DAIRY 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 milk producers (SSMPs). 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.

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 livestock 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 dairy 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 milk growers, the agricultural economic analysis in this document would serve as the basis (only) for the loan product to be developed.

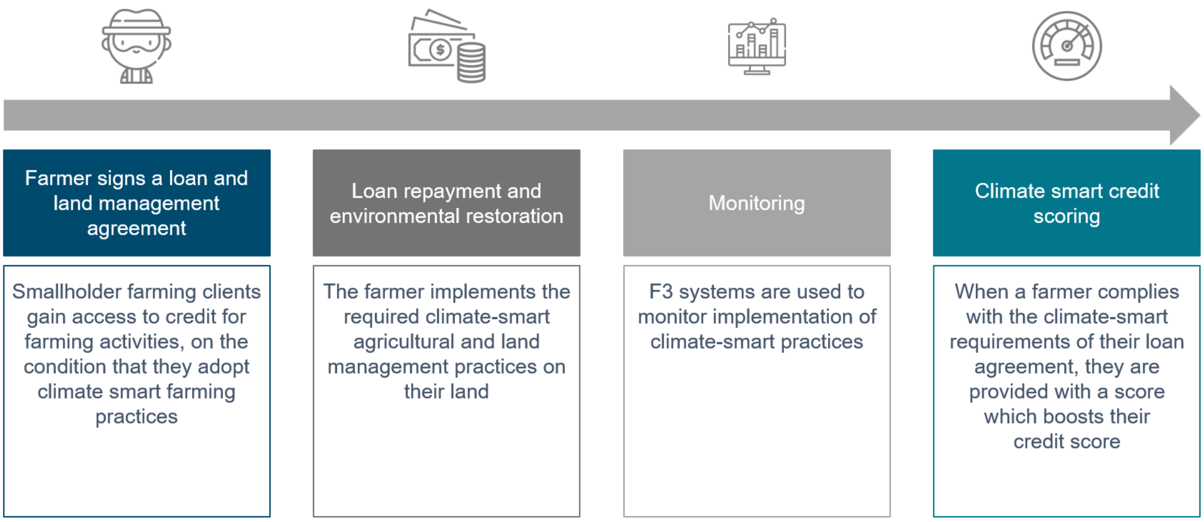


FIGURE 1: CLIMATE-SMART LENDING PROCESS

The dairy industry has become a key sector contributing to national economic growth in many developing countries. It helps to ensure food security, provide raw material for agro-industries, create employment opportunities and generate income and sometimes foreign exchange earnings. This is the case in a number of milk producing countries in Africa, where the top ten milk producers produced 74% of the milk production across the continent[1]. Although milk is also produced from camels, goats and sheep, the quantities produced are small compared to that from cows. This report only considers milk from cows.

[1] http://www.fao.org/faostat/en/#data/QL accessed 24th April 2019

1.2. Climate risks to dairy production

As with other agricultural commodities, climate change effects dairy production especially in relation to the production of fodder and crop residues fed to the cattle. As such climate risks include:

- Changes in the timing of seasons
- Increasing drought both between and within seasons
- Heavy rains leading to soil erosion and waterlogged growing conditions for both food and fodder crops
- Shortened growing season with unreliable rains due to earlier onset of cold weather
- Increased temperatures during the day
- Increased incidence of hail

These make the sector vulnerable to the impacts of climate change and resulting extreme weather.

At the same time, the dairy sector is also responsible for the emission of greenhouse gases dominated by methane, which is produced in the rumen of cattle during the normal process of feed digestion. This represents a significant loss of feed energy that increases feed requirements.

1.3. Dairy production

Dairy production systems are influenced by agro-climatic environment, population density, land productivity, market availability, as well as the prevalence of animal diseases. In areas of high population density, development of highly intensive smallholder dairy production systems is often typified by “zero-grazing”, where cattle are confined and stall fed with crop residues and planted fodder, particularly napier grass and purchased dairy concentrates. In areas of greater land availability, less intensive feeding combining grazing and stall-feeding is common, while in more marginal areas with lower population densities, free grazing on unimproved natural pasture is the norm.

Understanding the management and fodder production practices in each of systems is important in devising interventions which will impact on climate change and improve productivity. The intensive dairy cattle production systems in Kenya have been used as a model as they have many similarities to those in other sub Saharan African countries

1.4. Dairy value chain

The dairy value chain includes researchers, agri-input manufacturers and supply and service organisations, farmers, traders, processors, wholesalers and retailers through to shops and restaurants and consumers. Government, often the Ministry of Agriculture or other state bodies, is responsible for policy and the regulatory requirements for creating an enabling environment for production and marketing.

Within the value chain, it is important to distinguish between formal and informal marketing. In Kenya for example, 51% of milk production is traded but only 25% of this goes into the formal market and is sold for processing into dairy products. 75% is sold in the informal sector. This is often because consumers prefer unprocessed milk, pay less for it and farmers receive better returns than marketing into the formal sector.

1.5. Challenges faced by small scale diary producers

Typical challenges faced by dairy producers include: low quality of feeds and feeding systems, expensive farm inputs, poor animal husbandry and management of dairy marketing systems, low productivity of animals, high cost of purchased feed, low quality of raw milk delivered to milk processors, high cost of collection per unit of milk, seasonality of milk supply with large price fluctuations in milk prices with oversupply leading to low prices and undersupply leading to high prices, fragmented supply chains, poor knowledge of production system, value and chain and access to extension services.

Production systems are often rain dependent and as a result, farmers often face regular feed shortages during the dry season. In addition, limited land for cultivation also means some producers face year-round feed shortages. Common challenges to improving both food and fodder production include limited access to good quality seeds and declining soil fertility due to low soil organic matter, nutrient depletion and soil erosion.

1.6. Climate smart agriculture practices

Strategies for improving animal nutrition provide the basis for both improving productivity an mitigating the effects of climate change. CSA practices include the need to use (i) improved food and fodder varieties adapted to drier, warmer and/or cooler conditions with resistance to pests and diseases; (ii) integrated soil fertility management practices, through increased use of crop rotations, composts and manures, and cover crops integrated with the use of inorganic fertilisers, (iii) integrated soil and water conservation and drainage measures using contour barriers or terracing especially on steeper slopes, using grasses and trees on the terraces combined with rainwater harvesting techniques and improved irrigation, when water is available; (iv) agroforestry involving the planting of fodder trees and hedges not only to provide fodder but also to mitigate wind and water damage and improve soil fertility, including protection of areas of high biodiversity.

1.7. The dairy climate smart credit product

An integrated approach required for SSMPs to derive optimum benefit from CSA milk practices, starts with an area of 0.03 ha. This is a “Learner Level”, where CSA practices can be tried, tested and learnt from, before proceeding to progressively larger areas. These would be increased from 0.03 ha to 0.06 ha, 0.13 ha, 0.25 ha, 0.5 ha, 0.75 ha and then one ha or more. 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. Seven levels have been identified under the milk climate-smart credit product, which can be monitored with targets for each. These 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 milk research organisations or other extension agencies.

		0.03ha	0.06ha	0.13ha	0.25ha	0.5ha	0.75ha	1ha
Contractual Requirements	Plant Trees	8 trees	16 trees	31 trees	53 trees	125 trees	188 trees	250 trees
	Rainwater Harvesting Ditches	0	0	0	1	2	3	4
	Grass reinforcement of terraces	13m	25m	50m	100m	200m	300m	400m
	Contour Terracing	13m	25m	50m	100m	200m	300m	400m
	Crop Rotation	0.03ha	0.06	0.13ha	0.25ha	0.5ha	0.75ha	1ha
	Manure / Compost Spreading	0.03ha	0.06ha	0.13ha	0.25ha	0.5ha	0.75ha	1ha
		Loan 1	**Loan 2**	**Loan 3**	**Loan 4**	**Loan 5**	**Loan 6**	**Loan 7**
Non-Contractual Requirements	Improved Feed and Fodder Varieties	Improved varieties	Improved varieties	Improved varieties	Improved varieties	Improved varieties	Improved varieties	Improved varieties
	Join a Farmer's Group	Training	Training	Training	Training	Training	Training	Training

FIGURE 2: CLIMATE-SMART CREDIT PRODUCT FOR SMALL SCALE DAIRY FARMERS

1.8. Present and projected yield Levels

Both food and fodder yields will increase over time as soil health is restored, soil organic matter builds and soil and water conservation measures become effective. Yield increase estimates are difficult to quantify. They will be location specific, dependent on local agro-climatic conditions, but can be achieved alongside a reduction in costs particularly for inorganic fertiliser and input requirements, although an increase in labour will be required. Increases are likely over a period of time from a base of around 10 litres per cow per day, up to and exceeding 20 litres, as improved fodder is consistently planted, soil health is improved, soil organic matter builds and soil conservation measures become effective and other animal management practices change.

1.9. Dairy prices

Market prices reflect local supply and demand for milk. Additionally prices vary to changes in rainfall that influence the availability of fodder. The season of peak milk production is typically associated with the rainy season, when increased supply often drives down prices paid to farmers. For instance in Kenya processors were offering prices buying USD 0.35-0.40 per litre, although they have been revised downwards to about USD 0.30 per litre with many processors buying the raw milk from USD 0.23-0.27 per litre.

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

The impact 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. This includes (i) improving the resilience of natural resource use, (ii) reducing the risks associated with climate change, (iii) mitigating the effects of some of the causes of climate change and (iv) increasing productivity.

1.11. Farmer cost-benefit analysis

A key output of this exercise is a gross margin and farmer cost benefit analysis model for SSMPs under intensive or semi-intensive systems adopting climate-smart and sustainable land management measures required under the proposed climate-smart credit product. This demonstrates, in a generalised case, the positive financial return to climate-smart and sustainable land-management measures required under the milk 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	Yields (Y3 on)	Gross margin (Y3 on)	Labour (Y3 on)	Returns to labour (Y3 on)	Returns to labour (Y3 on)	Benefit cost ratio
	litres per year	USD	days per ha	USD	USD per day	after 10 years
Milk production without CSA practices	6,400	498	200	998	5.0	-
Milk production with CSA practices	11,059	2,345	237	2,900	12.2	4.1
					Discount rate :	10%

1.12. Dairy “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 IN YEAR 7

	Year 7 Yield Loss			
	10%	20%	30%	40%
Cash Position Improvement with CSL Lending (US$/10,000 clients)	3,229,744	4,279,744	4,839,744	4,839,744

Dairy “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 model and run it with available data from the environmental economic academic literature to show the benefits of implementing the CSA measures of the climate-smart credit product create a benefit with net present value of nearly USD 2,000 over 7 years.

#	Benefits associated with climate-smart lending dairy environmental requirements	0	1	3	4	5	6	7
1	Regulation of climate	475	475	475	475	475	475	475
2	Regulation of water timing and flows	11	11	11	11	11	11	11
3	Erosion control	9	9	9	9	9	9	9
4	Maintenance of soil quality	18	18	18	18	18	18	18
5	Pollination	-	-	-	-	-	-	-
6	Natural hazard mitigation	-	-	-	-	-	-	-
7	Habitat	11	11	11	11	11	11	11
8	Nutrient cycling	-	-	-	-	-	-	-
	Total Benefits (US$/ha)	524	524	524	524	524	524	524
	Additional Labour Costs	112.50	67.50	67.50	67.50	67.50	67.50	67.50
	Loan discounts	44.80	50.40	56.00	61.60	67.2	72.80	78.40
	Total Costs (US$/ha)	**157.30**	**117.90**	**123.50**	**129.10**	**134.70**	**140.30**	**145.90**
	Net Benefits (US$/ha)	**366.22**	**405.62**	**400.02**	**394.42**	**388.82**	**383.22**	**377.62**
	Discounted Net Benefits (US$/ha)	**366.2**	**368.7**	**300.5**	**269.4**	**241.4**	**216.3**	**193.8**
	NPV (US$/ha)	**1,956.4**						

Contents

2. An introduction to small scale dairies and climate risks to production

2.1. Introduction

Until relatively recently increases in demand for milk were driven mainly by population growth. However, they are now increasingly fuelled by rising per capita milk consumption in developing countries[2]. At the same time the cattle dairy industry has become a key sector contributing to national economic growth. It helps to ensure food security, provide raw material for agro-industries, create employment opportunities and generate income and sometimes foreign exchange earnings. This is the case in a number of milk-producing countries in Africa, where the top ten milk producers produced 74% of milk production in the continent (Figure 3)3. Although milk is also produced from camels, goats and sheep, the quantities produced are small compared to that from cows. This report only considers milk from cows.

