TEMPLATE COTTON 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 cotton 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.

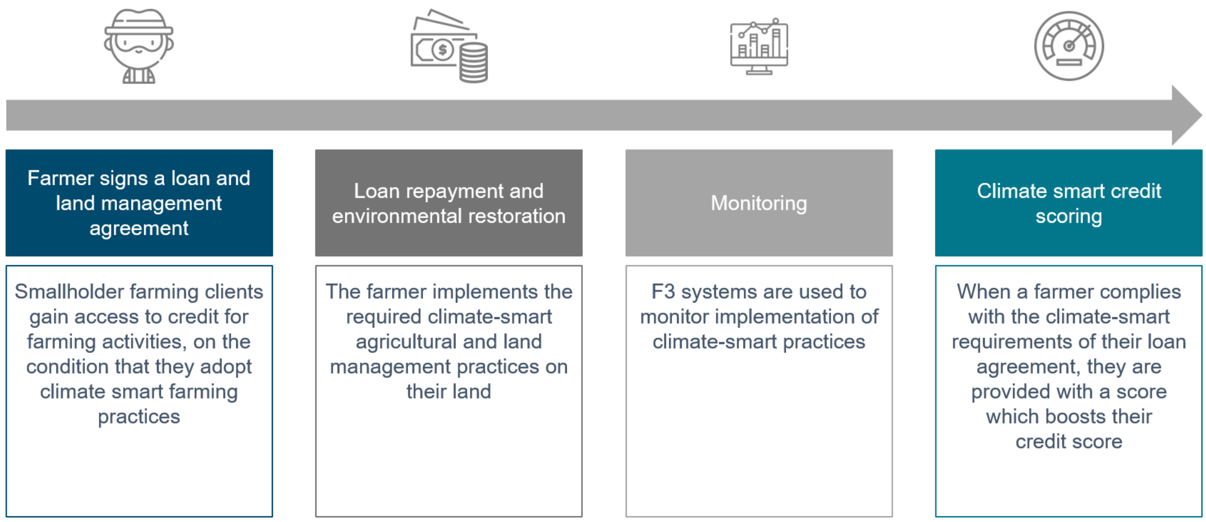

FIGURE 1: CLIMATE-SMART LENDING PROCESS

Cotton (*Gossypium hirsutum*) is grown commercially for both fibre and seed in more than 70 different countries, mostly in the longitudinal band between 37°N and 32°S, primarily in warm semi-arid and arid environments, where it is either grown rain-fed/dry land or with full or supplementary irrigation. Present global production is 45.6 million tons of seed cotton and 27.6 million tons of lint cotton grown on 34 million ha. The cotton industry is worth over US$50 billion a year with five countries – China, India, the USA, Pakistan and Brazil – producing over 90% of the cotton harvested each year. In many countries, cotton is grown on large estates, but across Africa and much of Asia it is almost exclusively grown by smallholder farmers as a cash crop, often alongside subsistence food crops such as maize, sorghum, soya beans or groundnuts, depending on climatic conditions.

Unfortunately, cotton is linked to several environmental issues including extensive usage of agro-chemicals and excessive use of water putting fresh water supplies for local populations at risk. No other plant is more attractive to pests and diseases than cotton, with high chemical use being a worldwide concern for the crop. Most growers use pesticides, although there is growing encouragement for small growers to produce organic cotton. Growing conditions vary according to agro-ecological context. Therefore, the climate-smart credit product requirements presented in this document are generalised, i.e. not tailored to a specific geographical area or agro-ecological context, but which can be adjusted simply according to the context in which it is deployed.

The financial and environmental justification and impact models related to use of the climate-smart credit product, also presented in this document, are similarly generalised. When precise crop and land management requirements are modified according to context, the financial, environmental and agricultural impact models will also be adjusted accordingly.

This document therefore sets out the template climate-smart cotton product and related models which can be easily adapted for use with specific application.

The purpose of this document is not to propose interest rates and appropriate loan tenor for loans for small scale coffee growers, which will be set by the financial institutions which use the F3 Life system. However, where a lender wishes to establish a loan product for cotton growers, the agricultural economic analysis in this document would serve as the basis (only) for the loan product to be developed.

1.2. Climate risks to cotton production

Cotton growers are already feeling the impacts of climate change, with daily and seasonal unpredictability in weather creating challenges to effective cotton production. As climatological and hydrological conditions change, substantial changes in temperature, rainfall and evapo-transpiration are occurring, reducing rainfall for dryland cotton and water availability for irrigated cotton. At the same time heat stress will depress yields, although in other areas increases in temperatures will favour cotton through lengthening of the cotton growing season. Rising temperatures favour the cotton plant development, unless day temperatures exceed 32ºC[1]. Hence cotton is likely to benefit from higher temperatures with new areas being established where it was not previously grown

1.3. Cotton production

Cotton is an important cash crop in many developing countries, significantly boosting export earnings and providing a living to millions of smallholder farmers. However, challenges including limited access to technologies and equipment, insufficient agricultural extension services and depleted natural resources, are driving down the sector's productivity and, ultimately, its profitability. Depending on climate and length of the growing period, cotton needs an annual rainfall of 700-1300 mm to meet its water requirements.

1.4. Cotton processing

Cotton gins are factories that complete the first stage of processing cotton, separating the lint from the seed. The cotton goes through several stages of cleaning to remove trash, sticks, dirt and other foreign matter. After cleaning, the gin removes the seed from the lint. The raw fibre or lint makes up approximately 35% of the seed cotton by weight. This is graded, pressed into bales and transported often for shipping to export markets for further processing.

1.5. Cotton value chain

The cotton value chain involves thousands of companies around the world, including agri-input manufacturer and supply organisations, producers, primary processors, graders, auction houses, traders, clothing manufacturers, wholesalers, retailers and shops. Lint Cotton is used by spinners, the textile industry and clothing and garment makers. The seed is used in the oil industry, for human and livestock feed.

The role of small scale growers is usually restricted to the start of the chain, when they deliver seed cotton to a cotton ginnery. 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 lint cotton.

1.6. Challenges faced by small scale cotton growers

Common challenges to cotton production, especially by small scale growers and across Africa include: (i) limited access to good quality seeds, (ii) decreasing soil fertility, (iii) heavy reliance on insecticides, (iv) increasing production costs, (v) low profitability, (vi) volatile markets and small domestic consumption in countries of production.

1 P. Ton, 2012. Cotton and Climate Change: Impacts and Options to mitigate and adapt. https://www.researchgate.net/publication/258614298_Cotton_and_Climate_Change_Impacts_andOptionsto_mitigate_and_adapt/stats

In view of these challenges, an increasing number of farmers are turning to organic cultivation to reduce production costs and hopefully obtain higher price if they are registered as certified organic producers.

1.7. Climate Smart Agriculture Practices

These include: (i) planting varieties 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 importantly, (v) integrated pest and disease management, through improved scouting and biological control methods.

1.8. The Cotton Climate smart credit product

A number of CSA practices have been identified for the cotton climate-smart credit product. Targets for each are based on those required for one ha and proportionately scaled down for smaller areas. These targets can be adjusted according to locally-specific agro-climatic conditions and based on recommendations from local cotton research organisations or extension agencies.

		0.03ha	0.06ha	0.13ha	0.25ha	0.5ha	0.75ha	1ha
Contractual Requirements	Tree-planting	8 trees	16 trees	32 trees	64 trees	128 trees	190 trees	250 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 Spreading	200kg	300kg	600kg	1,00kg	2,500kg	3,750kg	5,000kg
		Loan 1	**Loan 2**	**Loan 3**	**Loan 4**	**Loan 5**	**Loan 6**	**Loan 7**
Non-Contractual Requirements	Improved varieties (seeds)	2,000	3,000	6,000	13,000	25,000	38,000	50,000
	Integrated Pest Management	Training	Training	Training	Training	Training	Training	Training

FIGURE 2: PRACTICES REQUIRED UNDER THE COTTON CLIMATE-SMART CREDIT PRODUCT

1.9. Present Yield Levels

Over a 20-year period (1997-2018) average yields varied from less than 200 kg per ha in Tanzania up to over 1,750 kg per ha in Australia, with an overall mean of 600 kg per ha and 300 kg per ha in African countries.

1.10. Cotton prices

Annual seed cotton prices have shown a rising if variable trend with highs of USD 284 per tonne in 20102 but declining since then to USD 153 per tonne in 2017. Prices vary greatly between countries often being lower for African countries.

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

Yield increase estimates through the adoption of CSA cotton production practices are difficult to quantify and often depend on existing base yields. They will also be location specific, dependent on local agro-climatic conditions, but can be achieved alongside a gradual 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.

1.12. Farmer cost-benefit analysis

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

- Where the grower is producing cotton using inorganic fertilisers, herbicides, pesticides and fungicides.
- Where the grower is producing organic cotton using no fertiliser or other chemicals.

These demonstrate, in generalised cases, the positive financial return to climate-smart and sustainable land-management measures required under the cotton climate-smart credit product. This conclusion may not apply in all cases, and the model will need to be adapted for specific use-cases. Results are summarised in the Table below:

TABLE 1: RESULTS SUMMARY

	Scenario	Lint cotton yields (Y10) kg per ha	Gross margin (Y10) USD per ha	Labour required (Y10) days per ha	Returns to labour (Y10) USD per ha	Returns to labour (Y10) USD per day	Benefit cost ratio over 10 years
Non organic	Cotton without CSA practices	600	251	57	368	6.5	-
	Cotton with CSA practices	998	998	77	1,190	15.4	2.0
Organic	Cotton without CSA practices	300	214	45	325	7.3	-
	Cotton with CSA pactices	489	438	65	598	9.3	1.2
						Discount rate	10%

1.13. Cotton "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.

TABLE 2: CLIMATE SMART LENDING LENDER CASH POSITIONS

	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$)	3,122,000	3,122,000	3,122,000	3,122,000	3,122,000	3,122,000	3,122,000
Portfolio loss with no climate-smart lending	**(2,074,800)**	**(2,074,800)**	**(2,074,800)**	**(2,074,800)**	**(2,074,800)**	**(2,074,800)**	**(2,074,800)**
Portfolio loss with climate-smart lending	**(2,534,767)**	**(2,245,693)**	**(2,014,434)**	**(1,825,221)**	**(1,667,545)**	**(1,534,126)**	**(1,419,767)**
Savings due to CSA practices	(459,967)	(170,893)	60,366	249,579	407,255	540,674	655,033
Cost of capital w/o climate-smart lending	20%	20%	20%	20%	20%	20%	20%
Cost of capital w climate-smart lending	8%	8%	8%	8%	8%	8%	8%
Annual interest savings (US$)	374,640.00	374,640.00	374,640.00	374,640.00	374,640.00	374,640.00	374,640.00
Cash position improvement with climate-smart-lending (US$)	**(85,327)**	**203,747**	**435,006**	**624,219**	**781,895**	**915,314**	**1,029,673**

1.14. Cotton "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 624 over 7 years.

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2. An introduction to cotton and climate risks to production

2.1. Introduction

Cotton is grown commercially in more than 70 different countries, mostly in the longitudinal band between 37°N and 32°S, primarily in warm semi-arid and arid environments, where it is either grown rain-fed/dry land or with full or supplementary irrigation. The crop requires about 200 days of sunshine in the season to flourish and bear fruit with yields being determined by temperature and precipitation during the crop's vegetative growing period. It takes approximately six months from planting to harvest, after which cotton seed and fibre are separated in a ginnery. Raw lint cotton separated from the seed is pressed into large bales and sold to spinning mills for yarn manufacture from where it starts along the textile chain from spinning mill to finished garment. Seed is used primarily for oil extraction and livestock feed.

The cotton industry is worth over US$50 billion a year with five countries – China, India, the USA, Pakistan and Brazil – producing over 90% of the roughly 26 million tonnes of seed cotton harvested in each year. In many countries, cotton is grown on large estates, but across Africa and much of Asia it is almost exclusively grown by smallholder farmers as a cash crop, often alongside subsistence food crops such as maize, sorghum, soya beans or groundnuts, depending on climatic conditions. Irrigation, often used on large estates, is rare especially across Africa, where farmers largely rely on dryland production. Cotton provides employment to large numbers of people and supports the growth of several ancillary industries. Globally there are more than xx million smallholder farmers. It is a major foreign currency earning commodity for most cotton-producing countries. However, challenges associated with climate change and crop management threaten cotton production in all the major growing regions.

Cotton is grown for both fibre and seed. The most recent data available from FAO shows that present world production is 45.6 million tons of seed cotton and 27.6 million tons of lint cotton. Little current information is presently available on the area grown but this was estimated by FAO in 2013 to be about 34 million ha. Cotton is grown on large estates in the USA, Brazil and Australia is machine harvested, whereas most small growers across Africa and Indian harvesting mainly by hand. Although labour intensive, the major benefit of hand-picked cotton is higher grade being cleaner without soil, leaves, twigs, etc. associated with machine harvesting. Another benefit for hand picking, unlike machine harvest, is that no defoliant is required and consequently there is less chemical contamination.

