas surrounding tea farms. These areas should be given protected status where possible.	+++	++	++	+++	+++	+++	+++	++
Integrated pest and disease management	10	Use of multiple pest management tactics to prevent economically damaging out-breaks, while reducing risks to human health and the environment	++	-	-	-	-	+	-	-

* greatest on steeper slopes
** especially on areas without irrigation

-	no effect
+	small effect
++	intermediate effect
+++	large effect

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2. CSA tea practices impact on risks associated with climate change

CSA practice			Increased temperature	Intra-seasonal droughts	Inter-seasonal droughts	Shortened growing season	Increased rainfall intensity	Unpredictable seasons
Plant improved tea cultivars on suitable land	1	Seedlings and grafted plants tolerant to adversities of weather (drought, water logging, warm/cold weather conditions) and pests and diseases	++	++	++	++	-	++
		Selection of lands with suitable growing (ecological) conditions for new tea cultivation	++	++	++	++	-	++
		Removing land unsuitable for tea from cultivation linked to 12	++	++	++	++	++	++
Integrated soil fertility management	2	Improvement of soil organic matter content through applications of compost, tea waste,animal manure leading to a reduction in inorganic fertiliser applications	++	++	++	++	-	++
Soil and water conservation	3	Establish contour terraces/banks planted with grass and/or	-	++	++	++	+++	++
	4	Mulching with vegetative matter (such as Napier or Guatemala grass grown on contour terraces)	+	++	+	++	+++	+
	5	Use of green manure and cover crop (such as Crotalaria and Sesbania)	++	+	+	+	+++	+
	6	Rain water harvesting incorporated in the micro-watershed plan	-	++	++	++	+	++
	7	Irrigation during dry spells	-	+++	+++	+++	-	++
Agroforestry	8	Establish trees for shade, windbreaks, mulching, and erosion control between trees and on field boundaries	+++	++	++	++	+++	+++
	9	Afforestation, reforestation and establishment of indigenous trees in areas surrounding tea farms. These areas should be given protected status where possible.	++	++	++	++	++	++
Integrated pest and disease management	10	Use of multiple pest management tactics to prevent economically damaging out-breaks, while reducing risks to human health and the environment	-	-	-	-	-	-

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-	no effect
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3. The impact of tea CSA practices on mitigation of the factors causing climate change

CSA practice			Change in land use	Emission from inputs	Carbon sequestered in the soil	Carbon sequestered in biomass	N20 emissions	CH4 emissions
Plant improved tea cultivars on suitable land	1	Seedlings and grafted plants tolerant to adversities of weather (drought, water logging, warm/cold weather conditions) and pests and diseases	+	-	-	-	-	-
		Selection of lands with suitable growing (ecological) conditions for new tea cultivation	+++	-	-	-	-	-
		Removing land unsuitable for tea from cultivation	+++	-	-	-	-	-
Integrated soil fertility management	2	Improvement of soil organic matter content through applications of compost, tea waste, cattle manure eading to a reduction in inorganic fertiliser applications	+	-	+++	+++	+	-
Soil and water conservation	3	Establish contour terraces/banks planted with grass and/or trees with appropriate measures for safe removal of water (micro-watershed management)	+	-	++	++	-	-
	4	Mulching with vegetative matter (such as Napier or Guatemala grass grown on contour terraces)	++	-	++	++	++	-
	5	Use of green manure and cover crop (such as Crotalaria and Sesbania)	++	++	+	-	-	-
	6	Rain water harvesting incorporated in the micro-watershed plan	+	-	-	-	-	-
	7	Irrigation during dry spells	+++	-	-	++	-	-
Agroforestry	8	Establish trees for shade, windbreaks, mulching, and erosion control between trees and on field boundaries	+++	-	+++	+++	-	-
	9	Afforestation, reforestation and establishment of indigenous trees in areas surrounding tea farms. These areas should be given protected status where possible.	+	+	++	++	-	-
Integrated pest and disease management	10	Use of multiple pest management tactics to prevent economically damaging out-breaks, while reducing risks to human health and the environment	-	++	-	-	-	-

* greatest on steeper slopes
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-	no effect
+	small effect
++	intermediate effect
+++	large effect

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4. The impact of Tea CSA practices on productivity