FIGURE 3: MILK PRODUCTION FROM COWS IN SELECTED AFRICAN COUNTRIES (% OF TOTAL AFRICAN PRODUCTION)4

In Kenya, the largest producer in Africa, dairy farming is the single largest sub sector of agriculture contributing 14% of the Agricultural Gross Domestic Product (GDP) with an annual growth rate of 4.1%. It is the major activity in the livestock sector and an important source of livelihood to approximately one million small scale farmers. It is the most rapidly expanding dairy sub sector in sub-Sahara Africa having over 85% of the dairy cattle population in Eastern Africa. The Kenyan dairy cattle population is estimated to be 4.3 million head with an estimated annual milk production of over 4 billion litres. Over 50% of households with one acre (0.4 ha) of land or less keep cattle for milk. These smallholder dairy farmers own over 80% of the dairy herd and produce some 56% of total milk5. At the same time the dairy industry has and is witnessing growth as a result of numerous targeted interventions to promote development by both government and the private sector.

This pattern is repeated in a number of other sub Saharan African countries, where small-holder dairy development presents an important option, as in Kenya, to boost rural incomes, improve food

[2] FAO 2010: Status of and Prospects for Smallholder Milk Production – A Global Perspective, by T. Hemme and J. Otte. Rome
[3] http://www.fao.org/faostat/en/#data/QL accessed 24th April 2019
[4] ibid
[5] Odero-Waitituh J A 2017: Smallholder dairy production in Kenya; a review. Livestock Research for Rural Development. Volume 29, Article #139. Retrieved 30 April 2019, from http://www.lrrd.org/lrrd29/7/atiw29139.html

and nutritional security. At the same time it creates employment along the dairy value chain from production, collection, bulking and transportation, processing, distribution and marketing as well as provision of inputs and support services. As such it has the potential to make a major contribution to improving livelihoods.

2.2. Climate risks to dairy production

As with other agricultural commodities, climate change effects dairy production especially in relation to the production of fodder and the crop residues fed to the cattle. As such climate risks include:

- Changes in the timing of seasons
- Increasing drought both between and within seasons
- Heavy rains leading to soil erosion and waterlogged growing conditions for both food and fodder crops
- Shortened growing season with unreliable rains due to earlier onset of cold weather
- Increased temperatures during the day
- Increased incidence of hail

These make the sector vulnerable to the impacts of climate change and resulting extreme weather events. As agro-climatic conditions change and soil health for crop production declines, dairy productivity will also decline due to shortages of fodder. Consequently, there is strong farmer pressure to increase income by expanding into new areas[6]. As agriculture encroaches onto non-farmland, forested mid- and high-altitude regions can be lost with consequential disruption to the carbon sinks that these forests represent, with wildlife habitats and biodiversity being seriously threatened.

The dairy sector is also responsible for the emission of greenhouse gases dominated by methane, which is produced in the rumen of cattle during the normal process of feed digestion. This also represents a significant loss of feed energy that increases feed requirements. In addition, both methane and nitrous oxide emissions occur during the process of managing the livestock manure in pastures and buildings during storage and when spreading the manure. Methane is produced when manure decomposes under anaerobic conditions with the quantity of manure methane emissions being determined by the type of treatment or storage, the ambient climate and the composition of the manure. They are the result of physical, chemical and biological processes depending on the ambient conditions, the surroundings and livestock physiological stage and farming practices[7].

Due to these challenges, there is a need for interventions that make the dairy sector, more resilient to climate change and at the same time minimise its contribution to greenhouse gas emissions. Improving animal and herd productivity is important for both[8].

6 Waithaka, M.M., P.K. Thornton, M. Herrero, K.D. Shepherd, J.J. Stoorvogel, B. Salasya, N. Ndiwa, et al. 2005. System Prototyping and Impact Assessment for Sustainable Alternatives in Mixed Farming Systems in High-Potential Areas of Eastern Africa. Final Program Report to the Ecoregional Fund to Support Methodological Initiatives.

7 FAO and GDP. 2018. Climate change and the global dairy cattle sector – The role of the dairy sector in a low-carbon future. Rome. 36 pp. Licence: CC BY-NC-SA- 3.0 IGO

8 Ericksen, P. and Crane, T. 2018. The feasibility of low emissions development interventions for the East African livestock sector: Lessons from Kenya and Ethiopia. ILRI Research Report 46. Nairobi, Kenya: International Livestock Research Institute (ILRI).

2.3. Dairy production

Dairy production systems are influenced by agro-climatic environment, population density, land productivity, market availability, as well as the prevalence of animal diseases. In areas of high population density, development of highly intensive smallholder dairy production systems is often typified by "zero-grazing", where cattle are confined and stall fed with crop residues and planted fodder, particularly napier grass and purchased dairy concentrates. In areas of greater land availability, less intensive feeding combining grazing and stall-feeding is common, while in more marginal areas with lower population densities, free grazing on unimproved natural pasture is the norm. Profiles of dairy production in Kenya, Tanzania and Uganda are shown in Annex 3.

In areas of high population density, land tends to be limiting, whereas with free grazing, labour is usually limiting. Expenditure on purchased feeds and concentrates is higher with zero-grazing than in open grazing systems.

In Kenya three broad types of dairy production have been identified[9]:

- Intensive dairy production often practiced with zero grazing confining cattle to a limited physical space (a stall), where they are managed, fed, watered and milked. This system is mainly practiced in areas of high agricultural potential, often by urban and peri-urban producers and where a high population growth has resulted in reduction of land holding size. Animals are predominately milk breeds or crosses with potential for high milk productivity.
- Extensive production systems involving open range free grazing, often with little or no supplementary feed. It is practiced where grazing land is available with little use of purchased inputs. Animals are often local indigenous breeds and milk yields are comparatively low.
- Semi-intensive systems involving a combination of intensive and extensive, characterised by a lower population density than in the intensive system areas, relying on some grazing usually supplemented with cultivated fodder and/or purchased feed. In such systems cross-bred cattle are usually kept.

In Kenya, the semi-intensive dairy system contributes 44% of total milk supply from 55% of milking animals. The intensive and extensive dairy systems contribute 38% and 17% respectively, with 14% and 31% of the milking cows[10].

In Uganda dairy types include[11]:

- Four types of traditional milk production systems described as: small-holder extensive, medium-holder extensive, pastoral (semi-nomadic pastoralists) and agro-pastoral.
- Three types of more intensive commercial milk production systems described as: small-holder intensive, medium-holder intensive and large-scale (commercial) producers.

In Tanzania dairy types include[12]

[9] FAO & New Zealand Agricultural Greenhouse Gas Research Centre. 2017. *Options for low emission development in the Kenya dairy sector - reducing enteric methane for food security and livelihoods*. Rome. 43 pp.
[10] ibid
[11] FAO & New Zealand Agricultural Greenhouse Gas Research Centre. 2019. *Options for low emission development in the Uganda dairy sector - reducing enteric methane for food security and livelihoods*. Rome. 39 pp.
[12] FAO & New Zealand Agricultural Greenhouse Gas Research Centre. 2019. *Options for low emission development in the Tanzania dairy sector - reducing enteric methane for food security and livelihoods*. Rome. 34 pp.

- Traditional dairy farming with free grazing and low levels of feed supplementation. Tanzania Shorthorn Zebu is the main breed constituting 99% of the national herd. Most of the milk produced is for household consumption with the cattle playing an important cultural and social role.
- Intensive smallholder dairy farming in rural, urban and peri-urban environments and medium to large-scale farming. Cattle are usually kept under semi-zero grazing and are fed with cultivated fodder, crop residues, cut and carry forages and limited concentrate. Despite the number of animals in improved systems being low, only 3% of the national dairy herd, improved systems contribute to 30% of total milk production and have rapidly expanded in recent years.

Understanding the management and fodder production practices in each of these systems is important in devising strategies and CSA interventions which will impact on climate change and improve productivity. The dairy cattle production systems in Kenya[13] have been used as a model as they have many similarities to those in other sub Saharan African countries, and include:

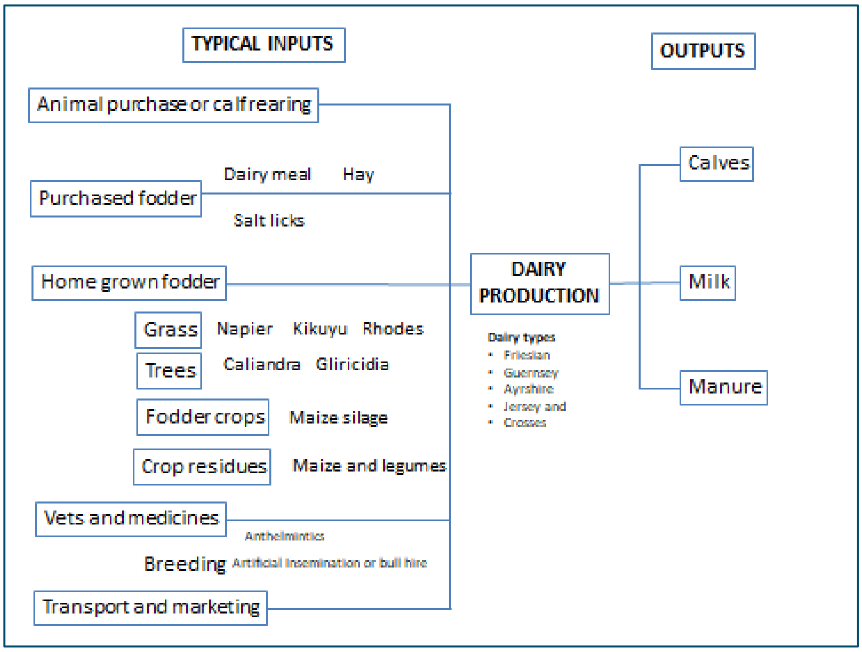
System	#	Description
Intensive (Stall feeding)	Diet	A major source of feed is fodder especially napier grass (Pennisetum purpureum) and crop residues usually from maize, legumes and other crops due to limited grazing land. Sometimes supplementation from sweet potato vines is also used. Other feedstuffs are usually purchased.
	Breeds	Exotic dairy breeds or crosses with Friesian and Ayrshire are dominant.
	Health	Mortality is approximately 12% for mature cows, and 13% for mature bulls 15% and 14% for female and male calves, respectively
	Reproductive practice	The age at first calving is approximately 29 months with a calving rate of 52% and a calving interval of about 20 months. Natural mating is the most widespread option of reproduction, with few farmers owning bulls, but hiring them for servicing cows. The bull to cow ratio is 1:76. Artificial insemination is sometimes used.
Semi-intensive	Diet	Major source of feed is from grazing natural pastures of unimproved annual and perennial grasses mainly kikuyu grass (Pennisetum clandestinum) and Rhodes grass (Chloris gayana). These are of low quality during the dry season. However, supplementation with fodder such as napier grass, sweet milk vines and crop residues e.g. maize stover, legume residues (from pigeon pea, cowpea, green gram and beans) are also used especially during periods of harvest.
	Breed	The indigenous cow is the most popular breed. However exotic breeds (Friesian Ayrshire, Jersey and Guernsey) and crossbreds of exotic and indigenous are also important.
	Health	Mortality approximately 14% for mature cows and 10% for mature bulls,13% and 19% for female and male calves, respectively.