Unfortunately, cotton is linked to several environmental issues including extensive usage of agro-chemicals and excessive use of water putting fresh water supplies for local populations at risk. No other plant is more attractive to pests and diseases than cotton, with high chemical use being a worldwide concern for the crop. Most growers use pesticides, although there is growing encouragement for small growers to produce organic cotton. Unfortunately cotton pests show increasing resistance to pesticides use and many countries have adopted genetically modified (GM) cotton to protect against some pests. For instance over 90% of cotton production in the USA, India, and China is now GM. In Sub-Saharan Africa, GM cotton is grown in South Africa, Sudan and Burkina Faso, but other countries have made a commitment not to allow GM cotton to be grown2.

A number of different initiatives are working to reduce agro-chemical use and support organic cotton. For instance Fairtrade works with farmers who've formed small producer organisations or and independent cooperatives in India and SSA notably in West Africa (Mali, Senegal, Cameroon and Burkina Faso) in producing Fairtrade certified cotton. This includes work with farmers to stop or reduce the usage of agrochemicals, introducing standards to protect farmers' health and safety and

2 https://www.cottonmadeinafrica.org/en/about-us/african-cotton

ban GM cotton. It also encourages cotton farmers to protect the natural environment and support adaptation to changing climate pattern.

2.2. Climate risks to cotton production

Cotton growers are already feeling the impacts of climate change, with daily and seasonal unpredictability in weather creating challenges to effective cotton production. As climatological and hydrological conditions change, substantial changes in temperature, rainfall and evapo-transpiration are occurring, reducing rainfall for dryland cotton and water availability for irrigated cotton. At the same time heat stress will depress yields, although in other areas increases in temperatures will favour cotton through lengthening of the cotton growing season. Rising temperatures favour cotton plant development, unless day temperatures exceed 32ºC[3]. Hence cotton is likely to benefit from higher temperatures with new areas being established where it was not previously grown

Although cotton has resilience to high temperature and drought due to its deep tap root, the crop is particularly sensitive to soil moisture availability, particularly during flowering and boll formation. Increased annual rainfall variability is predicted in many cotton growing areas. This includes both inter and intra-season droughts and heavy rainfall events leading to increased rainfall run-off, soil erosion, water-logged conditions and flooding. Hence production in areas presently suitable for cotton could decrease due to reduced rainfall and shortened seasons. At the same time new areas in more humid zones are likely to become suitable. Although the cotton plant can make limited adjustments to changes in climatic conditions, plant stress caused by either drought or waterlogged conditions will result in the loss of buds, flowers and bolls and therefore yield. Although cotton's vertical tap root provides resilience against spells of drought, it makes the crop vulnerable to water-logging.

With regards irrigated cotton, approximately 50% of production occurs in areas where cotton could not normally be grown under dryland conditions. This makes cotton particularly vulnerable to the availability of water for irrigation. With regards insect pests, these are expected to adapt to climate change through their capacity to adapt their body temperature to the temperature of the environment. Hence the pests currently plaguing cotton are expected to continue to thrive in changing environmental conditions.

Africa is the smallest contributor to global greenhouse gas emissions among the continents, but the most vulnerable to the impacts of climate change. The effects will not be limited to a rising average temperature and changing rainfall patterns, but also to increasing severity and frequency in droughts, heat stress and floods[4].

3 P. Ton, 2012. Cotton and Climate Change: Impacts and Options to mitigate and adapt. https://www.researchgate.net/publication/258614298_Cotton_and_Climate_Change_Impacts_andOptionsto_mitigate_and_adapt/stats

4 Emilio J.Gonzalez-Sanchez, Oscar Veroz-Gonzalez, Gordon Conway, Manuel Moreno-Garcia, Amir Kassam, Saidi Mkomwag, Rafaela Ordoñez-Fernandez, Paula Triviño-Tarradas, RosaCarbonell-Bojollo, 2019. Meta-analysis on carbon sequestration through Conservation Agriculture in Africa. Soil and Tillage Research Volume 190, July 2019, Pages 22-30. https://www.sciencedirect.com/science/article/pii/S0167198718313953?via%3Dihub

3. CSA Cotton crop and land management requirements

3.1. Cotton production

Cotton (*Gossypium hirsutum*) is an important cash crop in many developing countries, significantly boosting export earnings and providing a living to millions of smallholder farmers. However, challenges including limited access to technologies and equipment, insufficient agricultural extension services and depleted natural resources, are driving down the sector's productivity and, ultimately, its profitability[5].

Key stages in cotton production and a description of each provides the context in which the cotton credit product has been developed.

Stage	Description[6,7]
Agro-environment	Cotton is sensitive to temperature, with cool nights and low daytime temperatures resulting in vegetative growth with few fruiting branches. The crop is very sensitive to frost with a minimum of 200 frost-free days being required to reach maturity. The length of the total growing period is 150-180 days, with 50-85 days being required from planting to first bud formation, 25-30 days for flower formation and 50-60 days from flower opening to mature boll. Cotton is a short-day plant although day-neutral varieties exist, with the effect of day length on flowering being influenced by temperature. Germination is optimum at temperatures of 18-30°C, with a minimum of 14°C and a maximum of 40°C. Delayed germination exposes seeds to fungus infections in the soil. For early vegetative growth, temperature must exceed 20°C with 30°C being desirable. For bud formation and flowering, daytime temperature should be higher than 20°C and night temperature higher than 12°C, but not exceeding 40°C and 27°C respectively. Temperatures between 27 and 32°C are optimum for boll development and maturation but above 38°C yields are reduced. Depending on climate and length of the growing period, cotton needs some 700-1300 mm to meet its water requirements. In the early vegetative period, crop water requirements are low and high during the flowering period, when leaf area is at its maximum. Later in the growing period the requirements decline. The crop is extensively grown under rainfed conditions, although heavy rainfall can cause lodging. Continuous rain during flowering and boll opening will impair pollination and reduce fibre quality. Heavy rainfall during flowering causes flower buds and young bolls to fall. Strong and/or cold winds seriously affect the delicate young seedlings and at maturity will blow away fibre from opened bolls and cause soiling of the fibre with dust.

5 http://www.fao.org/agriculture/ippm/projects/regional/gcp-raf-482-ec/en/
6 FAOSTAT, 2013. http://www.fao.org/land-water/databases-and-software/crop-information/cotton/en/
7 Cotton Research and Development Corporation, 2018. Australian CottonProduction Manual, 2018. www.cottoninfo.com.au

Stage	Description[67]
Varieties:	Over the last decade cotton varieties have been developed with new features with improved fibre quality, disease resistance, maturity and regional adaptability, requiring less water and/or drought tolerant. The use of GM cotton is a key component of Integrated Pest Management (IPM) in a number of countries. It has made a significant contribution to the dramatic reduction in insecticides where used, up to 85% in Australia over the last decade[8]. Across the world, GM varieties now account for 21% of world cotton area. Apart from a reduction in pesticides, other claimed benefits include: increased populations of beneficial insects and wildlife in cotton fields reduced pesticide run off improved farm worker and neighbour safety a decrease in fuel usage improved soil quality reduced production costs increased yield further opportunities to grow cotton in areas of high pest infestation
Land preparation and planting	This should be undertaken well before planting done ideally incorporating green manure or animal manure. It should also ensure that weeds are substantially removed to prevent excessive growth of weeds during the early phases of the cotton crop, when the crop is very susceptible to weeds. Planting should be done as soon as the rainy season begins to ensure that seeds get adequate moisture for germination and growth. The crop can be planted on flat rows or ridges. Ridges are better on soils that are difficult to drain, and in regions with little rainfall, as this helps to conserve water under dry conditions and aid drainage under wet conditions. In small-holder cotton production, cotton planting is done by hand and about 3 to 4 seeds are planted per hole in flat rows or ridges. Thinning is done when the plants are 6 to 10 cm high, leaving the strongest two plants per hill. Optimum spacing ranges from 20 to 50 cm within rows and 60 to 90 cm between rows, with one or two plants per hill.

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Stage	Description[67]
Growth	Cotton is a perennial shrub that will reaches a height of 3.5 metres. Commercially it is grown as an annual crop reaching a height of about 1.2 metres. It takes about four to 14 days for seedlings to appear after planting, depending on temperature and soil moisture level. The cotton seedling grows into a young plant, sending down a long taproot to find water and nutrients. This taproot can grow as deep as 1.5 metres. Plant spacing normally varies between 50-100 x 30-50 cm. The first flower buds (called squares) appear within about 35 days. As the squares develop, the bud swells and begins to push through the bracts until it opens into an attractive flower. This happens after a further 25 days, when the first creamy-white, hibiscus-like flowers appear. The cotton plant continues to produce squares and flowers for about half the growing season. The last productive flower opens some three to four months after planting. Cotton flowers stay open for 24 hours. During this short time the flower must be fertilised to produce the seed that has the cotton fibre or lint attached to it. The fruit, called bolls, and then develop. The boll is considered a fruit because it contains seeds. Bolls reach full size about 25 days and after a further 35- 55 days, naturally burst along the boll's segments and dry out, exposing the underlying cotton segments, which hold the locks of cotton. When most of the bolls are open the crop is ready to pick. An average boll will contain nearly 500,000 fibres of cotton and each plant may bear 15-20 bolls. The growing season from emergence to picking is about 180 days.
Weed management	There are many different types of weeds found in cotton areas, and they vary between the regions. They reduce the productivity of the cotton plants by competing for nutrients, water and sometimes light. They can also reduce the quality and yield of the cotton by providing a haven for pests and diseases. During harvest, weeds can contaminate the crop, meaning extra time and cost is required in cleaning and processing. Weeds can also cause contamination of the cotton and discolouration of the cotton lint. Weed management strategies include proper crop rotation, timely soil cultivation, proper sowing density and cultivation techniques to remove the weeds. Control methods include hand hoeing, which is labour intensive, cultivation by tractor or use of oxen or herbicides. Once the cotton crop has developed a dense stand, weeds usually will remain below a level where they significantly compete with the main crop. Some weeds are important hosts for beneficial insects, or act as trap crops distracting pests from the cotton plant. Careful observation of weed populations and the use of shallow soil cultivation combined with selective hand weeding usually is enough to keep the weeds under control. Weeds should be controlled well during land preparation before sowing. In about 6 weeks after sowing, all emerging weeds that emerge should be removed. This helps to reduce later weeding requirements and reduces weed competition with the young cotton plants. Ridging is normally done once the cotton plants are about 0.5 to 1 meter high and this can be combined with a last weeding session. A positive side effect of ridging is the reduction of water evaporation.

Stage	Description[67]
Soil fertility practices	Cotton is grown on a wide range of soils but medium and heavy textured, deep soils with good water holding characteristics are preferred. Acid or dense subsoils limit root penetration. The pH range is 5.5-8 with 7-8 regarded as optimum. Ideal soils are clay-rich, vertisols (also called 'black cotton soils'). These ensure that the cotton tap roots can penetrate up to three meters and hence able to sustain short drought periods. Cotton is also grown on less ideal shallow, sandy soils, both under irrigated and rainfed conditions. This will, however, require well-adapted varieties and solid management practices. Decisions about soil fertility practices require consideration of a range of factors including crop rotations, crop residue management and irrigation. Ideally it requires knowledge of soil nutrient status through soil analysis to determine crop nutrient requirement (type, rate, application, frequency and timing). The fertilizer requirements of cotton under irrigation are 100- 180 kg/ha N, 20- 60 kg/ha P and 50- 80 kg/ha K and about half this under dryland conditions. Two-thirds of nutrients are taken up during the first 60 day growing period. Nitrogen should be readily available at the start of the growing season with normally two applications given, one after planting and the other prior to flowering. P and K are applied before planting.