Climate smart agricultural practice			Yield	Yield variability	Labour increase	Income increase
Plant improved tea cultivars on suitable land	1	Seedlings and grafted plants tolerant to adversities of weather (drought, water logging, warm/cold weather conditions) and pests and diseases	+++	++	++	+++
		Selection of lands with suitable growing (ecological) conditions for new tea cultivation	+++	+++	+	+++
		Removing land unsuitable for tea from cultivation	+++	+++	+++	+++
Integrated soil fertility management	2	Improvement of soil organic matter content through applications of compost, tea waste and/or cattle manure leading to a reduction in inorganic fertiliser applications	+++	+++	++	+++
Soil and water conservation	3	Establish contour terraces/banks planted with grass and/or trees with appropriate measures for safe removal of water (micro-watershed management)	+++	+++	++	+++
	4	Mulching with vegetative matter (such as Napier or Guatemala grass grown on contour terraces)	+++	+++	++	+++
	5	Use of green manure and cover crop (such as Crotalaria and Sesbania)	++	++	++	++
	6	Rain water harvesting incorporated in the micro-watershed plan	+++	+++	+++	+++
	7	Irrigation during dry spells	+++	+++	+++	+++
Agroforestry	8	Establish trees for shade, windbreaks, mulching, and erosion control between trees and on field boundaries	++	++	++	+++
	9	Afforestation, reforestation and establishment of indigenous trees in areas surrounding tea farms. These areas should be given protected status where possible.	+++	+++	++	++
Integrated pest and disease management	10	Use of multiple pest management tactics to prevent economically damaging out-breaks, while reducing risks to human health and the environment	+++	+++	+	+++

** greatest on steeper slopes*
*** especially on areas without irrigation*

-	*no effect*
+	*small effect*
++	*intermediate effect*
+++	*large effect*

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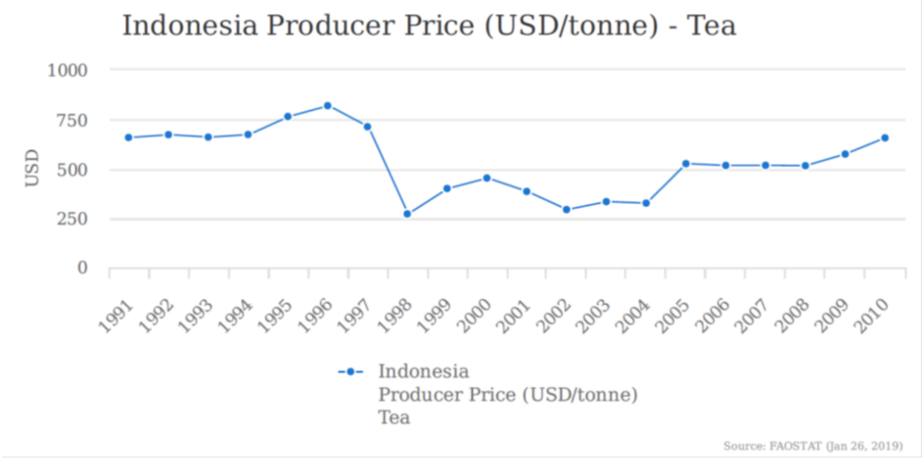
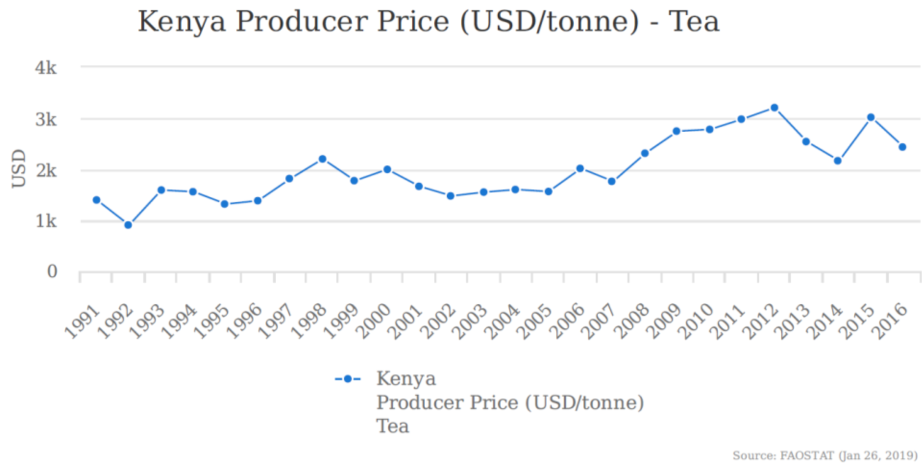
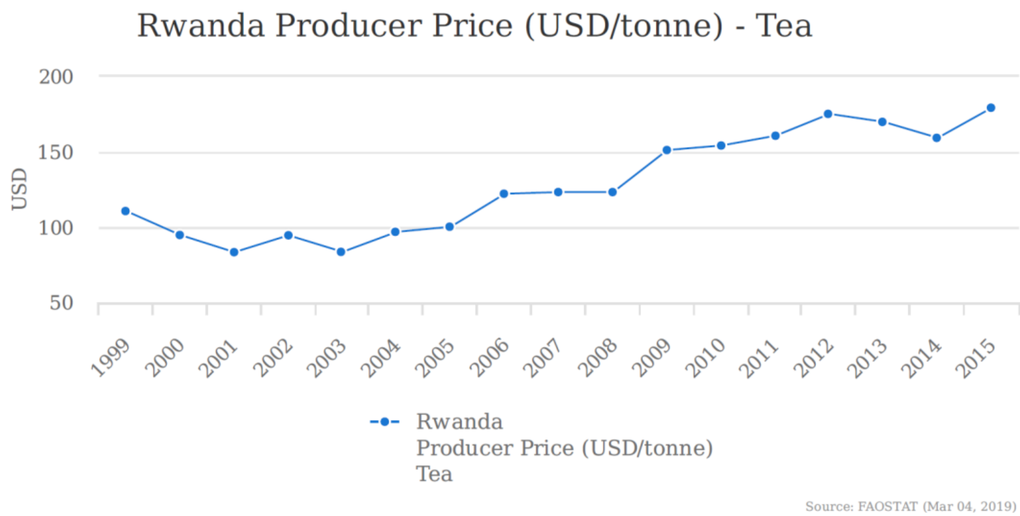
ANNEX 6: TEA PRICES IN SELECTED COUNTRIES[55]