[13] FAO & New Zealand Agricultural Greenhouse Gas Research Centre. 2017. Options for low emission development in the Kenya dairy sector - reducing enteric methane for food security and livelihoods. Rome. 43 pp.

System	#	Description
	Reproductive practice	The age at first calving is +/- 31 months with a calving rate of 51%. Natural mating is the most widespread method with a bull to cow ratio of 1:22. AI is sometimes used and the cow replacement rate is 89%.
Extensive systems	Diet	Animals in the system are primarily fed on natural unimproved grass
	Breed	The small East African Shorthorn Zebu, crosses between Zebu and the dual-purpose Sahiwal breed and Zebu X Boran are the dominant cattle breeds in these systems.
	Health	The mortality rate of both mature bulls and cows is 13%, 15% and 21% for female and male calves, respectively
	Reproductive practice	Age at first calving is about 4 years with a calving rate of 64%. Natural mating is the sole method of reproduction with the ratio of bull to cow at 1:20 and the cow replacement rate is 78%. There is no controlled breeding and reproduction is primarily influenced by the rainfall regime and the resultant seasonality in feed supply.

2.4. Typical intensive and semi-intensive dairy farms in Kenya14

Dairy farming in Kenya is concentrated in the high altitude agro-ecological zones of the central highlands and Rift Valley, which experience high and bimodal rainfall patterns and relatively low temperatures (15^{o}C - 24^{o}C). In these areas more than 75% of households engage in agriculture with 73% practicing an integrated crop dairy production system. Over 50% use up to one acre (0.4ha) of land to keep dairy animals. A typical dairy production system showing the range of inputs and outputs is shown in Figure 4.



[14] Kashangaki, J. and Ericksen, P. 2018. *Cost–benefit analysis of fodder production as a low emissions development strategy for the Kenyan dairy sector.* ILRI Project Report. Nairobi, Kenya: ILRI.

FIGURE 4: TYPICAL DAIRY PRODUCTION SYTEM IN INTENSIVE AND SEMI-INTENSIVE SYSTEMS

Smallholders using more intensive systems typically produce have a herd size of 1-5 pure or crossbred cows or a mixture of both. Less intensive systems combine stall-feeding and some grazing. In 2007, the Ministry of Livestock Development estimated that the national dairy cattle herd was made up of 50% cows, 10% heifers of over one year, 11% heifers of less than one year, 17% bulls and bull calves and 12% steers. This has not changed significantly to date[15].

An optimal dairy feeding regime consists of water, energy, protein, fibre, vitamins and minerals (75% energy, 24% protein and 1% minerals). Energy is required for body maintenance, milk production, growth, weight gain and reproduction, while protein is necessary to break down roughage into usable nutrients. Most of the energy can be derived from roughage and legumes, available from grasses such as napier, Guatemala, giant Setaria, Rhodes and Kiyuyu. Younger plants, particularly legumes (pasture and fodder) have a rich protein and vitamin content. Examples of protein sources include legume residues, sweet milk vines, Desmodium, lucerne, omena, sunflower and white clover as well as fodder trees such as Calliandra, Leucaena, Mulberry and Sesbania[16].

Rainfall is closely related to milk production, with high rainfall and availability of moisture having a strong influence on pasture growth and the changes in milk output. Increased rainfall leads to increased pasture growth and a subsequent increase in milk production. At the same time reduced rainfall results in a decline in pasture production and pasture quality, especially during the dry season[17]. Feeding purchased or stored feed in the dry season is reflected in increased milk production[18].

2.5. Dairy value chain

The dairy value chain includes researchers, agri-input manufacturers and supply organisations, farmers, traders, processors, wholesalers and retailers through to shops and restaurants and consumers. A typical value chain is shown below, with Government often the Ministry of Agriculture or other state body being responsible for policy and the regulatory requirements for creating an enabling environment for production, animal and human health and marketing.

TABLE 3: TYPICAL DAIRY VALUE CHAIN

Improved dairy health, feeding and land management practices	Agri-Input acquisition & production advice	Milk production	Marketing and transport	Processing	Marketing and consumption
− Researchers	**Production advice** − Extension agents (Govt & NGO) − Dairy Associations and Cooperatives − Other farmers **Vet products and purchased feed** − Agri-input producers	− Large Scale Farmers − Small scale growers − Community organisations − Farmers' groups or cooperatives	**Local use** − Household consumption − Fed to calves **Informal Marketing** − Local markets − Collectors/traders − Shops, hotels **Transport**	− Processors making alternative milk products	− Wholesalers − Supermarkets − Small retailers − Restaurants − Consumers

[15] Dankit Nassiuma and Njoroge Nyoike, 2014 Milk Production and Marketing Preliminary Survey Report, Nairobi, Kenya. For Kenya Dairy Board,
[16] Kashangaki, J. and Ericksen, P. 2018. Cost–benefit analysis of fodder production as a low emissions development strategy for the Kenyan dairy sector. ILRI Project Report. Nairobi, Kenya: ILRI.
[17] ibd
[18] Tegemeo Institute of Agricultural Policy and Development, 2016. Report of a Study on Assessing the Cost of Production Structures n Dairy Systems in Kenya. Egerton University, Nairobi. Kenya.

	– Agro-dealers – Coops – Vets **Production credit** – Micro-finance institutions, NGOs, Coops – Banks, Agri-banks		– Transporters – Farmers' groups or cooperatives **Formal marketing** – Directly to processors sometimes under contract		

Within the value chain, it is important to distinguish between formal and informal marketing[19], as illustrated in Figure 5, being an example from Kenya. This shows that although 51% of milk production is traded, only 25% goes into the formal market and sold for processing into dairy products. 75% is sold in thein formal sector. This is often because consumers prefer unprocessed milk, pay less for it and farmers receive better returns than marketing into the formal sector.

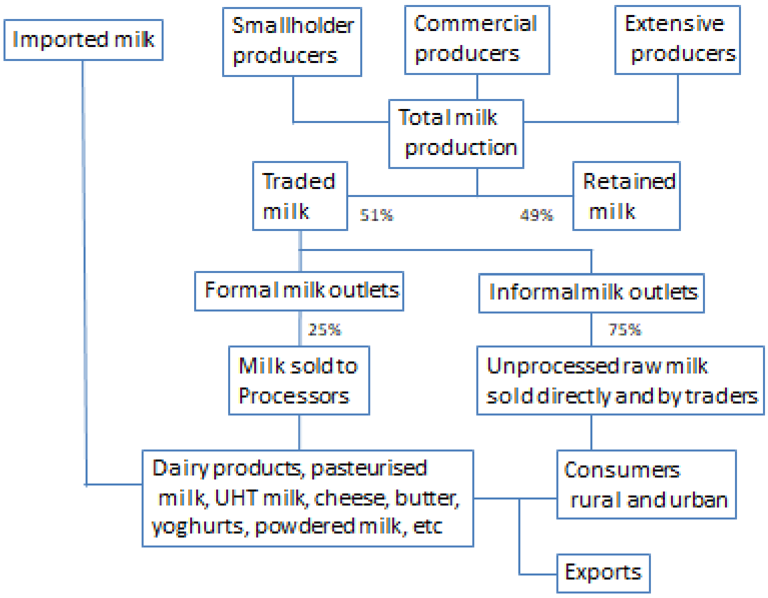


FIGURE 5: TYPICAL MILK MARKEING DISTRIBUTION

Dairy cooperatives and producer associations often dominate the marketing of milk on behalf of their members collecting milk, bulking it and then distributing it either raw or pasteurized, or in the case of processors as dairy products such as yoghurt, ghee, butter and cheese. All have the potential to improve productivity and enhance market participation by farmers as well as assisting farmers to acquire credit, farm inputs and Artificial Insemination (AI) services at relatively low cost. Some cooperatives also facilitate farmer access to crop inputs such as certified seed for improved feed and fodder or even buying hay in bulk to sell to members at low rates and under contractual marketing arrangements.

[19]Kashangaki, J. and Ericksen, P. 2018. Cost–benefit analysis of fodder production as a low emissions development strategy for the Kenyan dairy sector. ILRI Project Report. Nairobi, Kenya: ILRI.

2.6. Challenges faced by small scale dairy producers growers

Typical challenges faced by dairy producers include20:

- Low quality of feeds and feeding systems
- Expensive farm inputs
- Poor animal husbandry and management of dairy marketing systems
- Low productivity of animals
- High cost of milk production, particularly for purchased feed
- Low quality of raw milk delivered to milk processors
- High cost of collection per unit of milk
- Seasonality of milk supply with large price fluctuations in milk prices with oversupply leading very low prices and undersupply leading to high prices.
- Fragmented supply chains
- Poor knowledge of production system, value and chain and access to extension services

Production systems are often rain dependent and as a result, farmers can face regular feed shortages during the dry season. In addition, limited land for cultivation also means some producers face year-round feed shortages. Feeding and management typically make up about 80% of the total costs for a dairy enterprise, with feed constituting some 60-70% of the total.

Fodder production is often limited, due to:

- Limited land holdings with food crops given priority for reasons of food security
- Lack of specialization in dairying in areas suitable for milk production
- Limited knowledge about commercial fodder-feeding dairy practices
- Limited extension support for dairy farming.

Common challenges to improving both food and fodder production include:

- Limited access to good quality seeds
- Declining soil fertility due to low soil organic matter, nutrient depletion and soil erosion.

Improved agronomic production practices are urgently required especially in view of changing climate conditions. Unfortunately, small scale growers often have limited information on improved agronomic practices and market prices and lack the finance to purchase the necessary agricultural inputs to improve productivity.

A summary of the strategies being considered or undertaken in terms of Kenya's National Dairy Master Plan 2010 – 2030 is summarised in Annex 3.

[20] Kenya National Dairy Master Plan 2010 – 2030. Vol. I. Situational Analysis

3. CLIMATE SMART AGRICULTURE STRATEGIES FOR DAIRY PRODUCERS

Climate-smart agriculture (CSA) can contribute to the achievement of the sustainable development goals[21], through integrating three dimensions of sustainable development (economic, social and environmental) by jointly addressing food security and climate challenges. There is a need for interventions that make the dairy sector both more resilient to climate change and at the same time minimise its contribution to greenhouse gas emissions. Improving productivity can have a significant impact on both. This will also help to address a growing demand for milk.

Increasing productivity, protecting producers, consumers and the environment, requires an integrated approach encompassing a range of strategies: These include: improving feeding practices through use of improved fodder; planting improved crop varieties with pest/disease and drought/temperature tolerance or resistance; rotating with other crops; improving soil health through integrated soil fertility management using conservation agriculture principles, where feasible[22], as well as improved the genetic potential and health of animals. It is an approach that requires site-specific assessments to identify suitable agricultural production technologies and practices. Interventions fall into three broad categories, improving feed quality and availability, manure management and animal husbandry[23].