Stage	Description[67]
Plant Protection	*Pests:* Healthy cotton crops are very attractive to insects throughout their growing period with over 100 different types of pests attacking the crop. This makes crop protection an important part of cotton production. The main insects, requiring control in most regions include: Heliothis caterpillar or bollworm (*Helicoverpa punctigera* or *Helicoverpa armigera*) Green mirid (*Creontiades dilutes*) Mite (*Tetranychus urticae*) Cotton aphid (*Aphis gossypii*) Whitefly (*Bemisia tabaci*) There are many methods used to control insects to ensure high yields and good quality. Integrated Pest Management (IPM) is widely recognised as best practice. Methods used include: Crop rotation to kill the bollworm pupae living in the soil Ploughing the field after harvesting to destroy the bollworm pupae, although this does conflict with reduced or no tillage associated conservation agriculture Keeping non-crop areas free from weeds, volunteer cotton and other pest host crops Regular monitoring of insect populations and crop damage Encouraging beneficial insects, such as ladybirds, spiders, wasps and ants, to eat the pests Biological sprays containing viruses or the naturally occurring soil bacterium - Bacillus thuringiensis (Bt) that produces proteins toxic to bollworm Alternating pesticides to reduce the chance of pesticide resistance Management of crops to promote early maturity and harvesting Use of Bt GM cotton that is resistant to bollworm In Australia, a combination of these has seen a reduction in insecticide use of 87% since 2003, with some cotton crops presently not being sprayed at all. *Disease.* Different diseases attack different parts of the cotton plant — the leaves, stem, bolls and roots. Disease can cause the plant to lose flower buds and bolls, resulting in no cotton being produced. The most serious include: bacterial blight causing dark green angular spots on the underside of the leaf and young developing bolls; fusarium and verticillium wilt that infects the root system blocking the plant's ability to take up water. The main means of combating disease include rotations or fallows, resistant / tolerant cotton varieties, and fungicide seed dressing to protect the plant during its early days in the soil.
Harvesting	Once the cotton crop has matured and ripened, it is ready for harvesting. In developing countries cotton picking is commonly undertaken by hand, elsewhere it is largely mechanically harvested, after treatment with a defoliant. This

Stage	Description[67]
	enables the grower to hasten the opening of the cotton bolls which can then be picked in a short period of time. It is essential that the crop is harvested before weather and rain can damage or ruin its quality and reduce yield.
Yields	A good yield of cotton crop under irrigation is 4- 5 tonnes per ha of seed cotton, some 35% being lint. In general, the boll size and seed index (weight per 100 seeds) increase under good soil moisture conditions with the ratio of lint to seed decreasing under dry conditions. Under dryland conditions yields are often less than one tonne of seed cotton per ha. However, if only one of the favourable conditions is lacking, yields will be drastically reduced.
Ginning	Cotton gins are factories that complete the first stage of processing cotton, separating the lint from the seed. Seed cotton is delivered to the gin in bales. Gins are usually located in cotton areas to avoid costly transport. Cotton must be ginned at 5% moisture level. It is either dried, if too wet or moisture added, if too dry. Next, the cotton goes through several stages of cleaning remove trash, sticks, dirt and other foreign matter. After cleaning, the gin removes the seed from the lint. The raw fibre, now called lint, is pressed into bales weighing about 227 kg under high pressure. Samples are taken from each for grading and the bales are wrapped to protect the lint. They are now ready for transport often for shipping to export markets. Lint makes up approximately 35% of the seed cotton by weight. Once separated it is compacted into bales for easy transport, often directly to ports for export for further processing. Seeds comprise about 55% of seed cotton, being about 35% oil and 35% protein. However severe water deficit during growth will reduce oil and protein percentages. Seed is used for a variety of products including oil, plastics, livestock feed, cosmetics and margarine, as well as seed for the next crop. The remaining 10% of the seed cotton is largely waste, although it can be used in ethanol production or in products for cleaning oil spills or as an organic fertiliser.
Grades	The traditional method of grading cotton quality involves using specially trained ‘classers’ who manually examine the cotton fibres. This testing involves the classer taking a sample from each bale of cotton and assessing it by: Colour (bright or dull, white or grey) Trash content (the amount of stalk, leaf or dirt) Character (whether the sample has a smooth or lumpy appearance) Staple (length of fibre) Strength of the fibres Manual classers still largely determine the leaf, extraneous matter and preparation grades of cotton. At the end of the grading process each bale of cotton carries a grading description. This decides whether the cotton is sold for a higher or lower price.

Stage	Description[67]
Organic cotton	Organic cotton is usually defined as cotton that is grown without the use of inorganic chemicals such as pesticides, fertilisers, or defoliants and is grown from non GM seed. Organic cotton is certified organic by bodies in individual countries. Organic cotton textiles can also be manufactured according to organic fibre processing guidelines, although this varies according by the country in which the clothing is manufactured. Countries using GM varieties argue that when cotton production is combined with Integrated Pest Management (IPM) and biological pest control, it requires fewer chemicals and is consequently less harmful to both people and the environment. It is also argued that the cost of organic cotton production can be higher with consumers often unprepared to pay more for organic cotton. This means that the costs are born by the grower, making it a less profitable option. Organic cotton accounts for approximately 0.2% of global cotton production, the bulk of which comes from sub Saharan Africa and countries in the Middle East and South East Asia.

3.2. Cotton value chain

The cotton 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 seed cotton to a cotton ginnery. 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 lint cotton. A typical cotton 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 3: TYPICAL COTTON VALUE CHAIN

Improved varieties, land management & agronomic practices	**Agri-Input acquisition & production advice**	**Seed cotton production**	**Transport and Primary processing**	**Secondary processing** (Lint and seed)	**Marketing and consumption**
– Researchers	**Production advice** – Extension agents (Govt & NGO) – Grower Associations – Cooperatives – Other farmers **Cotton seed production** – Research stations – Seed producers **Fertilisers / pesticides** – Agri-input producers – Agro-dealers – Coops **Production credit** – Buyer credit (cotton ginneries) – Micro-finance institutions, NGOs, Coops – Banks, Agri-banks	– Large Scale Farmers – Small scale growers – Community organisations – Cooperatives – Estate owning companies	**Transport** – Transporters – Farmers' groups or cooperatives – Cotton ginnery – Collectors/traders **Initial processing** – Ginnery owning companies – Cooperatives – State enterprises	**Lint Cotton** – Spinners – Textile industry – Clothing and garment makers – Exporters **Seed** – Oil industry – Human consumption – Livestock feed – Exporters	– Wholesalers – Supermarkets – Small retailers – Consumers

Most cotton farmers in developing countries are small-holder farmers and growing less than 2 hectares of cotton. According to a recent survey[9] in Cameroon, the average cotton farm is 1.21ha, making extension services, as well as the collection of seed cotton more difficult and costly for gin operating cotton companies. They compete with fully-industrialised production and processing systems in Australia, USA, Brazil and elsewhere, which grow cotton on farms of more than 500 hectares. However some larger cotton utilising companies have well established supply chains linked to farmer groups or cooperatives. Under such schemes, they often manage the entire system from advisory services, procurement, processing to export and final marketing and in some cases fair trade or organic certification, which can be profitable when the market demands certified cotton.

3.3. Challenges faced by small scale cotton growers

While the smallholder cotton sector has exponentially increased its role in cotton production, this has often been due to an expansion in the area grown rather than an increase in land productivity.

9 Nicolas Gergely, 2009. The Cotton Sector of Cameroon, Africa Region Working Paper Series No. 126.

Common challenges to cotton production10, more especially across Africa include:

- Limited access to good quality seeds - Breeding of varieties specifically suitable for sustainable agriculture.
- Decreasing soil fertility - Many cotton farmers are faced with declining soil fertility. With increasing prices for inorganic fertilisers, a growing number of farmers started using the fertiliser designed for cotton on food crops, rather than their cotton.
- Heavy reliance on insecticides - Cotton production is often dominated by mono-cropping systems, which consume about 19 % of all insecticides used in agriculture worldwide. The high costs, as well as the health risks, are key concerns.
- Increasing production costs - Costs for nitrogen fertilizers, chemical pesticides, irrigation and labour have all increased in the last years. If this factor is matched by low cotton prices on the markets, then the cotton producers hardly make any profit. Unstable cotton prices are very common, as they react to small changes on the global market.
- Low profitability - sometimes low yields are insufficient to pay for the inputs let alone personal needs.
- Volatile markets- Large price fluctuations have led to economic losses, particularly when market information is not available. Oversupply can lead very low prices, just as undersupply can lead to high prices.
- Small domestic markets - with most produce being exported.

In view of these challenges, an increasing number of farmers are often forced to turn to organic cultivation to reduce production costs and hopefully obtain higher price if they are registered as certified organic producers.

Improved agronomic production practices are urgently required11. Unfortunately SSGs often have limited information on improved agronomic practices and market prices, and lack the finance to purchase the necessary agricultural inputs to improve productivity12. Other challenges faced by SSGs include deficient transport infrastructure, delayed payments, an increase in pests and diseases and the high costs of cotton production, which many farmers cannot afford.

It is however important to take into account socially responsible and sustainable cotton production practices promoted by some NGOs and multinational companies. For instance “Fair Trade” and “Organic cotton” certification play a positive role in raising SSGs incomes and ensuring sustainable production[13][14].

3.4. Climate Smart Agriculture strategies for cotton growers

10 FiBL, 2011. African Organic Agriculture Cotton Training Manual. Edited by Gilles Weidmann and Lukas Kilcher. Research Institute of Organic Agriculture FiBL, Frick. Research Institute of Organic Agriculture FiBL, Switzerland, www.fibl.org. ISBN 978-3-03736-197-9
11 Monroy L., Mulinge W., Witwer M., 2012. Analysis of incentives and disincentives for cotton in Kenya. Technical notes series, Monitoring African Food and Agricultural Policies project, Food and Agriculture Organization of the United Nations, Rome.
12 Ibid
13 Faitrade, 2019. Fairtrade Impact for Small-scale Cotton Farmers and workers https://www.fairtrade.net/products/cotton.html accessed 15 February 2019.
14Reiko Enomoto, 2011. Cotton Implementation Guide for smallholders in Africa. Sustainable Agriculture Division, Rainforest Alliance. Based on the Sustainable Agriculture Standard of the Sustainable Agriculture Network.

Climate-smart agriculture (CSA) contributes to the achievement of the sustainable development goals[15], 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 below following summarises the main climate change threats to sustainable cotton production, the likely impact and six broad mitigation strategies[16]. 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.

TABLE 4: CLIMATE CHANGE THREATS, IMPACT AND MITIGATION STRATEGIES

Climate change threats	Impact	Mitigation strategies
– Changes in the timing of seasons – Increasing drought both between and within seasons – Heavy rains leading to waterlogged growing conditions – Shortened growing season due to earlier onset of cold weather – Increased temperatures during the day – Increased incidence of hail	– Delay in the onset of rainfall and extension of the dry season – Increased soil erosion, soil fertility loss and reduced soil moisture availability – Heat stress and – Arrival or increase in pests and diseases – Reduced yield and quality of cotton – Declining suitability of some areas for growing cotton and consequential move to other more suitable areas – Damage to road infrastructure reducing accessibility to market – Biodiversity loss	– Planting resistant or tolerant varieties – Integrated soil fertility management – Improved soil and water conservation practices – Use of Integrated pest and disease management measures – Protection of areas of high biodiversity
–	–	–

3.5. Management practices for Climate Change Adaptation

15 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
16 FAO, 2016 Report of the Working Group on Climate Change of the FAO Intergovernmental Group on Cotton. Food and Agriculture Organization of the United Nations, Rome, 2016. ISBN 978-92-5-109279-8.

As climate change alters the economics of production, cotton farming communities will have to formulate different adaptation strategies. These include:

- Favouring a farming system that has plant diversity and soil fertility management through the inclusion of crop rotations including green manures and cover crops.
- Stopping any unnecessary loss of nutrients for the farming system, preventing soil erosion and abandoning the burning of cotton crop residues where still applied.
- Minimising the period that land lays bare, in order to slow down loss of organic matter and soil moisture and soil erosion.
- Adjusting planting dates to offset moisture stress during the warm period, to prevent pest outbreaks, and to make best use of the length of the growing season.
- Minimising soil tillage in order to prevent loss of soil organic matter – a natural source of soil fertility and a means of storing water for plant uptake.
- Using cotton varieties that are more resistant to heat stress, drought spells, weeds, pests and diseases.
- Optimising the use of sustainable, natural fertilising sources in cotton production, including nitrogen fixing crop rotations, compost and manures.
- Optimising the efficiency of additional fertilizer use where required, because of its costs and carbon fuel footprint. Inorganic fertilizer use is often high especially in irrigated agriculture.
- Optimising the use of pesticides, herbicides and defoliants because of their costs and carbon fuel footprint.
- Optimising water-use efficiency in irrigated cotton, because of the irrigation water’s costs and carbon fuel footprint.

Conservation Agriculture (CA) is a farming system that promotes continuous no or minimum soil disturbance or tillage, maintenance of a permanent soil mulch cover, and diversification of plant species. Through these principles it enhances biodiversity and natural biological processes above and below the ground surface, so contributing to increased water and nutrient use efficiency and productivity, to more resilient cropping systems, and to improved and sustained crop production. Conservation Agriculture is based on the practical application of three interlinked principles along with complementary good agricultural practice. The characteristics of CA make it one of the systems best able to contribute to climate change mitigation by reducing atmospheric greenhouse gas concentration[17].