[55] FAOSTAT, 2018. Statistical data base. Food and Agriculture Organisation of the United nations, Rome, Italy. http://www.fao.org/faostat/en/#data/PP/visualize accessed 26th January 2019

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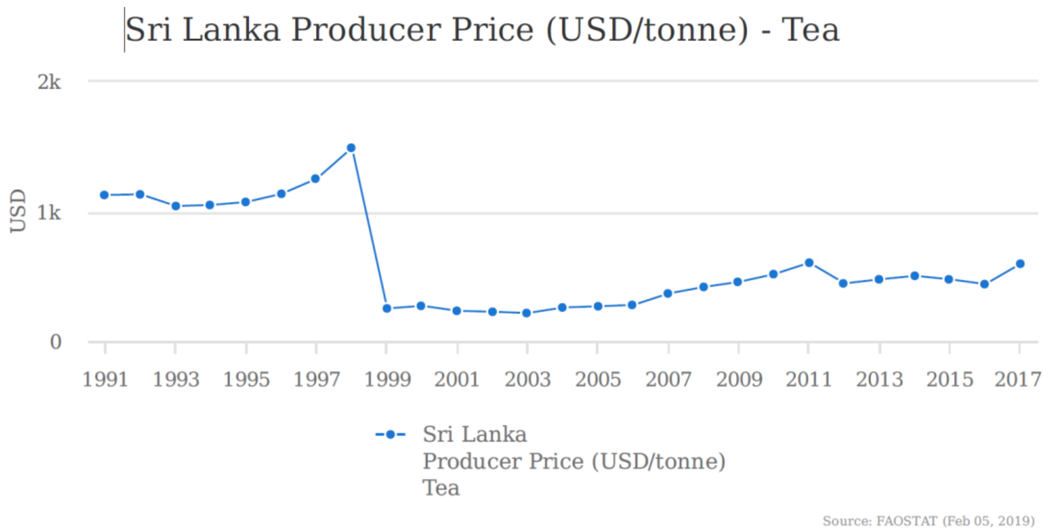

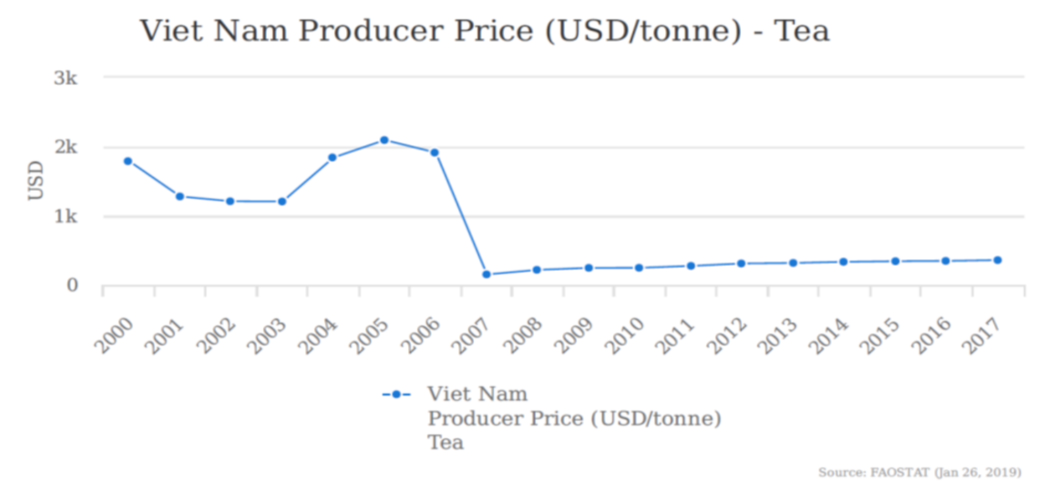

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