Feed quality improvement:

- Producing and feeding improved fodder. This is best suited to intensive and, semi-intensive dairy farms with mixed systems. However, this approach can be constrained by a lack of availability of land, capital, and the availability of quality fodder seed.
- Supplementation with feed blocks or other concentrates on intensive dairy farms to boost milk output.
- Producing silage from maize. Although farmers recognize that maize silage could significantly improve milk production, maize silage also competes with maize for human consumption.
- Improved grazing management is suitable for extensive dryland systems, and will produce similar mitigation results to improving fodder quality. However, this requires improved governance capacities to implement improved grazing regimes and prevent over-grazing. It is a long-term measure, as it is likely to take several years to implement and sustain improved pastures.

Manure management:

- The use of bio-digesters is suitable for intensive dairy farms with 4- 5 cows or more. The costs of installation, the need to transport liquid slurry and the labour required are barriers to adoption. They do however offer direct benefits to farmers and are already being supported by some NGOs and governments.

21 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

22 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

23 Ericksen, P. and Crane, T. 2018. The feasibility of low emissions development interventions for the East African livestock sector: Lessons from Kenya and Ethiopia. ILRI Research Report 46. Nairobi, Kenya: ILRI. .

- Manure storage and covering is appropriate for intensive and semi-intensive mixed systems, and will reduce total methane emissions from the manure. However a lack of knowledge on the benefits of manure composting and spreading to soil fertility is a barrier to uptake.

<u>Animal husbandry:</u>

Reducing the chronic disease burden from intestinal parasites and ticks using anthelmintics. However, often farmers do not perceive the real benefits due to a lack of trust in input quality control, vets and animal health services.

Artificial insemination (AI) could aid intensive dairy farms, by improving fertility, helping to introduce improved breeds and replacing less productive animals. However a lack of quality AI services, and the perceived costs and risks involved is a barrier to farmer uptake.

Access to improved feed and fodder year round will make the most rapid and important contribution to improving productivity. Feed availability, both quantity and quality, are pre-requisites to other productivity improvements including breed improvement. This intervention is most suited to intensive and semi-intensive SSDPs, requiring collection and ideally storage of fodder to feed to animals with limited grazing.

The table following summarises the main climate change threats to increased fodder production, the likely impact and key mitigation strategies. These include the need for: i) planting improved food and fodder varieties adapted to drier, warmer and/or cooler conditions with resistance to pests and diseases, ii) integrated soil fertility management (ISFM) practices through increased use of crop rotations, composts and manures and cover crops integrated with the use of inorganic fertilisers, iii) integrated soil and water conservation (ISWC) and drainage measures using contour barriers or terracing especially on steeper slopes, using fodder grasses and trees on the terraces combined with rainwater harvesting techniques and improved irrigation, when water is available, and iv) agroforestry involving the planting of fodder trees and hedges to mitigate wind and water damage and improve soil fertility, including protection of areas of high biodiversity.

TABLE 4: CLIMATE CHANGE THREATS, IMPACT AND MITIGATION STRATEGIES

Climate change threats	Impact	Mitigation strategies
1. Changes in the timing of seasons	– Delay in the onset of rainfall and extension of the dry season	i) Planting improved food and fodder varieties, which are disease and drought resistant or tolerant
2. Increasing drought both between and within seasons	– Increased soil erosion, soil fertility loss and reduced soil moisture availability	
3. Heavy rains leading to waterlogged growing conditions	– Heat stress and arrival or increase in pests and diseases	ii) Integrated soil fertility management
4. Shortened growing season due to earlier onset of cold weather	– Reduced yield and quality of milk – Declining suitability of some areas for producing milk and consequential move to other more suitable areas	iii) Improved soil and water conservation practices
5. Increased temperatures during the day		iv) Protection of areas of high biodiversity
6. Increased incidence of hail	– Biodiversity loss	

As climate change alters the economics of production, dairy farming communities will need to consider:

- Using improved crop (feed and fodder) varieties resistant or tolerant to heat stress, drought spells, weeds, pests and diseases

- 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 crop residues
- 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
- Optimising the use of sustainable, natural fertilising sources in crop 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
- Optimising the use of pesticides because of their costs and carbon fuel footprint
- Optimising water-use efficiency on irrigated crops, because of the irrigation water's costs and carbon fuel footprint

Following Conservation Agriculture (CA) principles especially with regards cereal and legume crops, including those used for fodder. 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, improved and sustained fodder production. The characteristics of CA make it one of the systems best able to contribute to climate change mitigation by reducing atmospheric greenhouse gas concentration[24].

24 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

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

CSA Practice	Management practices
Integrated soil fertility management (ISFM)	Improvement of soil organic matter content: 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. Adding organic matter in the form of compost and well matured animal manure is an essential component of ISFM. It provides both nutrients, increases soil moisture holding capacity and improves the structure of the soil and will lead to a reduced need for inorganic fertilisers. This should be undertaken through applications of 3-5 tonnes per ha Crop Rotations: Rotation is critical to avoid accumulation of pest and diseases in soil and crop and to improve soil fertility and soil health Typical rotations will include maize followed by a legume or fodder crop, grown under a system of conservation agriculture. Green manures and cover crops: These form an integral part of both ISFM and soil and water conservation (SWC) and are described under soil and water conservation.
Soil and water conservation	Emphasis should be given to increasing the infiltration of rainwater into the soil and safe disposal from it during periods of high rainfall using the following measures: Application of manure and compost helps increase organic matter content in the soil, improving soil structure and water infiltration and water retention. Planting aligned along the contour and not up and down the slope. Active rainwater harvesting through pits or trenches leading to wells can help to recharge groundwater levels In addition, the following should be undertaken: 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 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. 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 milk for nutrients, water or light. Common species include: Crotalaria spp, Desmodium intortum, Canavalia ensiformis, Dolichos lablab, Medicago sativa, Mucuna pruriens and Macroptilium atropurpureum.

CSA Practice	Management practices
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. Grasses can be mixed or replaced with hedgerows of leguminous fodder trees such as Leucaena diversifola, Calliandra calothyrsus, Sesbania sesban and Gliricidia sepium.
Protecting water sources and areas of biodiversity	If the cropped area has a water-course running along the edge or within its boundary, no 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.

A number of incentives are necessary to increase adoption of improved fodder production[25]. These include:

- Improved and reliable markets (access, input and output prices) with guaranteed market demand, market access and reliable transport infrastructure are major determinants of the resources a smallholder farmer is likely to devote to dairy farming. Improved markets are likely to motivate farmers to invest in improved fodder.
- Guaranteed stable returns act as an incentive for farmers to invest in new innovations. The risk this poses deters farmers from intensification towards more diversified economic activities. At present, few agencies are willing to bear the price fluctuation risk. Cooperatives are often unable to do so since they do not have sufficient reserves. As a result, farmers are often reluctant to adopt new innovations.
- The provision of information services. Although many cooperatives or processors have extension officers, their presence is limited. Information about the value and profitability of improved fodder production is required, as is basic information on animal husbandry practices including that of other farmers' experiences.
- Gender issues. Although women are responsible for many livestock husbandry tasks in dairy systems, they often face barriers to adopting improved practices. Women often have a heavy labour burden and are unlikely to adopt practices that add to this unless there is a corresponding additional direct benefit. However, women often have little control of decisions regarding either the animals or the milk, or the income derived from sales. They are often constrained relative to men in participation in formal markets, but often have more control in informal markets26.

[25] Kashangaki, J. and Ericksen, P. 2018. Cost–benefit analysis of fodder production as a low emissions development strategy for the Kenyan dairy sector. ILRI Project Report. Nairobi, Kenya: ILRI.
[26] Tavenner, K. and Crane. T.A. 2016. Best practice guide to socially and gender-inclusive development in the Kenyan intensive dairy sector. ILRI project report. Nairobi, Kenya: ILRI.

4. THE CLIMATE SMART DAIRY 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 approach required for small holder dairy producers to derive optimum benefit from CSA dairy practices dictate that loans advanced should be guided by the size of the area to be planted, starting with an area of 0.03 ha, this being equivalent to 1/32nd of one ha. This can be regarded as "Learner Level", where CSA practices can be tried, tested and learnt from, before proceeding to progressively larger areas. These would be increased from 0.03 ha 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.

Certain practices have been identified under the dairy 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.

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

TABLE 5: PRACTICES REQUIRED UNDER THE DAIRY CLIMATE-SMART CREDIT PRODUCT

					CSA requirements per ha							CSA input requirements (USD)							
			units	No. per ha	Loan 1 0.03	Loan 2 0.06	Loan 3 0.13	Loan 4 0.25	Loan 5 0.5	Loan 6 0.75	Loan 7 1	USD/ unit	Loan 1 0.0	Loan 2 0.1	Loan 3 0.1	Loan 4 0.25	Loan 5 0.5	Loan 6 0.75	Loan 7 1
Plant improved crop and fodder varieties	1	Varieties tolerant or resistant to adversities of weather (drought, water logging, warm/cold weather conditions) and pests and diseases	kg	25	1	2	3	6	13	19	25	**1**	0.8	1.6	3.1	6	13	19	25
Integrated soil fertility management on crop areas	2	Improvement of soil organic matter content through applications of compost, crop residues, cattle manure (3-5 tonnes per ha) leading to a reduction in inorganic fertiliser applications	100 kg piles of manure or similar	40	1	3	5	10	20	30	40	0	0	0	0	0	0	0	0
		Ensuring appropriate crop rotations are followed. These should include cereals (probably maize), legumes (soya beans, beans, groundnuts,)or a fallow period growing a leguminous cover crop as a green manure with residues used	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Soil and water conservation	3	Establish contour terraces/banks planted with grass and/or trees with appropriate measures for safe removal of water (micro-watershed management)	metres	400	13	25	50	100	200	300	400	0	0.0	0.0	0.0	0	0	0	0
	4	Establishing suitable fodder grasses (such as Napier,Rhodes or Guatemala grown on contour terraces)	sq. metres	400	13	25	50	100	200	300	400	0.01	0.1	0.3	0.5	1	2	3	4
	5	Rain water harvesting ditches incorporated in the micro-watershed plan	No.	4	0	0	0	1	2	3	4	0	0.0	0.0	0.0	0	0	0	0
		Irrigation during dry spells where feasible	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Agroforestry	6	Establish trees for windbreaks, mulching, improving soil fertility and erosion control that can be fed to livestock	seedlings	250	8	16	31	63	125	188	250	0.5	3.9	7.8	15.6	31	63	94	125
												Total	**4.8**	**9.6**	**19.3**	**39**	**77**	**116**	**154**

		0.03ha	0.06ha	0.13ha	0.25ha	0.5ha	0.75ha	1ha
Contractual Requirements	Plant Trees	8 trees	16 trees	31 trees	53 trees	125 trees	188 trees	250 trees
	Rainwater Harvesting Ditches	0	0	0	1	2	3	4
	Grass reinforcement of terraces	13m	25m	50m	100m	200m	300m	400m
	Contour Terracing	13m	25m	50m	100m	200m	300m	400m
	Crop Rotation	0.03ha	0.06	0.13ha	0.25ha	0.5ha	0.75ha	1ha
	Manure / Compost Spreading	0.03ha	0.06ha	0.13ha	0.25ha	0.5ha	0.75ha	1ha
		Loan 1	**Loan 2**	**Loan 3**	**Loan 4**	**Loan 5**	**Loan 6**	**Loan 7**
Non-Contractual Requirements	Improved Feed and Fodder Varieties	Improved varieties	Improved varieties	Improved varieties	Improved varieties	Improved varieties	Improved varieties	Improved varieties
	Join a Farmer's Group	Training	Training	Training	Training	Training	Training	Training

FIGURE 6: CSL DAIRY PRODUCT

The impact[27,28] 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 both infiltration of water into the soil and improving run-off control measures, 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 milk production, sequestering carbon both in the soil and in increased biomass, and N20 emissions through reducing fuel use

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

Details of the impact of each of these components are shown qualitatively (- no effect, + some effect, ++ intermediate effect and +++ large effect) in Annex 3, with that on productivity shown below.