The five mitigation strategies identified in the table below involve important management practices, which will improve productivity as well mitigating the effects of climate change. These include:

17 Emilio J.Gonzalez-Sanchez, Oscar Veroz-Gonzalez, Gordon Conway, Manuel Moreno-Garcia, Amir Kassam, Saidi Mkomwag, Rafaela Ordoñez-Fernandez, Paula Triviño-Tarradas, RosaCarbonell-Bojollo, 2019. Meta-analysis on carbon sequestration through Conservation Agriculture in Africa. Soil and Tillage Research Volume 190, July 2019, Pages 22-30. https://www.sciencedirect.com/science/article/pii/S0167198718313953?via%3Dihub

CSA Practice	Description[18,19,20]
Planting improved cotton varieties	Varieties tolerant to adversities of weather (drought, water logging, and warm/cold weather conditions) and pests and diseases should be used. At the same time it is important that land unsuitable for cotton cultivation should be removed and replaced with new areas with suitable ecological conditions for new cotton.
Integrated soil fertility management (ISFM)	Inorganic fertilisers can improve soil fertility through 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 cotton 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, cotton waste, animal manure (3-5 tonnes per ha) The application is important to increase water holding and nutrient supply and to improve the structure of the soil. Intercropping of more drought resistant crops like sorghum, sunflower, sesame or castor can help to reduce the risk of crop failure. Soil cultivation should be shallow and kept to a minimum in order to avoid soil erosion and enhance build-up of organic matter. In deep or heavy soils an intensive production system can be established with sufficient inputs of organic manures, intensive crop rotation and green manuring. Frequent shallow soil cultivation helps to improve soil aeration and nutrient supply. It also reduces evaporation and suppresses weeds. When the cotton crop is well established after 6 to 9 weeks, it is recommended to apply additional organic manure and to earth up ridges in order to accelerate decomposition and to bury weeds. Attention must be paid that the soil is not prone to water erosion. In case of the risk of eroding contour lines or terraces, other soil conservation measures are required as the basis of improving soil fertility. Well composted manure or other organic fertilizer can replace the extracted nutrients and contribute to maintenance of soil fertility. Availability of nutrients to the crop, however, depends on other factors as well, such as sufficient soil organic matter and active soil organisms, deep rooting of the crop and humid soil conditions. Cotton's nutrient requirements are highest between first flowering and boll formation. A second small peak in nutrient demand is during the second flush, after the first picking. A top-dressing of organic manure during this critical growing period contributes to increasing yields.

18 The University of Georgia College of Agricultural and Environmental Science, 2018. S Georgia Cotton Production Guide, 2018. www.ugacotton.com
19 FiBL, 2011. African Organic Agriculture Training Manual.. Edited by Gilles, Weidmann and Lukas Kilcher. Research Institute of Organic Agriculture FiBL, ISBN 978-3-03736-197-9

20. IPBO, 2017. Cotton in Africa Fact Series. International Plant Biotechnology Outreach. Technologiepark 3, 9052 Ghent, Belgium - www.ipbo.vib-ugent.be

CSA Practice	Description[18,19,20]
	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	Cotton has high water requirements for boll setting and renewed growth, but dry conditions are also needed for ripening and harvest. In rainfed cotton production, major emphasis should be given to increasing the infiltration of rainwater into the soil and to its conservation. The following measures contribute to increased availability of water: Application of compost and organic manures helps increase organic matter content in the soil, which is known to improve soil structure, hence increasing water infiltration and water retention. Minimum tillage and shallow soil cultivation (hoeing) reduces water evaporation from the soil. Ridging around the growing plants is also a common practice to conserve water.
	Covering the soil with mulching materials helps to preserve humidity in the soil and to prevent water loss, while enhancing increased biological life in the upper-parts of the soil. Active rainwater harvesting through pits or trenches leading to wells can help to recharge groundwater levels Virtually all cotton cultivation in sub-Saharan Africa is rainfed and other methods should be considered. These include: 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 steeper 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 cotton 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 cotton bushes. It should be applied between the rows of cotton and if possible around the edge of the cotton fields, wherever there is exposed soil. However, it should not be placed too close to the cotton 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. Cotton residue should be incorporated into the soil and never burnt unless it is diseased.

CSA Practice	Description[18,19,20]
	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 cotton 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. The establishment of a low cost drip irrigation system can be a low cost option, where water is available.
Protecting water sources and areas of biodiversity	If the cotton area has a water-course running along the edge or within its boundary, neither cotton 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.
Agroforestry soil fertility trees	In areas with heavy wind and frost, agroforestry with wind breaks should be considered. Different trees are needed to break the wind, protect from strong rains, and provide shade, mulch and fodder. Useful species are *Leucena leucocephala, Moringa oleifera, Faidherbia albidia*, Neem and other adapted trees, which do not consume too much water and can provide additional food and fodder, as well as serving as mulch. However, the trees need regular pruning because the cotton plants do not tolerate much shade.
Integrated pest and disease management (IPM)	Healthy cotton plants have some means of defence. They compensate for affected shoots and leaves through additional growth. They also produce substances such as gossypol that deter insects from eating them. Notwithstanding cotton pests can lead to 50- 90 % yield losses, unless controlled. Early observation and knowledge of the ecology of the insects, together with tools for monitoring (pegboard, pesticides and advice) are desirable in order to manage the risks effectively. Pests that threaten the cotton production system include: Early-season pests: Aphids (Aphis spp.), Whiteflies (Bemisia spp.), Cotton leaf roller (Sylepta), Lygus bugs (Lygus), etc. Mid-season pests: Cotton bollworm (Helicoverpa armigera), Spiny bollworm (Earias spp.), cotton leaf eater (Spodoptera spp.), red bollworms (Diparopsis spp.) or pink bollworm (Pectinophora gossypiella) and false codling moth (Cryptophlebia leucotreta). Late-season pests: Aphids (Aphis spp.), Whiteflies (Bemisia spp.), Cotton strainers (Dysdercus spp.), etc. IPM methods include:

CSA Practice	Description[18,19,20]
	Use of varieties with hairy leaves and higher gossypol content, which are less susceptible to pest attacks. Pheromone traps and dispensers attract the adult moths and can thus prevent the laying of eggs. Aphids (Aphis spp.) and whiteflies (Bemisia spp.) are typical secondary pests. They have a wide range of natural enemies under natural growing conditions. Where no pesticide sprays are used, aphids and whiteflies normally maintain lower numbers. Healthy soils and a balanced nutrition based on applying compost and organic manures to enhance plant health. Shallow soil cultivation, adequate soil moisture as well as no water logging contributes to establishing favourable soil conditions. Diverse cropping systems and natural habitats around the fields enhance development of natural enemy populations like birds and beneficial insects, which help to control pests. Crop rotation, intercropping and trap crops are very effective measures to prevent pests in cotton. Intercrops like pulses and trap crops like sunflower or maize distract pests from the cotton plants. Experience from Tanzania shows that the sunflower is an efficient trap crop for the American bollworm, as the pest prefers sunflowers to cotton. It is, therefore, recommended to sow one row of sunflowers every 15 meters at the same time as the cotton crop. If preventive measures are properly implemented, pest problems are reduced. A certain level of pest attack will not significantly reduce the cotton yield. Below the economic threshold, the cost and effort to control the pest is higher than the damage it causes. Spraying pesticides, bio-pesticides or microbial sprays should be used only when the preventive measures prove insufficient to keep pests below the economic threshold. Detail is shown in Table 4 following.

TABLE 5: PEST MANAGEMENT PREVENTIVE AND BIO-CONTROL MEASURES

Preventive measures	Bio-pesticide control measures
Bollworms	
▪ Trap crops: sunflower, okra, castor	▪ Bt-spray, NPV spray
▪ Hand-pick damaged capsules	▪ Neem, botanical preparations
▪ Encourage natural enemies	▪ Buttermilk spray
▪ Remove cotton stalks	▪ Pheromone traps, light traps
▪ Cattle grazing after picking is over	▪ Trichogramma cards
Aphids, jassids, thrips, whitefly	

▪ Intercrop of suitable legumes. ▪ Avoid high manure application ▪ Avoid waterlogging and water shortage ▪ Promote natural enemies by growing flowering plants	▪ Neem, botanical preparations (chilli, sweet flag, turmeric etc.) ▪ Soft soap spray ▪ Cow urine spray ▪ Potato starch spray
Cotton stainers	
▪ Frequent soil cultivation to destroy the eggs (also along field borders) ▪ Encourage birds (trees) ▪ Avoid stand-over of cotton	▪ Pyrethrum spray ▪ Botanical sprays (neem, custard apple, garlic bulb, Derris species) ▪ Grazing of chickens
Cutworms	
▪ Early soil cultivation ▪ Remove weeds in and around fields ▪ Encourage birds, spiders etc. (trees, hedges)	▪ Apply neem cake into the soil ▪ Pyrethrum, Derris or thyme spray ▪ Cutworm baits ▪ Hand picking or Bt-spray at night

4. THE CLIMATE SMART COTTON 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 cotton 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, 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 on the next page. The reason for having very small learner and starter levels is that these will not only support the learning process of individual growers, but would be available for demonstration, learning and if necessary modification through experience by relevant stakeholders.

A number of practices have been identified under the cotton climate-smart credit product, which can be monitored. Targets for each are based on those required for one ha and proportionately scaled down for smaller areas. 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.

Although use of integrated pest and disease management practices should be initiated from the onset, they should be provided through training rather than setting specific targets.

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

TABLE 6: PRACTICES REQUIRED UNDER THE COTTON CLIMATE-SMART CREDIT PRODUCT

			units	No. per ha	CSA requirements per unit (ha) Loan 1 0.03	Loan 2 0.06	Loan 3 0.13	Loan 4 0.25	Loan 5 0.50	Loan 6 0.75	Loan 7 1
Plant improved cotton cultivars on suitable land	1	Varieties tolerant orresistant to adversities of weather (drought, water logging, warm/cold weather conditions) and pests and diseases	'000 seed	50	2	3	6	13	25	38	50
Integrated soil fertility management	2	Improvement of soil organic matter content through applications of compost, cotton residues, cattle manure (3-5 tonnes per ha) leading to a reduction in inorganic fertiliser applications	kg	5,000	156.25	312.5	625	1250	2500	3750	5000
	-	Ensuring appropriate crop rotations are followed. These should include cereals (maize or sorghum), legumes (soya beans, groundnuts, cowpeas)or a fallow period growing a leguminouc cover crop as a green manure with residues used for mulching	-	-	-	-	-	-	-	-	-
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, Guatemala or vetiver grass grown on contour terraces)	sq. metres	4,000	125	250	500	1,000	2,000	3,000	4,000
	5	Rain water harvesting ditches incorporated in the micro-watershed plan	metres	4	0	0	0	1	2	3	4
	6	Irrigation during dry spells where feasible	-	-	-	-	-	-	-	-	-
Agroforestry	7	Establish trees for windbreaks, mulching, improving soil fertility and erosion control	seedlings per unit of land	50	2	3	6	13	25	38	50
	8	Afforestation, reforestation and establishment of trees on field boundaries, surrounding water courses, around homes and areas surrounding cotton fields.	-	200	6	13	25	50	100	150	200
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.						

		0.03ha	0.06ha	0.13ha	0.25ha	0.5ha	0.75ha	1ha
Contractual Requirements	Tree-planting	8 trees	16 trees	32 trees	64 trees	128 trees	190 trees	250 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 Spreading	200kg	300kg	600kg	1,00kg	2,500kg	3,750kg	5,000kg
		Loan 1	**Loan 2**	**Loan 3**	**Loan 4**	**Loan 5**	**Loan 6**	**Loan 7**
Non-Contractual Requirements	Improved varieties (seeds)	2,000	3,000	6,000	13,000	25,000	38,000	50,000
	Integrated Pest Management	Training	Training	Training	Training	Training	Training	Training

FIGURE 3: COTTON CLIMATE-SMART CREDIT PRODUCT

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 Areas grown and yield levels

Latest FAO data[21] show that of the 90 countries producing cotton, the top eleven producers produced approximately 90% of the total production of 27.6 million tonnes of lint cotton. The percentage of global production for the top ten producers is shown in below. Detail for individual countries is shown below.

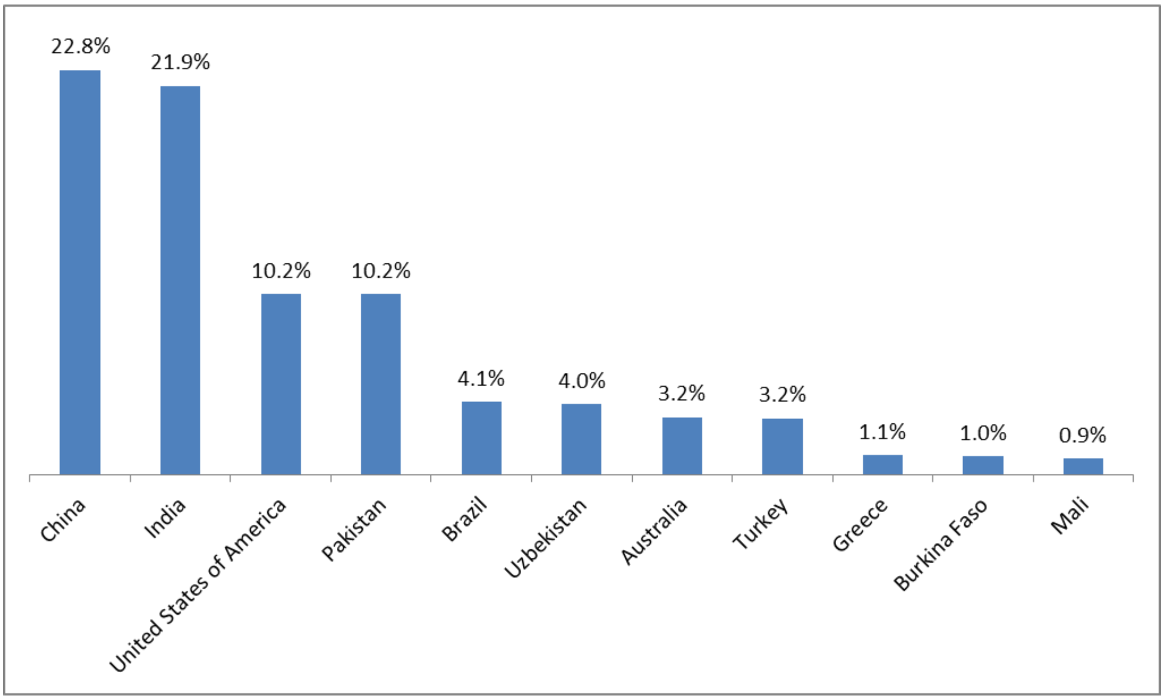

FIGURE 4: PERCENTAGE OF GLOBAL LINT COTTON PRODUCTION -2013 (HA)

Over the period 1997-2017, Asia produced 64% of global cotton, the Americas-24%, Africa-7%, Oceana-3% and Europe 2%. Of the 35 producers in Africa, the top ten countries produced nearly 80% of the African crop.

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

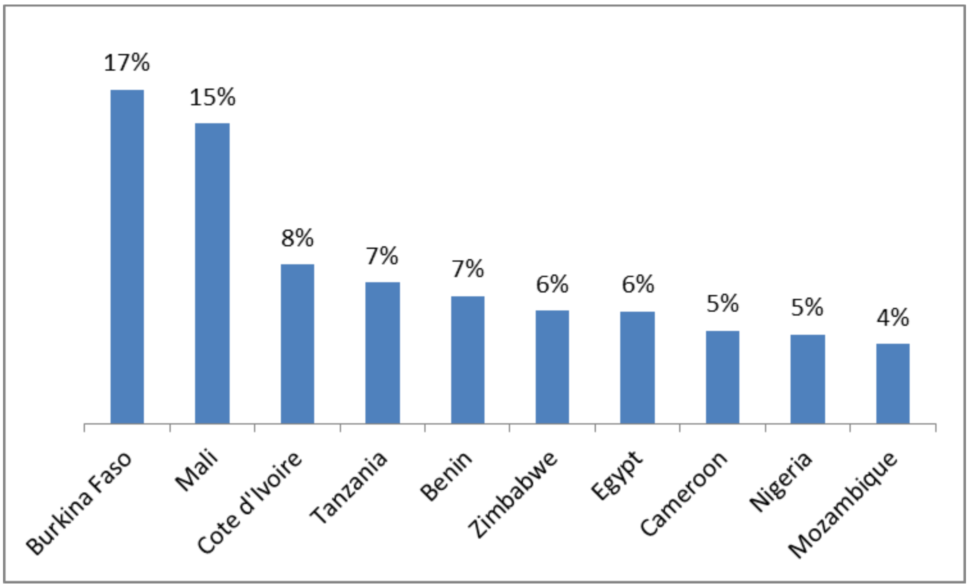

FIGURE 5: PRODUCTION PERCENTAGE OF AFRICAN LINT COTTON PRODUCTION, 2013 (HA)

Over a 20-year period (1997-2018) average yields varied from less than 200 kg per ha in Tanzania up to over 1,750 kg per ha in Australia[22], with an overall mean of 600 kg per ha and 300 kg per ha in African countries.

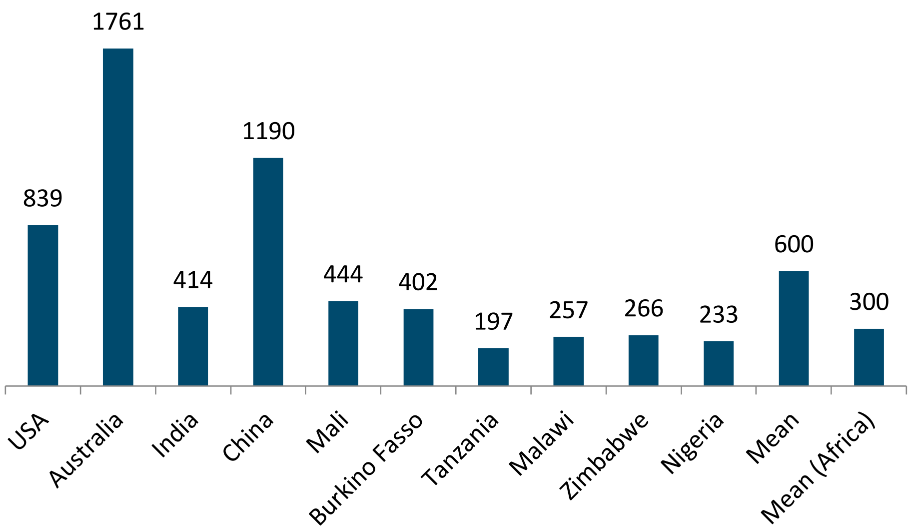

FIGURE 6: LINT COTTON YIELDS FOR SELECTED COUNTRIES, 1997-2018 (KG PER HA)

Clearly with irrigation, yields are higher, but there is potential to increase the very low yields achieved under dryland conditions following basic principles of CA and CSA.

5.2. Cotton Prices

Annual lint cotton prices have shown a rising if variable trend with highs of USD 4.50 per kg in 2011/12 but declining since then to less than USD 1 per kg in 2017[23]. Prices in those exporting countries where cotton production is highly mechanised, USA, Australia and Brazil tends to be

22 National Cotton Council of America, 2018. http://www.cotton.org/econ/cropinfo/cropdata/harvested-area.cfm accessed 12 March 2019

23 FAOSTAT, 2017. Producer lint cotton prices. http://www.fao.org/faostat/en/#data/PP

considerably higher than countries in Sub Saharan Africa, partly due to grower subsidies. Lint prices in SSA tended to be 40-60% less than

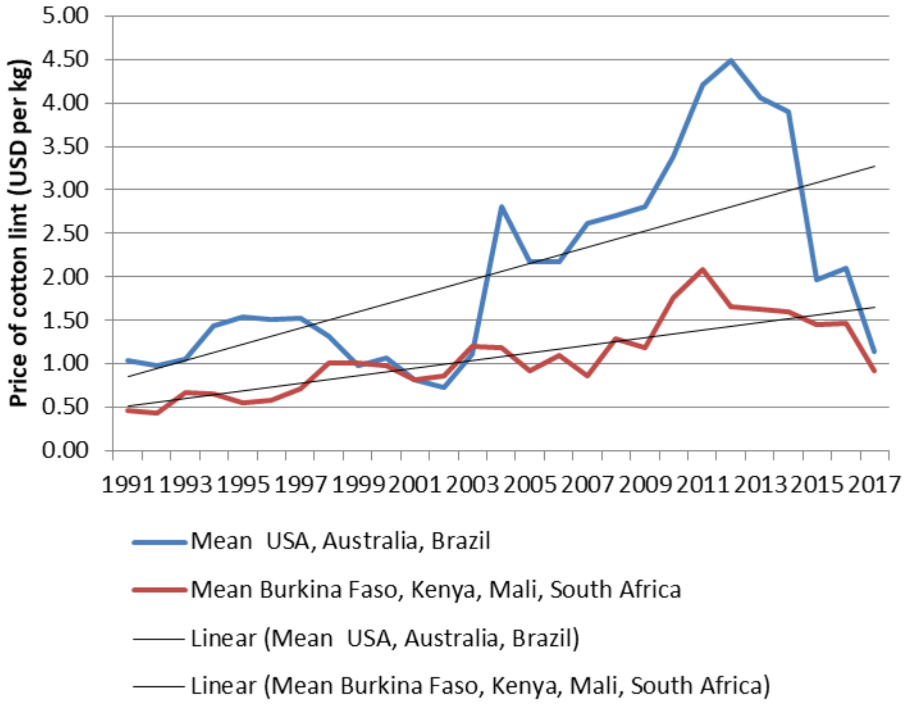

FIGURE 7: AVERAGE ANNUAL PRICE OF LINT COTTON FROM SELECTED COUNTRIES (USD PER KG)

Unfortunately, data available from FAO is patchy with no data from many countries. Prices also vary between countries with prices often lower for African countries (Figure 8)[24].

Figure 8: Lint cotton mean prices from selected countries - 1991-2017 (USD per tonne)

24 Ibid

Although the world cotton price is continuously under pressure due to high stock levels and strong competition from synthetic fibres, cotton prices are expected to be relatively stable in nominal terms for the foreseeable future. This makes cotton less competitive because prices for polyester are significantly lower than both international and domestic cotton prices. During 2018-27, relative stability is expected as government support policies continue to stabilise markets in major cotton-producing countries[25].

World production is expected to grow at a slower pace than consumption, reflecting the anticipated lower price levels and projected releases of global stocks accumulated between 2010 and 2014. The global land use devoted to cotton is projected to remain. Global cotton yields will grow slowly as production gradually shifts from relatively high yielding countries, notably China, to relatively low-yielding ones in South Asia and West Africa.

World cotton use is expected to grow at 0.9% p.a. as a result of slower economic and population growth in comparison with 2000s, reaching 28.7 Mt in 2027. It is expected that the global cotton trade will grow more slowly compared to previous years. Trade in 2027 is expected, however, to exceed the average of the 2000s. To obtain value-added in the textile industry, there has been a shift in the past several years towards trading cotton yarn and man-made fibres rather than raw cotton, and this is expected to continue. The United States remains the world's largest exporter, accounting for 36% of exports. Brazil is expected to be the second largest exporter overtaking India. The third largest exporter will be Australia. Cotton producing countries in Sub-Saharan Africa will also increase

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

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

- ***Planting improved cotton 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 cotton from cultivation and ensure new areas have suitable agro-climatic and marketing conditions.
- ***Improving soil health*** through integrated soil fertility management practices, including use of appropriate crop rotations, application of composts and manures combining this with mulching and use of green manure cover crops. This will over time reduce the requirements or need 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, windbreaks, mulching, and erosion control*** within cotton fields 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

25 OECD FAO Agricultural Outlook, 2018. http://www.agri-outlook.org/commodities/cotton.html accessed 6 march 2019.

- The impact[26,27] 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
- ***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 cotton 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.

26 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

27 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)

Details of the impact of each of these components are shown qualitatively (- no effect, + some effect, ++ intermediate effect and +++ large effect) below, with that on productivity shown too.