TABLE 6: IMPACT OF CSA DAIRY PRACTICES ON PRODUCTIVITY

1. The impact of dairy CSA practice on the resilience of natural resource uses

CSA practice			Farm level biodiversity	Groundwater availability	Soil erosion	Plant available nutrients	Infiltration of water into the soil	Soil microbial diversity	Soil aggregation	Soil water holding capacity
Improved feed and fodder varieties	1	Varieties tolerant or resistant to adversities of weather (drought, water logging, warm/cold weather conditions) and pests and diseases	-	-	-	-	-	-	-	-
Integrated soil fertility management	2	Improvement of soil organic matter content through applications of compost, crop residues, cattle manure (3-5 tonnes per ha) 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, beans, groundnuts, broad beans)or a fallow period growing a leguminous cover crop as a green manure with residues used for mulching	++	+	++	++	++	++	+	++
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	Establishing vegetative matter (such as Napier, Guatemala or vetiver grass grown on contour terraces)	+	+	+++	++	++	+	-	++
	6	Rain water harvesting ditches incorporated in the micro-watershed plan	-	++	++	+	++	+	+	++
Agro-forestry	7	Establish trees for shade, windbreaks, mulching, and erosion control between fields and on field boundaries	+++	++	++	+++	+++	++	+	++
	8	Afforestation, reforestation and establishment of trees on field boundaries, surrounding water courses, around homes and areas surrounding fields.	+++	++	++	+++	+++	++	+	++

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

27 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

28 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)

5. Yield and mitigation benefits

5.1. Introduction

This section explains the yield and climate mitigation benefits of the proposed climate-smart credit product land-use requirements. We also provide some context, as this informs the impact analysis in following sections with regards to base level yield and price with reference to countries of interest.

5.2. Kenya production and yield levels

Data from Kenya shows steadily increasing production from around one million tonnes (1,000 m litres) in 1982 to over 4 billion tonnes (or litres) in 2016. At the same time annual yields per cow have increased from less than 4000 kg to 6000kg (or litres)[29]. This equates to 10 litres per cow per year.

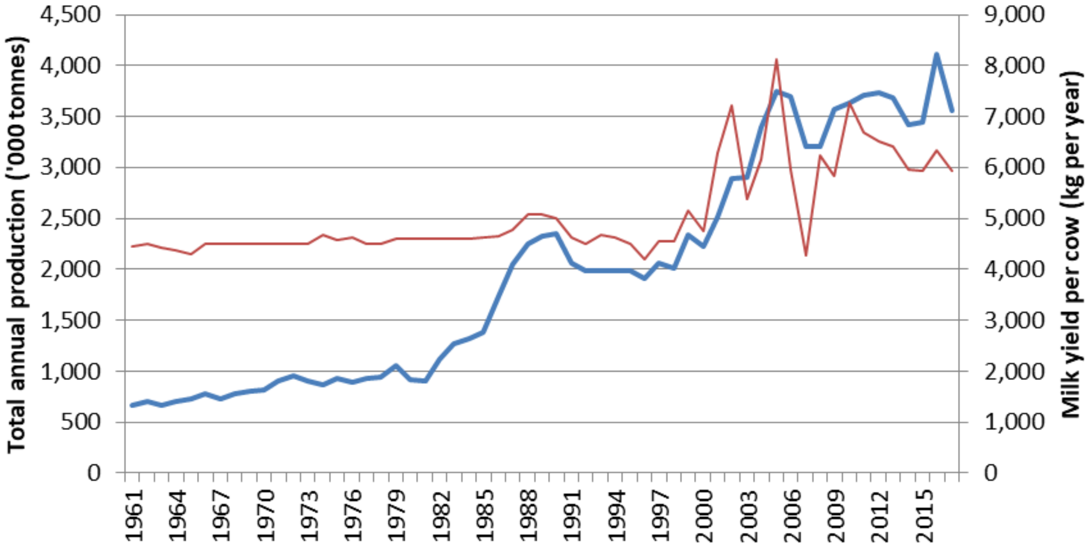


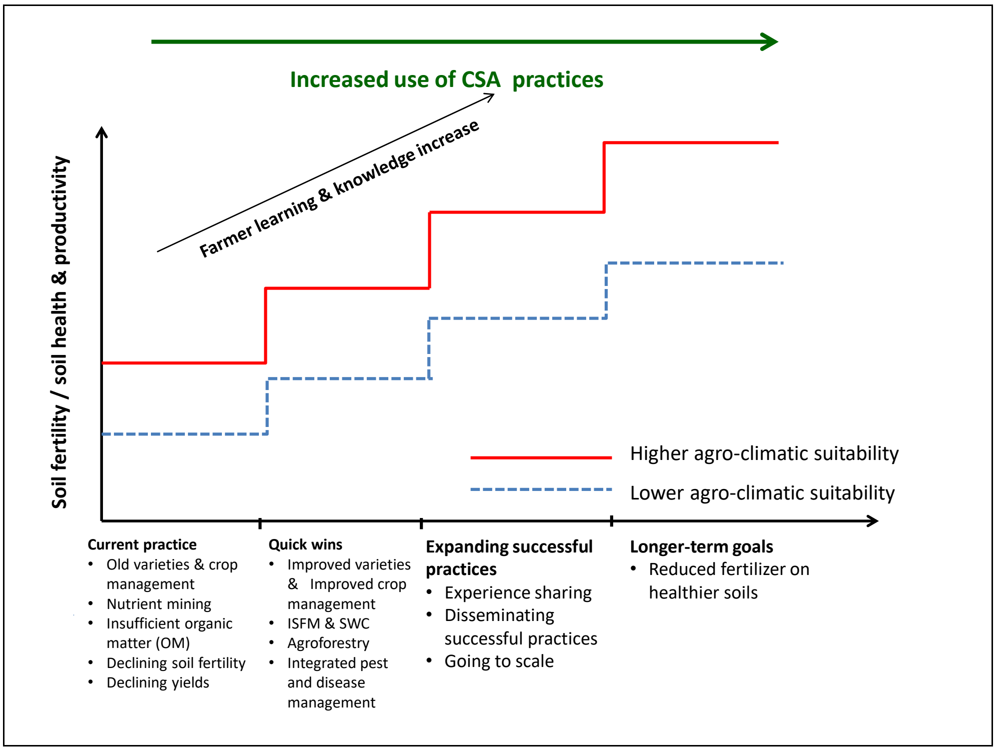
FIGURE 7: KENYA ANNUAL MILK PRODUCTION AND LACTATION YIELDS PER COW30

5.3. Yields increases through Adoption of CSA Dairy Practices

CSA practices aim to increase yields of both fodder and milk. Crop (food and fodder) yields can increase over time as soil health is restored, soil organic matter builds and soil and water conservation measures become effective s. This is likely to involve a step-wise process through farmer learning and knowledge increase, but also dependent on agro-climatic potential below.

[29] FAOSTAT, 2017. http://www.fao.org/faostat/en/#data/QL
[30] Ibid

FIGURE 8: STEP WISE PRODUCTIVITY YIELD IN RESPONSIVE AND LESS RESPONSIVE SOILS31



Yield increase estimates through the adoption of practices are difficult to quantify. They will be location specific, dependent on local agro-climatic conditions, but can be achieved alongside a reduction in costs particularly for inorganic fertiliser and input requirements, although an increase in labour will be required.

ILRI's[32] cost benefit analysis of fodder production as a strategy for the Kenyan dairy sector farm level dairy profitability identified best and worst case scenarios for milk yield and profit increases. Yield increases ranged from a low of 67% (from 12 to 20 litres per cow per day) to a high of 160% (from 5 to 13 litres per cow per day) with a mean increase of 136% (from 7.2 to 17 litres per cow per day). They concluded that with constant on-farm management parameters with market prices not changing beyond the current range, fodder intensification can increase both milk yield and profit margins for typical smallholder farming households.

These increases are likely over a period of time from a base of around 10 litres per cow per day, up to and exceeding 20 litres, as improved fodder is consistently planted, soil health is improved, soil organic matter builds and soil conservation measures become effective and other animal management practices improve. 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 no reliable data exists of how individual CSA practices contribute to yield increases, although the table below provides quantification in percentage terms.

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

32 Kashangaki, J. and Ericksen, P. 2018. Cost–benefit analysis of fodder production as a low emissions development strategy for the Kenyan dairy sector. ILRI Project Report. Nairobi, Kenya: ILRI.

TABLE 7: QUANTIFICATION OF THE IMPACT OF CSA PRACTICE ON MILK YIELDS LEVELS OVER TIME

Climate smart agricultural practice			% yield increase	Agronomic reasons for benefit
New varieties	1	Varieties tolerant or resistant to adversities of weather (drought, water logging, warm/cold weather conditions) and pests and diseases	30%	Great genetic potential with resistance /tolerance to drought as well as pests and diseases
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	30%	Improving soil organic matter content increases soil moisture holding capacity, improves soil health allowing a reduction in time of the need for inorganic fertiliser
	-	Ensuring appropriate crop rotations are followed. These should include cereals (maize or sorghum), legumes (soya beans, beans, groundnuts, broad beans)or a fallow period growing a leguminous cover crop as a green manure with residues used for mulching		Introducing a break between potato 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	3	Establish contour terraces/banks planted with grass and/or trees with appropriate measures for safe removal of water (micro-watershed management)	20%	Reduced soil erosion and consequential increase in soil fertility, Stabilisation of contour banks and use as mulch material
	4	Establishing 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
	5	Rain water harvesting ditches incorporated in the micro-watershed plan		Harvest and store rain water to increase soil moisture availability for the crop
Agroforestry	6	Establish trees for windbreaks, mulching, improving soil fertility and erosion control	20%	The provision of shade, windbreaks, mulching, and erosion control
	7	Afforestation, reforestation and establishment of trees on field boundaries, surrounding water courses, around homes and areas surrounding fields.		This will support IPM through build up of natural predators of cotton pests
		Total	100%	over a ten year period

Note: Although % increases are attributed to each CSA practice, integration/coordination of all practices at the same time is required to derive full impact

5.4. Milk Prices

Market prices reflect not only local supply and demand, but also the costs involved in moving milk from producer to consumption centres in urban areas, which lower the prices received by farmers. Additionally prices vary due to changes in rainfall that influence the availability of fodder. The season of peak milk production is typically associated with the rainy season, when increased supply often drives down prices paid to farmers. For instance, in Kenya processors were offering prices buying USD 0.35-0.40 per litre, although they have been revised downwards to about USD 0.30 per litre with many processors are currently buying the raw milk from USD 0.23-0.27 per litre.

In many developing countries including Kenya farmers are paid on the quantity of milk they produce. Possible changes in regulatory frameworks will base prices on the quality or fat content of milk delivered to processors. This aims both to encourage farmers to produce higher quality milk and to treat dairy farming as a commercial enterprise. This new system was among the changes proposed in new dairy sector regulations aimed at improving the safety of milk produced[33]. The system is also expected to deal with adulteration where water may be used to boost the amount of milk delivered.

At the same time regulation of the quality of animal feed sold in the market is under consideration. This aims to rein in those producers bringing substandard feeds to the market, sometimes blamed for high levels of aflatoxin and other toxins in dairy and meat products[34].

[33] Ibid
[34] ibid

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

Research indicates that cost savings are possible by adopting CSA practices, mainly by reducing the amount of purchased fodder[35], applying less inorganic fertiliser to crops as soil health improves through application of manures, composts and mulching materials.