TABLE 7: CSA COTTON PRACTICES IMPACT ON PRODUCTIVITY

Climate smart agricultural practice			Yield	Yield variability	Labour increase	Income increase
Plant improved cotton varieties on suitable land	1	Varieties 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 cotton cultivation	+++	+++	-	+++
		Removing land unsuitable for tea from cultivation	+++	+++	-	+++
Integrated soil fertility management	2	Improvement of soil organic matter content through applications of compost, cotton residues and/or cattle manure leading to a reduction in inorganic fertiliser applications	+++	+++	++	+++
	3	Ensuring appropriate crop rotations are followed. These should include cereals (maize or sorghum), legumes(soya beans, groundnuts, cowpeas) and a fallow period growing a leguminous cover crop a green manure	+++	+++	-	+++
Soil and water conservation	4	Establish contour terraces/banks planted with grass and/or trees with appropriate measures for safe removal of water (micro-watershed management)	+++	+++	++	+++
	5	Mulching with vegetative matter (such as Napier or Guatemala grass grown on contour terraces)	+++	+++	++	+++
	6	Rain water harvesting incorporated in the micro-watershed plan	+++	+++	+++	+++
	7	Irrigation during dry spells where feasible	+++	+++	+++	+++
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

5.4. Yields Increases through Adoption of CSA Cotton 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.

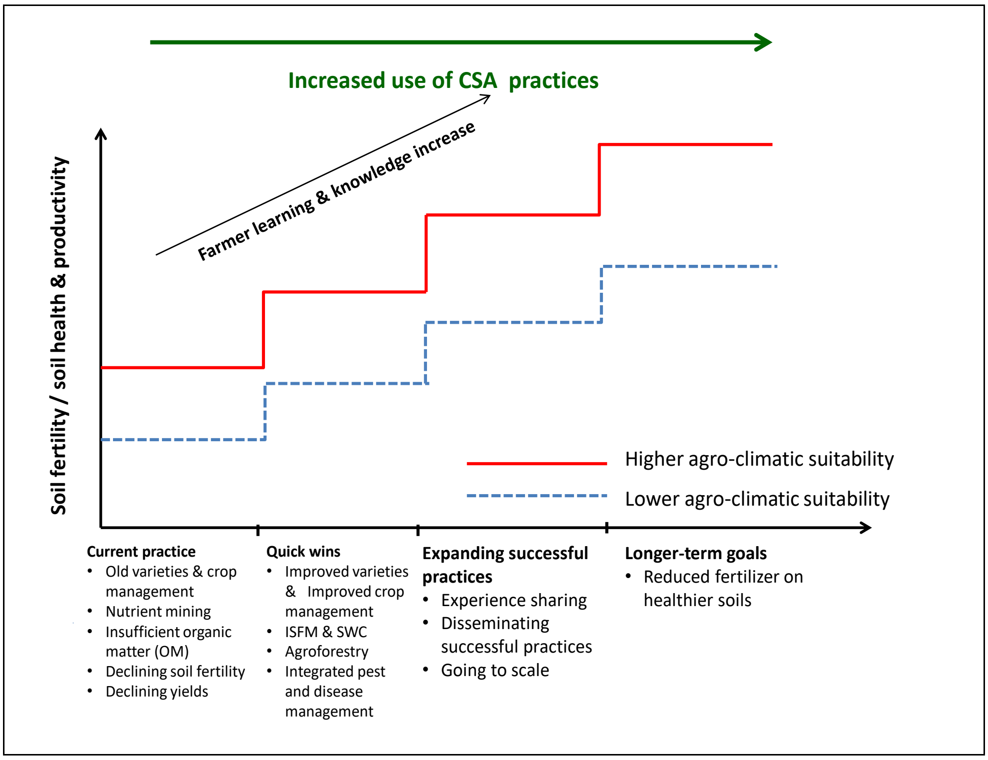

FIGURE 9: STEP WISE PRODUCTIVITY YIELD IN RESPONSIVE AND LESS RESPONSIVE SOILS

Progressive yield increases, based on research and practical experience in a number of countries, can occur from a base of less a tonne per ha^{-1} of made cotton by more than 100% or more up to and exceeding three tonnes ha^{-1} 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. Unfortunately mistakes made during establishment of the cotton 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 cotton production practices are difficult to quantify and depend on existing base yields. 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.

The table below quantifies the impact of the CSA practices on cotton the additional 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 areas, these being 0.03, 0.06, 0.12, 0.25, 0.5, 0.75 and one ha.

TABLE 8: QUANTIFICATION OF THE IMPACT OF CSA PRACTICE ON COTTON YIELD LEVELS OVER TIME

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 tonnes per ha 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
	3 Ensuring appropriate crop rotations are followed. These should include cereals (maize or sorghum), legumes (soya beans, groundnuts, cowpeas)or a fallow period growing a leguminouc cover crop as a green manure with residues used for mulching using reduced tillage techniques		Introducing a break between cotton crops prevents a build up of pests and diseases. Use of a legume crop improves soil nitrogen, and reduced tillage protects the soil from soil erosion and soil moisture evaporation.
Soil and water conservation	4 Establish contour terraces/banks planted with grass and/or trees with appropriate measures for safe removal of water (micro-watershed management)	25%	Reduced soil erosion and consequential increase in soil fertility, Stabilisation of contour banks and use as mulch material
	5 Mulching with vegetative matter (such as Napier, Guatemala or vetiver grass grown on contour terraces)		Protect the soil against raindrop action, soil erosion and reduce soil temperature
	6 Rain water harvesting ditches incorporated in the micro-watershed plan		Harvest and store rain water to increase soil moisture availability for the crop
	7 Irrigation during dry spells where feasible		Enhanced soil moisture will aid crop growth and boll fill
Agroforestry	7 Establish trees for windbreaks, mulching, improving soil fertility and erosion control	25%	The provision of shade, windbreaks, mulching, and erosion control
	9 Afforestation, reforestation and establishment of trees on field boundaries, surrounding water courses, around homes and areas surrounding cotton fields.		This will support IPM through build up of natural predators of cotton pests
Integrated pest and disease management	10 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%	

5.5. Cost Increases and Reductions through Use of CSA Cotton 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 cottons 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 cotton as well, with argument that use of inorganic fertiliser and pesticides are necessary to attain sustainable yields[28]

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

28 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.

28 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

TABLE 9: QUANTIFICATION OF THE IMPACT OF CSA PRACTICE ON COTTON INPUT COSTS

					CSA requirements per unit (ha)								**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**
			units	**No. per ha**	**0.03**	**0.06**	**0.13**	**0.25**	**0.50**	**0.75**	**1**	**USD/ unit**	**0.03**	**0.06**	**0.13**	**0.25**	**0.50**	**0.75**	**1.0**
Plant improved cotton cultivars on suitable land	1	Varieties tolerant orresistant to adversities of weather (drought, water logging, warm/cold weather conditions) and pests and diseases	'000 seed	50	2	3	6	13	25	38	50	**5**	7.8	15.6	31.3	63	125	188	250
Integrated soil fertility management	2	Improvement of soil organic matter content through applications of compost, cotton residues, cattle manure (3-5 tonnes per ha) leading to a reduction in inorganic fertiliser applications	kg	5,000	156.25	312.5	625	1250	2500	3750	5000	0	0	0	0	0	0	0	0
	-	Ensuring appropriate crop rotations are followed. These should include cereals (maize or sorghum), legumes (soya beans, groundnuts, cowpeas)or a fallow period growing a leguminouc cover crop as a green manure with residues used for mulching	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
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, Guatemala or vetiver grass grown on contour terraces)	sq. metres	4,000	125	250	500	1,000	2,000	3,000	4,000	0.01	1.3	2.5	5.0	10	20	30	40
	5	Rain water harvesting ditches incorporated in the micro-watershed plan	metres	4	0	0	0	1	2	3	4	0	0	0	0	0	0	0	0
	6	Irrigation during dry spells where feasible	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Agroforestry	7	Establish trees for windbreaks, mulching, improving soil fertility and erosion control	seedlings per unit of land	50	2	3	6	13	25	38	50	0.2	0.3	0.6	1.3	3	5	8	10
	8	Afforestation, reforestation and establishment of trees on field boundaries, surrounding water courses, around homes and areas surrounding cotton fields.	-	200	6	13	25	50	100	150	200	0.2	1.3	2.5	5.0	10	20	30	40
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	**10.6**	**21.3**	**42.5**	**85**	**170**	**255**	**340**

TABLE 10: QUANTIFICATION OF THE IMPACT OF CSA PRACTICE ON COTTON LABOUR REQUIREMENTS

			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**	**0.50**	**0.75**	**1.00**	Costs per day	**0.03**	**0.06**	**0.13**	**0.25**	**0.50**	**0.75**	**1.00**
Plant improved cotton cultivars on suitable land	1	Varieties tolerant orresistant to adversities of weather (drought, water logging, warm/cold weather conditions) and pests and diseases	**2**	0.1	0.1	0.3	0.5	1	1.5	2	2.5	0.2	0.3	0.6	1.3	2.5	3.8	5.0
Integrated soil fertility management	2	Improvement of soil organic matter content through applications of compost, cotton residues, cattle manure (3-5 tonnes per ha) leading to a reduction in inorganic fertiliser applications	5	0.2	0.3	0.6	1	3	4	5	2.5	0.4	0.8	1.6	3.1	6.3	9.4	12.5
	-	Ensuring appropriate crop rotations are followed. These should include cereals (maize or sorghum), legumes (soya beans, groundnuts, cowpeas)or a fallow period growing a leguminouc cover crop as a green manure with residues used for mulching	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
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)	20	0.6	1.3	2.5	5	10	15	20	2.5	1.6	3.1	6.3	12.5	25.0	37.5	50.0
	4	Mulching with vegetative matter (such as Napier, Guatemala or vetiver grass grown on contour terraces)	5	0.2	0.3	0.6	1	3	4	5	2.5	0.4	0.8	1.6	3.1	6.3	9.4	12.5
	5	Rain water harvesting ditches incorporated in the micro-watershed plan	4	0.1	0.3	0.5	1	2	3	4	2.5	0.3	0.6	1.3	2.5	5.0	7.5	10.0
	6	Irrigation during dry spells where feasible	-	-	-	-	-	-	-		-	-	-	-	-	-	-	
Agroforestry	7	Establish trees for windbreaks, mulching, improving soil fertility and erosion control	5	0.2	0.3	0.6	1	3	4	5	2.5	0.4	0.8	1.6	3.1	6.3	9.4	12.5
	8	Afforestation, reforestation and establishment of trees on field boundaries, surrounding water courses, around homes and areas surrounding cotton fields.	20	0.6	1.3	2.5	5	10	15	20	2.5	1.6	3.1	6.3	12.5	25.0	37.5	50.0
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	5	0.2	0.3	1	1	3	4	5	2.5	0.4	0.8	1.6	3.1	6.3	9.4	12.5
			Total	**2**	**4**	**8**	**15**	**31**	**46**	**61**	**Total**	**5.2**	**10.3**	**20.6**	**41**	**83**	**124**	**165**

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

The risks to cotton 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 cotton 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,

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 cotton flourishes. Growth of cotton is temperature-dependent, with cotton bushes not growing when temperatures are either too low or too high, regardless of other climatic factors. The crop requires temperatures.

CSA cotton lending products can be used in any of the suitable environments especially where cotton 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

Many cotton 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 cotton. Certification comes with costs, which will be profitable if there is a market that demands certified cotton. 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 cotton growing areas, where SSGs make an important contribution to total production.

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 cotton 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 cotton 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 cotton 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 Cotton Sector will be required in helping to ensure economic and social sustainability of cotton production.

Perceived profitability has been recognised as a key factor in explaining farmers' decisions to adopt or not adopt sustainable land management (SLM) technologies[29]. 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 cotton farm gate price of US$0.50 per kg for green leaf, this being 25% of the made cotton price together with an opportunity price for labour of US$ 2.50 per day and Table 9 following set out the variables affecting base-line and CSA output and input prices

[29] 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

TABLE 11: VARIABLES AFFECTING THE BASE-LINE COTTON PRODUCTION PRACTICES

Base Case Outputs	**Unit**	**No.**	**Value per kg**	**Source**
Lintcotton yield (non organic)	kg/ha	600	1.50	Report Section 4.1 and 4.2
Lint cotton yield (organic)	kg/ha	300	1.50	
Base Case Inputs	**Unit**	**No.**	**Cost/unit (USD)**	Report Section 2.1 and 2.4
Seed	'000 seed	50	2.5	
Urea (non-organic only)	kg/ha	90	0.9	
Phosphate (non organic only)	kg/ha	70	0.8	
Potash (non organic only)	kg/ha	100	0.7	
Pesticides and herbicides -when used (non organic only)	ha	1	200	
Base case labour requirments	**Unit**	**No**	**USD / day**	Report Section 2.5
Land preparation	days/ha	2.5		
Planting and fertilising/manuring	days/ha	2		
Weeding	days/ha	20		
Pest and disease control	days/ha	3		
Harvesting and transport	days/100 kg	4		
Destruction/incorporation of cotton plant	days/ha	5		
	Typical opportunity cost		2.5	

Discount Rate =	10%

TABLE 12: VARIABLES AFFECTING THE CSA COTTON PRODUCTION PRACTICES

CSA Practice Outputs		**Unit**	**#**	**Value per kg**	**Source**
Increased yields (non organic)		% base case per year	5%	1.50	Report Section 4.1 and 4.2
Increased yields (organic)		% base case per year	5%	1.50	
CSA additional input costs (non-organic and organic)	**Year**	**Units**	**No.**	**Cost (USD)**	Report section 2.7
Green manure cover crops (seed) Y1	Y1	kg/ha	5	2.00	
Planting grass on contour terraces (plant materials) Y1	Y1	kg/ha	10	2.00	
Agroforestry shade trees (seedlings) Y1	Y1	trees/ha	250	0.20	
CSA Input cost savings (non organic only)	**Y1-10**	% of base case per yea	5%		
CSA additional labour costs (non organic and organic)		**Unit**	**No.**	**USD / day**	
ISFM compost /manure making, transport and spreading	Y1-Y10	days/ha	5		Report Section 2.7
SWC contour terraces contruction	Y1-Y10	days/ha	20		
SWC contour terraces maintenance	Y2-Y10	days/ha	2		
SWC cover crops	Y1-Y10	days/ha	3		
SWC grass mulching	Y1-Y10	days/ha	3		
SWC rain water harvesting construction	Y1	days/ha	4		
SWC rain water harvesting maintenance	Y2-10	days/ha	1		
Agroforestry trees (establishment and maintenance)	Y1	days/ha	25		
Agroforestry trees (establishment and maintenance)	Y2-10	days/ha	5		
CSA saving on labour costs		% of base case per year	0%		
		Typical opportunity cost		2.5	Typical opportunity cost

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 cotton growers adopting climate-smart and sustainable land management measures required under the proposed climate-smart credit product. These are

- Firstly, where the grower is producing cotton using both inorganic fertilisers, herbicides, pesticides and fungicides.
- Secondly, where the grower is producing organic cotton using no fertiliser and no chemicals.

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

Scenario 1: Cotton production using inorganic fertiliser and integrated pest management strategies incorporating chemical control measures and all CSA practices adopted

Error! Reference source not found. The table below shows a base situation where the grower is not u sing CSA practices. This is compared with cotton using CSA practices . Results are presented over a single year reflecting the additional input required by CSA although it can be expected that fertiliser and IPM chemical use will decrease over time.

TABLE 13: COTTON GROSS MARGIN ANALYSIS - BASE CASE, NO CSA PRACTICES

	#		Units	Qty/ha	Price/unit USD	Y1-Y10
Income	Yield		kg/ha			600
	Value		USD/kg			1.50
Gross Income			**USD per ha**			**900**
Input costs						
	Seed		'000 seed	50	2.50	125
	Fertiliser	Urea	kg/ha	90	0.9	81
		Phosphate	kg/ha	70	0.8	56
		Potash	kg/ha	100	0.7	70
	Herbicides and pesticides (typical cost)		per ha	1	200	200
			sub-total			**532**
Margin over input costs before labour costs, loan repayments or levies			**USD / ha**			**368**
Labour costs	Land preparation		days	3	2.50	6
	Planting and fertilising		days	2	2.50	5
	Weeding		days	20	2.50	50
	Pest and disease control		days	3	2.50	8
	Harvesting and transport		days/100 kg	24	2.50	36
	Destruction/incorporation of cotton stalks		days	5	2.50	13
			sub-total	**57**		**117**
Total variable costs			**USD per ha**			**649**
Gross Margin over inputs and labour costs before loan repayments or levies			**USD per ha**			**251**
Total labour input			**days**			**57**
Returns to labour			**USD /ha**			**368**
Returns to labour			**USD/ day**			**6.5**

TABLE 14: COTTON GROSS MARGIN ANALYSIS – NON-ORGANIC WITH CSA PRACTICES

		Units	Qty/ha		Price/unit USD	Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	Y9	Y10
Income	Yield	kg/ha	5%		increase over base pa	630	662	695	729	766	804	844	886	931	977
	Value	USD/kg				1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50
Gross Income		**USD per ha**				**945**	**992**	**1,042**	**1,094**	**1,149**	**1,206**	**1,266**	**1,330**	**1,396**	**1,466**
Input costs	Base costs	USD per ha				532	532	532	532	532	532	532	532	532	532
	Savings on base input costs		5%	per year	-	-27	-53	-80	-106	-133	-160	-186	-213	-239	-266
	Additional costs														
	SWC (plant grass on contour) Y1 only	kg/ha	10		2.00	20									
	SWC (cover crops)	kg/ha	5		2.00	10	10	10	10	10	10	10	10	10	10
	Agroforestry (trees) Y1 only	seedlings	250		0.20	50									
		sub-total				**585**	**489**	**462**	**436**	**409**	**382**	**356**	**329**	**303**	**276**
Margin over input costs before labour costs, loan repayments or levies		**USD / ha**				**360**	**503**	**580**	**658**	**740**	**824**	**911**	**1,001**	**1,094**	**1,190**
			Y1	Y2-Y10											
Labour costs	Base costs	days	57	57	2.5	141	141	141	141	141	141	141	141	141	141
	Savings on base costs	%	0%	0%	-	0	0	0	0	0	0	0	0	0	0
	Additional costs														
	ISFM (compost making , transport and spreading)	days	5	5	2.5	13	13	13	13	13	13	13	13	13	13
	SWC (contour/ terraces) Y1 construction	days	20	-	2.5	50									
	SWC (contour/ terraces) Y2-Y10 maintenance	days	-	2	2.5		5	5	5	5	5	5	5	5	5
	SWC (use grass as mulch)	days	3	3	2.5	8	8	8	8	8	8	8	8	8	8
	SWC (intercrop or cover crop management)	days	3	3	2.5	8	8	8	8	8	8	8	8	8	8
	SWC rainwater harvesting Y1 construction	days	4	-	2.5	3									
	SWC rainwater harvesting Y2-19 maintence	days	-	1	2.5		3	3	3	3	3	3	3	3	3
	Agroforestry (trees)Y1 estblishment]	days	25	-	2.5	63									
	Agroforestry (trees) Y2-10 maintenance	days	-	5	2.5		13	13	13	13	13	13	13	13	13
	Additional harvesting and transport	days/100 kg	1	1	2.5	3	3	3	3	3	3	3	3	3	3
		sub-total	**118**	**77**	**-**	**287**	**192**	**192**	**192**	**192**	**192**	**192**	**192**	**192**	**192**
Total variable costs		**USD per ha**				**872**	**681**	**654**	**627**	**601**	**574**	**548**	**521**	**494**	**468**
Gross Margin over inputs and labour costs before loan repayments or levi		**USD per ha**				**73**	**312**	**388**	**467**	**548**	**632**	**719**	**809**	**902**	**998**
Total labour input		**days**				**118**	**77**	**77**	**77**	**77**	**77**	**77**	**77**	**77**	**77**
Returns to labour		**USD /ha**				**360**	**503**	**580**	**658**	**740**	**824**	**911**	**1,001**	**1,094**	**1,190**
Returns to labour		**USD/ day**				**3.1**	**6.5**	**7.5**	**8.5**	**9.6**	**10.7**	**11.8**	**13.0**	**14.2**	**15.4**

Scenario 2: Cotton production using no inorganic fertiliser or chemical pest and disease control measures.

This compares the situation without and with CSA practices.

TABLE 15: COTTON GROSS MARGIN ANALYSIS – ORGANIC WITHOUT CSA PRACTICES

	#		Units	Qty/ha	Price/unit USD	Y1-Y10
Income	Yield		kg/ha			300
	Value		USD/kg			1.50
Gross Income			**USD per ha**			**450**
Input costs						
	Seed		'000 seed	50	2.50	125
	Fertiliser	Urea	kg/ha	0	0.9	0
		Phosphate	kg/ha	0	0.8	0
		Potash	kg/ha	0	0.7	0
	Herbicides and pesticides (typical cost)		per ha	0	200	0
			sub-total			**125**
Margin over input costs before labour costs, loan repayments or levies			**USD / ha**			**325**
Labour costs	Land preparation		days	3	2.50	6
	Planting		days	2	2.50	5
	Weeding		days	20	2.50	50
	Pest and disease control		days	3	2.50	8
	Harvesting and transport		days/100 kg	12	2.50	30
	Destruction/incorporation of cotton stalks		days	5	2.50	13
			sub-total	**45**		**111**
Total variable costs			**USD per ha**			**236**
GrossMargin over inputs and labour costs before loan repayments or levies			**USD per ha**			**214**
Total labour input			**days**			**45**
Returns to labour			**USD /ha**			**325**
Returns to labour			**USD/ day**			**7.3**

TABLE 16: COTTON GROSS MARGIN ANALYSIS – ORGANIC WITH CSA PRACTICES

		Units	Qty/ha		Price/unit USD	Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	Y9	Y10
Income	Yield	kg/ha	5%	Increase over base pa		315	331	347	365	383	402	422	443	465	489
	Value	USD/kg				1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50
Gross Income		**USD per ha**				**473**	**496**	**521**	**547**	**574**	**603**	**633**	**665**	**698**	**733**
Input costs	Base costs	USD per ha				125	125	125	125	125	125	125	125	125	125
	Savings on base input costs		0%	per year	-	0	0	0	0	0	0	0	0	0	0
	Additional costs														
	SWC (plant grass on contour) Y1 only	kg/ha	10		2.00	20									
	SWC (cover crops)	kg/ha	5		2.00	10	10	10	10	10	10	10	10	10	10
	Agroforestry (trees) Y1 only	seedlings	250		0.20	50									
		sub-total				**205**	**135**	**135**	**135**	**135**	**135**	**135**	**135**	**135**	**135**
Margin over input costs before labour costs, loan repayments or levies		**USD / ha**				**268**	**361**	**386**	**412**	**439**	**468**	**498**	**530**	**563**	**598**
			Y1	Y2-Y10											
Labour costs	Base costs	days	57	57	2.5	141	141	141	141	141	141	141	141	141	141
	Savings on base costs	%	0%		-	0	0	0	0	0	0	0	0	0	0
	Additional costs														
	ISFM (compost making , transport and spreading)	days	5	5	2.5	13	13	13	13	13	13	13	13	13	13
	SWC (contour/ terraces) Y1 construction	days	20	-	2.5	50									
	SWC (contour/ terraces) Y2-Y10 maintenance	days	-	2	2.5		5	5	5	5	5	5	5	5	5
	SWC (use grass as mulch)	days	3	3	2.5	8	8	8	8	8	8	8	8	8	8
	SWC (intercrop or cover crop management)	days	3	3	2.5	8	8	8	8	8	8	8	8	8	8
	SWC rainwater harvesting Y1 construction	days	4	-	2.5	3									
	SWC rainwater harvesting Y2-19 maintence	days	-	1	2.5		3	3	3	3	3	3	3	3	3
	Agroforestry (trees)Y1 estblishment]	days	25	-	2.5	63									
	Agroforestry (trees) Y2-10 maintenance	days	-	5	2.5		13	13	13	13	13	13	13	13	13
	Additional harvesting and transport	days/100 kg	-11	-11	2.5	-29	-29	-29	-29	-29	-29	-29	-29	-29	-29
		sub-total	**105**	**65**	**-**	**255**	**160**	**160**	**160**	**160**	**160**	**160**	**160**	**160**	**160**
Total variable costs		**USD per ha**				**460**	**295**	**295**	**295**	**295**	**295**	**295**	**295**	**295**	**295**
Gross Margin over inputs and labour costs before loan repayments or lev		**USD per ha**				**12**	**201**	**226**	**252**	**279**	**308**	**338**	**370**	**403**	**438**
Total labour input		**days**				**105**	**65**	**65**	**65**	**65**	**65**	**65**	**65**	**65**	**65**
Returns to labour		**USD /ha**				**268**	**361**	**386**	**412**	**439**	**468**	**498**	**530**	**563**	**598**
Returns to labour		**USD/ day**				**2.5**	**5.6**	**6.0**	**6.4**	**6.8**	**7.2**	**7.7**	**8.2**	**8.7**	**9.3**

Results are summarised below:

TABLE 17: RESULTS SUMMARY

	Scenario	Lint cotton yields (Y10) kg per ha	Gross margin (Y10) USD per ha	Labour required (Y10) days per ha	Returns to labour (Y10) USD per ha	Returns to labour (Y10) USD per day	Benefit cost ratio over 10 years
Non organic	Cotton without CSA practices	600	251	57	368	6.5	-
	Cotton with CSA practices	998	998	77	1,190	15.4	2.0
Organic	Cotton without CSA practices	300	214	45	325	7.3	-
	Cotton with CSA pactices	489	438	65	598	9.3	1.2
						Discount rate	10%

8. Lender financial impact model

1.1. 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.

1.2. 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

1.3. 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$)	3,122,000	3,122,000	3,122,000	3,122,000	3,122,000	3,122,000	3,122,000
Portfolio loss with no climate-smart lending	**(2,074,800)**	**(2,074,800)**	**(2,074,800)**	**(2,074,800)**	**(2,074,800)**	**(2,074,800)**	**(2,074,800)**
Portfolio loss with climate-smart lending	**(2,534,767)**	**(2,245,693)**	**(2,014,434)**	**(1,825,221)**	**(1,667,545)**	**(1,534,126)**	**(1,419,767)**
Savings due to CSA practices	(459,967)	(170,893)	60,366	249,579	407,255	540,674	655,033
Cost of capital w/o climate-smart lending	20%	20%	20%	20%	20%	20%	20%
Cost of capital w climate-smart lending	8%	8%	8%	8%	8%	8%	8%
Annual interest savings (US$)	374,640.00	374,640.00	374,640.00	374,640.00	374,640.00	374,640.00	374,640.00
Cash position improvement with climate-smart-lending (US$)	**(85,327)**	**203,747**	**435,006**	**624,219**	**781,895**	**915,314**	**1,029,673**

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$ 624 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.