The table overleaf provides quantification of the cost increases associated with the CSA practices. These have been determined on a per ha basis and scaled down for smaller areas. The following quantifies the impact of the CSA practice on the additional labour requirements in both days and cost per ha, again scaled down for the smaller areas.

[35] Kashangaki, J. and Ericksen, P. 2018. Cost–benefit analysis of fodder production as a low emissions development strategy for the Kenyan dairy sector. ILRI Project Report. Nairobi, Kenya: ILRI.

TABLE 8: QUANTIFICATION OF THE IMPACT OF CSA PRACTICE ON MILK INPUT COSTS

Climate Smart Agriculture strategies for dairy producers					**CSA requirements per ha**							**CSA input requirements (USD)**							
					Loan 1	**Loan 2**	**Loan 3**	**Loan 4**	**Loan 5**	**Loan 6**	**Loan 7**	**USD/ unit**	**Loan 1**	**Loan 2**	**Loan 3**	**Loan 4**	**Loan 5**	**Loan 6**	**Loan 7**
			units	**No. per ha**	**0.03**	**0.06**	**0.13**	**0.25**	**0.5**	**0.75**	**1**		**0.0**	**0.1**	**0.1**	**0.25**	**0.5**	**0.75**	**1**
Plant improved crop and fodder varieties	1	Varieties tolerant or resistant to adversities of weather (drought, water logging, warm/cold weather conditions) and pests and diseases	kg	25	1	2	3	6	13	19	25	**1**	0.8	1.6	3.1	6	13	19	25
Integrated soil fertility management on crop areas	2	Improvement of soil organic matter content through applications of compost, crop residues, cattle manure (3-5 tonnes per ha) leading to a reduction in inorganic fertiliser applications	100 kg piles of manure or similar	40	1	3	5	10	20	30	40	0	0	0	0	0	0	0	0
		Ensuring appropriate crop rotations are followed. These should include cereals (probably maize), legumes (soya beans, beans, groundnuts,)or a fallow period growing a leguminous cover crop as a green manure with residues used for mulching	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Soil and water conservation	3	Establish contour terraces/banks planted with grass and/or trees with appropriate measures for safe removal of water (micro-watershed management)	metres	400	13	25	50	100	200	300	400	0	0.0	0.0	0.0	0	0	0	0
	4	Establishing suitable fodder grasses (such as Napier,Rhodes or Guatemala grown on contour terraces)	sq. metres	400	13	25	50	100	200	300	400	0.01	0.1	0.3	0.5	1	2	3	4
	5	Rain water harvesting ditches incorporated in the micro-watershed plan	No.	4	0	0	0	1	2	3	4	0	0.0	0.0	0.0	0	0	0	0
		Irrigation during dry spells where feasible	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Agroforestry	6	Establish trees for windbreaks, mulching, improving soil fertility and erosion control that can be fed to livestock	seedlings	250	8	16	31	63	125	188	250	0.5	3.9	7.8	15.6	31	63	94	125
												Total	**4.8**	**9.6**	**19.3**	**39**	**77**	**116**	**154**

TABLE 9: QUANTIFICATION OF THE IMPACT OF CSA PRACTICE ON MILK LABOUR REQUIREMENTS

Climate Smart Agriculture strategies for dairy producers

					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**
			units	**No. per ha**	Days per ha	**0.03**	**0.06**	**0.13**	**0.25**	**0.5**	**0.75**	**1**	Costs per day	**0.0**	**0.1**	**0.1**	**0.25**	**0.5**	**0.75**	**1**
Plant improved potato varieties on suitable land	1	Varieties tolerant or resistant to adversities of weather (drought, water logging, warm/cold weather conditions) and pests and diseases	kg	25	10	0.3	0.6	1.3	2.5	5	7.5	10	2.5	0.8	1.6	3.1	6	13	19	25
Integrated soil fertility management	2	Improvement of soil organic matter content through applications of compost, crop residues, cattle manure (3-5 tonnes per ha) leading to a reduction in inorganic fertiliser applications	100 kg piles of manure or similar	40	5	0.2	0.3	0.6	1	3	4	5	2.5	0.4	0.8	1.6	3	6	9	13
		Ensuring appropriate crop rotations are followed. These should include cereals (maize or sorghum), legumes (soya beans, beans, groundnuts, broad beans)or a fallow period growing a leguminous cover crop as a green manure with residues used for mulching	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Soil and water conservation	3	Establish contour terraces/banks planted with grass and/or trees with appropriate measures for safe removal of water (micro-watershed management)	metres	400	20	0.6	1.3	2.5	5	10	15	20	2.5	1.6	3.1	6.3	13	25	38	50
	4	Establishing vegetative matter (such as Napier, Guatemala or vetiver grass grown on contour terraces)	sq. metres	400	5	0.2	0.3	0.6	1	3	4	5	2.5	0.4	0.8	1.6	3	6	9	13
	5	Rain water harvesting ditches incorporated in the micro-watershed plan	No.	4	8	0.3	0.5	1.0	2	4	6	8	2.5	0.6	1.3	2.5	5	10	15	20
		Irrigation during dry spells where feasible	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	
Agroforestry	6	Establish trees for windbreaks, mulching, improving soil fertility and erosion control	seedlings	250	5	0.2	0.3	0.6	1	3	4	5	2.5	0.4	0.8	1.6	3	6	9	13
					Total	**2**	**3**	**7**	**13**	**27**	**40**	**53**	**Total**	**4.1**	**8.3**	**16.6**	**33**	**66**	**99**	**133**

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

The risks to milk 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 milk 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 large losses are likely to be experienced.

6. Agro-climatic and market parameters for CSA lending

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 milk production can flourish. Increased yields are dependent on ensuring year round fodder availability produced at affordable prices. CSA milk lending products can be used in any of the suitable environments especially where milk yields may have declined due to poor livestock, fodder and crop management practices resulting from soil health 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

CSA lending for small scale dairy production can be deployed in all those milk producing areas, where producers 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 dairy milk 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 milk 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 milk production is possible by applying best practices for both dairy and crop management. These include planting improved crop (food and feed) varieties that are drought and disease resistant or tolerant, improving soil health through application of organic and inorganic fertilizers to maintain optimum soil quality and crop nutrient levels, soil and water conservation measures, including using grasses and planting trees to produce fodder and reduce crop losses due to biotic stress factors. Full commitment of all stakeholders in the dairy value chain will be required in helping to ensure economic and social sustainability of milk production.

Perceived profitability has been recognised as a key factor in explaining farmers' decisions to adopt or not adopt sustainable land management (SLM) technologies36. 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 milk farm gate price of USD 0.35 per litre, together with an opportunity price for labour of US$ 2.50 per day. The tables following set out those variables affecting base-line, CSA output and input prices for milk production.

36 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 10: VARIABLES AFFECTING THE BASE-LINE MILK PRODUCTION PRACTICES (SOURCES ELABORATED IN ASSOCIATED SPREADSHEETS)

#	Units	Base case
Area (ha)	**ha**	**1**
Area (acres)	**acres**	**2.5**
Total herd	**No**	**4**
Milking cows	**No**	**2**
Average productivity per cow per day	litres	10
Lactating period	days	320
Fresh milk produced per cow per year	litres	3,200
Fresh milk produced per farm (ha) per year	litres	6,400
Average price	USD per litre	0.35
Number of calves per year	No	2
Value of calves	USD	50
Manure produced per animal per year	tonnes	0.5
Manure from farm	tonnes	2
Value of manure per tonne	USD	20

Purchased inputs	Units	Qty	No.	USD
Dairy meal/fodder	70 kg bag	12	65	780
Purchased hay	bales	300	2	600
Salt licks				100
Water costs				60
Vet and medicines				50
Breeding costs (bull hire or AI)				40
Transport and marketing				50

Labour costs	days	
Cattle and feed management	200	
Opportunity cost of labour	2.5	per day

TABLE 11: VARIABLES AFFECTING THE CSA MILK PRODUCTION PRACTICES (SOURCES ELABORATED IN ASSOCIATED SPREADSHEETS)

#	Units	CSA Y1	CSA Y2	CSA Y3-on
Area (ha)	**ha**	**1**	**1**	**1**
Area (acres)	**acres**	**2.5**	**2.5**	**2.5**
Total herd	**No**	**4**	**4**	**4**
Milking cows	**No**	**2**	**2**	**2**
Average productivity per cow per day	litres	12	14.4	17.28
Lactating period	days	320	320	320
Fresh milk produced per cow per year	litres	3840	4608	5529.6
Fresh milk produced per farm (ha) per year	litres	7680	9216	11059
Average price	USD per litre	0.35	0.35	0.35
Number of calves per year	No	2	2	2
Value of calves	USD	50	50	50
Manure produced per animal per year	tonnes	0.5	500	500
Manure from farm	tonnes	2	2	2
Value of manure per tonne	USD	20	20	20
Increased milk yield		**0.2**	**per year up until the 3rd year**	
Purchased inputs	**Units**	**Qty**	**No.**	**USD**
Savings on purchased feed per year		0.1		
Purchasing grass planting material for terraces	kg	2	20	40
Purchasing inputs for fodder area	per ha cost			100
Purchasing tree seedlings	seedlings	250	0.5	125
Increased labour costs for CSA interventions (days)		**Y1**	**Y2**	**Y3**
Increased labour for feeding animals		20	20	20
Establishing contour terraces on crop fields		20	-	-
Maintaining contour terraces on crop fields		-	5	5
Establishing grass on terraces		5	0	-
Maintaining grass on terraces		-	2	2
Pasture/fodder estbalishment		5	5	5
Establishing trees		5	27	-
Maintaining trees		-	5	5
Total labour		**55**	**64**	**37**

7.4. Results

The key output of this exercise is a gross margin and a farmer cost benefit analysis model for small scale milk producers adopting climate-smart and sustainable land management measures required under the proposed climate-smart credit product.

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

The table below compares a base situation where the farmer is not using CSA practices with production using CSA practices. Results of the CSA practices are presented over a three year reflecting both the additional input required by CSA and the gradual increase in milk yields over the three year period.

TABLE 12: MILK GROSS MARGIN ANALYSIS COMPARING BASE CASE AND CSA MILK PRODUCTION PRACTICES

	#				Base case	CSA production		
		Units			**Y1-10**	**Y1**	**Y2**	**Y3-10**
Outputs	Total milk produced per year	litres			6400	7680	9216	11059.2
	Average price	USD per litre			0.35	0.35	0.35	0.35
	Income from milk per year	USD			2240	2688	3225.6	3870.72
	Calves produced	No			2	2	2	2
	Value of calves	USD			50	50	50	50
	Income from calves	USD			100	100	100	100
	Manure from farm	tonnes			2	2	2	2
	Value of manure per kg	USD			20	20	20	20
	Value of manure	USD			40	40	40	40
	Gross dairy income	USD			2380	2828	3365.6	4010.72
Inputs		Units	Qty	Cost per unit				
Purchased inputs	Dairy meal/fodder	70 kg bag	12	65	780	780	780	780
	Purchased hay	bales	300	2	302			
	Savings on purchased inputs per year		0.1		0	-78	-85.8	-69.42
	Salt licks				100	100	100	100
	Water costs				60	60	60	60
	Vet and medicines				50	50	50	50
	Breeding costs (bull hire or AI)				40	40	40	40
	Transport and marketing				50	50	50	50
	Costs of CSA practices							
	Purchasing grass planting material for terraces	kg	2	20	-	40	-	-
	Purchasing inputsfor fodder area	per ha		100	-	100	100	100
	Purchasing tree seedlings	seedlings	250	0.4	-	100	-	-
	Total inputs				**1,382**	**1,242**	**1,094**	**1,111**
	Income less purchased inputs				**998**	**1,586**	**2,271**	**2,900**
			days	Cost per day				
Labour costs	Cattle and feed management		200	2.5	500	500	500	500
	Increase labour costs of CSA practices	Y1	10	2.5		25	25	25
	Establishing contour terraces on crop fields	Y1	20	2.5	0	50	0	0
	Maintaining contour terraces on crop fields	Y2-	5	2.5	0	0	12.5	12.5
	Establishing grass on terraces	Y1	5	2.5	0	12.5	0	0
	Maintaining grass	Y2-	2	2.5	0	0	5	5
	Pasture/fodder estbalishment	Y1-	5	2.5	0	12.5	12.5	12.5
	Establishing trees	Y1	5	2.5	0	12.5	0	0
	Maintaining trees	Y2-	5	2.5	0	0	12.5	12.5
	Total labour				**500**	**613**	**568**	**555**
Total production costs					**1,882**	**1,855**	**1,662**	**1,666**
Gross margin					**498**	**974**	**1,704**	**2,345**
	Labour required	days			200	255	264	237
	Returns to labour	USD per ha			998	1,586	2,271	2,900
	Returns to labour	USD per day			5	6	9	12
	B:C ratio				1	2	2	2
	Returns per cow	USD			249	487	852	1,173
	Returns per litre produced	**USD**			0	0	0	0

Results are summarised below:

TABLE 13: RESULTS SUMMARY

		Year										
		0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**9**	**9**	
Scenario	**Milk production**	**Y1**	**Y2**	**Y3**	**Y4**	**Y5**	**Y6**	**Y7**	**Y8**	**Y9**	**Y10**	**Total**
Base	Gross margin	498	498	498	498	498	498	498	498	498	498	
	Discounted gross margin	498	453	412	374	340	309	281	256	211	211	3,345
CSA	Gross margin	974	1,704	2,345	2,345	2,345	2,345	2,345	2,345	2,345	2,345	
	Discounted gross margin	974	1,549	1,938	1,762	1,602	1,456	1,324	1,203	995	995	13,797
	B:C ratio	2.0	3.4	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.1

Discount rate = 10%

8. Lender financial impact model

8.1. Introduction

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

8.2. Model assumptions

The underlying assumptions of this model are as follows:

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

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

8.3. Model outputs

Whilst the output of this exercise is the general model template for climate-smart lending for dairy, 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.

TABLE 14: LENDER FINANCIAL IMPACT ANALYSIS

	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$)	12,124,000	12,124,000	12,124,000	12,124,000	12,124,000	12,124,000	12,124,000
Portfolio loss with no climate-smart lending	**(6,549,107)**	**(6,549,107)**	**(6,549,107)**	**(6,549,107)**	**(6,549,107)**	**(6,549,107)**	**(6,549,107)**
Portfolio loss with climate-smart lending	**(6,695,263)**	**(5,922,478)**	**(5,304,250)**	**(4,798,427)**	**(4,376,908)**	**(4,020,238)**	**(3,714,521)**
Savings due to CSA practices	(146,155)	626,629	1,244,857	1,750,680	2,172,199	2,528,869	2,834,586
Cost of capital w/o climate-smart lending	20%	20%	20%	20%	20%	20%	20%
Cost of capital w climate-smart lending	8%	8%	8%	8%	8%	8%	8%
Annual interest savings (US$)	1,454,880.00	1,454,880.00	1,454,880.00	1,454,880.00	1,454,880.00	1,454,880.00	1,454,880.00
Cash position improvement with climate-smart-lending (US$)	**1,308,725**	**2,081,509**	**2,699,737**	**3,205,560**	**3,627,079**	**3,983,749**	**4,289,466**

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 milk 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 owing to the costs associated with a 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.

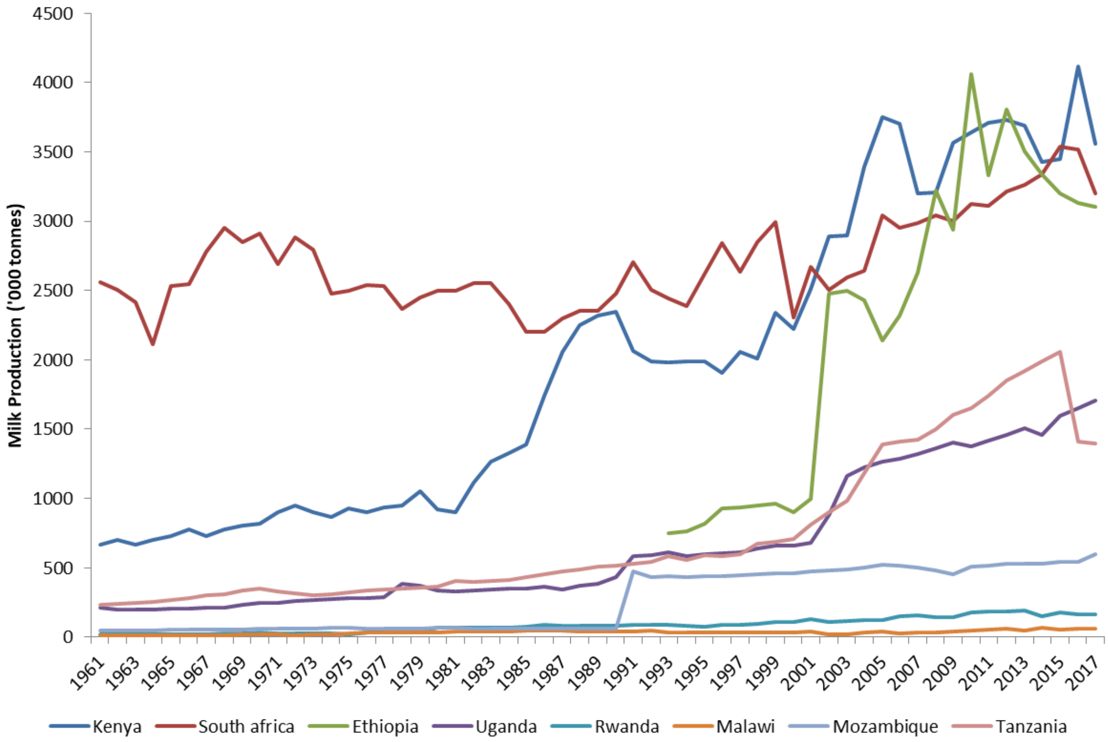
We do not include yield benefits of the required measures to avoid double-counting.

9.3. Model outputs

The table provides the summary outputs for the environmental cost benefit analysis. The net present value (NPV) of implementing the system is nearly US$ nearly 2,000 over 7 years.

#	Benefits associated with climate-smart lending dairy environmental requirements	0	1	3	4	5	6	7
1	Regulation of climate	475	475	475	475	475	475	475
2	Regulation of water timing and flows	11	11	11	11	11	11	11
3	Erosion control	9	9	9	9	9	9	9
4	Maintenance of soil quality	18	18	18	18	18	18	18
5	Pollination	-	-	-	-	-	-	-
6	Natural hazard mitigation	-	-	-	-	-	-	-
7	Habitat	11	11	11	11	11	11	11
8	Nutrient cycling	-	-	-	-	-	-	-
	Total Benefits (US$/ha)	524	524	524	524	524	524	524
	Additional Labour Costs	112.50	67.50	67.50	67.50	67.50	67.50	67.50
	Loan discounts	44.80	50.40	56.00	61.60	67.2	72.80	78.40
	Total Costs (US$/ha)	**157.30**	**117.90**	**123.50**	**129.10**	**134.70**	**140.30**	**145.90**
	Net Benefits (US$/ha)	**366.22**	**405.62**	**400.02**	**394.42**	**388.82**	**383.22**	**377.62**
	Discounted Net Benefits (US$/ha)	**366.2**	**368.7**	**300.5**	**269.4**	**241.4**	**216.3**	**193.8**
	NPV (US$/ha)	**1,956.4**						

Annex 1: Milk production yields for dairy producing countries in sub Saharan Africa – 1961-2017[37]



37 FAOSTAT, 2018. Statistical data base. Food and Agriculture Organisation of the United Nations, Rome, Italy. http://www.fao.org/faostat/en/#data/PP/ accessed 20th April 2019

Annex 2: Profiles Dairy production in Kenya, Tanzania and Uganda[38][39]

The dairy industry in Kenya is one of the largest in Sub-Saharan Africa and is worth about USD 2 billion, accounting for 14% of agricultural output and 3.5% of the total GDP. Key figures on the sector are presented below.

- Agriculture share of exports 65%
- Dairy sub-sector share of Kenya GDP 4%
- Dairy sub-sector value KES 170 billion (USD 2 billion)
- Total milk production 5 billion (kg) litres
- Milk production by smallholders 80%
- Processed to raw milk market 3:7
- Smallholder dairy farmers 1,400,000
- Medium and large-scale dairy farmers 3,500
- Milk consumption per capita 115 litres per annum
- Active major milk processors 30
- Market leading milk processors Brookside, New KCC
- Direct economic impact of dairy sub-sector Employs 1.8 million people

Dairy is the fastest growing sub-sector of Kenyan agriculture. In 2013, the Kenya Dairy Board reported an annual growth rate of 6% in the volume of milk processed driven by increased investment in production, processing and marketing over the last few years, increasing the country's capacity to process milk. Average milk production ranges from 4 to 69 litres per cow per day.

Uganda[40]

The dairy industry in Uganda is estimated to contribute more than 50%of the total output from the livestock sub-sector, which in turn contributes nearly 20% of the total agricultural GDP. The dairy industry employs many people who are engaged in various economic activities along the dairy value chain, particularly in milk production, collection, bulking and transportation, processing, distribution and marketing as well as provision of inputs and support services.

The industry has witnessed tremendous growth over the last decade, growing at an average rate of 5-7% per annum as a result of the favourable macroeconomic environment, policy and institutional reforms, as well as numerous targeted interventions to promote development of the industry by government and the private sector.

Milk production has grown at an average rate of 6.3% per annum from 659.5 million litres in 1999 to an estimated 1.4 billion litres in 2010, in consequence of the herd expansion, which has grown at an average of 6.3% per annum from 5.8 million in 1999 to 12.1 million in 2010. The sector currently contributes to the livelihoods of 1.2 million dairy farming households. According to the 2008 National Livestock Census, the majority (94%) of the cattle-owning households keep indigenous cattle, while 6% of the cattle rearing households keep improved dairy breeds (exotics and their crosses with indigenous breeds).

Dairy production systems in Uganda may be classified into two broad categories, namely "traditional" and "commercial" milk production systems.

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[38] Kashangaki, J. and Ericksen, P. 2018. Cost–benefit analysis of fodder production as a low emissions development strategy for the Kenyan dairy sector. ILRI Project Report. Nairobi, Kenya: ILRI.
39 USAID and Climate Focus 2018
[40] FAO & New Zealand Agricultural Greenhouse Gas Research Centre. 2019. Options for low emission development in the Uganda dairy sector - reducing enteric methane for food security and livelihoods. Rome. 39 pp. Licence: CC BY-NC-SA 3.0 IGO.

Tanzania[41]

The dairy industry is largest agricultural sub-sector in Tanzania. It contributes 30 percent to agricultural Gross Domestic Product (GDP) and 1.8 percent of total national GDP. The sector currently provides income and employment to about 1.7 million households across the dairy value chain. In terms of nutrition and food security, per capita consumption of milk in 2014 was 40 litres and demand for dairy products is projected to continue to grow rapidly as a consequence of population growth. The sector is severely constrained by low livestock reproductive rates, high mortality and high disease prevalence. Most of the milk production is directed for household consumption.