#	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$/ha)	173	173	173	173	173	173	173
	Additional Labour Costs	(149.00)	(54.00)	(54.00)	(54.00)	(54.00)	(54.00)	(54.00)
	Loan discounts	15.60	15.60	15.60	15.60	15.60	15.60	15.60
	Total Costs (US$/ha)	**(133.40)**	**(38.40)**	**(38.40)**	**(38.40)**	**(38.40)**	**(38.40)**	**(38.40)**
	Net Benefits (US$/ha)	**39.39**	**134.39**	**134.39**	**134.39**	**134.39**	**134.39**	**134.39**
	Discounted Net Benefits (US$/ha)	**39.4**	**122.2**	**111.1**	**101.0**	**91.8**	**83.4**	**75.9**
	NPV (US$/ha)	**624.7**						

ANNEX 1: COTTON PRODUCTION - 2013[30][31]

Area	Cotton seed tonnes	Cotton lint tonnes	% of total Cotton lint
China	12,620,000	6,298,989	24.8%
India	12,293,100	6,052,000	23.8%
United States of America	3,812,900	2,810,650	11.1%
Pakistan	4,071,366	2,805,651	11.0%
Brazil	2,152,833	1,127,675	4.4%
Uzbekistan	1,849,000	1,094,000	4.3%
Australia	1,439,000	893,601	3.5%
Turkey	1,287,000	877,500	3.5%
Greece	507,000	296,000	1.2%
Burkina Faso	430,000	280,000	1.1%
Mali	449,646	251,802	1.0%
Syrian Arab Republic	409,945	220,475	0.9%
Turkmenistan	396,000	198,000	0.8%
Mexico	323,000	193,000	0.8%
Argentina	298,650	190,000	0.7%
Myanmar	280,000	135,000	0.5%
Tajikistan	225,000	111,600	0.4%
Kazakhstan	218,200	131,000	0.5%
United Republic of Tanzania	214,000	118,000	0.5%
Cote d'Ivoire	207,000	133,500	0.5%
Benin	191,000	107,000	0.4%
Cameroon	156,000	78,000	0.3%
Zimbabwe	145,000	95,000	0.4%
Egypt	133,920	94,000	0.4%
Nigeria	130,000	75,000	0.3%
Malawi	103,000	42,400	0.2%
Iran	102,381	60,670	0.2%
Zambia	92,000	44,650	0.2%
Mozambique	80,000	67,000	0.3%
Ethiopia	70,000	30,000	0.1%
Bolivia	69,500	29,000	0.1%
Spain	57,007	48,452	0.2%
Chad	53,000	36,000	0.1%
Sudan	52,000	44,540	0.2%
Peru	45,000	27,000	0.1%
Togo	45,000	30,500	0.1%
Kyrgyzstan	43,600	21,800	0.1%
Azerbaijan	43,000	16,738	0.1%
Afghanistan	42,173	13,917	0.1%
Bangladesh	36,700	21,000	0.1%
Colombia	35,307	24,394	0.1%
Peru	31,000	16,335	0.1%

[30] FAOSTAT, 2018. Statistical data base. Food and Agriculture Organisation of the United Nations, Rome, Italy. http://www.fao.org/faostat/en/#data/PP/ accessed 30th December 2018

[31]

Area	Cotton seed tonnes	Cotton lint tonnes	% of total Cotton lint
Uganda	30,000	16,500	0.1%
South Sudan	29,000	16,000	0.1%
Senegal	28,818	12,000	0.0%
Korea	25,700	13,000	0.1%
Iraq	23,000	12,500	0.0%
Guinea	22,000	15,000	0.1%
Democratic Republic of the Congo	19,000	7,300	0.0%
Israel	16,950	11,700	0.0%
Kenya	13,000	4,150	0.0%
Central African Republic	11,900	8,000	0.0%
Yemen	11,900	6,000	0.0%
Madagascar	9,000	4,800	0.0%
South Africa	8,582	5,205	0.0%
Ghana	8,100	5,400	0.0%
Venezuela	7,000	3,900	0.0%
Niger	5,800	3,300	0.0%
Lao	4,840	3,160	0.0%
Thailand	4,813	2,426	0.0%
Somalia	4,480	1,960	0.0%
Angola	3,200	1,000	0.0%
Nicaragua	3,000	1,120	0.0%
Guinea-Bissau	2,900	1,350	0.0%
Indonesia	2,398	1,199	0.0%
Ecuador	2,300	1,430	0.0%
Burundi	2,238	946	0.0%
Viet Nam	2,165	1,083	0.0%
Honduras	1,800	810	0.0%
Guatemala	1,775	790	0.0%
Tunisia	1,260	660	0.0%
Eswatini	1,100	520	0.0%
Costa Rica	1,030	665	0.0%
Haiti	600	330	0.0%
Botswana	590	300	0.0%
Albania	540	230	0.0%
Gambia	284	187	0.0%
Cambodia	173	87	0.0%
Bulgaria	155	78	0.0%
Morocco	133	66	0.0%
Nepal	95	53	0.0%
El Salvador	80	53	0.0%
Antigua and Barbuda	65	30	0.0%
Philippines	55	18	0.0%
Algeria	51	27	0.0%
Grenada	30	10	0.0%
Montserrat	11	4	0.0%
Total	45,552,139	25,407,186	100.0%

ANNEX 2: COTTON YIELDS FROM SELECTED COUNTRIES – 1997-2018[32] (KG PER HA)

Year	USA	Australia	India	China	Mali	Burkina Faso	Tanzania	Malawi	Zimbabwe	Nigeria	Mean	Mean (Africa)
1990	712	1556	268	808	589	439	295	189	269	94	522	313
1991	732	1783	265	870	533	411	370	61	91	140	526	268
1992	786	1427	311	660	549	392	438	222	305	185	528	349
1993	680	1248	287	750	533	318	257	115	318	237	474	296
1994	795	1511	309	785	527	345	458	236	187	311	546	344
1995	603	1427	319	881	503	305	469	274	395	455	563	400
1996	792	1537	332	891	454	443	605	168	323	452	600	408
1997	756	1542	302	1025	431	494	348	213	332	201	564	337
1998	702	1359	302	1013	436	400	392	185	359	218	536	332
1999	681	1625	302	1031	443	367	275	239	353	180	550	309
2000	710	1583	278	1091	494	441	442	204	308	249	580	356
2001	792	1722	308	1104	487	438	233	213	191	262	575	304
2002	747	1684	302	1222	429	404	310	223	258	250	583	313
2003	820	1746	400	979	485	457	312	372	303	241	611	362
2004	960	2043	472	1120	420	440	400	418	269	241	678	365
2005	933	1790	468	1158	420	473	1003	418	289	229	718	472
2006	914	1961	528	1301	375	405	209	397	296	229	662	319
2007	987	2092	559	1301	346	368	295	405	315	248	692	330
2008	913	2014	533	1323	402	421	603	311	245	235	700	369
2009	871	1937	512	1317	384	363	504	291	287	248	671	346
2010	912	1580	527	1266	399	376	229	272	273	253	608	300
2011	887	1831	513	1348	393	404	330	247	327	218	650	320
2012	1001	2253	527	1440	363	448	521	194	204	237	719	328
2013	923	2051	578	1488	412	421	462	365	225	199	712	347
2014	940	2445	501	1486	420	446	332	264	212	203	725	313
2015	860	1992	459	1573	390	364	257	163	116	193	637	247

[32] National Cotton Council of America, 2018. Yield data. http://www.cotton.org/econ/cropinfo/cropdata/index.cfm accessed 13 march 2019

2016	973	1524	542	1711	413	408	209	300	146	182	641	276
2017	1016	1975	507	1764	433	308	282	200	294	190	697	284
2018	941	1818	481	1791	403	374	363	281	218	190	686	305
Mean	**839**	**1761**	**414**	**1190**	**444**	**402**	**386**	**257**	**266**	**233**	**619**	**331**

ANNEX 3: SEED COTTON PRICES FROM SELECTED COUNTRIES – 1991-2018 (USD PER TONNE)[33]

Year	USA	Australia	Brazil	China	India	Pakistan	Burkina Faso	Kenya	Mali	South Africa	Mean (all)	Mean (Africa)
1991	71	-	56.8	83.4	-	22	-	-	-	-	58	-
1992	98	-	35.8	95	-	29.1	-	-	-	-	64	-
1993	113	-	41.5	104.5	-	32	-	-	-	-	73	-
1994	101	-	64.5	117.5	-	30.7	-	-	-	-	78	-
1995	106	-	68.9	331.1	-	29.8	-	-	-	-	134	-
1996	139	-	73.2	428.4	-	31.2	-	-	-	-	168	-
1997	133	-	79.3	292.2	-	29.7	68.3	-	-	-	121	68.30
1998	142	-	65	292.4	-	30.7	67.3	-	-	-	119	67.30
1999	98	-	47.5	295.6	-	26.8	64.9	-	-	-	107	64.90
2000	116	-	51.1	363.4	-	26.5	59.7	-	-	-	123	59.70
2001	100	-	38.8	447.5	119.8	22	60	-	-	-	131	60.00
2002	111	193	36	533.2	120.5	17.8	62.4	-	-	-	153	62.40
2003	129	273	54	363.9	131.8	18.4	74.8	-	175	-	153	124.90
2004	118	314	64.1	247.9	117.1	18.9	87.3	41.4	213.9	-	136	114.20
2005	106	231	61	320.5	121.6	19.3	82.9	37.9	224.9	-	134	115.23
2006	122	227	64.7	323.6	118.9	20.4	81.9	45.6	178.3	-	131	101.93
2007	179	271	74.2	338.1	186.2	22.2	-	45.6	61.6	-	147	53.60
2008	246	288	84.8	333.9	182.7	19.9	-	52.9	131.8	-	168	92.35
2009	174	296	75	352.8	-	23.6	-	50.4	72.9	-	149	61.65
2010	177	354	85.6	413.6	-	29.8	-	90.9	202.5	-	193	146.70
2011	287	418	139.6	390	-	-	-	109.8	305.3	-	275	207.55
2012	278	450	171.4	443.6	-	-	-	79.8	282.2	-	284	181.00
2013	271	372	170.3	217.9	-	-	-	73.1	-	137.2	207	105.15
2014	214	367	170.4	-	-	-	-	71.6	-	132.5	191	102.05
2015	250	308	137.2	-	-	-	-	64.1	-	135	179	99.55

[33] FAOSTAT, 2013. http://www.fao.org/faostat/en/#data/PP, accessed 14 March 2019

2016	215	329	154.7	-	-	-	-	62	-	126.6	177	94.30
2017	153	-	-	-	-	-	-	-	-	-	153	-

- No data available

Annex 4: Seed cotton prices from selected countries – 1991-2018 (USD per tonne)[34]

Year	USA	Australia	Brazil	China	India	Pakistan	Burkina Faso	Kenya	Mali	South Africa	Mean (all)	Mean (Africa)
1991	1281	-	796	1216	1597	653	-	-	-	-	1109	
1992	1210	-	748	1194	-	693	-	-	-	-	961	
1993	1287	-	839	1163	-	646	-	-	-	-	984	
1994	1587	-	1304	1247	-	650	-	-	-	-	1197	
1995	1687	-	1394	1763	-	628	-	-	-	-	1368	
1996	1554	-	1480	1731	-		-	-	721	-	1372	721
1997	1459	-	1602	1701	1568		683	-	632	-	1274	658
1998	1327	-	1313	1435	1603		673	-	686	1438	1211	933
1999	992	-	961	921	1397		649	-	715	1326	995	897
2000	1098	-	1034	1250	1333		597	-	502	1182	999	760
2001	858	-	784	915	1341		600	-	552	887	848	680
2002	741	-	727	1156	1349	469	625	-	680	913	832	739
2003	1140	-	1091	1820	1475	485	748	-	737	1559	1132	1015
2004	1197	5914	1295	1240	1311	484	873	862	901	1717	1579	1088
2005	941	4353	1233	1603	1361	484	829	790	948	1159	1370	932
2006	1047	4192	1308	1618	1331	503	819	950	751	1068	1359	897
2007	1351	5021	1499	1691	-	549	-	949	820	1312	1649	770
2008	1082	5340	1715	1783	-	525	-	1103	851	1495	1737	862
2009	1429	5485	1517	1969	-	645	-	1050	1009	1322	1803	845
2010	1865	6543	1730	4167	-	800	-	1893	817	1645	2433	1089
2011	2061	7736	2821	2995	-	-	-	2287	1287	1879	3009	1363
2012	1669	8318	3463	3078	-		-	1479	1189	1837	3005	1126
2013	1847	6874	3441	-	-	-	-	1524	-	1734	3084	1629
2014	1448	6797	3445	-	-	-	-	1493	-	1709	2978	1601
2015	1422	1708	2773	-	-	-	-	1337	-	1583	1765	1460
2016	1554	1614	3127	-	-	-	-	1293	-	1652	1848	1472

[34] FAOSTAT, 2013. http://www.fao.org/faostat/en/#data/PP, accessed 14 March 2019

2017	1561	1864	-	-	-	-	-	-	-	1853	1759	1853