From the milk that is marketed, 98% is sold directly to neighbours, middleman and collective bulking centres and only 2.4 percent of the marketed milk is in the form of processed products.

The distribution of dairy farming in Tanzania is largely explained by the agro-ecological zoning and proximity to markets and feed resources. Milk production takes place in all parts of the country, but is highly concentrated around Lake Victoria, Northern and Central Tanzania and Southwest region. Herd size distribution also varies geographically, with larger holders concentrated in the Northern and Western regions, and smaller holdings prevalent in the Southern and Southern Highlands.

Milk production in Tanzania is predominantly by traditional farmers (pastoralists, agro-pastoralists and smallholder mixed farmers). This represents 97%of the total dairy herd, which produces about 70% of the milk in the country. Milk production fluctuates greatly during the year due to a long dry season that limits feed and water availability for the animals.

Traditional dairy farming involves open range free grazing by the cattle, often with low levels of feed supplementation. Tanzania Shorthorn Zebu is the main breed kept by traditional farmers constituting 99%of the national herd. Most of the milk produced in these systems is directed for household consumption and cattle play an important cultural and social role.

Intensive dairy farming is composed of rural smallholder farms, urban and peri-urban smallholder farms and medium to large-scale farming. Cattle are usually kept under semi-zero grazing and are fed with cultivated fodder, crop residues, cut and carry forages and limited concentrate. Despite the number of animals in improved systems being low, representing only 3%of the national dairy herd, improved systems contribute to 30% of the total milk produced.

[41] FAO & New Zealand Agricultural Greenhouse Gas Research Centre. 2019. Options for low emission development in the Tanzania dairy sector - reducing enteric methane for food security and livelihoods. Rome. 34 pp. Licence: CC BY-NC-SA 3.0 IGO

Annex 3: The Kenya National Dairy master plan

The Kenyan government attaches high importance to the dairy subsector and have developed policies aimed at improving its productivity and competitiveness through increased market-orientation, increased value addition and greater use of improved farming practices. A Master Plan has been developed to guide the desired transformation process[42]. The master plan for implementing the national dairy development policy incorporates four action plans[43].

1 Improving productivity and competitiveness

- Enabling milk producers to appropriately/adequately feed their dairy animals for increased and efficient milk production
- Enabling milk producers manage seasonality of feed supply
- Enabling milk producers and traders to improve competitiveness and profits in milk enterprises
- Managing seasonal milk gluts
- Developing breeding objectives and selection criteria for smallholder producers' to embrace commercial approach to milk production

2 Efficient delivery of demand driven research, extension, finance and market information services by public, private and NGOs to chain operators

- Building capacity for efficient service delivery
- Improving prevention and control of animal diseases
- Enhancing efficiency in milk collection and transportation system
- Reducing post-harvest milk losses along the value addition chain
- Increasing milk value addition and branding
- Expanding domestic milk consumption
- Exporting more milk and milk products in the regional and global markets

3 Enforcement of policy and regulatory frameworks, infrastructure

- Increasing quantity and quality of concentrates in the market Reviewing and harmonizing policies, regulations and control.
- Designing enabling policy and regulation frameworks.
- Expanding export market for milk and milk products.

4 Addressing cross cutting issues in the dairy value chain to sustain high productivity and competitiveness

- Mainstreaming gender and youth in the dairy value chain support.
- Improving security to encourage investments in the dairy industry in Kenya.
- Improving better understanding of climate change implications for and adaptation in the dairy industry in Kenya.
- Enhancing mitigation and adaptation to climate change variability and change in the dairy industry Improving environmental quality, conservation and management in the dairy value chain.
- Enabling milk producers to improve water use efficiency in milk production.

[42]MoALF, 2010. Kenya National Dairy Master Plan 2010 – 2030. Vol. I. Situational Analysis Minisrty of Agriculture, Livestock and Fisheries. State Department of Livestock.
[43] Kenya Government, 2013. The National Dairy Development Policy. Towards a Competitive and Sustainable Dairy Industry for Economic Growth in the 21st Century and Beyond. Ministry of Agriculture, Livestock And Fisheries. State Department of Livestock. Sessional Paper No. 5 Of 2013.

Key constraints

Feed is the major constraint to achieving targeted milk production because of heavy dependency on rain-fed forage and pasture production while there is poor adoption of conservation of animal feeds to smooth seasonal fluctuations in milk production. At the same time efficient utilisation of dairy concentrates is required to match the high cost of quality concentrates. Unfortunately weak enforcement of standards has often failed to discourage infiltration of substandard commercial feeds into the market.

A key component is improved quantity and quality of feed to improve productivity and support animal population increases. The actions proposed to enhance better feeding for increased animal productivity include: Increase area under pasture and fodder, increase availability of seeds of improved forage varieties, promote adoption of feed conservation technologies, enforce standards of both raw materials and finished concentrates and train more farmers to make home ration formulation and on mixing of feeds. These feeding strategies when adopted will also enhance reproductive performance in the national herd.

Milk marketing is currently characterised by inadequate milk collection facilities, inappropriate distribution and location of cooling facilities, high transport costs and poor road network in milk producing areas, limited access and high cost of electricity, inadequate clean water and lack of waste disposal system. The actions proposed to address these include: mobilize milk producers to form groups/co-operative societies (hubs) to collect and transport milk to processors in a cost effective manner, build capacity of players in milk value addition chain to reduce post-harvest losses, improve infrastructure, and promote quality- based payment system for milk and quality audit along the milk value chain.

Annex 4: The impact of CSA dairy management practices[44]

1. Improving the resilience of natural resource use (farm level biodiversity, groundwater availability, soil erosion, plant available nutrients, infiltration of water into the soil, soil microbial diversity soil aggregation and soil water holding capacity)
2. Reducing the risks associated with climate change (increased temperature, intra-seasonal droughts, in season droughts, shortened growing season, increased rainfall intensity and unpredictable seasons)
3. Mitigating the effects of some of the causes of climate change (change in land use, emission from inputs, carbon sequestered in the soil, carbon sequestered in biomass, N_20 emissions, and CH^4 emissions)
4. Increasing productivity (yield, yield variability, labour and income)
5. Quantification of the impact of CSA practice on productivity (farmer benefits and costs)

1. The impact of dairy CSA practice on the resilience of natural resource uses

CSA practice			Farm level biodiversity	Groundwater availability	Soil erosion	Plant available nutrients	Infiltration of water into the soil	Soil microbial diversity	Soil aggregation	Soil water holding capacity
Improved feed and fodder varieties	1	Varieties tolerant or resistant to adversities of weather (drought, water logging, warm/cold weather conditions) and pests and diseases	-	-	-	-	-	-	-	-
Integrated soil fertility management	2	Improvement of soil organic matter content through applications of compost, crop residues, cattle manure (3-5 tonnes per ha) leading to a reduction in inorganic fertiliser applications	+	++	++	+++	+++	+++	+++	+++
	-	Ensuring appropriate crop rotations are followed. These should include cereals (maize or sorghum), legumes (soya beans, beans, groundnuts, broad beans)or a fallow period growing a leguminous 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)	+++	+++	+++	+++	+++	+++	+++	+++
	4	Establishing vegetative matter (such as Napier, Guatemala or vetiver grass grown on contour terraces)	+	+	+++	++	++	+	-	++
	5	Rain water harvesting ditches incorporated in the micro-watershed plan	-	++	++	+	++	+	+	++
Agro-forestry	6	Establish trees for shade, windbreaks, mulching, and erosion control between fields and on field boundaries	+++	++	++	+++	+++	++	+	++
	7	Afforestation, reforestation and establishment of trees on field boundaries, surrounding water courses, around homes and areas surrounding fields.	+++	++	++	+++	+++	++	+	++

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

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

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

CSA practice			Increased temperature	Intra-seasonal droughts	Inter-seasonal droughts	Shortened growing season	Increased rainfall intensity	Unpredictable seasons
Improved feed and fodder varieties	1	Varieties tolerant or resistant to adversities of weather (drought, water logging, warm/cold weather conditions) and pests and diseases	++	++	++	+++	-	++
Integrated soil fertility management	2	Improvement of soil organic matter content through applications of compost, crop residues, cattle manure (3-5 tonnes per ha) leading to a reduction in inorganic fertiliser applications	+	+	+	+	+	+
	-	Ensuring appropriate crop rotations are followed. These should include cereals (maize or sorghum), legumes (soya beans, beans, groundnuts, broad beans)or a fallow period growing a leguminous 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)	-	+++	+++	+++	+++	+
	4	Establishing vegetative matter (such as Napier, Guatemala or vetiver grass grown on contour terraces)	+	++	++	++	++	++
	5	Rain water harvesting ditches incorporated in the micro-watershed plan	++	++	++	++	++	++
Agro-forestry	6	Establish trees for shade, windbreaks, mulching, and erosion control between trees and on field boundaries	+++	+++	+++	+++	+++	+++
	7	Afforestation, reforestation and establishment of trees on field boundaries, surrounding water courses, around homes and areas surrounding cotton fields.	++	++	++	++	++	++

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

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

3. The impact of dairy CSA practices on mitigation of the factors causing climate change

Climate smart agricultural practice			Change in land use	Emission from inputs	Carbon sequestered in the soil	Carbon sequestered in biomass	N20 emissions	CH4 emissions
Improved feed and fodder varieties	1	Varieties tolerant or resistant to adversities of weather (drought, water logging, warm/cold weather conditions) and pests and diseases	+	-	-	-	-	+
Integrated soil fertility management	2	Improvement of soil organic matter content through applications of compost, crop residues, cattle manure (3-5 tonnes per ha) leading to a reduction in inorganic fertiliser applications	+	-	+++	+++	+	+
	-	Ensuring appropriate crop rotations are followed. These should include cereals (maize or sorghum), legumes (soya beans, beans, groundnuts, broad beans)or a fallow period growing a leguminous 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)	+	-	+	-	-	-
	4	Establishing vegetative matter (such as Napier, Guatemala or vetiver grass grown on contour terraces)	++	-	+	+	+	-
	5	Rain water harvesting ditches incorporated in the micro-watershed plan	-	-	++	-	+	-
Agro-forestry	6	Establish trees for shade, windbreaks, mulching, and erosion control between trees and on field boundaries	+++	-	++	+++	-	-
	7	Afforestation, reforestation and establishment of trees on field boundaries, surrounding water courses, around homes and areas surrounding cotton fields.	+++	-	++	+++	-	-

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

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

4. The impact of dairy CSA practices on productivity

Climate smart agricultural practice			Yield	Yield variability	Labour	Income
Improved feed and fodder varieties	1	Varieties tolerant or resistant to adversities of weather (drought, water logging, warm/cold weather conditions) and pests and diseases	+++	+++	-	+++
Integrated soil fertility management	2	Improvement of soil organic matter content through applications of compost,crop residues,composted manure (3-5 tonnes per ha) leading to a reduction in inorganic fertiliser applications	++	++	++	++
	-	Ensuring appropriate crop rotations are followed. These should include cereals (maize or sorghum), legumes (soya beans, beans, groundnuts, broad beans)or a fallow period growing a leguminous 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)	++	++	++	++
	4	Establishing vegetative matter (such as Napier, Guatemala or vetiver grass grown on contour terraces)	++	++	++	++
	5	Rain water harvesting ditches incorporated in the micro-watershed plan	++	++	++	++
Agro-forestry	6	Establish trees for windbreaks, mulching, improving soil fertility and erosion control	++	++	++	++
	7	Afforestation, reforestation and establishment of trees on field boundaries, surrounding water courses, around homes and areas surrounding cotton fields.	++	++	++	+++

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

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